Advances in Subseasonal Prediction of 100-m Wind Speed in the Western U.S.

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Wind: Viable Source of Renewable Electricity

U.S. Wind Industry 2019 Q3 Market Report:

- U.S. now has >100 GW of wind energy capacity
- Wind supplies power to ~32 million homes, sustains 500 U.S. factories, and delivers more than $1B/yr in new revenue to rural communities and states
- Texas leads the way with >27 GW of cumulative capacity

Value of Accurate Wind Forecasts

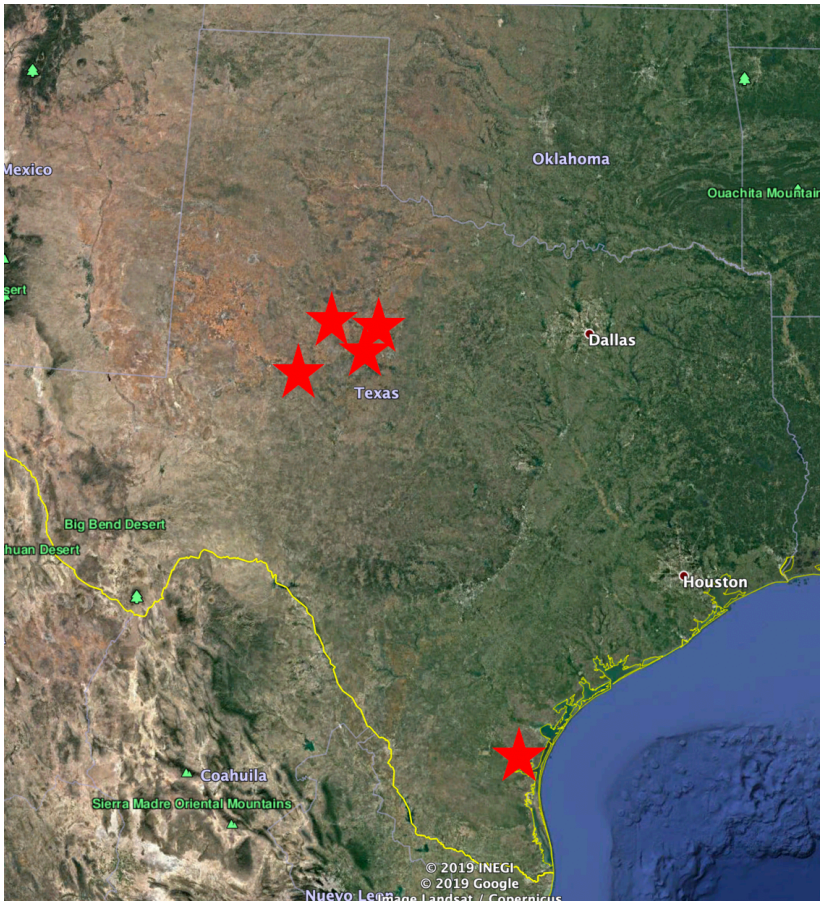
- Load balancing (nowcasting and short-term forecast)
- Reducing the occurrence/duration of outages and mitigating the physical impacts of extreme weather on wind power systems (short-to-medium range forecast)
- **Competitive advantage in energy market trading (medium range/subseasonal forecast)**
- More efficient project construction, operations, and maintenance planning (seasonal forecast)
- Financial risk assessment of wind farm investments (decadal projections)

100 m Wind Forecasts

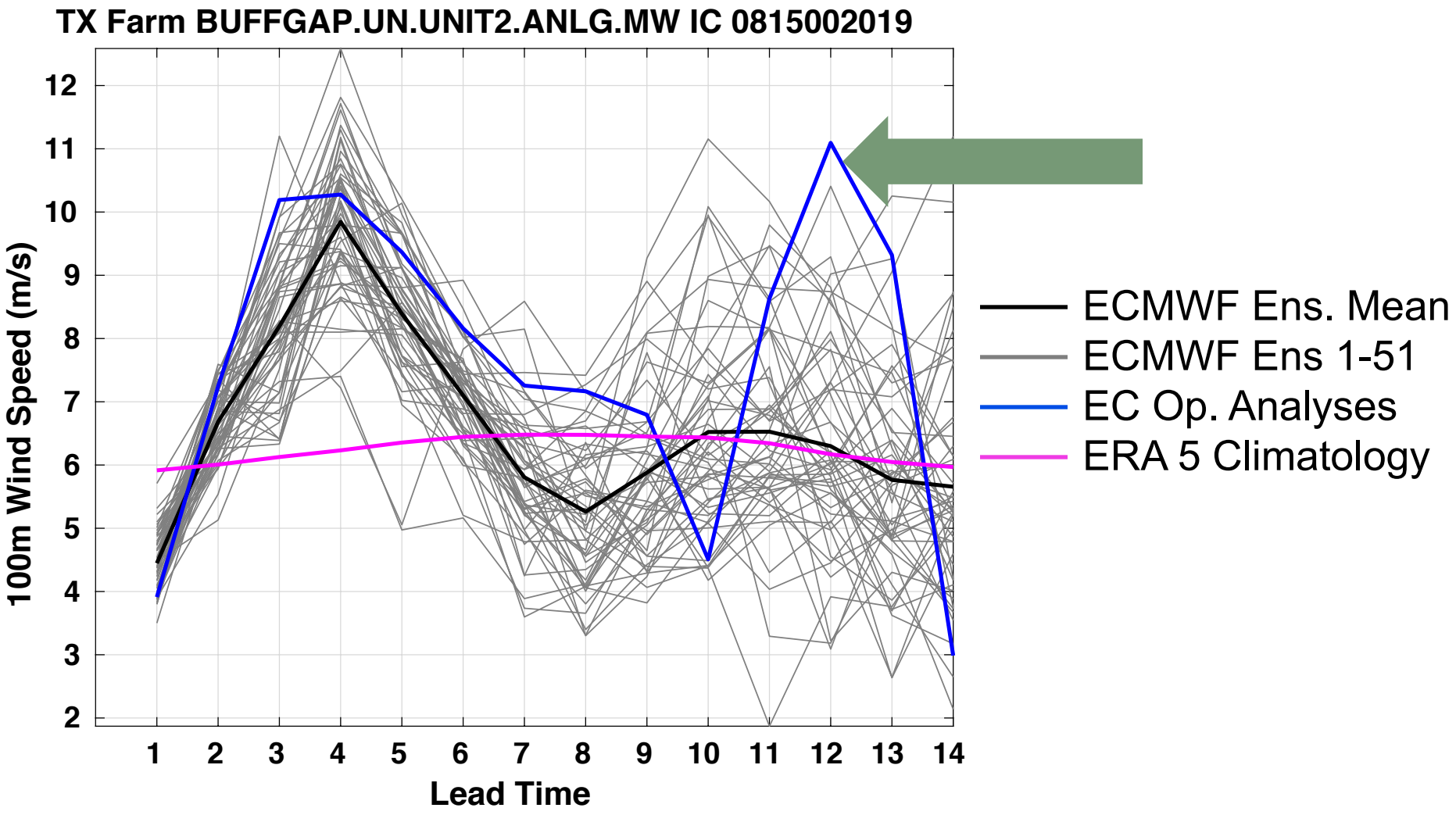
- **ECMWF ENS** 0Z and 12Z forecasts are available out to 15 days, with 3 hourly resolution out to 10 days.
- **ECMWF ENS Extended** is initialized twice per week (Monday and Thursday) and is available out to 46 days, with 6 hours resolution.
- Daily average values of the 100m wind speed are computed for each of 51 ensemble members
- CFAN calibrates the ECMWF forecasts using historical error information

Wind Forecast Evaluation – ERCOT

- Five wind farms were analyzed for July – Sept 2019
- Daily forecasts were verified against ECMWF operational analysis and ERA 5 reanalyses

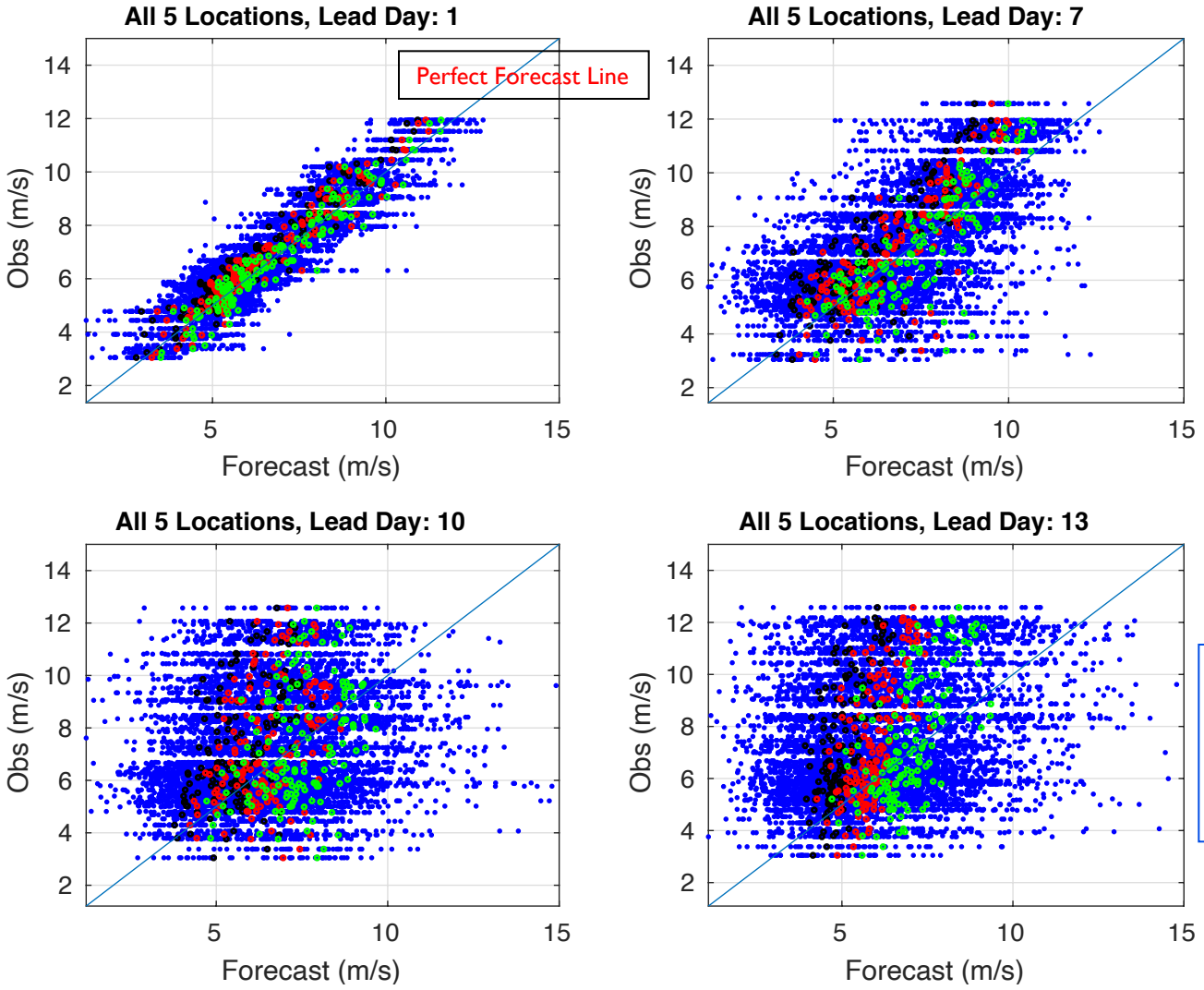


Wind Forecast Evaluation – Case Study



Wind Forecast Evaluation – 15 days

ECMWF ENS (medium range)



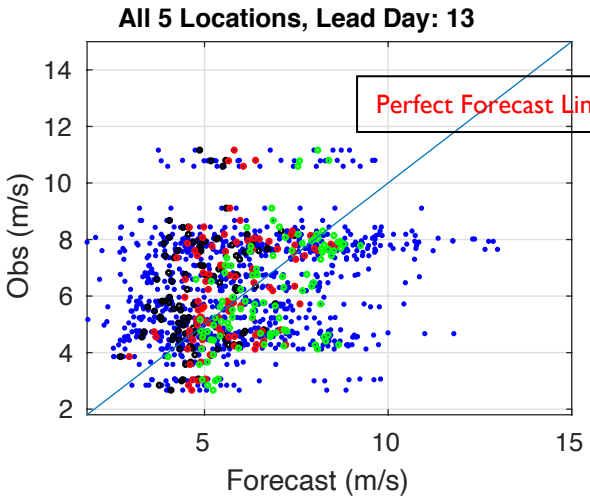
- At longer lead times, upper percentiles match better the observed wind distribution
- Forecasts underestimate high wind & overestimate low wind, especially at longer lead time.
- Error distribution varies with season (not shown)

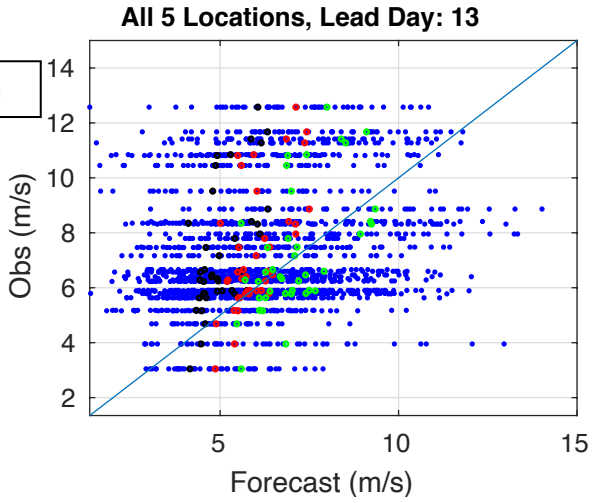
Individual ens.
30st percentile
50st percentile
70st percentile

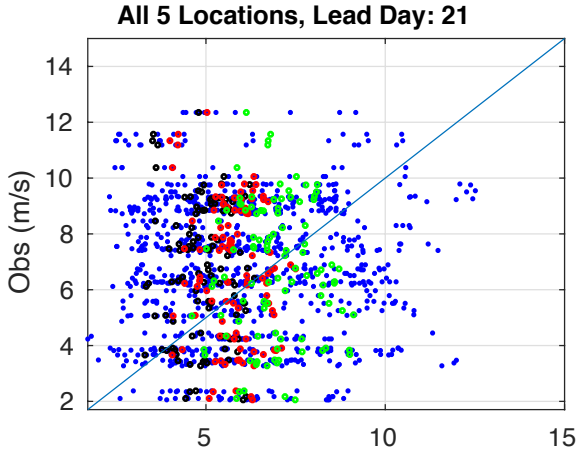
Wind Forecast Evaluation – Subseasonal

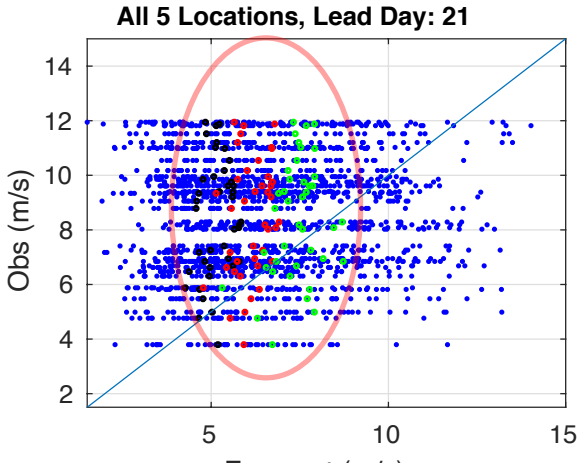
Forecast vs. Operational Analyses

Hindcast vs. ERA 5 Reanalyses









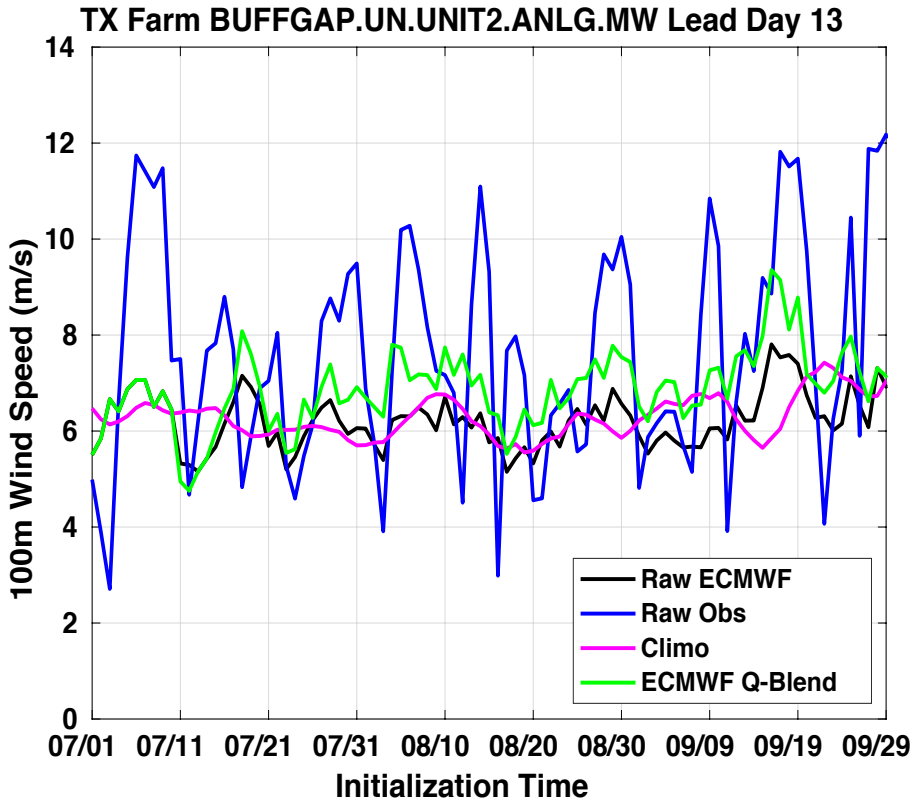
- Forecast exhibits different biases when compared to the reforecast.
- Very little skill beyond week two.

Individual ens.
30st percentile
50st percentile
70st percentile

Wind Forecast Calibration

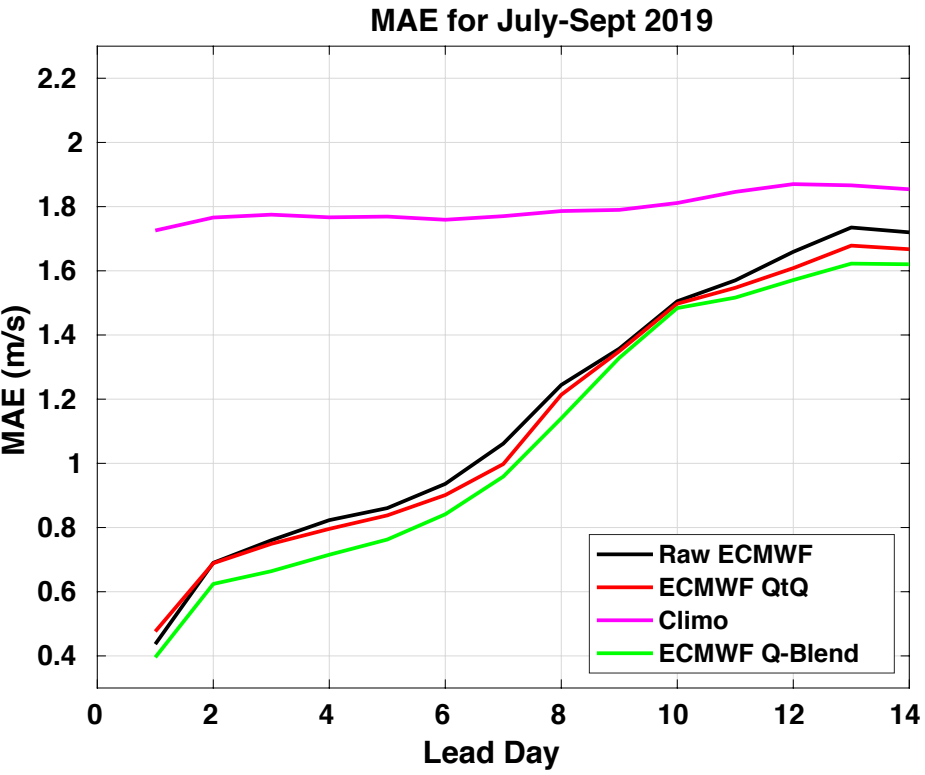
Training data set - moving 60-day window, using past 30 days of forecast and 30 days in the future from previous year.

- Adaptive CDF (q-to-q mapping) for each grid point
- Adaptive error minimization) for each grid point

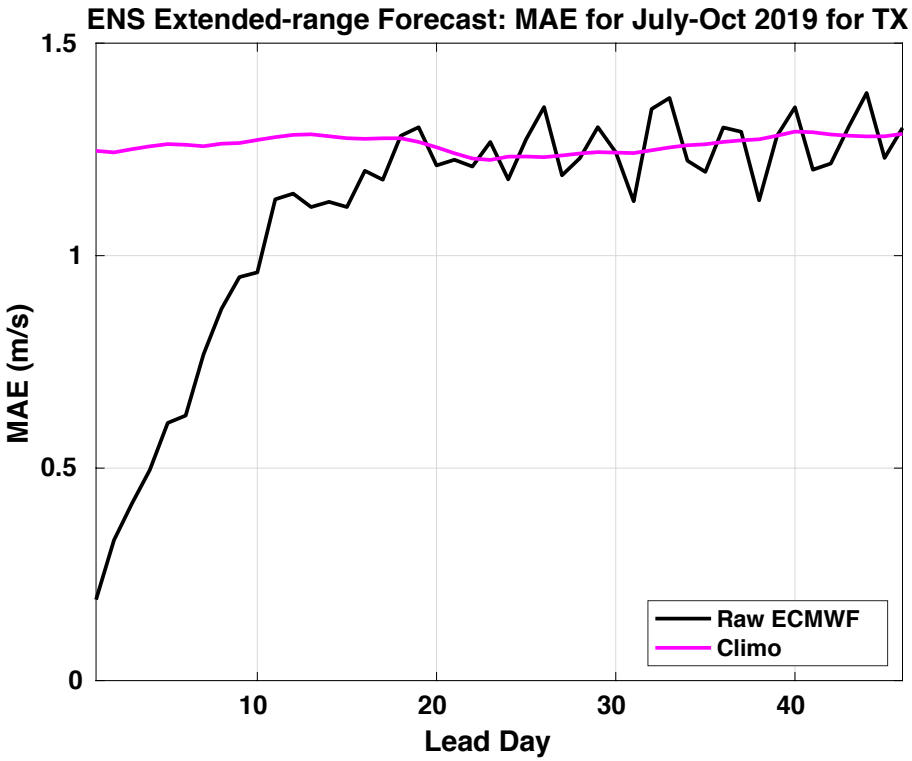


Wind Forecast Evaluation – MAE

ECMWF ENS (medium range)



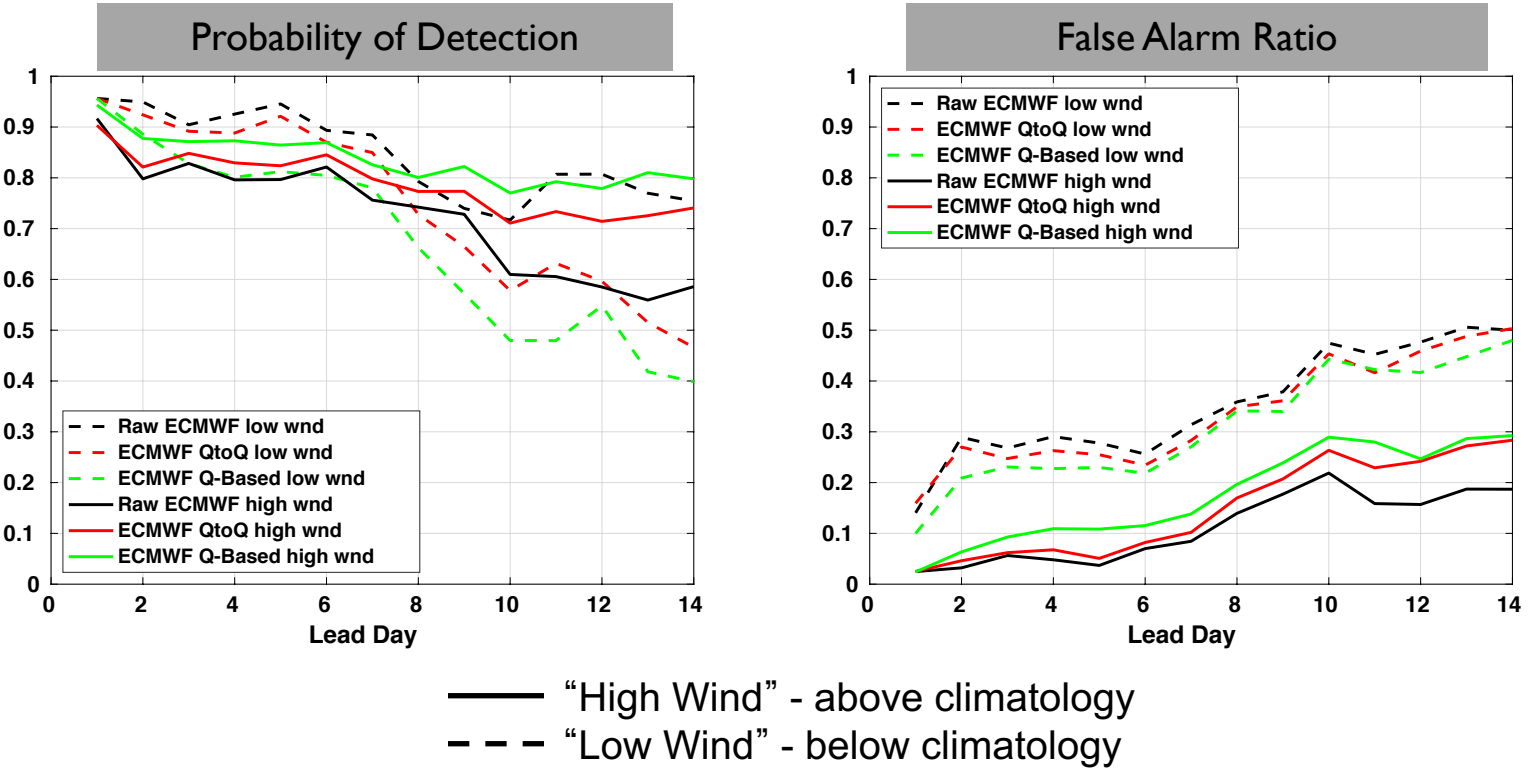
Extended ENS (subseasonal)



- Forecast error is smaller than climatology forecast <18 days
- CFAN correction reduces the MAE for < 15 days; larger data sample needed to apply the CFAN calibration to subseasonal

Categorical Verification of Forecast

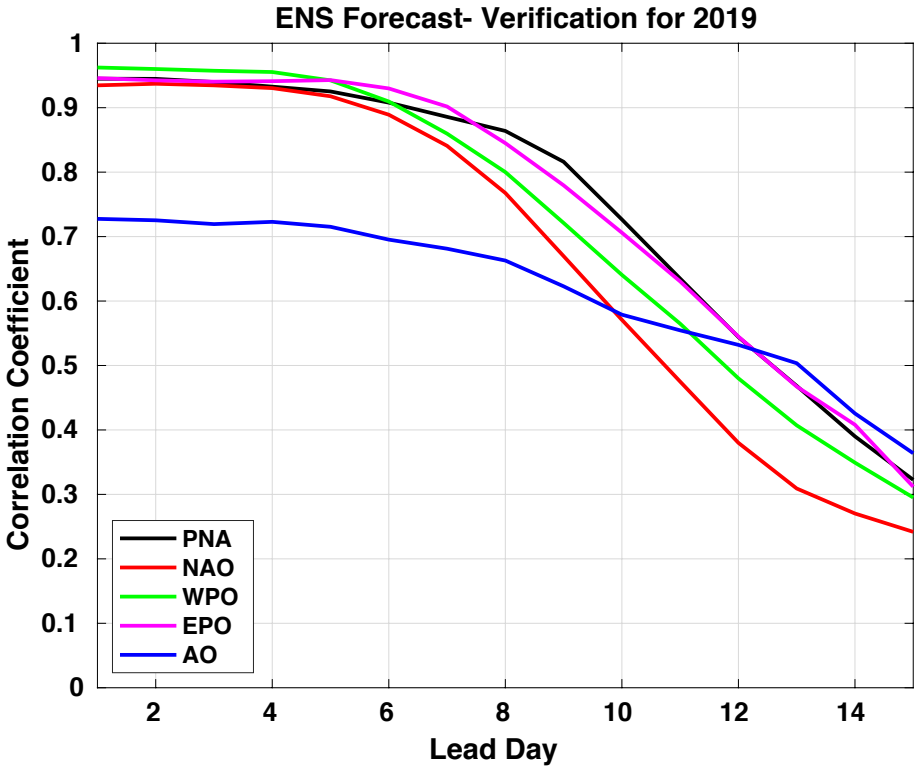
How skillful is the forecast in predicting above/below long-term climatology?



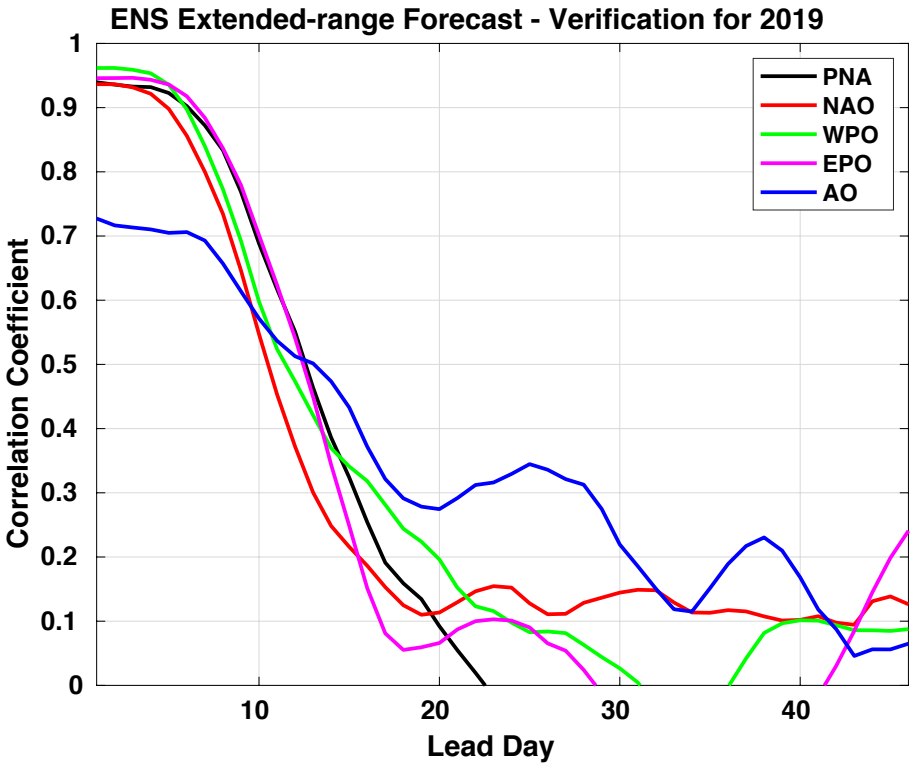
- Substantial improvement of "high wind" forecast when applying CFAN correction up to day 14

Large-Scale Weather Patterns
2019 Forecast Verification

ECMWF ENS (medium range)



Extended ENS (subseasonal)



Texas Wind – Teleconnections Relationship

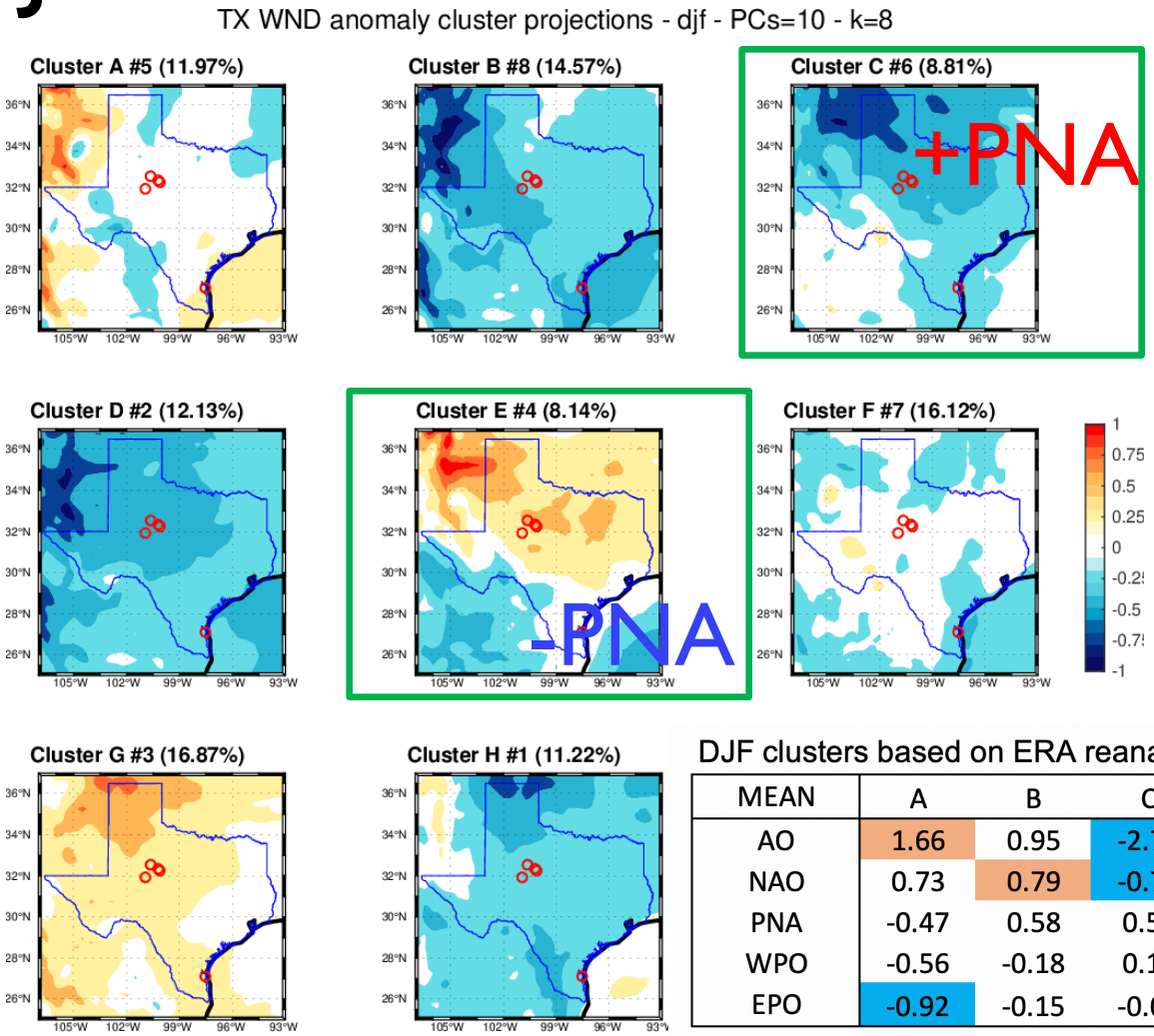
- ERA 5 daily average 100 m wind (1979-2018)
- Historical daily PNA, NAO, WPO, EPO, AO

Anomaly Correlations Values

DJF Wnd	PNA	JJA Wnd	PNA
Location 1	**-0.34**	Location 1	**-0.45**
Location 2	**-0.32**	Location 2	**-0.45**
Location 3	**-0.32**	Location 3	**-0.46**
Location 4	**-0.34**	Location 4	**-0.46**
Location 5	**-0.32**	Location 5	**-0.26**

Projection of Large-scale Regimes on Texas Wind

DJF



DJF clusters based on ERA reanalises 1978-2018

MEAN	A	B	C	D	E	F	G	H
AO	1.66	0.95	-2.72	-0.80	-1.23	0.17	0.73	-0.97
NAO	0.73	0.79	-0.75	-0.03	-0.38	0.49	0.37	0.07
PNA	-0.47	0.58	0.52	0.80	-0.83	0.64	-0.06	0.24
WPO	-0.56	-0.18	0.14	0.05	-0.91	0.75	0.65	-0.74
EPO	-0.92	-0.15	-0.04	-0.19	0.18	0.79	0.68	-0.87

Conclusions

CFAN provides operation subseasonal forecasts of 100 m windspeeds for the western U.S., based on ECMWF forecasts

ECMWF 100 m wind forecasts show skill beyond climatology out to ~17 days

CFAN's calibrated 100 m wind forecasts improve forecast skill significantly, particularly for 'high wind' cases

Clustering around weather regimes helps identify forecast 'windows of opportunity' when forecast skill is expected to be higher at longer forecast horizons

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