GEOG Climate Science Lab

TEXAS A&M UNIVERSITY




AMSR-E Soil Moisture Assessment in Oklahoma: Comparison of Multiple Root Zone Datasets

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http://climatology.tamu.edu/

https://www.facebook.com/GeogCSL

MOISST Workshop 2014 **Stillwater, Oklahoma**

Motivation

NATIONAL GEOGRAPHIC Daily News

Home Animals Ancient Energy Environment Travel/Cultures Space/Tech Water Weird News Photos News Video News Blogs

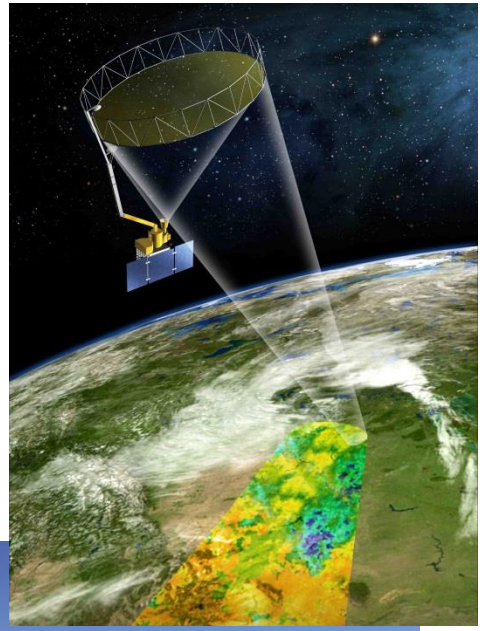
IN FOCUS

Parched: A New Dust Bowl Forms in the Heartland

"Exceptional drought" makes for tough times in Oklahoma.

A farmer walks in a dust storm on drought-stricken lands near Felt, Oklahoma, on August 1, 2013.

PHOTOGRAPH BY ED KASHI, VII



Previous Work

Hydrol. Earth Syst. Sci., 17, 1–16, 2013
www.hydrol-earth-syst-sci.net/17/1/2013/
doi:10.5194/hess-17-1-2013

Hydrology and Earth System Sciences
Open Access

Estimating root zone soil moisture using near-surface observations from SMOS

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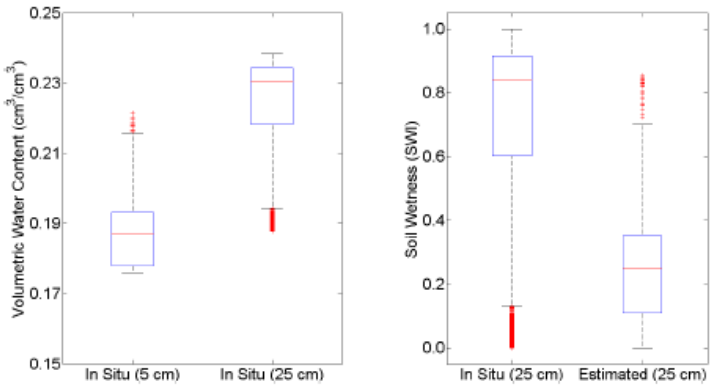


Fig. 14. Box plots of (left) volumetric water content at the 5 and 25 cm layers and (right) SWI from 25 cm in situ observations and 25 cm in situ estimates. The box plots show data from all Oklahoma stations.

- Root zone estimates based on surface retrievals from SMOS were generally comparable to Mesonet data
- SMOS-based root zone estimates did not compare well with observations at sites with highly heterogeneous soils between 5 and 25 cm

Questions

1. Can root zone products based on satellite surface retrievals accurately depict soil moisture conditions in heterogeneous soil conditions?

2. Are products based on data assimilation more accurate in such conditions than data derived using simpler methods?

3. Where can we expect SMAP-based root zone products to perform well or poorly?

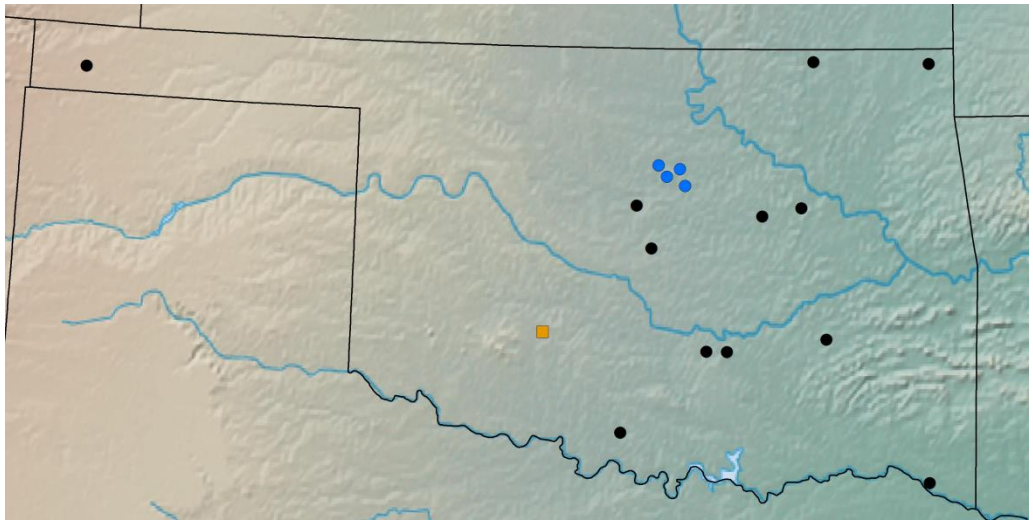
Datasets

Satellite Soil Moisture

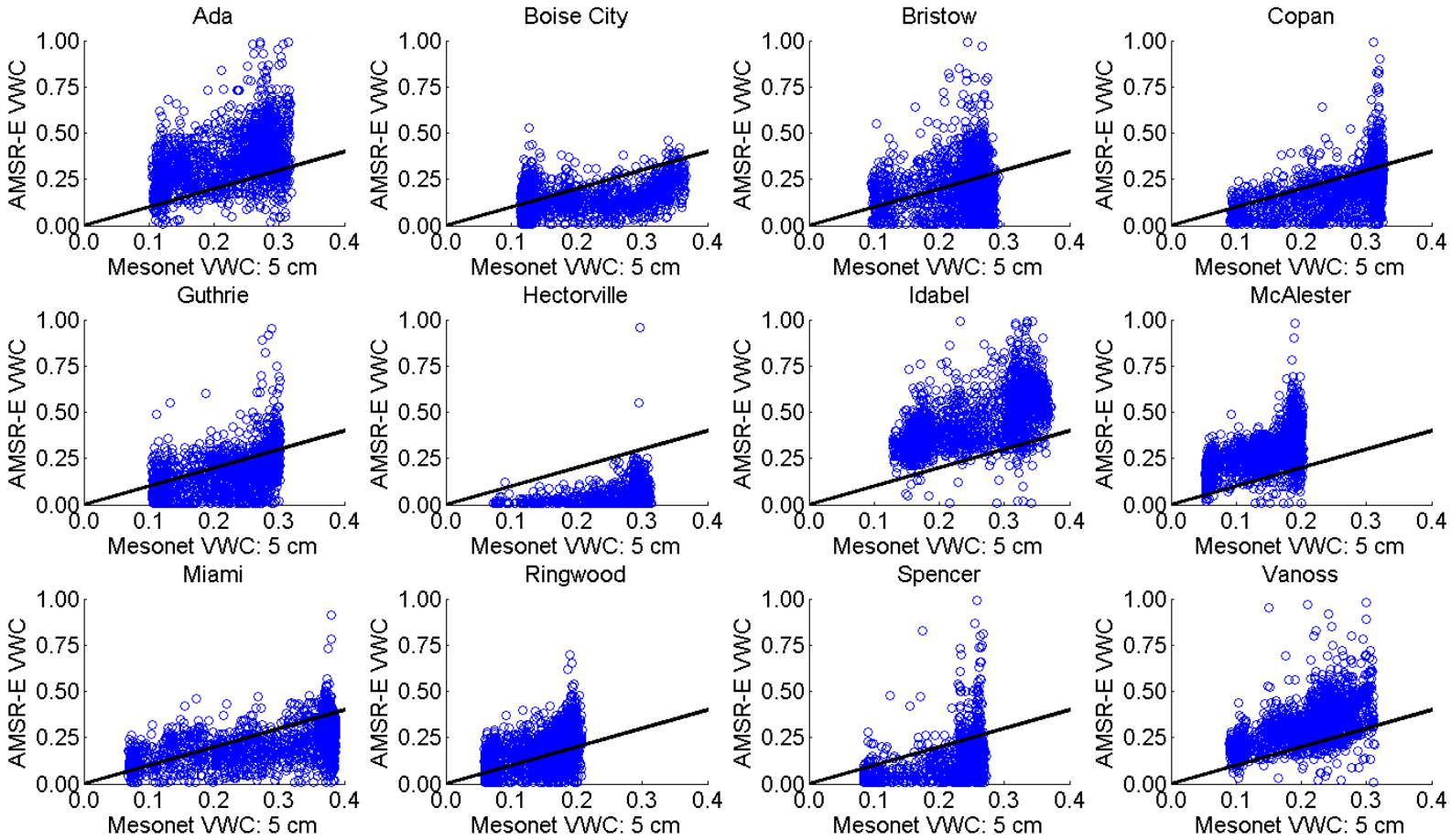
- AMSR-E Daily L3 Descending - 0.25° resolution (GES_DISC_LPRM_AMSRE_D_SOILM3_V002)
- Root Zone: 2-Layer Palmer Water Balance Model (GES_DISC_LPRM_AMSRE_D_RZSM3_V001, Bolten *et al.* 2010)

In Situ Soil Moisture

- Oklahoma Mesonet daily observations (12 stations, 5 & 25 cm)



Surface – Near Surface Comparison



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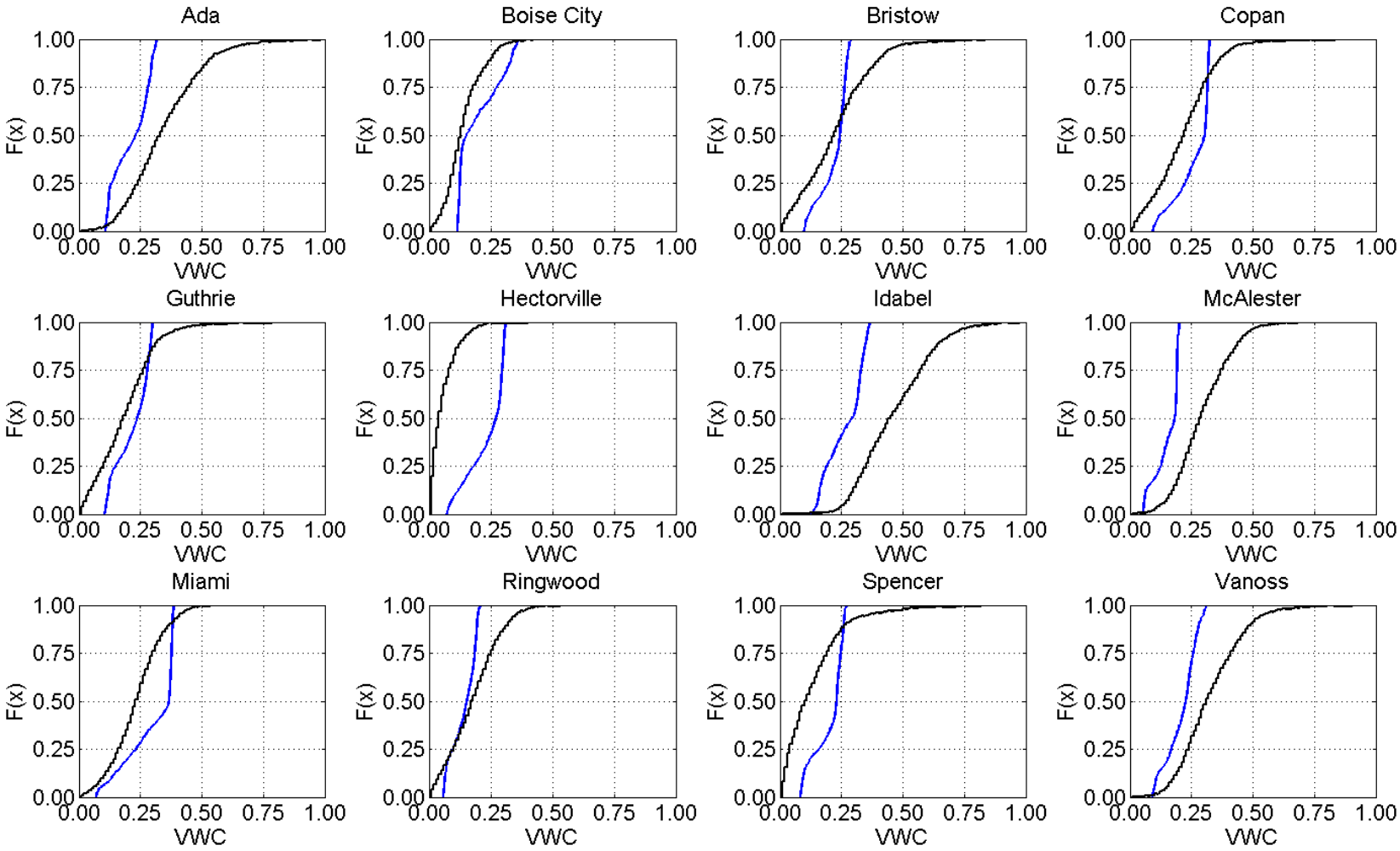

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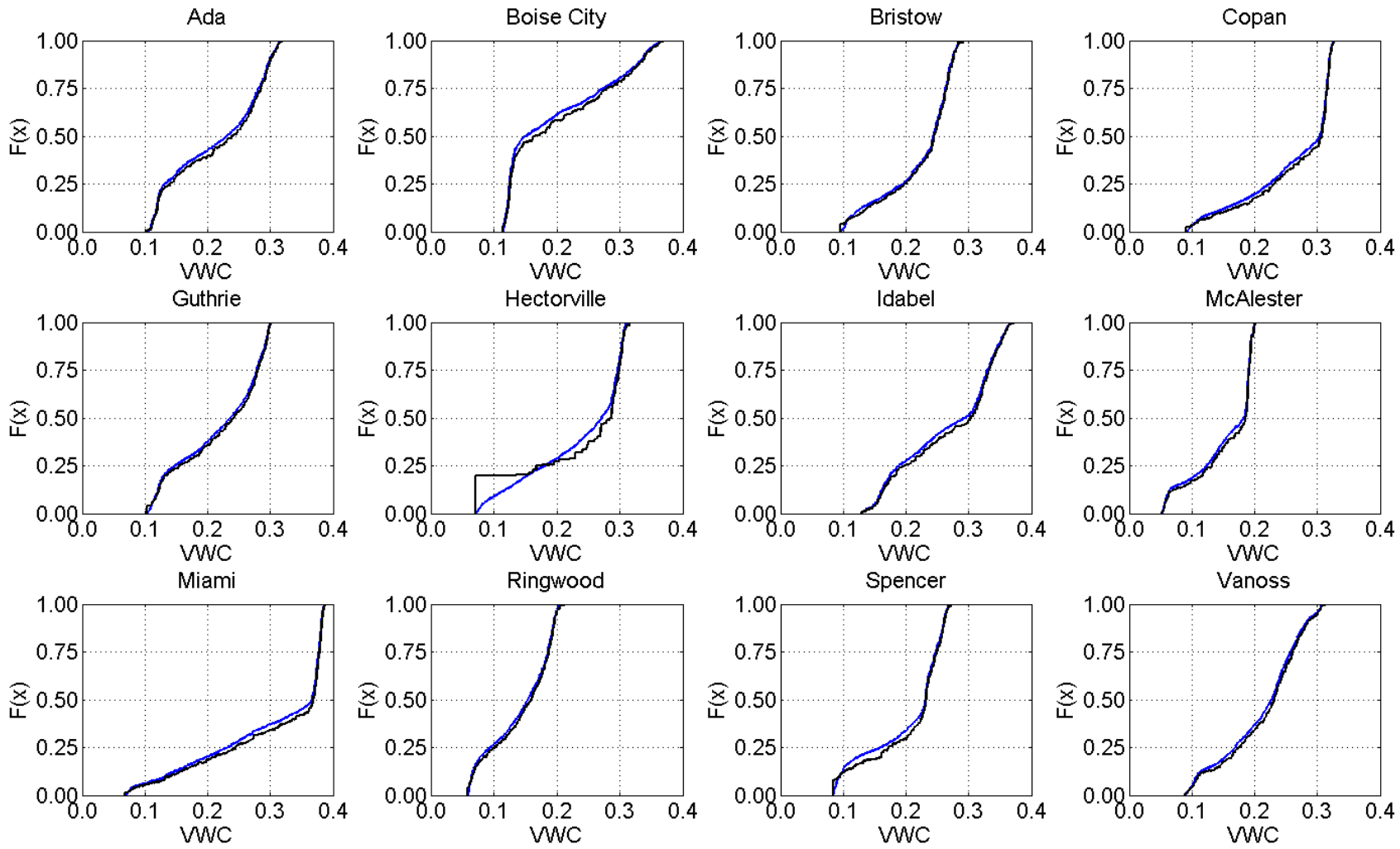
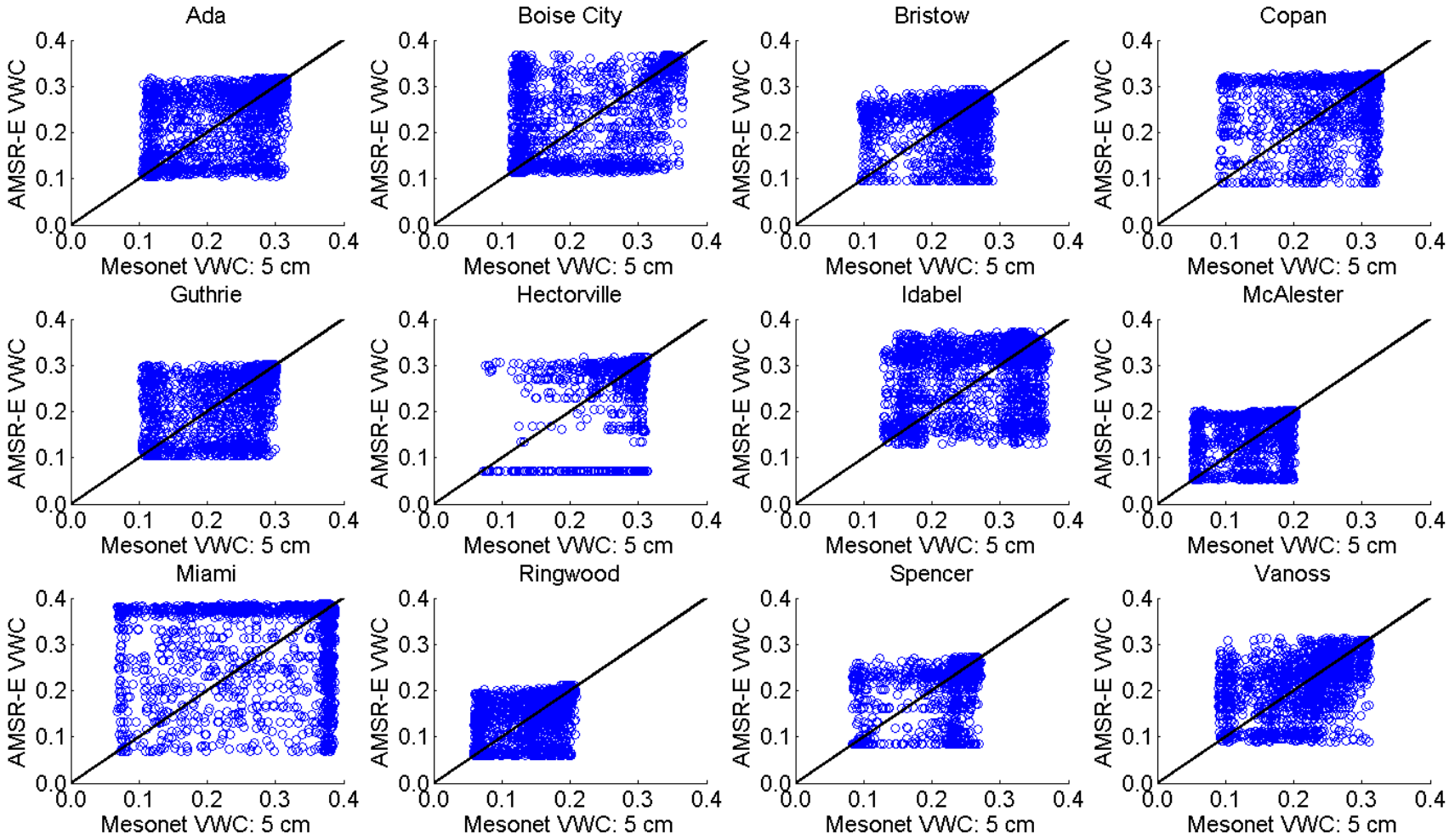
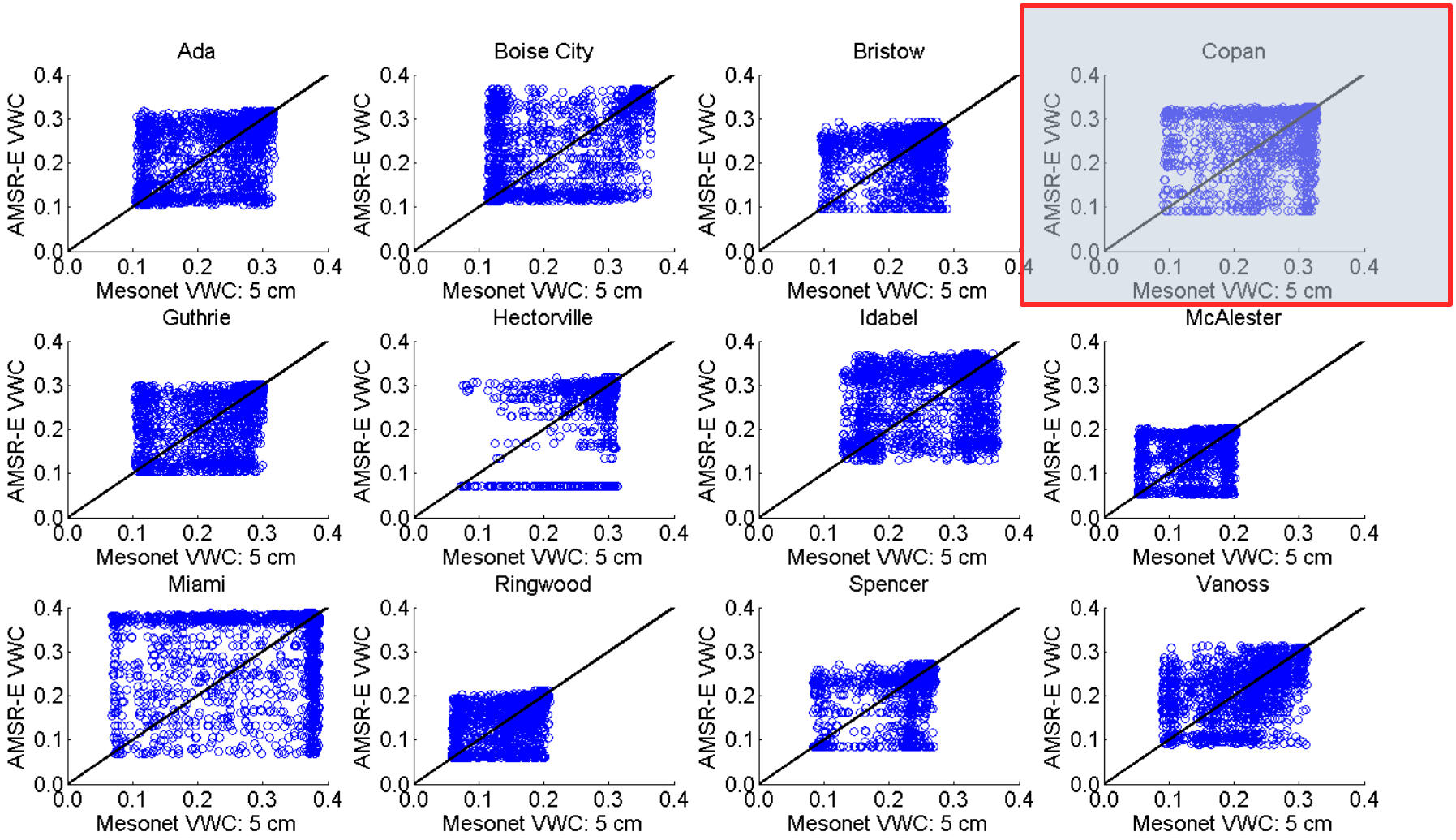


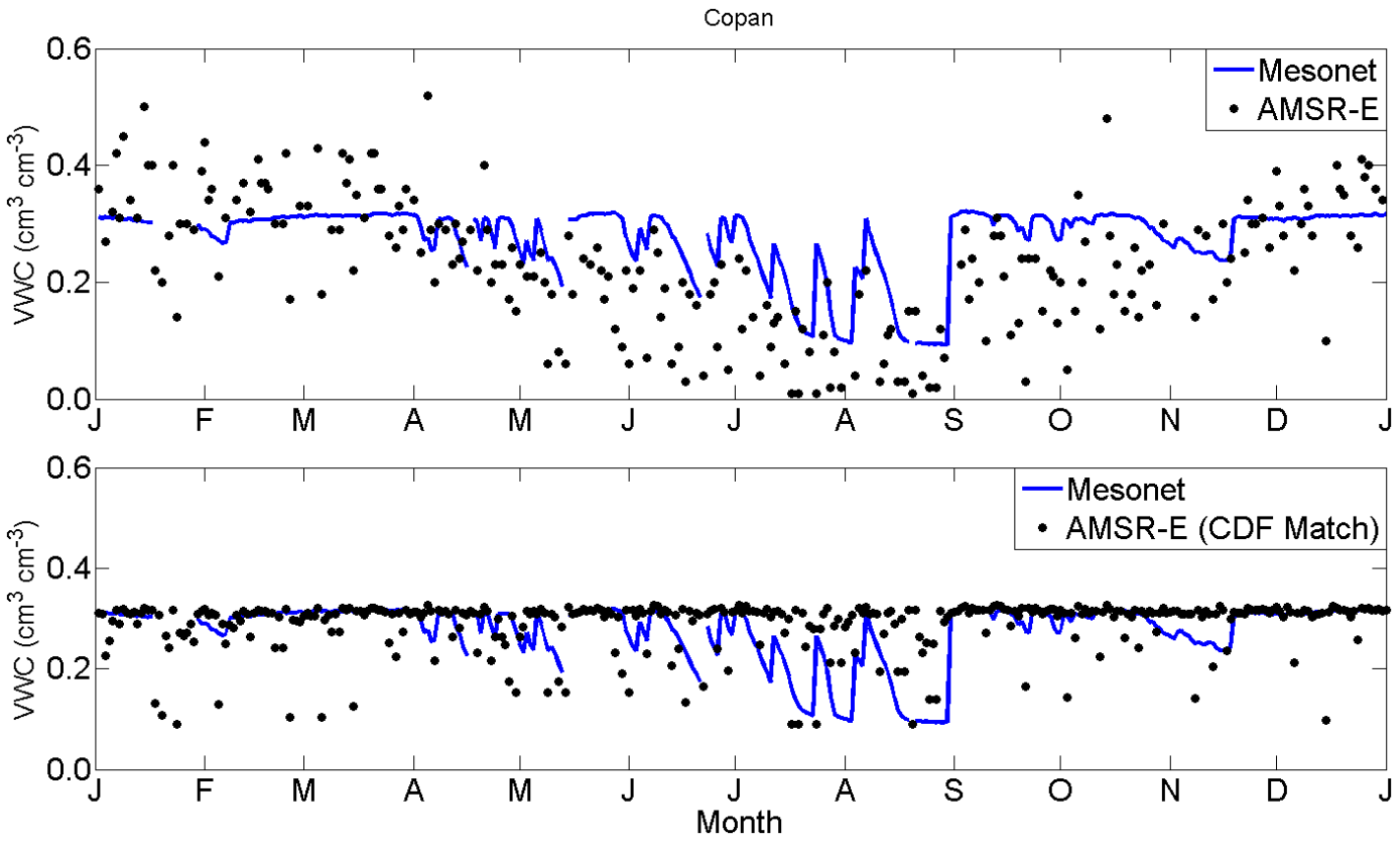
Surface – Near Surface Comparison



Surface – Near Surface Comparison



Surface – Near Surface Comparison

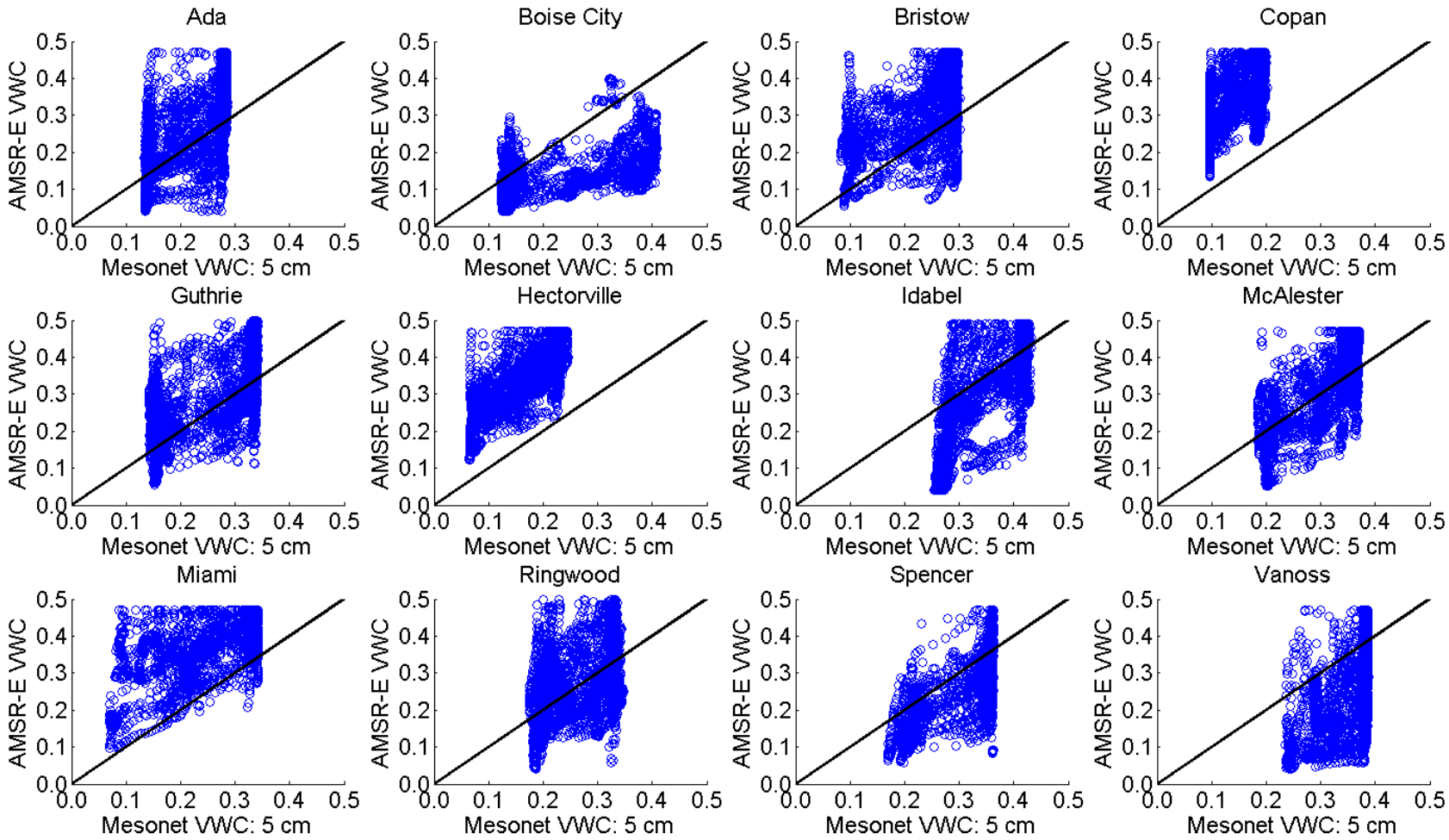


Surface – Near Surface Comparison

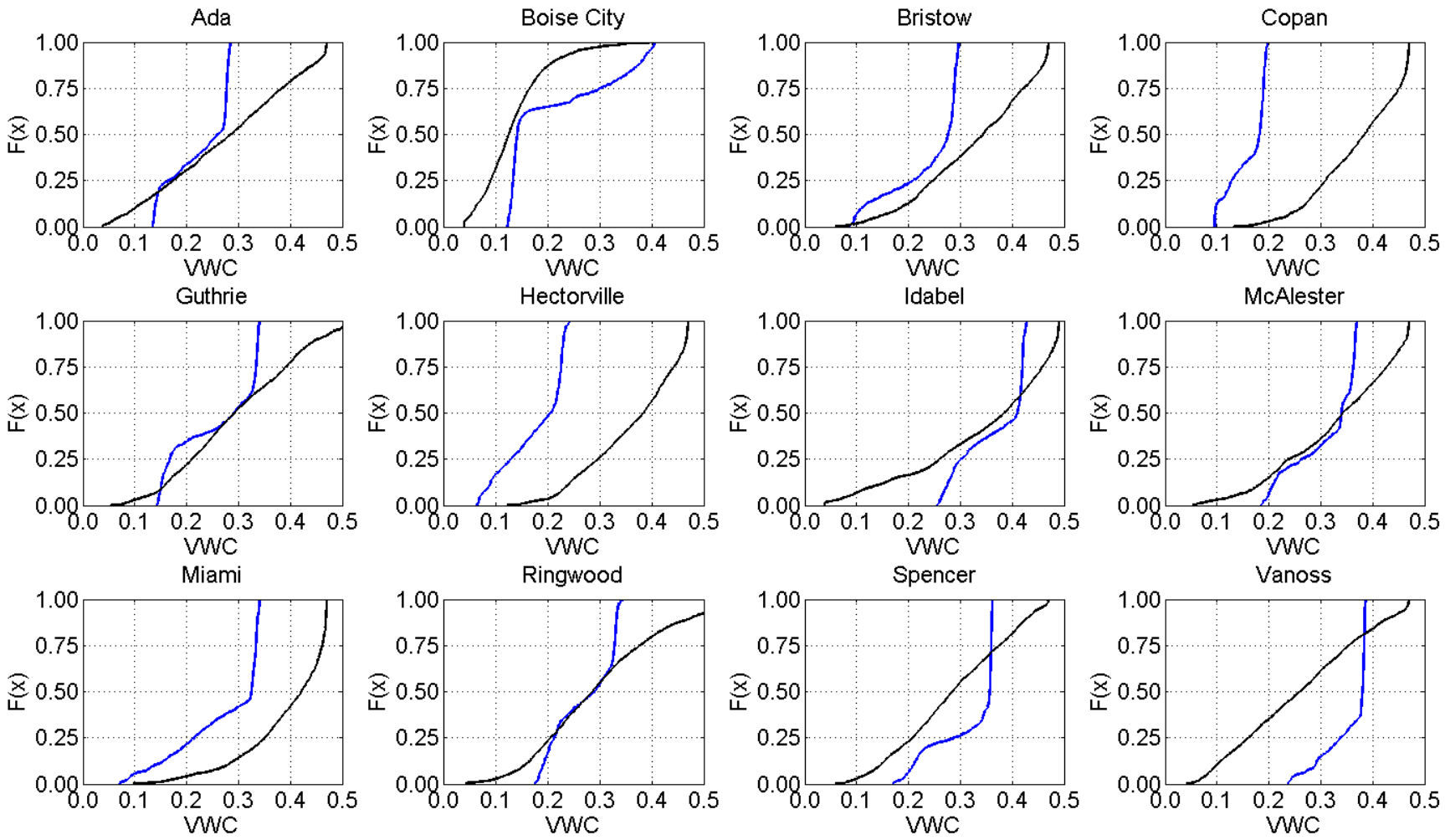
Mesonet (5 cm) - AMSRE Volumetric Water Content					
Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
Ada	0.15	-0.13	0.19	0.25	-3.51
Boise City	0.08	0.06	0.10	0.18	0.06
Bristow	0.11	0.00	0.14	0.05	-2.78
Copan	0.09	0.05	0.12	0.30	-0.72
Guthrie	0.08	0.04	0.11	0.23	-0.63
Hectorville	0.21	0.20	0.21	0.08	-1.85
Idabel	0.20	-0.20	0.23	0.34	-5.70
McAlester	0.15	-0.14	0.17	0.28	-8.15
Miami	0.10	0.07	0.12	0.26	-0.06
Ringwood	0.08	-0.04	0.10	0.26	-1.47
Spencer	0.12	0.08	0.14	0.12	-1.32
Vanoss	0.12	-0.11	0.15	0.32	-3.21
Super Site	0.08	0.05	0.11	0.30	-1.33
Average	**0.12**	**-0.01**	**0.15**	**0.22**	**-2.45**

Mesonet (5 cm) - AMSRE Volumetric Water Content (CDF Match)					
Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
Ada	0.05	0.00	0.07	0.33	0.44
Boise City	0.05	0.00	0.08	0.34	0.47
Bristow	0.05	0.00	0.07	0.05	0.17
Copan	0.04	0.00	0.06	0.34	0.50
Guthrie	0.04	0.00	0.06	0.28	0.48
Hectorville	0.05	0.02	0.08	0.13	0.57
Idabel	0.05	0.00	0.07	0.36	0.46
McAlester	0.03	0.00	0.05	0.30	0.36
Miami	0.06	0.00	0.09	0.34	0.42
Ringwood	0.03	0.00	0.04	0.32	0.49
Spencer	0.04	0.01	0.06	0.16	0.59
Vanoss	0.03	0.00	0.05	0.45	0.57
Super Site	0.03	0.00	0.04	0.48	0.78
Average	**0.04**	**0.00**	**0.06**	**0.28**	**0.46**

Root Zone Comparison



Root Zone Comparison



Root Zone Comparison

AMSR-E EnKF

Mesonet (25 cm) - AMSRE Volumetric Water Content					
Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
Ada	0.09	-0.06	0.11	0.45	-2.62
Boise City	0.09	0.07	0.11	0.30	-0.25
Bristow	0.11	-0.09	0.12	0.35	-2.35
Copan	0.21	-0.21	0.22	0.44	-36.91
Guthrie	0.07	-0.04	0.09	0.44	-0.40
Hectorville	0.19	-0.19	0.19	0.67	-10.82
Idabel	0.07	0.02	0.09	0.60	-1.31
McAlester	0.06	-0.02	0.08	0.58	-0.54
Miami	0.12	-0.12	0.14	0.48	-1.88
Ringwood	0.08	-0.03	0.10	0.28	-2.29
Spencer	0.07	0.03	0.08	0.48	-0.80
Vanoss	0.11	0.09	0.14	0.27	-9.66
Super Site	0.07	-0.02	0.08	0.50	-0.51
Average	**0.11**	**-0.04**	**0.12**	**0.44**	**-5.82**

AMSR-E EnKF– CDF Match

Mesonet (25 cm) - AMSRE Volumetric Water Content (CDF Match)					
Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
Ada	0.03	0.00	0.04	0.48	0.40
Boise City	0.05	0.00	0.08	0.43	0.32
Bristow	0.04	0.00	0.06	0.37	0.21
Copan	0.02	0.00	0.03	0.51	0.43
Guthrie	0.03	0.00	0.05	0.58	0.52
Hectorville	0.02	0.00	0.03	0.74	0.72
Idabel	0.02	0.00	0.04	0.64	0.60
McAlester	0.02	0.00	0.04	0.62	0.58
Miami	0.03	0.00	0.06	0.59	0.53
Ringwood	0.04	0.00	0.05	0.30	0.10
Spencer	0.02	0.00	0.04	0.67	0.64
Vanoss	0.02	0.00	0.03	0.52	0.45
Super Site	0.03	0.00	0.04	0.48	0.78
Average	**0.03**	**0.00**	**0.05**	**0.54**	**0.46**

Mesonet (5 cm) - AMSRE Volumetric Water Content					
	MAE	**MBE**	**RMSE**	**R^2**	**NS**
Average	**0.12**	**-0.01**	**0.15**	**0.22**	**-2.45**

Mesonet (5 cm) - AMSRE Volumetric Water Content (CDF Match)					
	MAE	**MBE**	**RMSE**	**R^2**	**NS**
Average	**0.04**	**0.00**	**0.06**	**0.28**	**0.46**

Data Assimilation vs. Exponential Filter

AMSR-E EnKF

AMSR-E Filter

Data Assimilation vs. Exponential Filter

AMSR-E EnKF

Mesonet (25 cm) - AMSRE Volumetric Water Content					
Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
Ada	0.09	-0.06	0.11	0.45	-2.62
Boise City	0.09	0.07	0.11	0.30	-0.25
Bristow	0.11	-0.09	0.12	0.35	-2.35
Copan	0.21	-0.21	0.22	0.44	-36.91
Guthrie	0.07	-0.04	0.09	0.44	-0.40
Hectorville	0.19	-0.19	0.19	0.67	-10.82
Idabel	0.07	0.02	0.09	0.60	-1.31
McAlester	0.06	-0.02	0.08	0.58	-0.54
Miami	0.12	-0.12	0.14	0.48	-1.88
Ringwood	0.08	-0.03	0.10	0.28	-2.29
Spencer	0.07	0.03	0.08	0.48	-0.80
Vanoss	0.11	0.09	0.14	0.27	-9.66
Super Site	0.07	-0.02	0.08	0.50	-0.51
Average	**0.11**	**-0.04**	**0.12**	**0.44**	**-5.82**

AMSR-E Filter

Mesonet (25 cm) – Filter AMSRE Volumetric Water Content					
Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
Ada	0.13	-0.12	0.16	0.26	-6.39
Boise City	0.08	0.08	0.12	0.25	-0.38
Bristow	0.06	0.01	0.07	0.21	-0.20
Copan	0.08	-0.06	0.10	0.34	-6.34
Guthrie	0.09	0.08	0.11	0.24	-1.18
Hectorville	0.14	0.14	0.15	0.32	-5.79
Idabel	0.11	-0.10	0.13	0.41	-3.61
McAlester	0.06	0.01	0.08	0.30	-0.56
Miami	0.07	0.03	0.08	0.32	-0.02
Ringwood	0.10	0.10	0.12	0.36	-3.05
Spencer	0.22	0.22	0.23	0.14	-13.46
Vanoss	0.08	0.03	0.09	0.30	-3.61
Super Site	0.03	0.00	0.05	0.48	0.44
Average	**0.10**	**0.04**	**0.12**	**0.29**	**-3.71**

Data Assimilation vs. Exponential Filter

AMSR-E EnKF

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Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
Ada	0.09	-0.06	0.11	0.45	-2.62
Boise City	0.09	0.07	0.11	0.30	-0.25
Bristow	0.11	-0.09	0.12	0.35	-2.35
Copan	0.21	-0.21	0.22	0.44	-36.91
Guthrie	0.07	-0.04	0.09	0.44	-0.40
Hectorville	0.19	-0.19	0.19	0.67	-10.82
Idabel	0.07	0.02	0.09	0.60	-1.31
McAlester	0.06	-0.02	0.08	0.58	-0.54
Miami	0.12	-0.12	0.14	0.48	-1.88
Ringwood	0.08	-0.03	0.10	0.28	-2.29
Spencer	0.07	0.03	0.08	0.48	-0.80
Vanoos	0.11	0.09	0.14	0.27	-9.66
Super Site	0.07	-0.02	0.08	0.50	-0.51
Average	**0.11**	**-0.04**	**0.12**	**0.44**	**-5.82**

AMSR-E Filter

Mesonet (25 cm) – Filter AMSRE Volumetric Water Content					
Station	**MAE**	**MBE**	**RMSE**	**R^2**	**NS**
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Copan	0.08	-0.06	0.10	0.34	-6.34
Guthrie	0.09	0.08	0.11	0.24	-1.18
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Idabel	0.11	-0.10	0.13	0.41	-3.61
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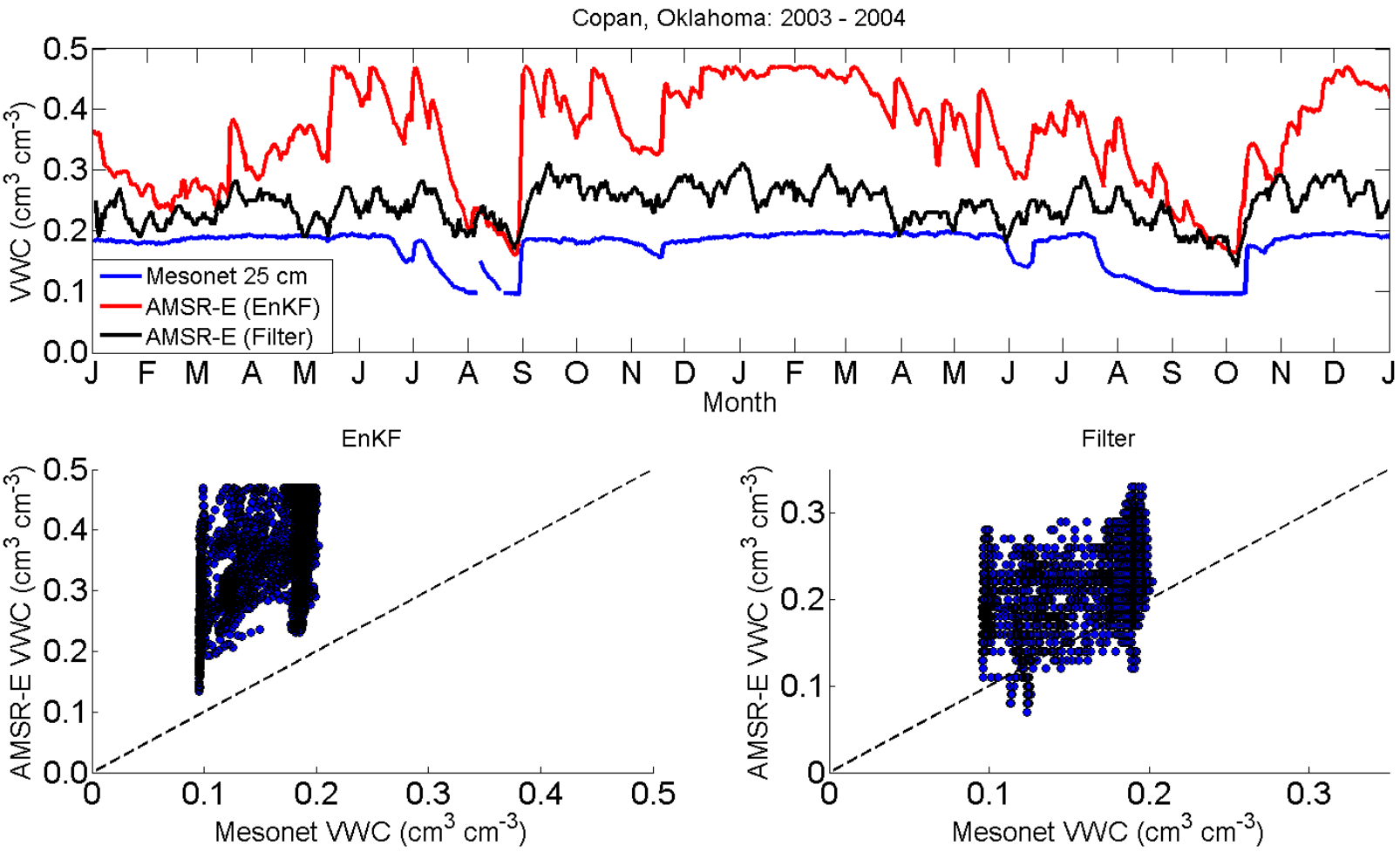
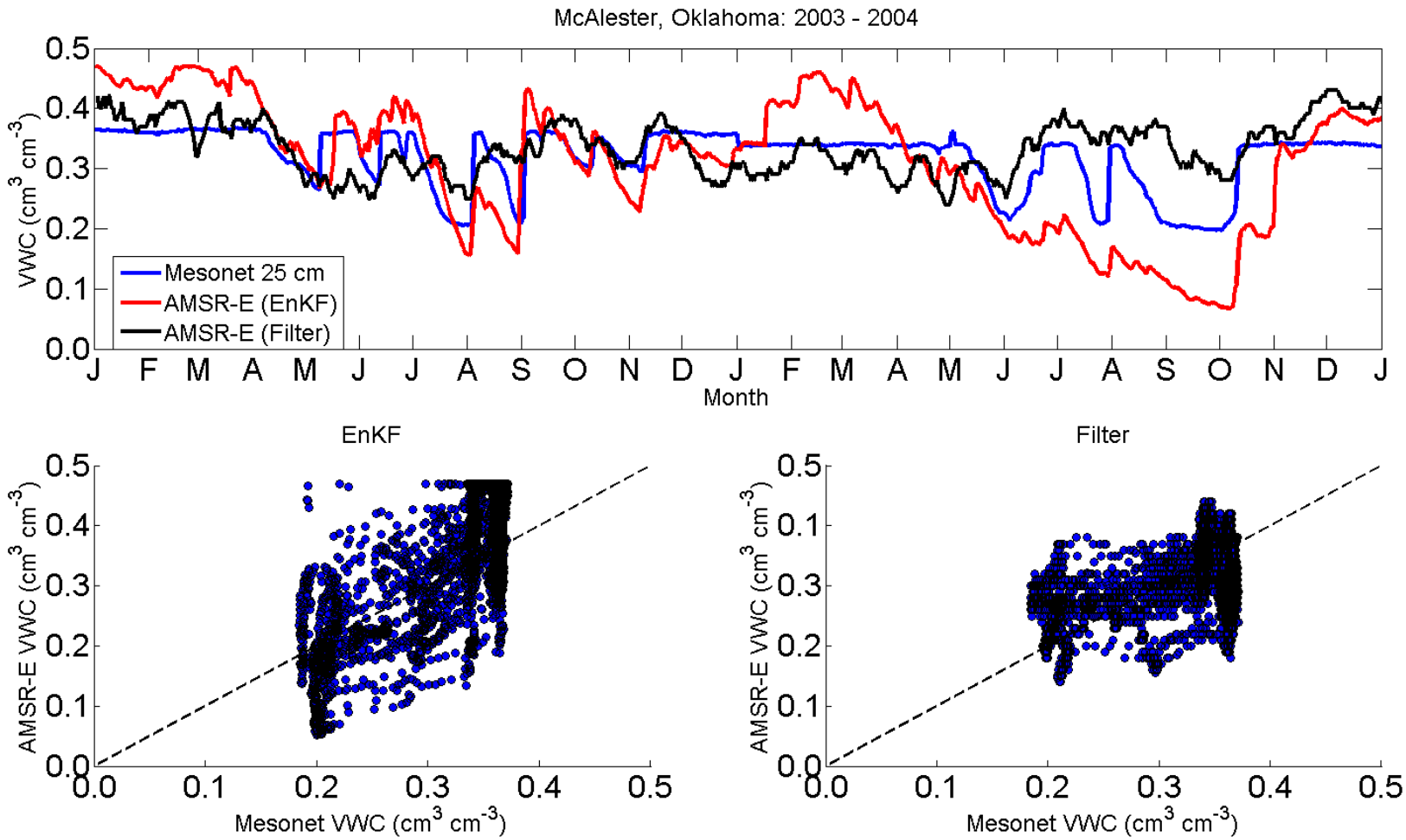
Miami	0.07	0.03	0.08	0.32	-0.02
Ringwood	0.10	0.10	0.12	0.36	-3.05
Spencer	0.22	0.22	0.23	0.14	-13.46
Vanoos	0.08	0.03	0.09	0.30	-3.61
Super Site	0.03	0.00	0.05	0.48	0.44
Average	**0.10**	**0.04**	**0.12**	**0.29**	**-3.71**

Data Assimilation vs. Exponential Filter



Data Assimilation vs. Exponential Filter



Data Assimilation vs. Exponential Filter

AMSR-E EnKF– CDF Match

Mesonet (25 cm) - AMSRE Volumetric Water Content (CDF Match)

Station	MAE	MBE	RMSE	R^2	NS
Ada	0.03	0.00	0.04	0.48	0.40
Boise City	0.05	0.00	0.08	0.43	0.32
Bristow	0.04	0.00	0.06	0.37	0.21
Copan	0.02	0.00	0.03	0.51	0.43
Guthrie	0.03	0.00	0.05	0.58	0.52
Hectorville	0.02	0.00	0.03	0.74	0.72
Idabel	0.02	0.00	0.04	0.64	0.60
McAlester	0.02	0.00	0.04	0.62	0.58
Miami	0.03	0.00	0.06	0.59	0.53
Ringwood	0.04	0.00	0.05	0.30	0.10
Spencer	0.01	0.00	0.04	0.67	0.64
Vanoos	0.02	0.00	0.03	0.52	0.45
Super Site	0.01	0.00	0.03	0.38	0.25
Average	**0.03**	**0.00**	**0.05**	**0.54**	**0.46**

Mesonet (25 cm) - AMSRE Volumetric Water Content

	MAE	MBE	RMSE	R^2	NS
Average	**0.11**	**-0.04**	**0.12**	**0.44**	**-5.82**

AMSR-E Filter – CDF Match

Mesonet (25 cm) – Filter AMSRE Volumetric Water Content (CDF Match)

Station	MAE	MBE	RMSE	R^2	NS
Ada	0.03	0.00	0.04	0.48	0.44
Boise City	0.05	0.02	0.09	0.34	0.25
Bristow	0.04	-0.03	0.06	0.29	0.14
Copan	0.02	0.00	0.02	0.55	0.52
Guthrie	0.04	0.00	0.07	0.36	0.22
Hectorville	0.03	0.00	0.05	0.39	0.27
Idabel	0.03	0.00	0.05	0.45	0.39
McAlester	0.03	-0.01	0.05	0.47	0.43
Miami	0.04	-0.02	0.06	0.43	0.37
Ringwood	0.03	0.00	0.04	0.45	0.41
Spencer	0.03	-0.01	0.06	0.26	0.16
Vanoos	0.01	-0.01	0.03	0.59	0.56
Super Site	0.01	0.00	0.02	0.33	0.52
Average	**0.03**	**-0.01**	**0.05**	**0.42**	**0.35**

Mesonet (25 cm) – Filter AMSRE Volumetric Water Content

	MAE	MBE	RMSE	R^2	NS
Average	**0.10**	**0.04**	**0.12**	**0.29**	**-3.71**

Conclusions

- AMSR-E surface soil moisture product performed better than SMOS (Ford *et al.* 2014), however RMSE > 0.04 at all sites
- Root zone product performed similarly, benefited greatly from CDF – matching
- Data assimilation and exponential filter smoothing methods attained similar accuracy despite sites having high soil texture heterogeneity

Acknowledgements

- This project is funded by the NSF Climate & Large-scale Dynamics (CAREER ATM-1056796)

- Contributors: Steven Quiring, Elizabeth Harris

- Thanks to Oklahoma Mesonet for data contribution