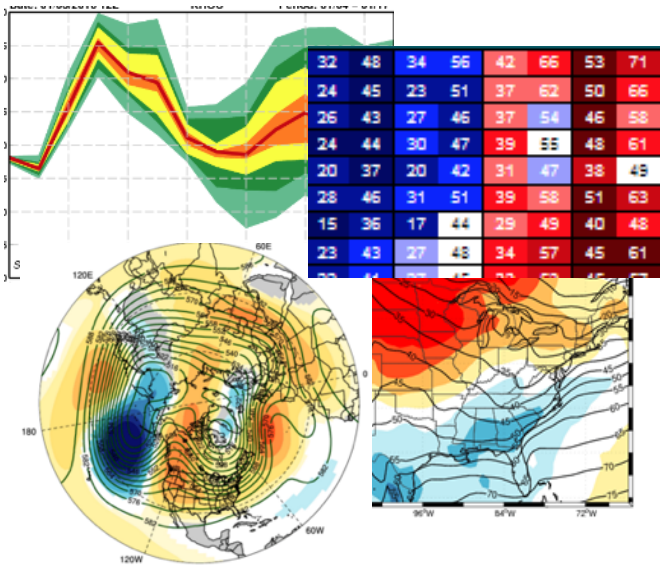
Probabilistic Subseasonal Weather Forecasts for the Energy Sector

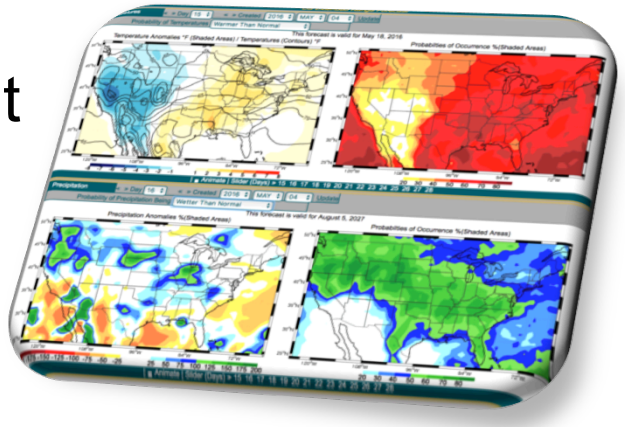


Judith Curry & Violeta Toma

Climate Forecast Applications Network

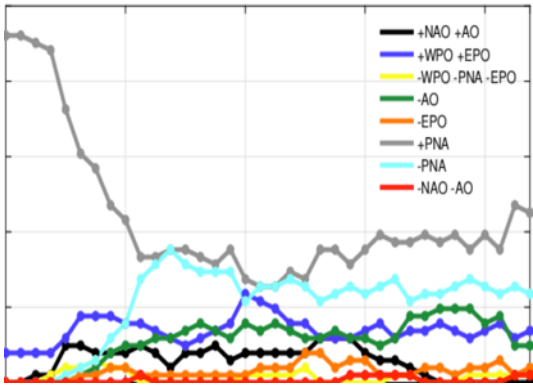
Innovations in Subseasonal Forecasting

- **Forecast 'window of opportunity'** with objective forecast confidence assessment
- Probabilities and scenarios of **extreme weather events**
- Sophisticated **post-processing** that produces superior ensemble calibration
- **Ensemble clustering and regime analysis:** enhances prediction skill for extreme events
- Innovative **multi-model approach:** CFS & ECMWF
- Advanced online **decision support** tools

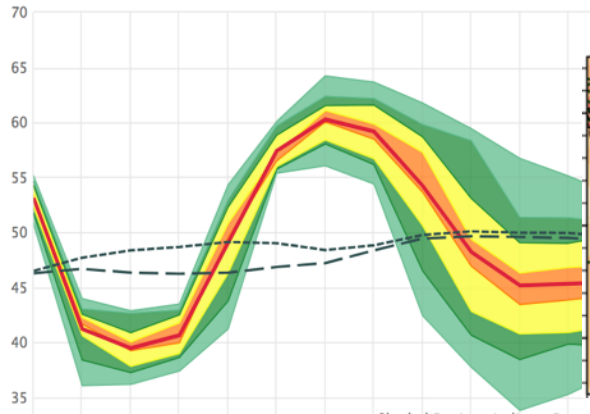


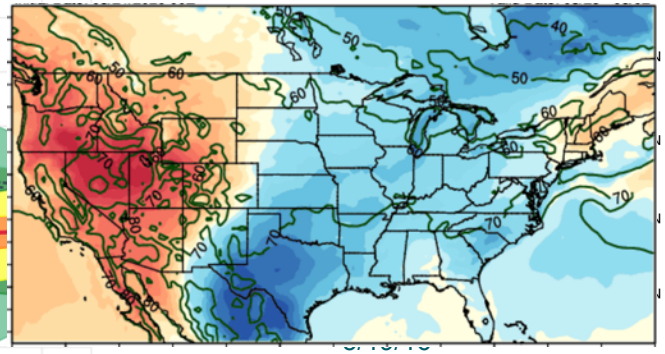
Interpreting the Ensemble Predictions

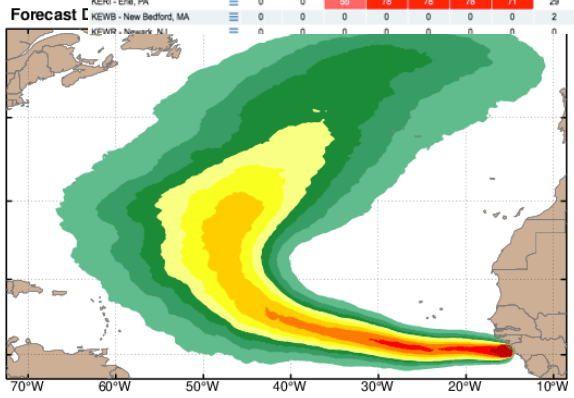
- ✧ Mean/median values and anomalies
- ✧ Quantile probabilities
- ✧ Extreme event probabilities
- ✧ Ensemble clustering
- ✧ Synthetic ensembles



Location	05/22	05/23	05/24	05/25	05/26	05/27	05/28	05/29	05/30
KABE - Allentown, PA	0	0	0	0	6	18	20	20	20
KACY - Atlantic City, NJ	0	0	0	0	0	0	0	0	0
KALB - Albany, NY	6	6	2	10	53	73	73	73	37
KAOO - Altoona, PA	0	0	0	8	27	27	27	18	10
KAQW - North Adams, MA	0	0	0	2	65	65	65	61	29
KAUG - Augusta, ME	0	0	0	0	18	78	78	78	59
KAVP - Wilkes-Barre, PA	0	0	0	2	41	41	41	27	20
KBAF - Westfield/Springfield, MA	0	0	0	0	12	39	39	39	35
KBDL - Windsor Locks, CT	0	0	0	0	10	27	27	27	18
KBDR - Bridgeport, CT	0	0	0	0	0	0	6	6	6
KBGM - Binghamton, NY	0	0	0	2	29	29	29	12	12
KBGR - Bangor, ME	0	0	0	0	20	75	75	75	41
KBML - Berlin, NH	14	0	0	0	71	98	98	88	53
KBOS - Boston, MA	0	0	0	0	0	12	12	12	12
KBTV - Burlington, VT	4	4	20	39	75	75	75	67	29
KBUF - Buffalo, NY	31	35	35	35	67	67	67	39	8
KBWI - Baltimore, MD	0	0	0	0	0	0	0	0	0
KCAR - Caribou, ME	0	0	0	41	86	90	82	75	31
KCEF - Springfield/Chicopee, MA	0	0	0	0	24	35	35	35	22
KCON - Concord, NH	0	0	0	0	24	76	76	76	59
KCXY - Harrisburg, PA	0	0	0	0	16	16	18	18	14
KDCA - Washington, DC (National)	0	0	0	0	0	0	0	0	0
KDUJ - Dubois, PA	0	0	0	43	43	43	43	24	6
KELM - Elmira/Corning, NY	0	6	6	10	57	57	57	33	16
KERI - Erie, PA	0	0	55	78	78	78	71	29	8
KEWB - New Bedford, MA	0	0	0	0	0	0	0	2	2
KEWR - Newark, NJ									







Objective Forecast Confidence Evaluation

Framework:

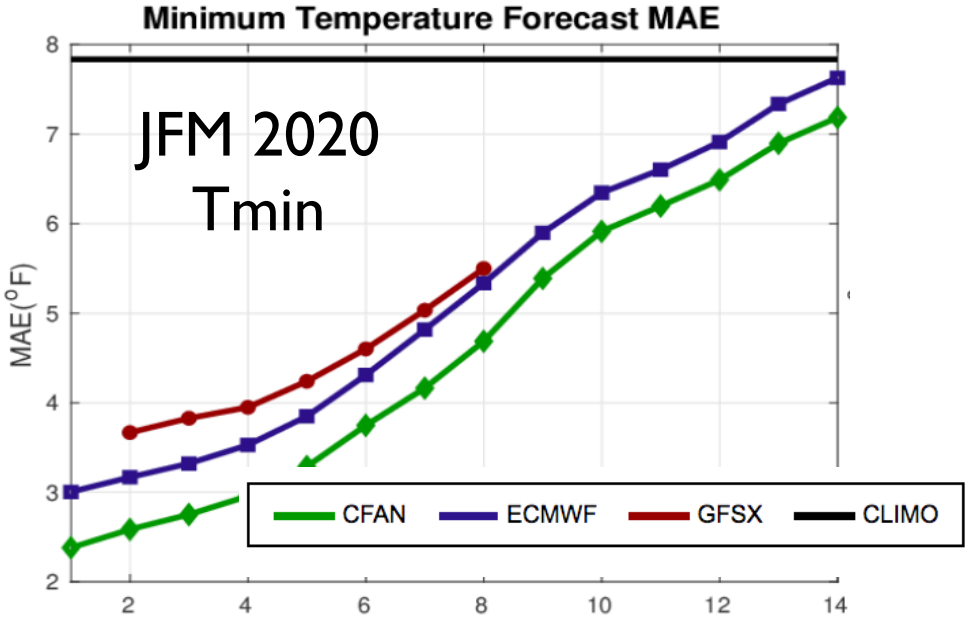
- ✧ Identify forecast ‘windows of opportunity’
- ✧ Assessments based on seasonal/annual forecast verification statistics
- ✧ Real-time verification statistics for each forecast

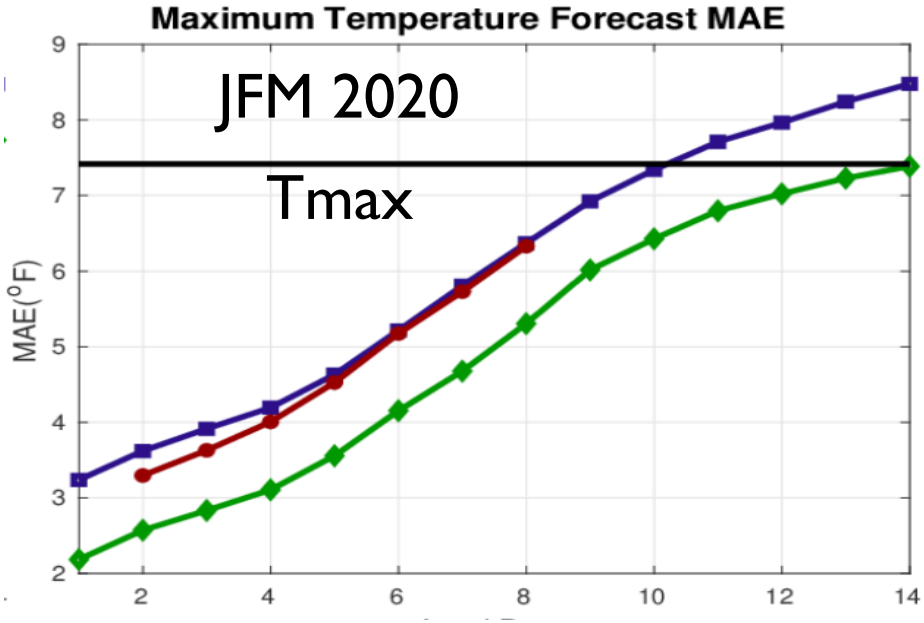
Temperature Forecasts for the Energy Sector

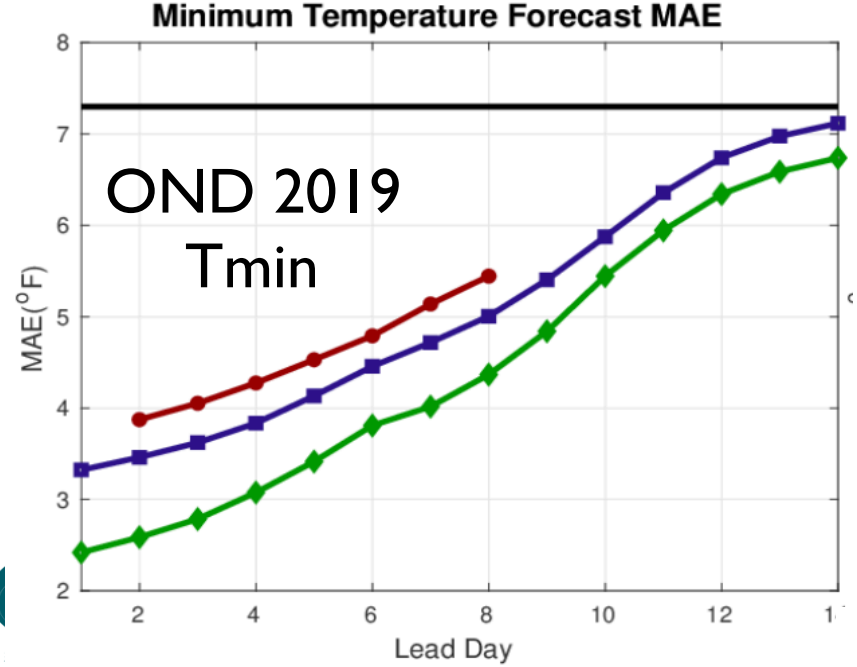
Correcting Bias & Distributional Errors

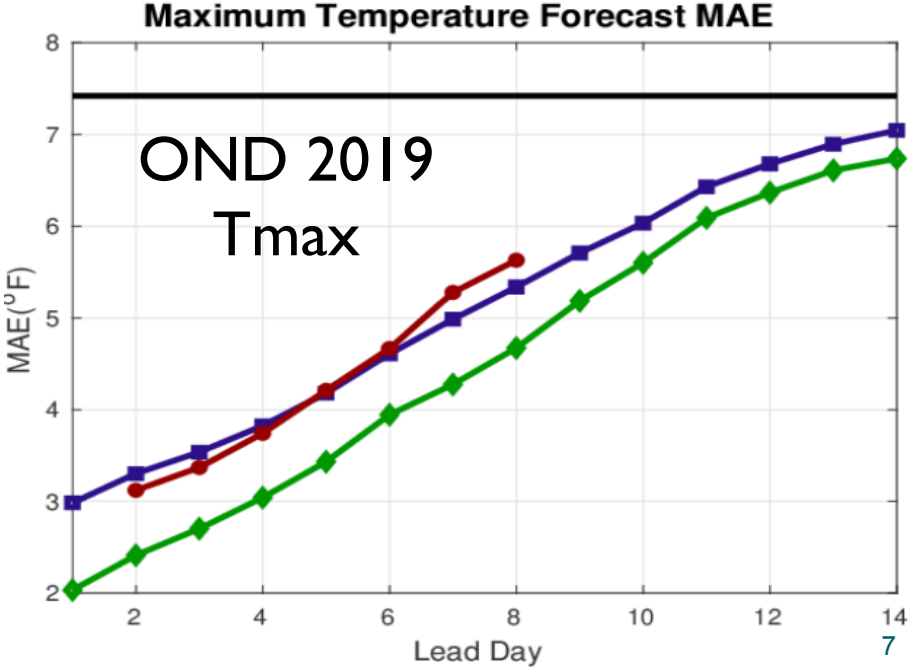
- Ensemble: **quantile-to quantile** distributional adjustment (static; reforecasts)
- Ensemble: Additional distributional adjustment method (dynamic; using previous 60 days forecast)
- Mean: Adaptive Decaying Average (**Kalman filtering**) applied to Q-to-Q and raw ensemble mean (dynamic; using previous 30 days forecast)
- Consensus: **Adaptive weighting scheme** for all forecast streams based on previous 30 day performance (dynamic)

15 day U.S. temperature forecast verification

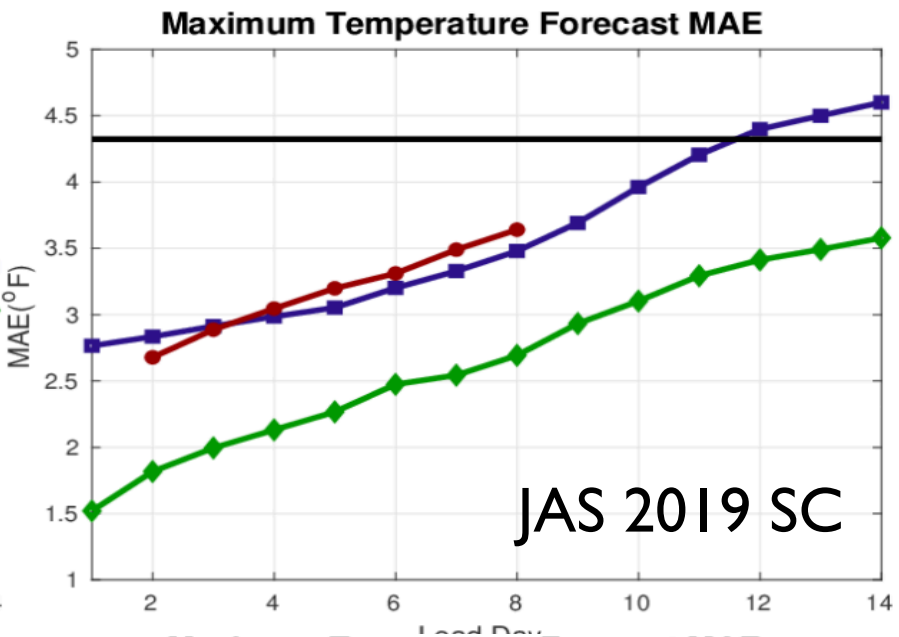


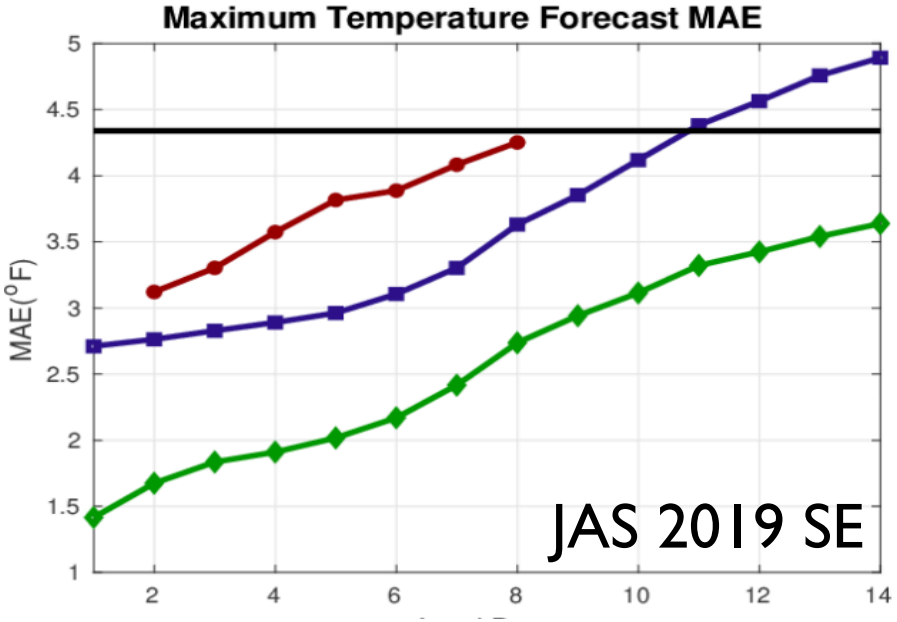


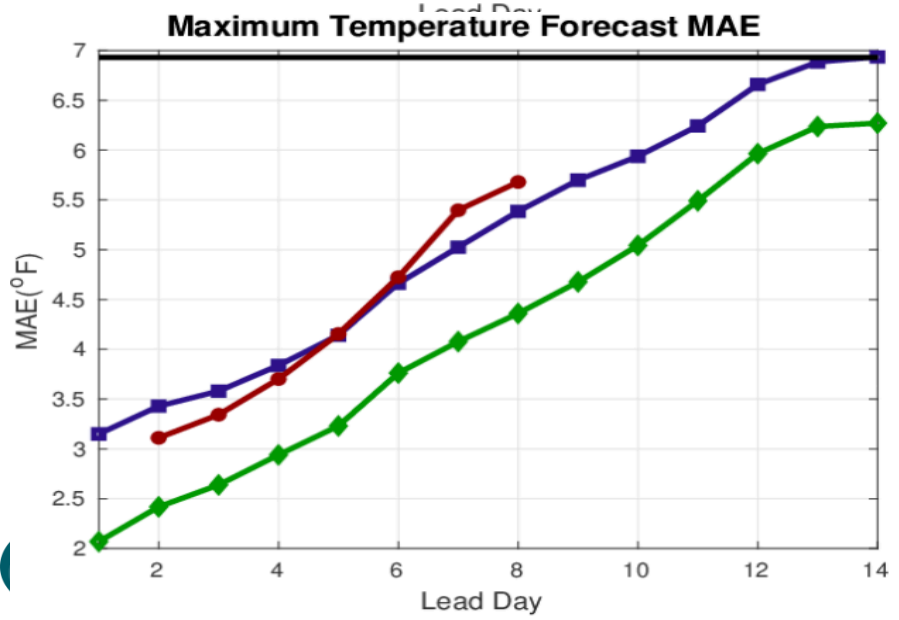


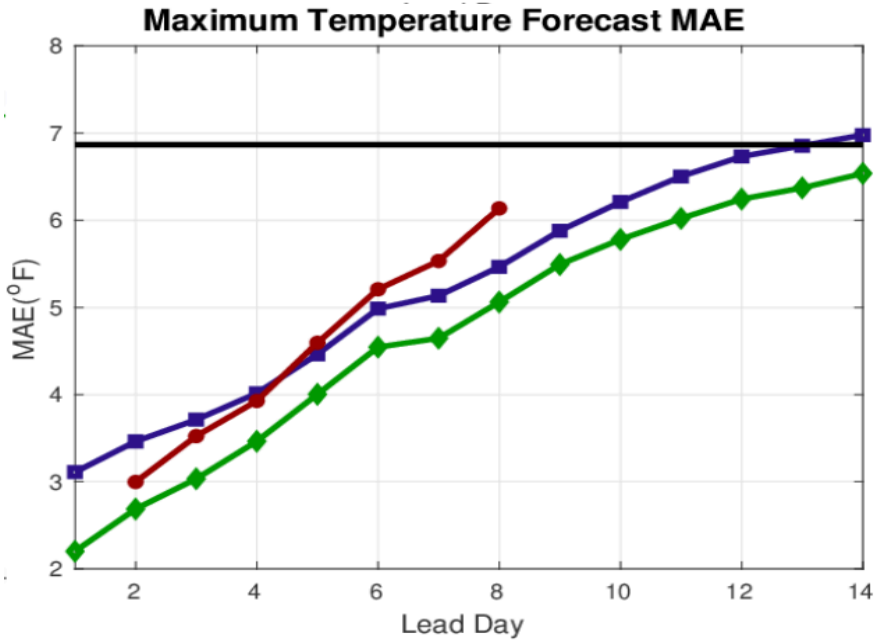


Regional Tmax Verification







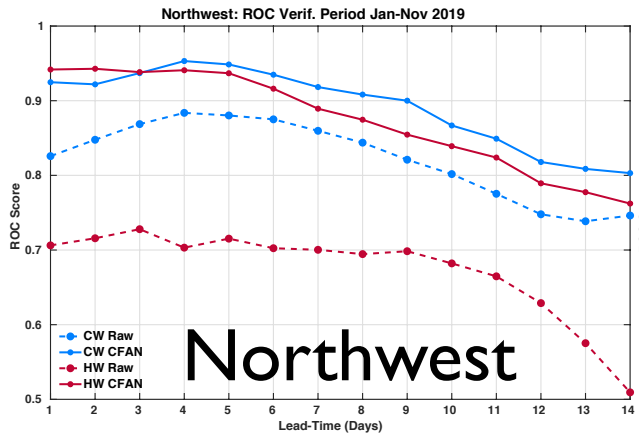


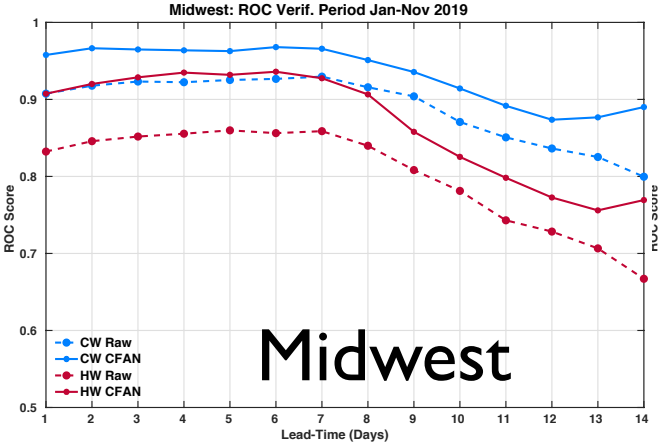
Forecasting heat/cold wave probabilities

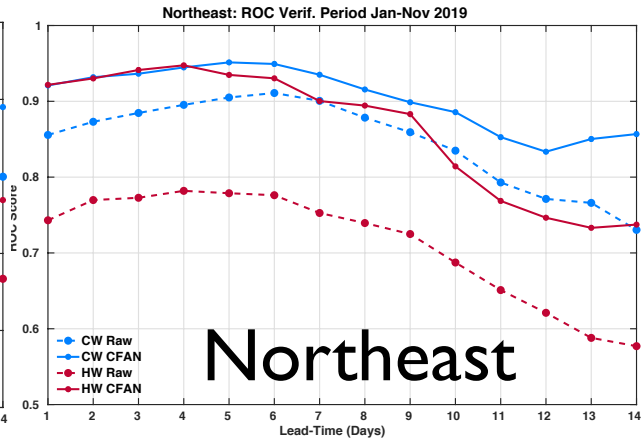
- **Probability of heat/cold wave**: % of ensemble members **exceeding/below** the 80th quantile of observed historical distribution for at least three consecutive days

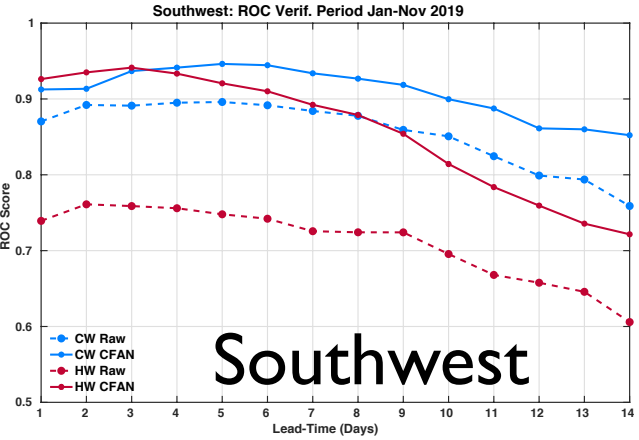
- Evaluate skill using ROC, hit rate, false alarm rate

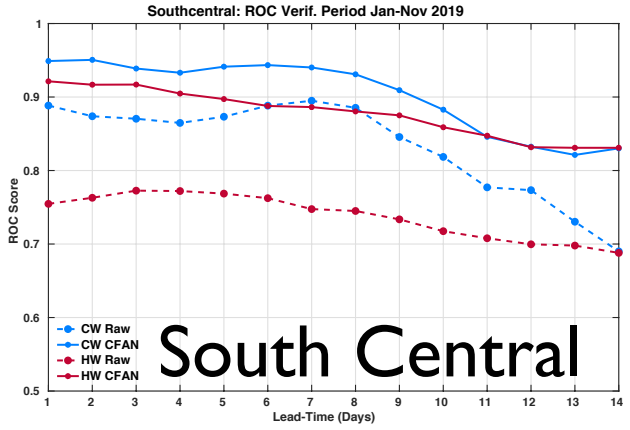
Regional ROC scores: 15 day HW/CW forecasts

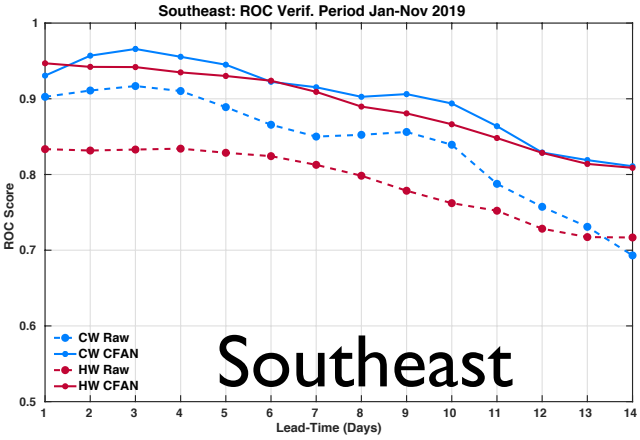








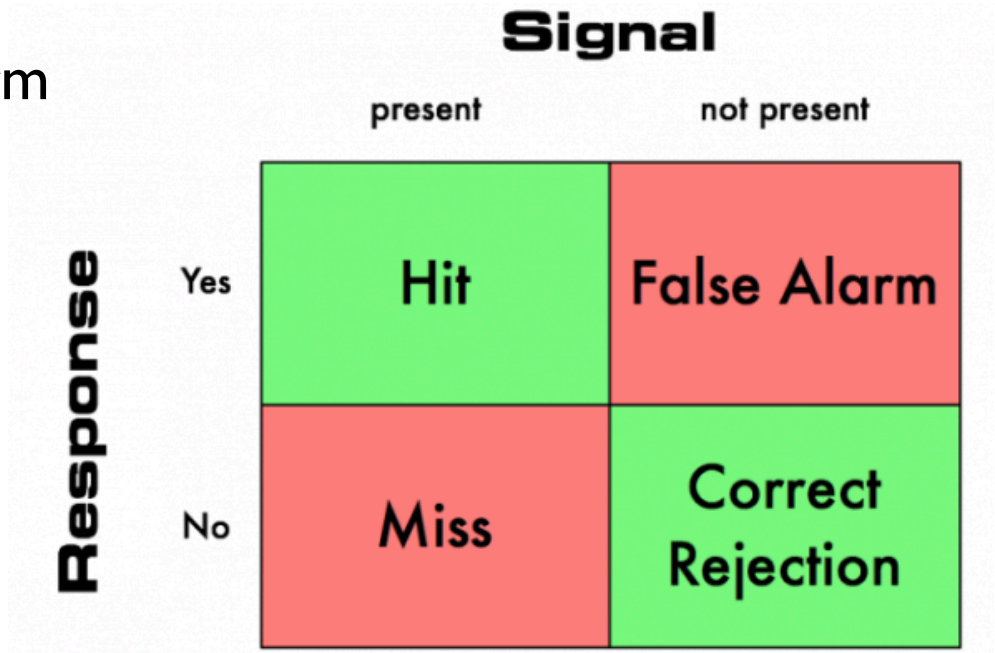




- Overall skill is higher for cold waves
- Substantial value added from CFAN's calibrations, esp for heat waves

HW/CW forecast interpretation

- **20%** HW/CW probability: high hit / low miss rate, but high probability of false alarm in week 2
- **50%** HW/CW probability: low hit rate >10 days for HW; threshold of useful forecast for CW>10 days
- **80%** HW/CW probability: low probability of false alarm



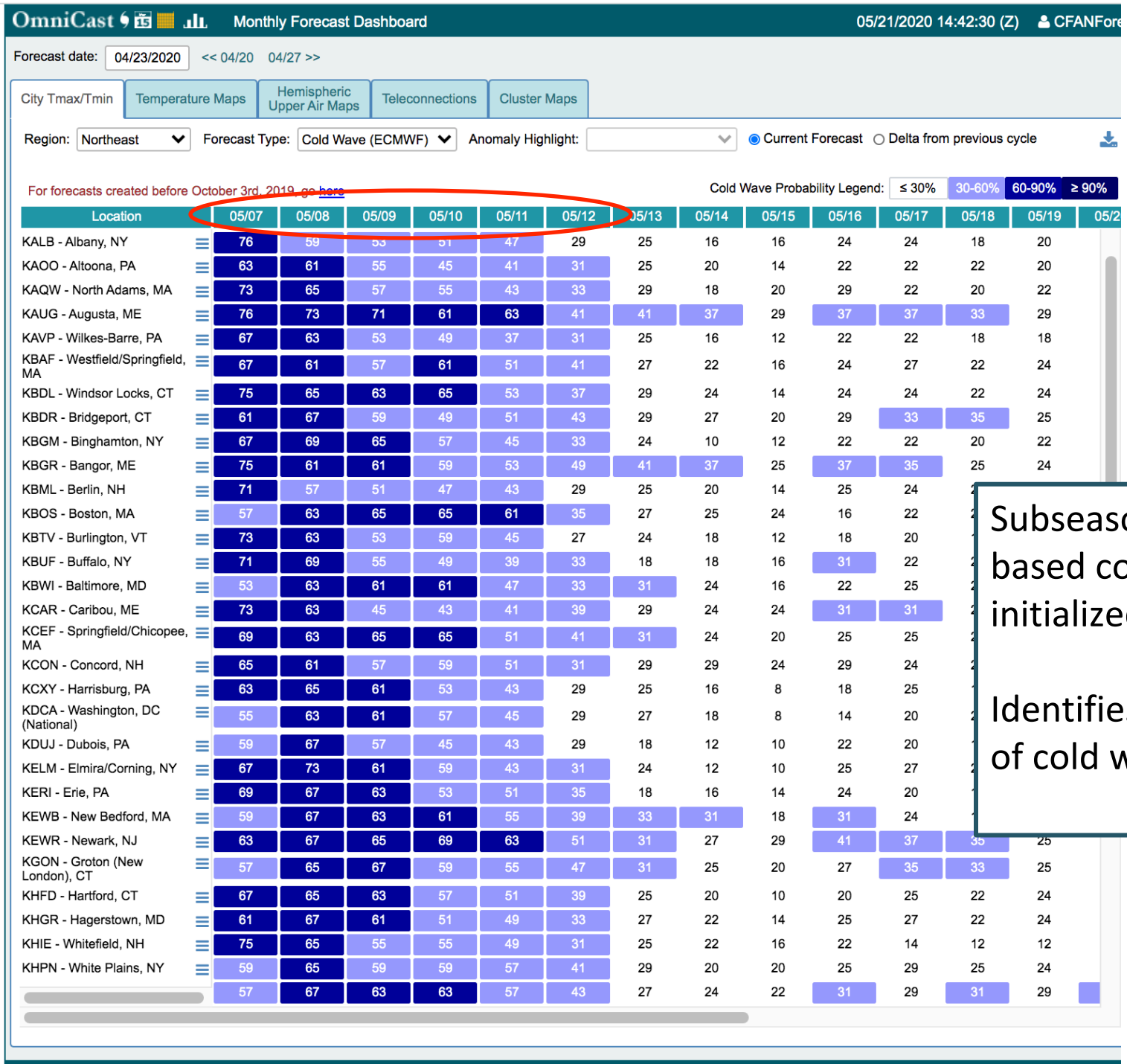
Cold wave NE, Mid Atlantic: 5/7 – 5/12

LOW TEMPERATURE RECORDS SET OR TIED

Eastern US – Saturday, May 9, 2020

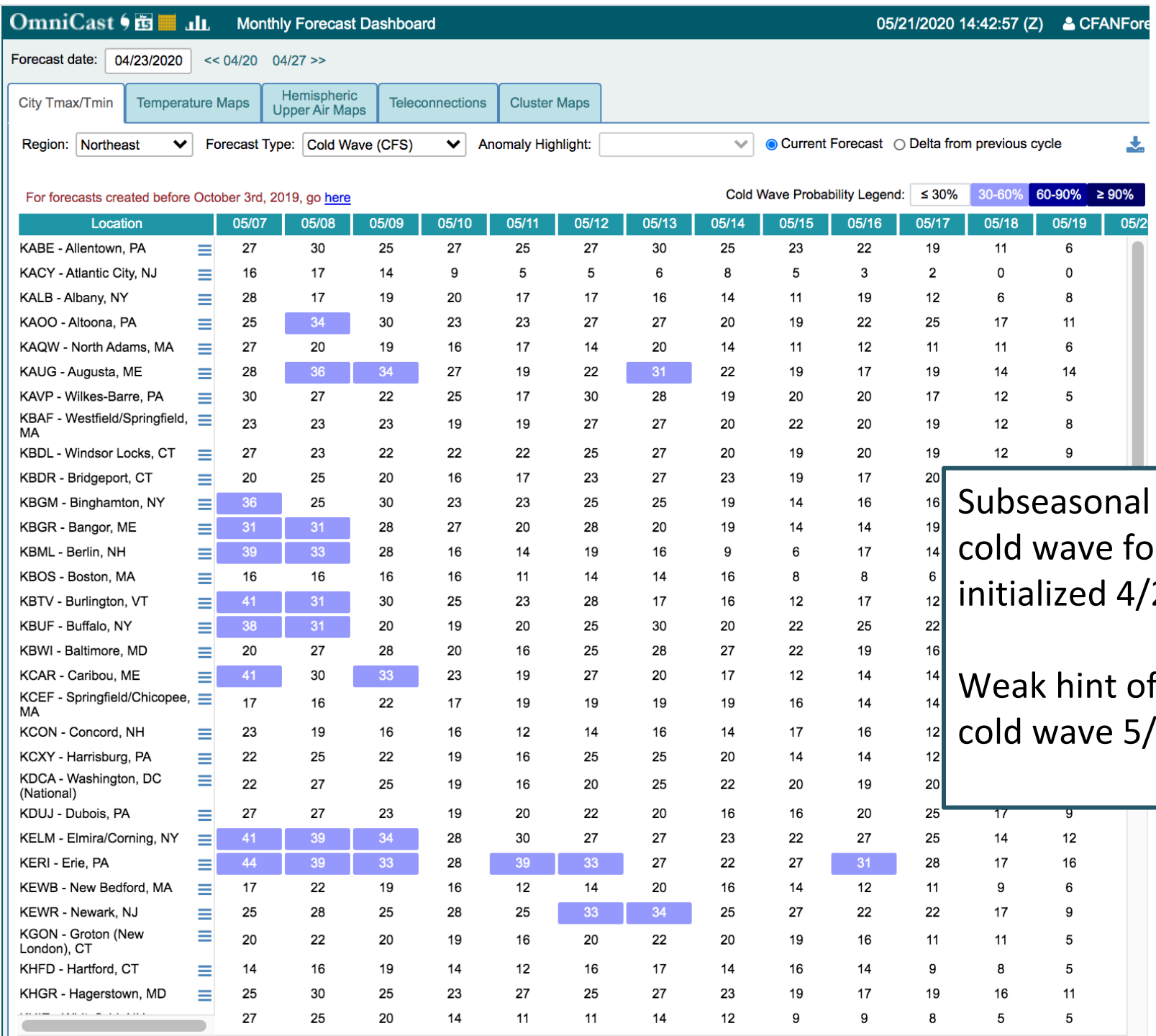
	Saturday's Low	Previous Record
Altoona PA	27	29 in 1966
Baltimore MD – BWI	34	36 in 2017
Binghamton NY	24*	27 in 1966
Bluefield WV	28	29 in 1923
Bradford PA	22	24 in 1966
Bridgeport CT	35	37 in 1977
Buffalo NY	29	29 in 1947
Cincinnati OH	28	30 in 1947
Columbus OH	30	30 in 1983
Dayton OH	28	31 in 1947

	Saturday's Low	Previous Record
New York City – JFK	34	38 in 1977
New York City – LGA	36	37 in 1947
Parkersburg WV	28	32 in 1983
Pittsburgh PA	29	30 in 1983
Reading PA	33	34 in 1976
Rochester NY	29	31 in 1962
Saranac Lake NY	23	24 in 2019
State College PA	27*	27 in 1966
Syracuse NY	30	30 in 1966
Wallops Island VA	38	40 in 1977

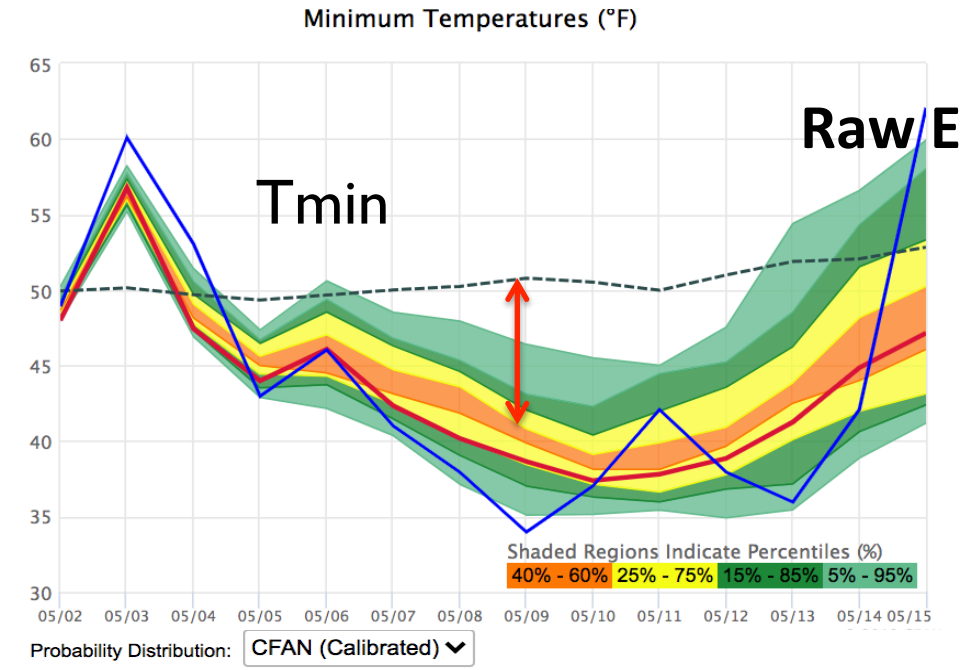


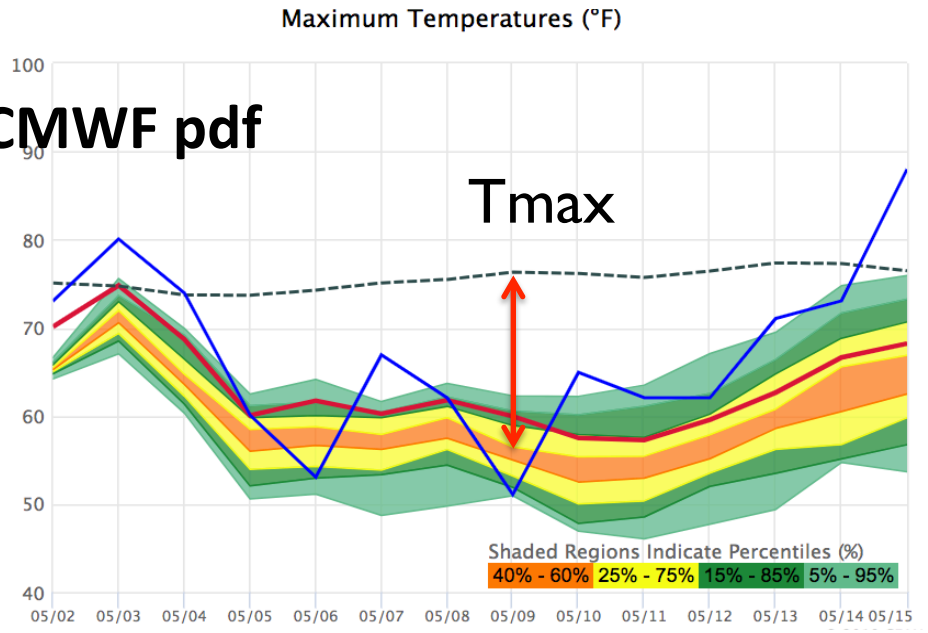
Subseasonal ECMWF-based cold wave forecast initialized 4/23

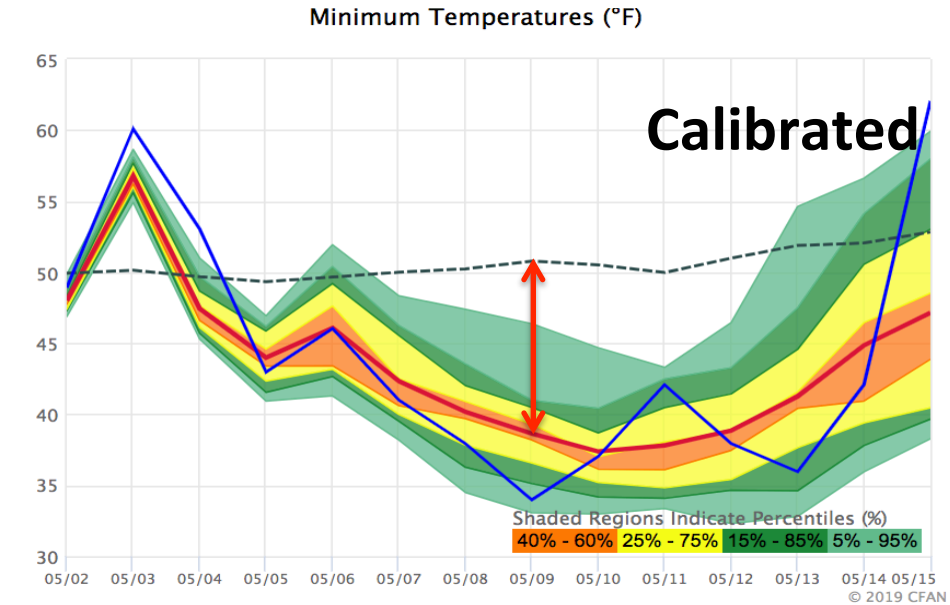
Identifies high probability of cold wave 5/7 - 5/12

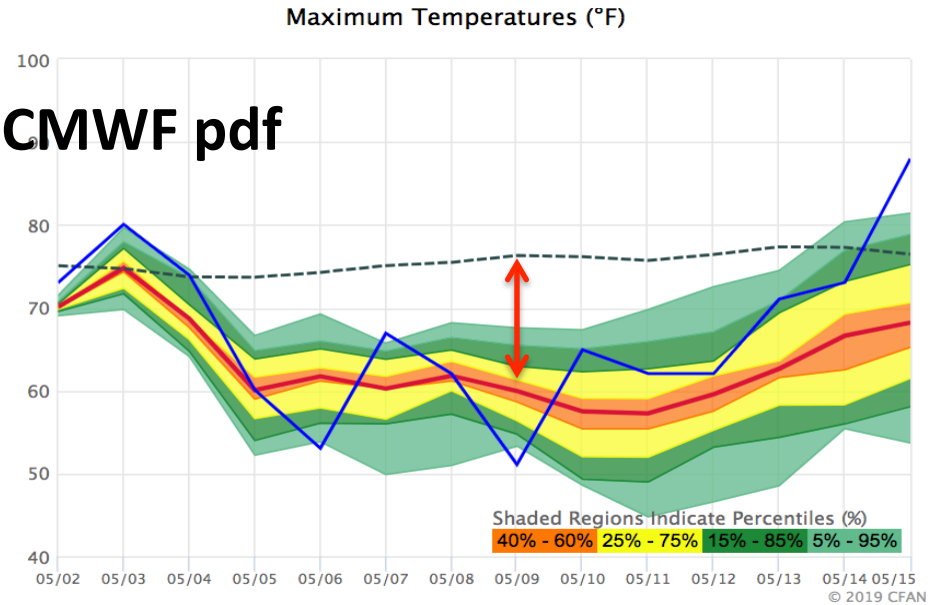

OmniCast
Monthly Forecast Dashboard
05/21/2020 14:42:57 (Z)
CFANFore
Forecast date: 04/23/2020
<< 04/20
04/27 >>
City Tmax/Tmin
Temperature Maps
Hemispheric Upper Air Maps
Teleconnections
Cluster Maps
Region: Northeast
Forecast Type: Cold Wave (CFS)
Anomaly Highlight:
Current Forecast
Delta from previous cycle
For forecasts created before October 3rd, 2019, go here
Cold Wave Probability Legend: ≤ 30% 30-60% 60-90% ≥ 90%
Location 05/07 05/08 05/09 05/10 05/11 05/12 05/13 05/14 05/15 05/16 05/17 05/18 05/19 05/2
KABE - Allentown, PA 27 30 25 27 25 27 30 25 23 22 19 11 6
KACY - Atlantic City, NJ 16 17 14 9 5 5 6 8 5 3 2 0 0
KALB - Albany, NY 28 17 19 20 17 17 16 14 11 19 12 6 8
KAOO - Altoona, PA 25 34 30 23 23 27 27 20 19 22 25 17 11
KAQW - North Adams, MA 27 20 19 16 17 14 20 14 11 12 11 11 6
KAUG - Augusta, ME 28 36 34 27 19 22 31 22 19 17 19 14 14
KAVP - Wilkes-Barre, PA 30 27 22 25 17 30 28 19 20 20 17 12 5
KBAF - Westfield/Springfield, MA 23 23 23 19 19 27 27 20 22 20 19 12 8
KBDL - Windsor Locks, CT 27 23 22 22 22 25 27 20 19 20 19 12 9
KBDR - Bridgeport, CT 20 25 20 16 17 23 27 23 19 17 20
KBGM - Binghamton, NY 36 25 30 23 23 25 25 19 14 16 16
KBGR - Bangor, ME 31 31 28 27 20 28 20 19 14 14 19
KBML - Berlin, NH 39 33 28 16 14 19 16 9 6 17 14
KBOS - Boston, MA 16 16 16 16 11 14 14 16 8 8 6
KBTV - Burlington, VT 41 31 30 25 23 28 17 16 12 17 12
KBUF - Buffalo, NY 38 31 20 19 20 25 30 20 22 25 22
KBWI - Baltimore, MD 20 27 28 20 16 25 28 27 22 19 16
KCAR - Caribou, ME 41 30 33 23 19 27 20 17 12 14 14
KCEF - Springfield/Chicopee, MA 17 16 22 17 19 19 19 19 16 14 14
KCON - Concord, NH 23 19 16 16 12 14 16 14 17 16 12
KCXY - Harrisburg, PA 22 25 22 19 16 25 25 20 14 14 12
KDCA - Washington, DC (National) 22 27 25 19 16 20 25 22 20 19 20
KDUJ - Dubois, PA 27 27 23 19 20 22 20 16 16 20 25 17 9
KELM - Elmira/Corning, NY 41 39 34 28 30 27 27 23 22 27 25 14 12
KERI - Erie, PA 44 39 33 28 39 33 27 22 27 31 28 17 16
KEWB - New Bedford, MA 17 22 19 16 12 14 20 16 14 12 11 9 6
KEWR - Newark, NJ 25 28 25 28 25 33 34 25 27 22 22 17 9
KGON - Groton (New London), CT 20 22 20 19 16 20 22 20 19 16 11 11 5
KHFD - Hartford, CT 14 16 19 14 12 16 17 14 16 14 9 8 5
KHGR - Hagerstown, MD 25 30 25 23 27 25 27 23 19 17 19 16 11
27 25 20 14 11 11 14 12 9 9 8 5 5
Subseasonal CFS-based cold wave forecast initialized 4/23
Weak hint of cold
cold wave 5/7 - 5/13

15 day probabilistic temperature forecast: 5/2



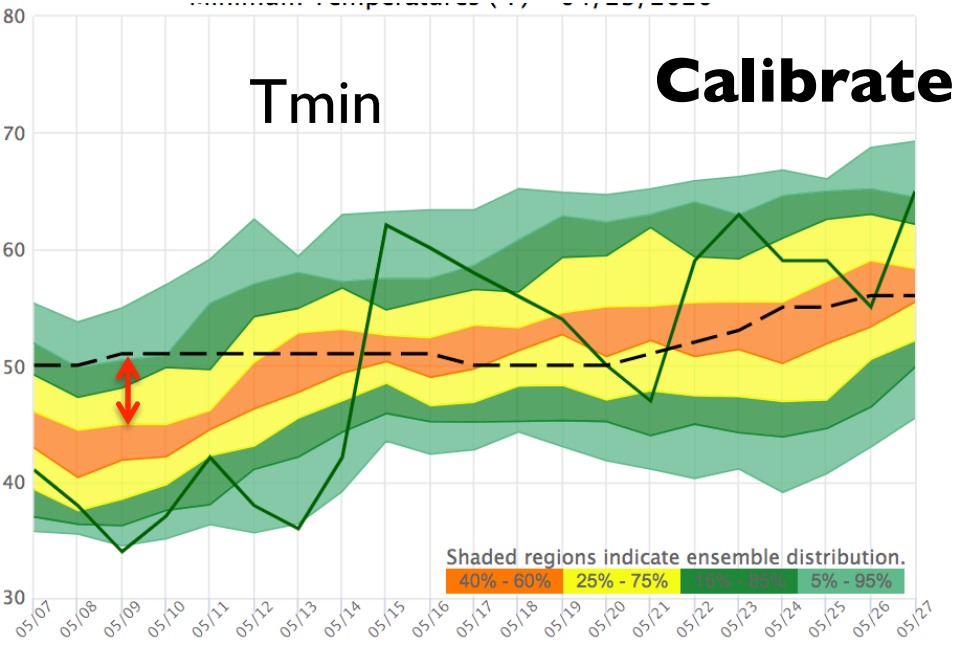


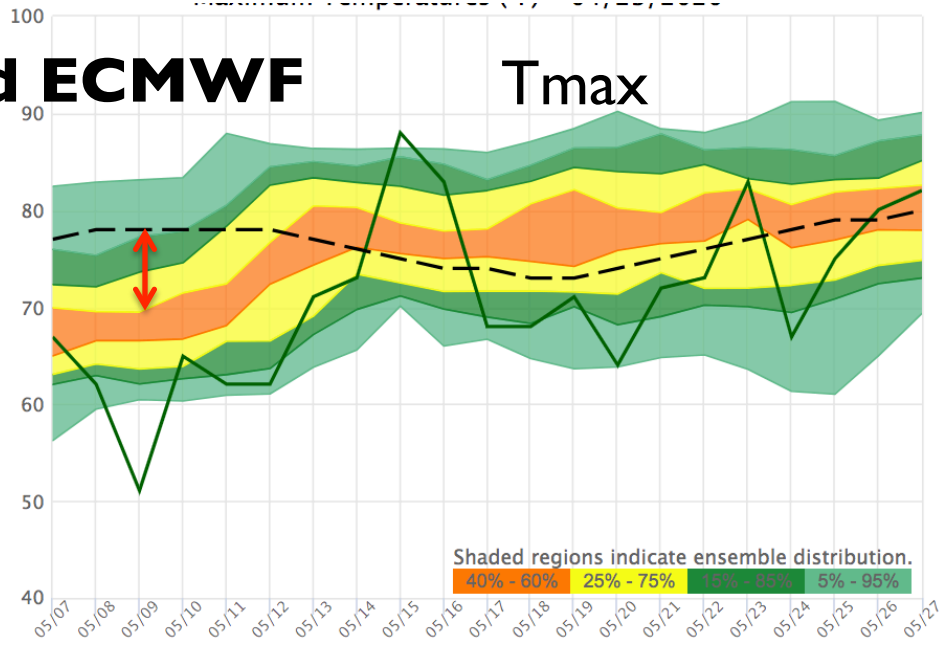


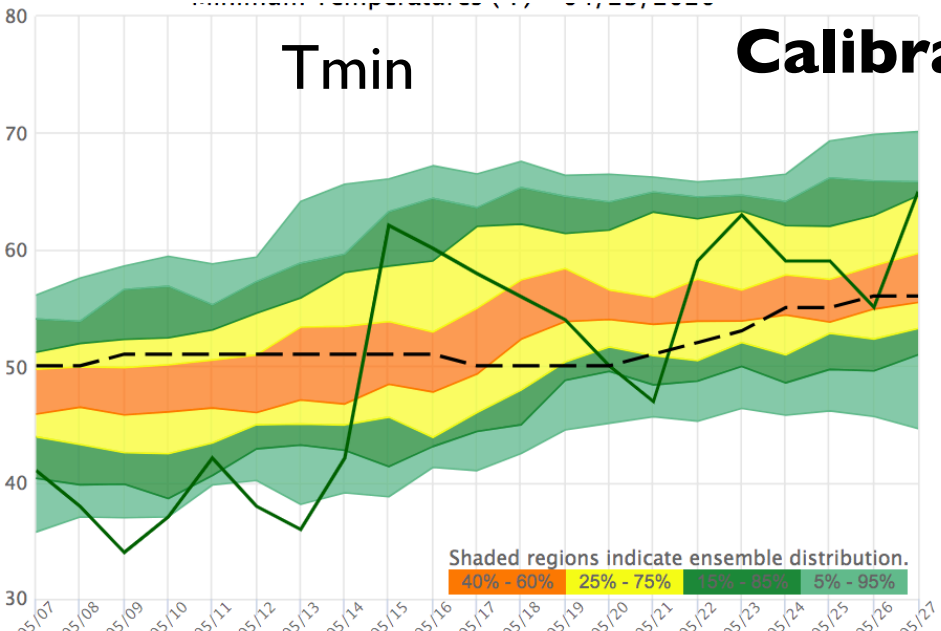


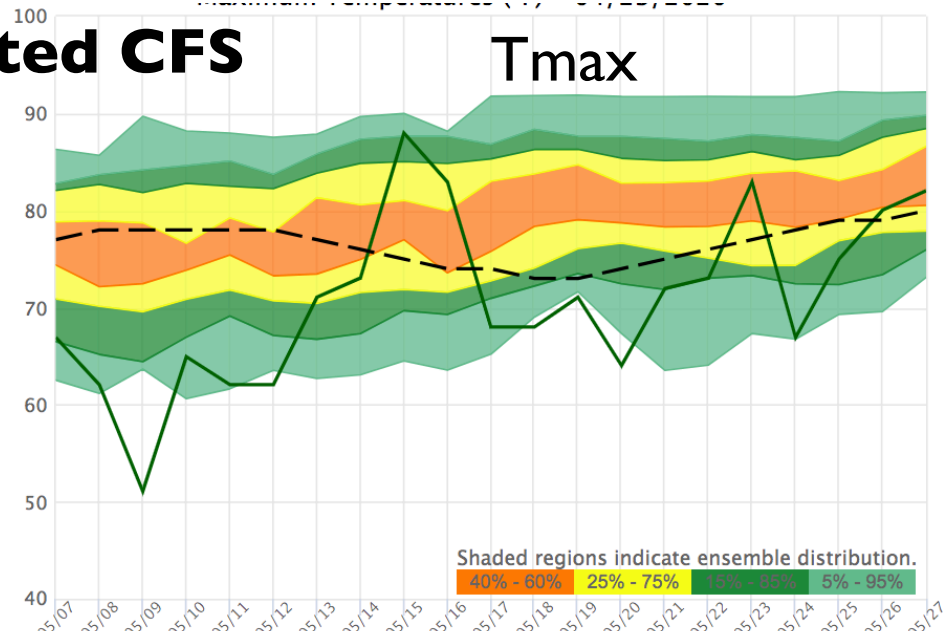
CFAN | ECMWF Ens. Mean | ECMWF HRES. | 10 year climo | 30 year climo | GFSX | Observed

Subseasonal probabilistic temperature forecast:





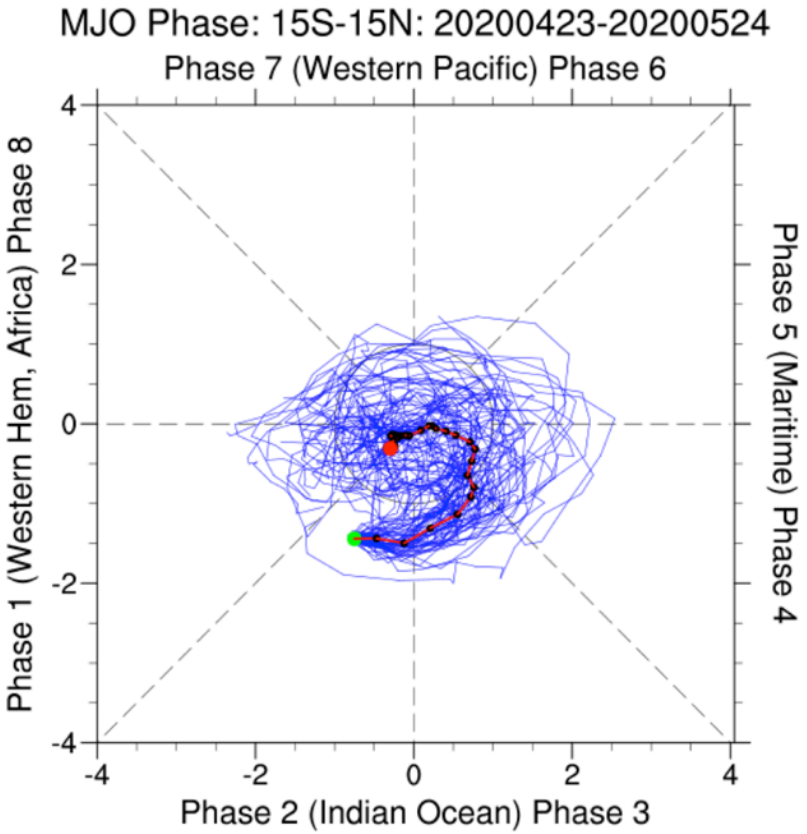




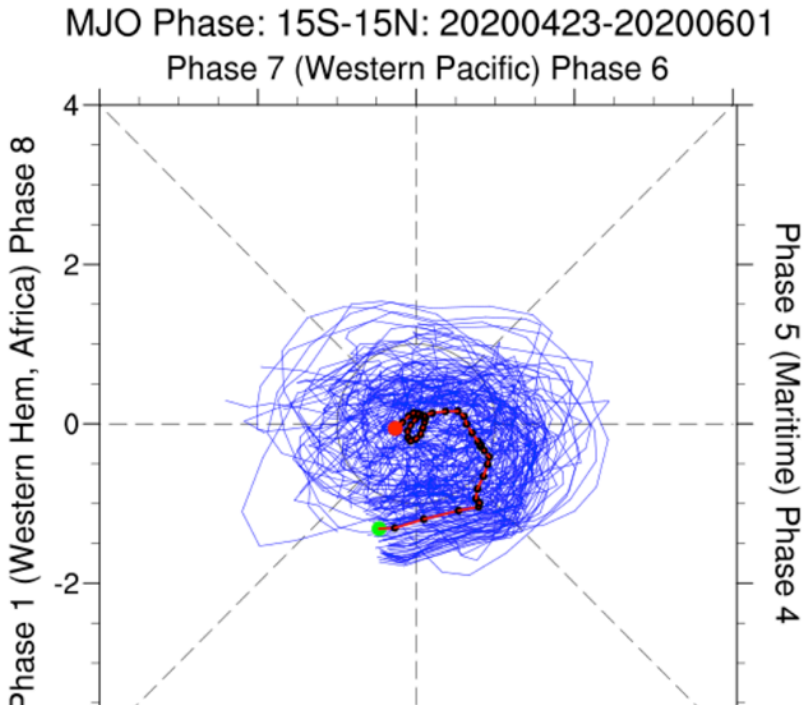
How much confidence should an energy trader place in the 4/23 forecast of the cold wave?

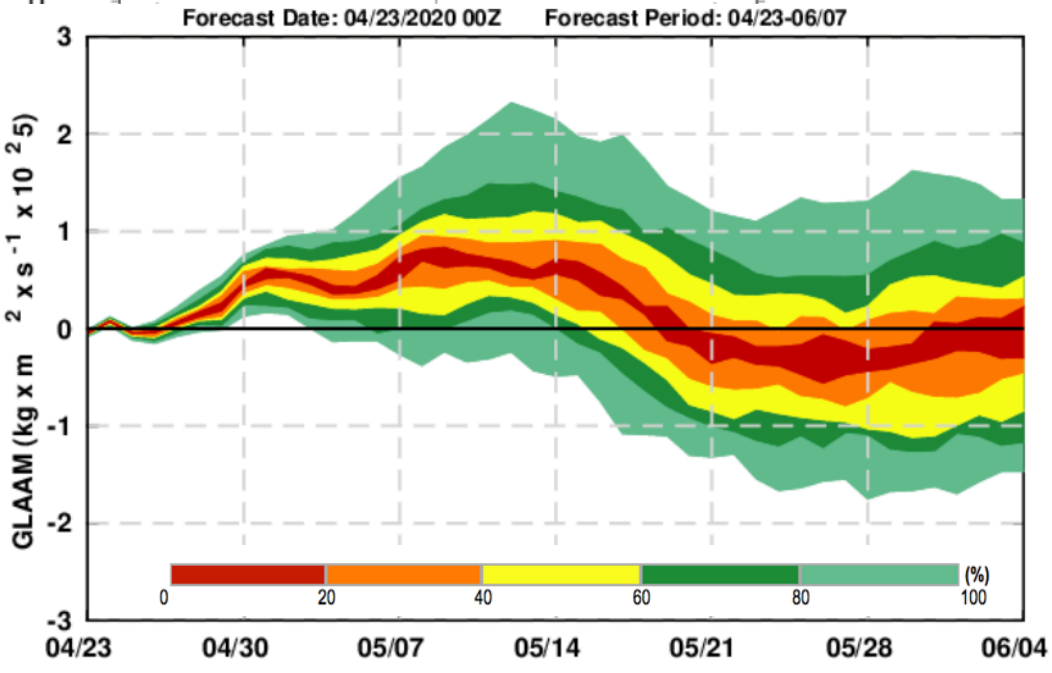
- Magnitude of the CW signal
- Forecast window of opportunity: strength of MJO, GLAAM, teleconnection indices (AO, NAO, PNA)
- Recent verification statistics

ECMWF

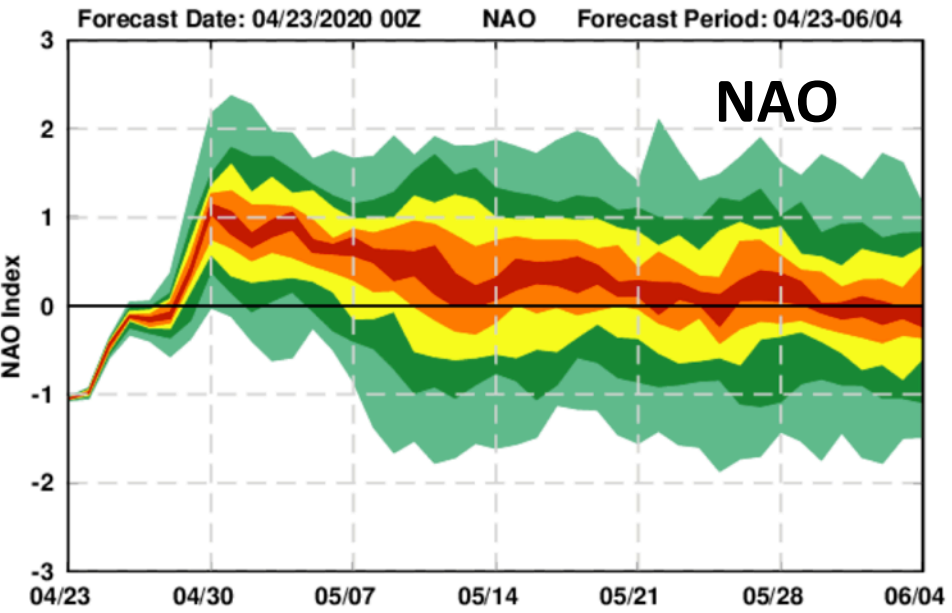


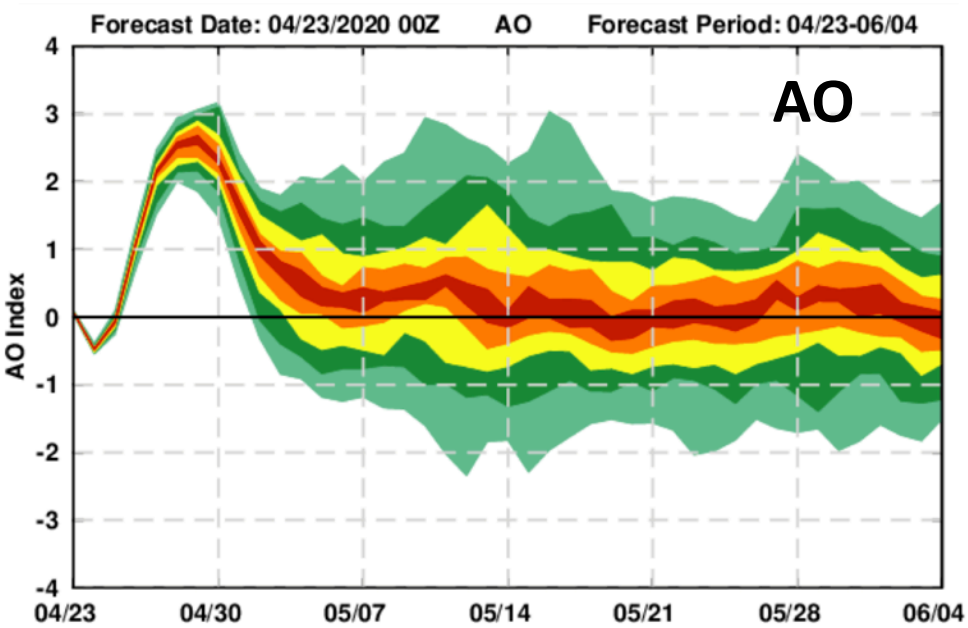
CFS

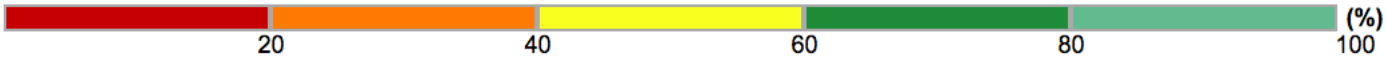




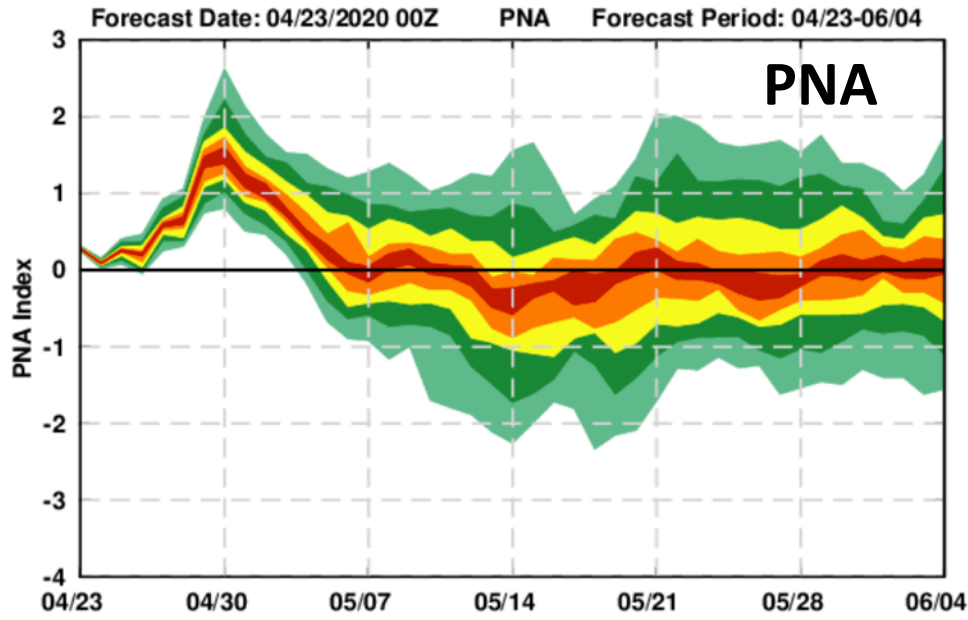
MJO and GLAAM: coherent signals through week 3



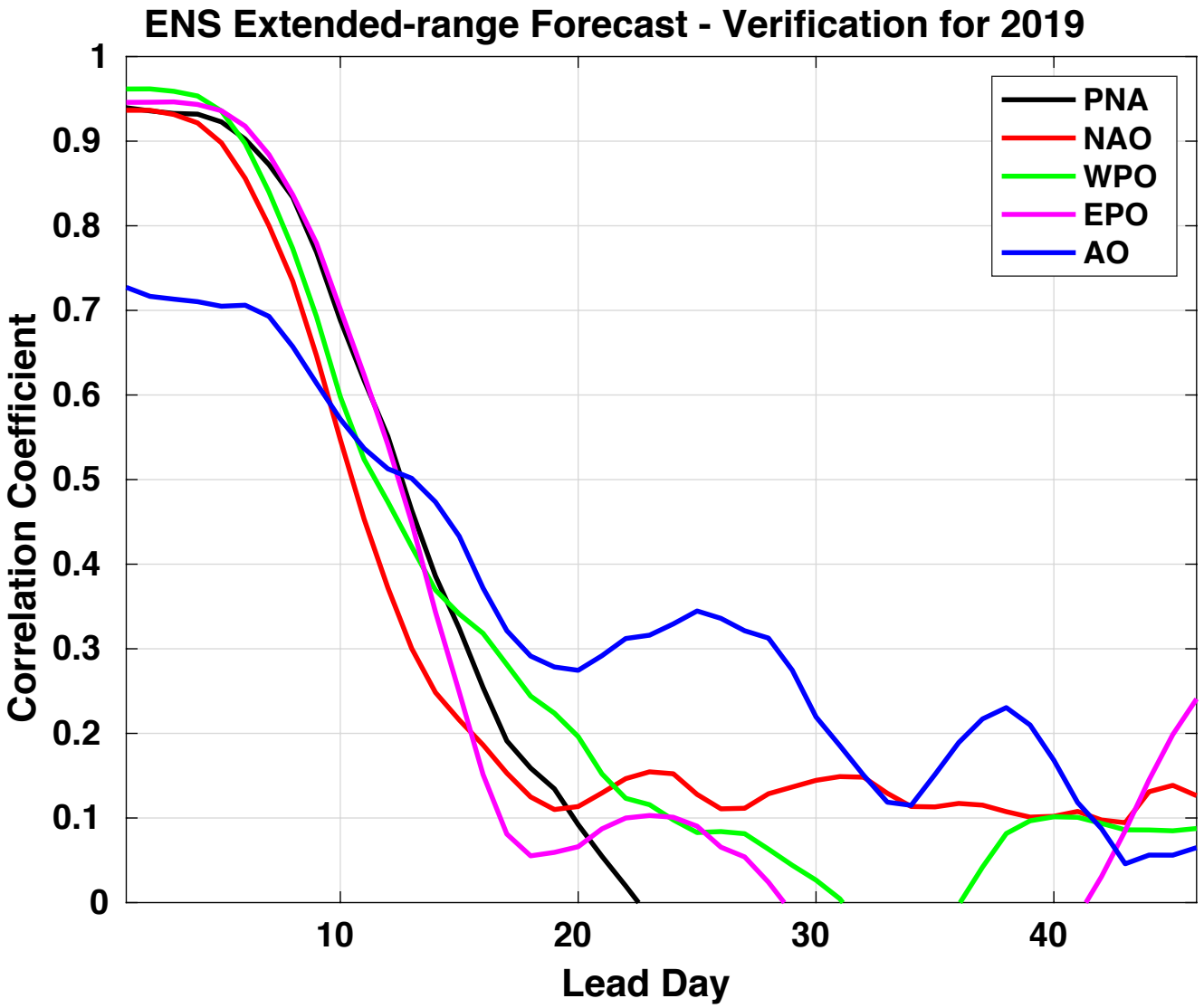




Coherent signals in NAO, AO, PNO in weeks 2-3 increase confidence in the forecast



Large-Scale Weather Patterns
2019 Forecast Verification



5/2 forecast for Baltimore

City Temperatures » KBWI - Baltimore, MD

Temperature Anomaly Legend: ≤ -12 | ≤ -8 | ≤ -4 | ≤ -2 | > -2 & < 2 | ≥ 2 | ≥ 4 | ≥ 8 | ≥ 12 | N/A

Forecast Type	05/02		05/03		05/04		05/05		05/06		05/07		05/08		05/09		05/10		05/11		05/12		05/13		05/14		05/15	
CFAN w/30 Year Climatology	48	70	57	75	47	69	44	60	46	62	42	60	40	62	39	60	37	57	38	57	39	60	41	63	45	67	47	68
CFAN w/10 Year Climatology	48	70	57	75	47	69	44	60	46	62	42	60	40	62	39	60	37	57	38	57	39	60	41	63	45	67	47	68
ECMWF Quantile to Quantile	45	72	54	79	45	71	40	62	41	63	39	62	37	64	34	61	33	59	34	58	35	61	38	65	42	69	45	71
ECMWF Ens. Mean	49	65	57	71	49	65	45	57	46	58	44	57	42	58	40	56	39	54	40	54	41	57	43	60	47	64	49	65
ECMWF HRES	48	69	57	73	47	65	45	59	47	65	45	62	41	61	37	58	35	49										
GFS MOS			56	75	52	69	44	61	47	70	42	66	41	64	42	63												
10 Year Climatology	50	75	50	75	50	74	49	74	50	74	50	75	50	75	51	76	51	76	50	76	51	76	52	77	52	77	53	76
30 Year Climatology	48	74	48	73	48	73	48	73	48	74	49	74	49	75	50	76	50	76	50	77	51	77	51	76	51	76	52	76
Observed	49	73	60	80	53	74	43	60	46	53	41	67	38	62	34	51	37	65	42	62	38	62	36	71	42	73	62	88

- CFAN's **Q-to-Q** calibration for Tmin matched the observed
- ECMWF **Ens Mean** (uncalibrated) closest to observed Tmax

Real-time verification: 5/2 forecast Baltimore

Mean absolute error

Verification method: ○ Mean Absolute Error ○ Mean Bias — Forecast verification based on Mean Absolute Error (°F).

Forecast Type	Lead 1		Lead 2		Lead 3		Lead 4		Lead 5		Lead 6		Lead 7		Lead 8		Lead 9		Lead 10		Lead 11		Lead 12		Lead 13		Lead 14	
15 Days Verification																												
CFAN	2.05	2.40	2.24	3.04	2.27	2.89	2.58	3.34	2.96	4.10	3.55	3.92	3.30	4.08	4.35	4.61	5.23	5.83	5.77	5.27	5.36	5.18	5.80	5.77	6.27	5.43	6.19	6.58
ECMWF Quantile to Quantile	3.56	2.79	3.40	3.49	3.19	3.58	3.44	4.16	3.98	4.43	4.28	4.18	3.63	5.46	4.15	5.64	4.73	6.51	5.46	6.19	4.83	6.54	5.23	7.42	5.35	7.04	5.48	8.35
ECMWF Ensemble Mean	2.35	4.25	2.61	4.47	2.68	3.97	2.98	4.35	3.37	4.67	3.60	4.89	3.56	4.27	4.41	4.74	4.98	4.75	5.73	4.86	5.45	4.99	5.83	5.14	6.26	5.02	6.12	5.31
ECMWF Deterministic	2.00	3.09	1.92	3.57	2.09	3.37	2.31	3.85	2.47	5.80	3.79	5.82	3.46	4.21	6.22	7.67	5.47	9.15										
GFSX			3.27	3.75	3.47	4.02	2.74	4.34	3.20	4.41	2.73	3.73	3.73	4.67	4.52	5.19												
30 Days Verification																												
CFAN	1.83	1.87	2.17	2.40	2.49	2.55	2.64	3.06	2.82	3.23	3.47	3.24	3.39	4.29	4.11	5.32	4.77	6.55	5.47	6.29	5.72	6.69	6.12	7.11	6.19	6.55	5.68	6.73
ECMWF Quantile to Quantile	2.84	2.48	2.89	3.02	2.94	3.04	2.99	3.61	3.29	3.80	3.56	3.67	3.43	4.71	3.66	5.21	4.23	6.05	5.34	6.18	5.64	7.28	5.95	7.84	5.91	7.24	5.36	7.55
ECMWF Ensemble Mean	2.17	4.77	2.45	4.97	2.69	4.59	2.83	4.76	3.08	5.09	3.34	5.46	3.44	5.68	4.05	6.56	4.49	7.11	5.45	7.12	5.78	7.14	6.12	7.38	6.19	7.00	5.69	6.88
ECMWF Deterministic	1.85	3.03	1.86	3.27	2.30	3.15	2.74	3.71	2.75	4.83	3.63	5.08	3.86	4.67	5.22	7.02	5.25	9.20										
GFSX			3.37	3.07	3.23	3.44	2.93	3.72	3.33	3.71	3.16	3.94	4.70	5.77	4.23	5.63												
90 Days Verification																												
CFAN	2.09	2.54	2.43	2.98	2.44	2.94	2.66	3.41	2.99	3.80	3.59	4.35	3.84	5.05	4.05	5.48	4.56	6.58	5.17	6.18	5.45	7.04	5.43	7.29	5.73	7.08	5.73	7.22
ECMWF Quantile to Quantile	2.63	2.80	2.72	3.18	2.74	3.24	2.90	3.58	3.22	3.76	3.77	4.53	3.97	5.23	4.16	5.58	4.45	6.46	5.11	6.46	5.45	7.54	5.36	7.80	5.63	7.65	5.63	7.55
ECMWF Ensemble Mean	2.36	5.32	2.45	5.62	2.52	5.32	2.66	5.55	3.07	5.82	3.58	6.29	3.81	6.47	4.11	6.66	4.45	7.13	5.17	7.16	5.46	7.55	5.41	7.75	5.72	7.77	5.73	7.94
ECMWF Deterministic	2.14	3.58	2.29	3.87	2.30	3.72	2.67	4.17	2.93	4.98	3.81	5.62	4.59	6.16	4.96	7.17	5.78	7.88										
GFSX			3.22	3.75	3.54	3.98	3.21	4.50	3.68	4.41	4.17	4.93	5.05	6.38	4.39	5.73												

Last 15 days

Last 30 days

Last 90 days

CFAN's Q-to-Q calibration often picks up record temperatures

Bias error

Verification method: ○ Mean Absolute Error ○ Mean Bias — Forecast verification based on Mean Bias (°F).

Forecast Type	Lead 1		Lead 2		Lead 3		Lead 4		Lead 5		Lead 6		Lead 7		Lead 8		Lead 9		Lead 10		Lead 11		Lead 12		Lead 13		Lead 14	
15 Days Verification																												
CFAN	0.45	0.48	0.28	0.66	0.01	0.42	0.69	0.97	0.8	1.09	0.29	1.48	1.14	2.32	1.48	2.52	1.55	3.06	1.77	2.24	2.02	2.46	2.42	3.02	3.36	3.14	4.02	3.97
ECMWF Quantile to Quantile	3.21	2.35	2.98	2.48	2.59	2.72	2.62	3.2	2.79	2.74	2.67	3.02	1.66	4.28	1.53	3.96	1.9	3.95	1.58	4.58	1.09	5.18	0.67	6	0.23	6.1	0.89	6.9
ECMWF Ensemble Mean	1.16	3.47	1.25	3.35	1.42	3.23	1.3	2.91	1.09	3.33	1.63	2.77	2.31	1.85	2.35	2.12	1.96	2.17	2.58	1.4	2.88	0.98	3.11	0.42	3.75	0.46	4.15	0.09
ECMWF Deterministic	0.9	2.09	0.78	1.33	0.18	1.32	0.87	0.58	1.21	1.06	0.48	2.14	1.32	0.2	1.58	0.28	1.65	0.47										
GFSX			1.66	1.87	2.8	1.6	1.53	2.47	1.46	1.47	0.86	1.6	2	2.94	0.93	2.67												

Last 15 days

4/23 forecast for Baltimore

CW/HW Probabilities: KBWI - Baltimore, MD ○ ECMWF ○ CFS

Cold Wave Probability Legend: ≤ 30% | 30-60% | 60-90% | ≥ 90%

Heat Wave Probability Legend: ≤ 30% | 30-60% | 60-90% | ≥ 90%

Forecast Type	05/07	05/08	05/09	05/10	05/11	05/12	05/13	05/14	05/15	05/16	05/17	05/18	05/19	05/2
Cold Wave Probability ECMWF (%)	53	63	61	61	47	33	31	24	16	22	25	24	22	25
Heat Wave Probability ECMWF (%)	8	6	6	6	14	20	29	29	18	16	22	25	35	31

Temperature forecasts

Monthly Forecast » KBWI - Baltimore, MD

Temperature Anomaly Legend: ≤ -12 | ≤ -8 | ≤ -4 | ≤ -2 | > -2 & < 2 | ≥ 2 | ≥ 4 | ≥ 8 | ≥ 12 | N/A

Forecast Type	05/07		05/08		05/09		05/10		05/11		05/12		05/13		05/14		05/15		05/16		05/17		05/18		05/19	
CFAN Consensus	47	74	48	74	48	75	48	75	49	76	50	76	51	75	51	75	51	75	51	74	52	74	52	75	53	75
ECMWF Filtered	47	64	47	63	48	63	48	64	49	65	51	67	52	68	53	69	53	69	54	70	54	70	55	70	55	70
ECMWF Bias adjusted	46	70	46	71	46	71	47	73	48	74	49	75	50	76	50	76	50	75	51	75	51	74	51	75	51	75
ECMWF Q-to-Q	45	68	43	69	44	69	45	70	46	72	48	74	50	76	51	77	52	78	51	77	52	77	53	77	54	78
CFS Filtered	47	66	47	66	47	66	48	67	48	67	48	67	49	68	50	69	50	69	51	70	52	71	53	73	54	73
CFS Bias adjusted	49	77	50	77	50	78	50	78	50	78	50	76	50	75	50	75	50	74	50	74	50	74	51	75	51	76
CFS Q-to-Q	47	76	48	75	48	76	48	76	49	76	49	76	51	77	51	77	52	78	52	77	53	79	55	80	56	81
10yr Climo	50	77	50	78	51	78	51	78	51	78	51	78	51	77	51	76	51	75	51	74	50	74	50	73	50	73
30yr Climo	49	75	49	75	50	76	50	76	50	76	51	76	51	76	51	76	52	76	52	76	52	76	52	76	52	76
Observed	41	67	38	62	34	51	37	65	42	62	38	62	36	71	42	73	62	88	60	83	58	68	56	68	54	71

- CFAN's consensus forecast only slightly better than climatology
- ECMWF q-to-q forecast performs the best

Real-time verification: 5/2 forecast for

Mean absolute error

Forecast Verification

Verification method: ◉ Mean Absolute Error ○ Mean Bias — **Last 60 days** — ⓘ Forecast verification based on Mean Absolute Error.

Forecast	Lead 15		Lead 16		Lead 17		Lead 18		Lead 19		Lead 20		Lead 21		Lead 22		Lead 23		Lead 24		Lead 25		Lead 26		Lead 27		Lead 2
60 Days																											
CFAN consensus	5.2	7.5	5.7	7.3	6	7.4	5.8	7.3	5.8	7.5	5.8	7.2	5.8	7.7	5.7	7.9	6.3	7.7	6.6	7.6	6.6	7.7	6.7	7.9	6.3	7.5	5.9	
Filtered ECMWF	5.5	7.1	5.9	7.3	5.9	7.8	5.7	7	5.8	6.5	5.6	7.2	5.6	7.2	5.7	6.5	6.2	7	6.5	7.6	6.6	6.9	6.7	6.8	6.2	7.5	5.8	
Calibrated ECMWF	5.1	8	5.6	7.7	5.8	7.8	5.6	7.7	5.6	7.8	5.6	7.3	5.5	7.6	5.5	7.9	6.1	7.5	6.5	7.5	6.5	7.7	6.6	7.8	6.3	7.4	5.9	
Filtered CFS	5.7	8.7	6.1	9.2	6.8	10	6.9	8.9	7	8.6	7.3	9.7	7.5	9.2	7.1	8.2	7.3	8.7	7.7	8.9	7.3	7.8	7.3	7.8	7.2	8.5	6.8	
Calibrated CFS	5.4	7.3	6	7.2	6.4	7.5	6.3	7.2	6.5	7.3	6.6	7.4	6.6	7.9	6.4	7.9	6.8	8	6.9	7.8	6.7	7.9	6.8	8.2	6.6	7.7	6.1	
Climo Forecast	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	7.4	7.2	

Bias error

Verification method: ○ Mean Absolute Error ◉ Mean Bias — **Last 60 days** — ⓘ Forecast verification based on Mean Bias.

Forecast	Lead 15		Lead 16		Lead 17		Lead 18		Lead 19		Lead 20		Lead 21		Lead 22		Lead 23		Lead 24		Lead 25		Lead 26		Lead 27		Lead 2
60 Days																											
CFAN consensus	1.4	2.8	1	2.6	1.7	2	1.5	2.9	0.9	3.6	1.1	2.7	1.5	3.1	0.8	4	0.6	3.5	1.6	3.1	1.4	3.8	1.1	3.8	1.3	2.9	1.2	
Filtered ECMWF	0.9	3	0.3	3.4	0.9	4.2	0.5	3.5	0	2.9	0.3	4	0.7	3.8	0.1	3	0.1	3.6	0.9	4.2	0.8	3.6	0.4	3.6	0.7	4.6	0.6	
Calibrated ECMWF	1.1	3.5	0.8	3.4	1.7	2.9	1.4	3.8	0.9	4.5	1.2	3.4	1.6	3.7	1	4.5	0.8	4	1.9	3.4	1.8	4	1.5	4	1.7	3	1.6	
Filtered CFS	3.8	7.1	3.7	7.4	4.7	8.1	4.7	7.3	4.2	6.5	4.5	7.5	4.9	7.1	4.3	6.1	4	6.6	4.9	6.9	4.6	6.2	4.2	6.1	4.4	7.1	4.4	
Calibrated CFS	2.2	1.9	2	1.7	2.9	1	2.6	1.9	2	2.7	2	1.9	2.3	2.4	1.5	3.5	1.2	3.1	2.1	2.8	1.8	3.5	1.4	3.7	1.6	2.7	1.5	
Climo Forecast	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.5	

- CFAN's forecast for Tmin is significantly better than climatology
- CFAN's forecast for Tmax matches climatology

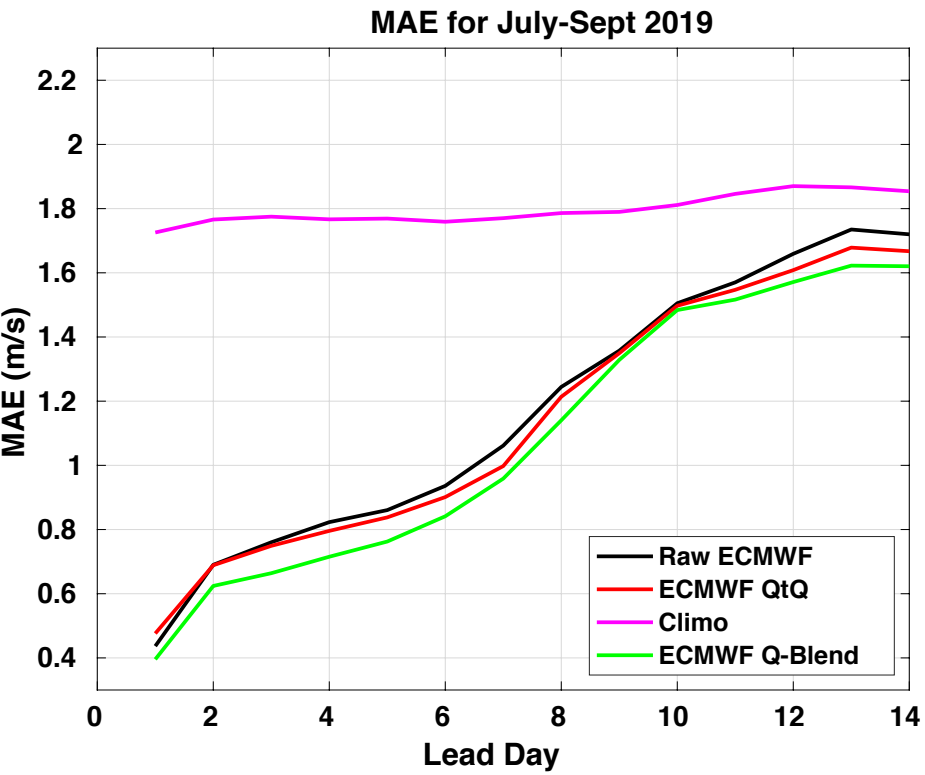
Subseasonal T forecasts: conclusions

- Deterministic daily temperature forecasts on subseasonal time scales is currently a hopeless endeavour
- Ensemble-based heat/cold wave probabilities have greater predictability on subseasonal time scales
- Calibration of the ensemble distribution is key to forecasting heat/cold wave probabilities.

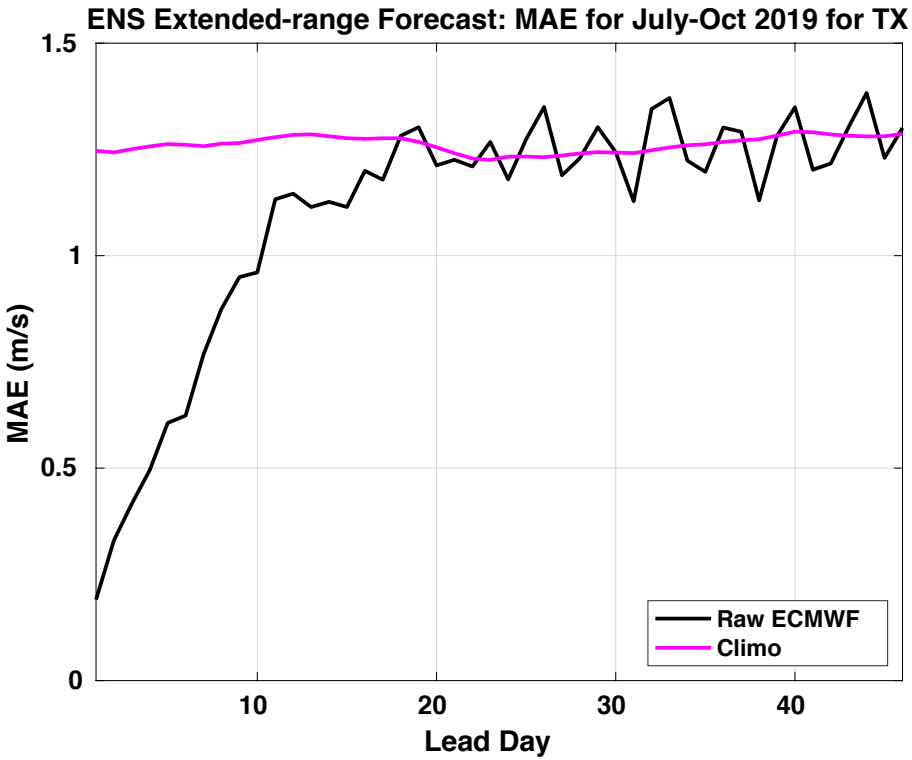
Advances in Subseasonal Prediction of 100-m Wind Speed in the Western U.S.

Wind Forecast Evaluation – ERCOT

ECMWF ENS (medium range)



Extended ENS (subseasonal)

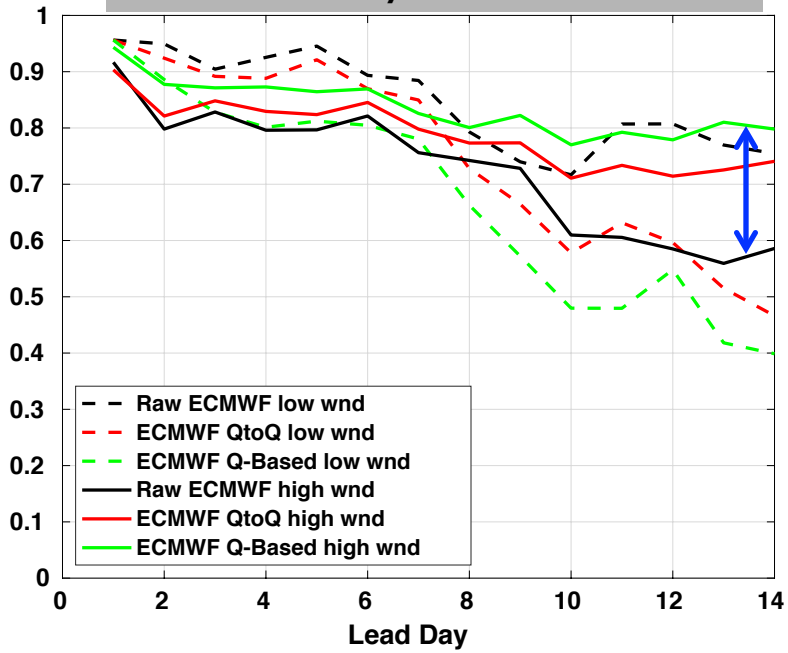


- Forecast error is smaller than climatology forecast <18 days
- CFAN calibration reduces the MAE significantly

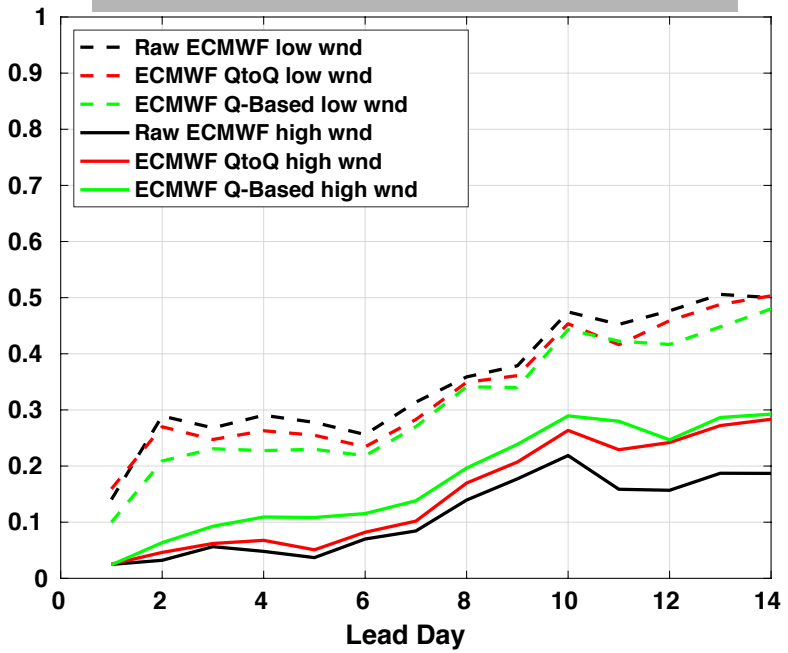
Categorical Verification of Forecast

Is forecast skillful in predicting above/below long-term climatology?

Probability of Detection



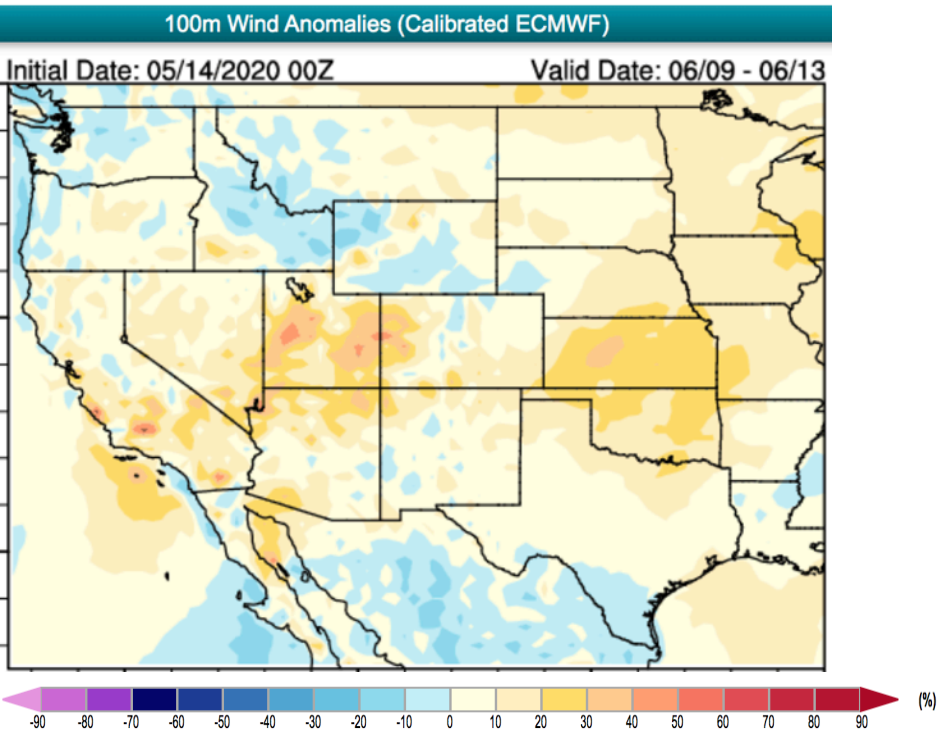
False Alarm Ratio

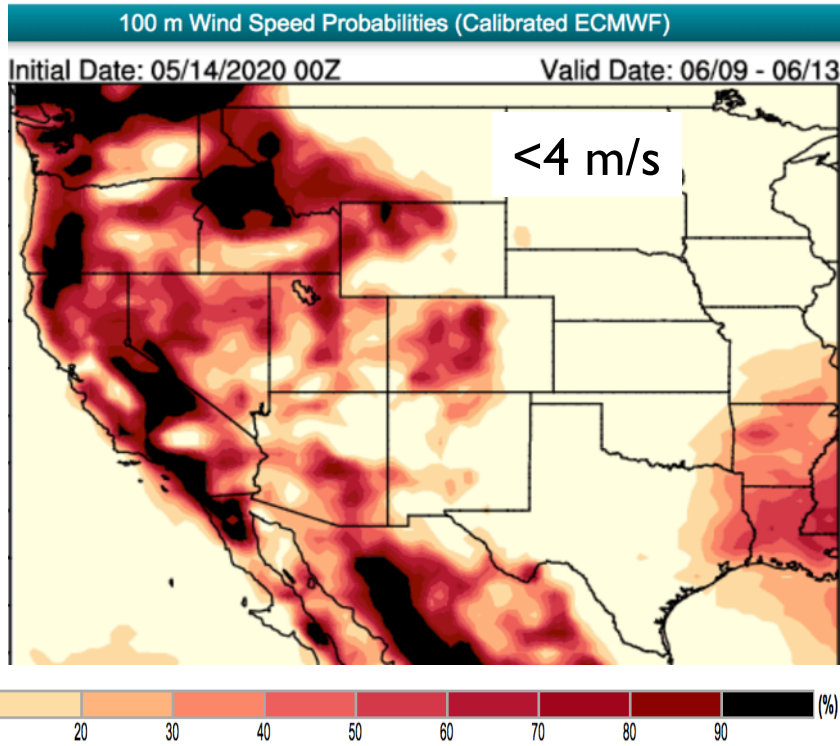


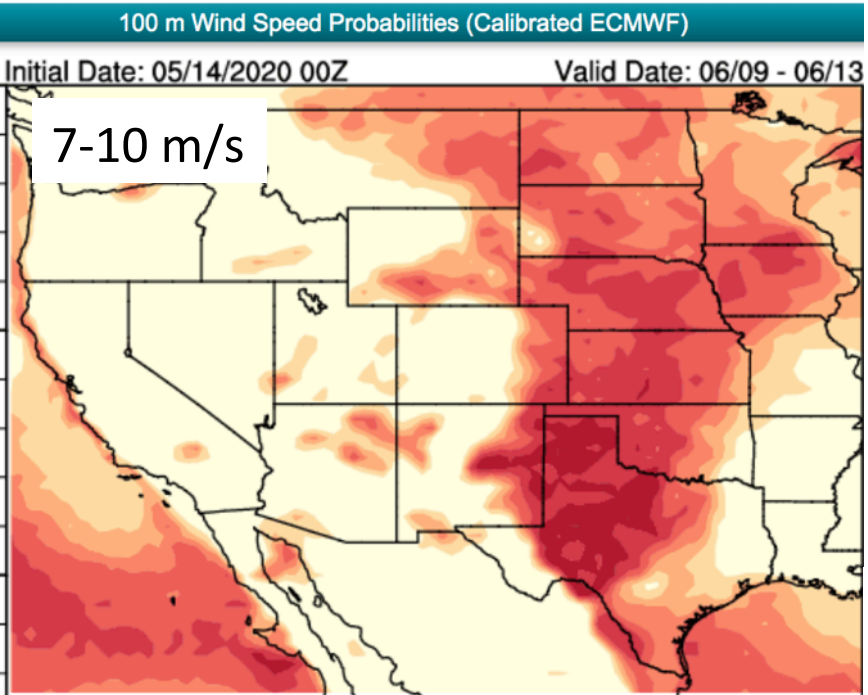
"High Wind" - above climatology

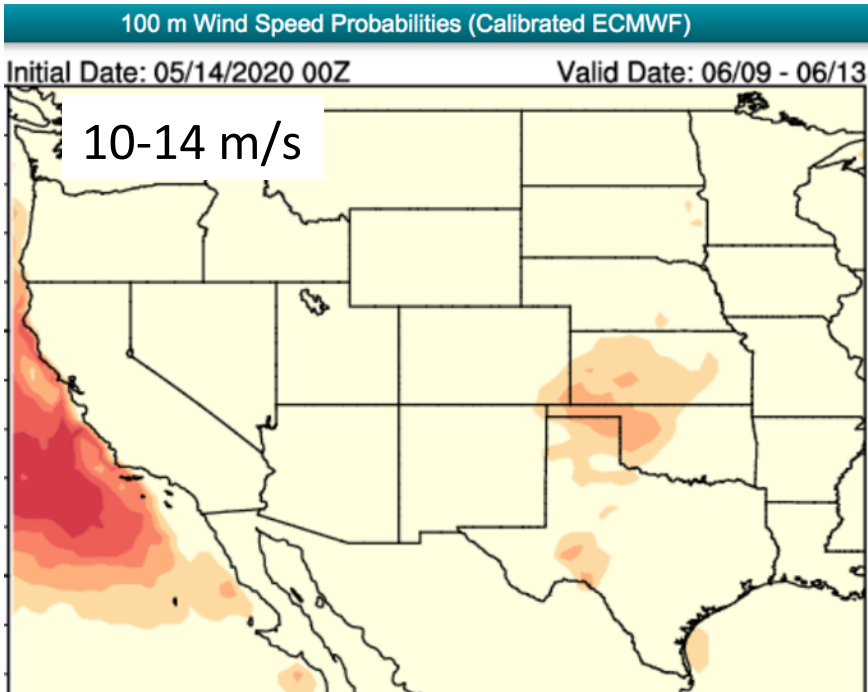
"Low Wind" - below climatology

- Substantial improvement of "high wind" forecast when applying CFAN calibration


100m Wind Anomalies (Calibrated ECMWF)
Initial Date: 05/14/2020 00Z
Valid Date: 06/09 - 06/13
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
(%)


100 m Wind Speed Probabilities (Calibrated ECMWF)
Initial Date: 05/14/2020 00Z
Valid Date: 06/09 - 06/13
<4 m/s
10 20 30 40 50 60 70 80 90
(%)


100 m Wind Speed Probabilities (Calibrated ECMWF)
Initial Date: 05/14/2020 00Z
Valid Date: 06/09 - 06/13
7-10 m/s


100 m Wind Speed Probabilities (Calibrated ECMWF)
Initial Date: 05/14/2020 00Z
Valid Date: 06/09 - 06/13
10-14 m/s

Conclusions: subseasonal wind forecasts

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

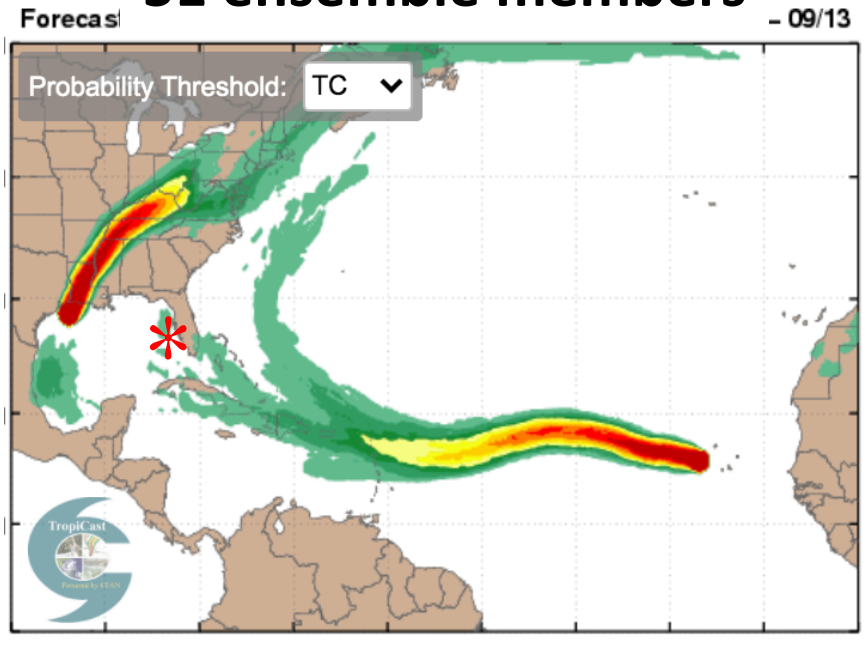
CFAN's calibrated 100 m wind forecasts improve forecast skill particularly for 'high wind' cases

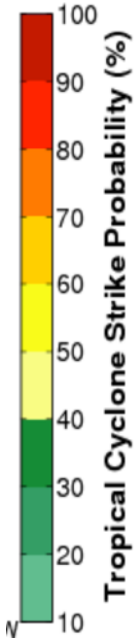
Clustering around weather regimes helps identify forecast 'windows of opportunity'

Extended-range tropical cylcone forecasts

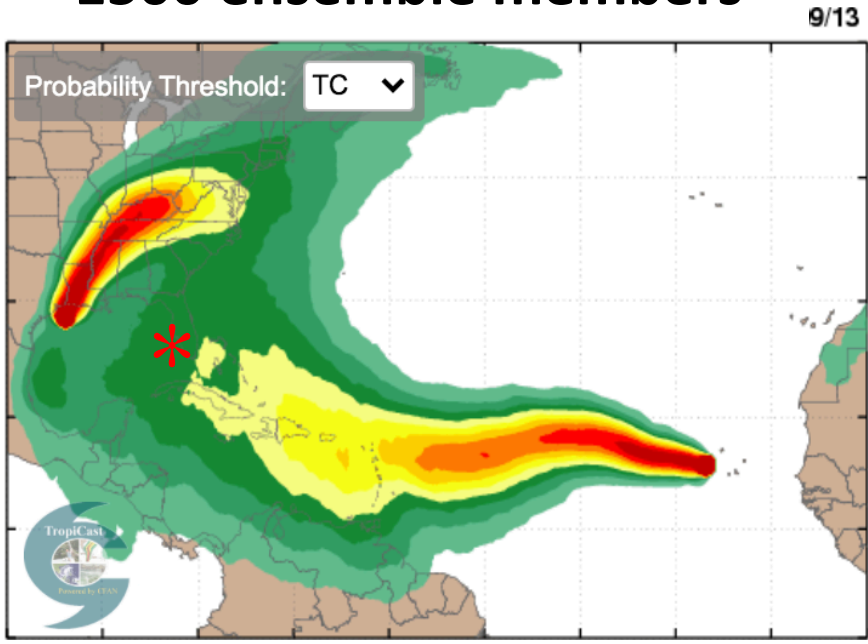
Hurricane Irma: 11 days b4 landfall

Raw ECMWF – 51 ensemble members

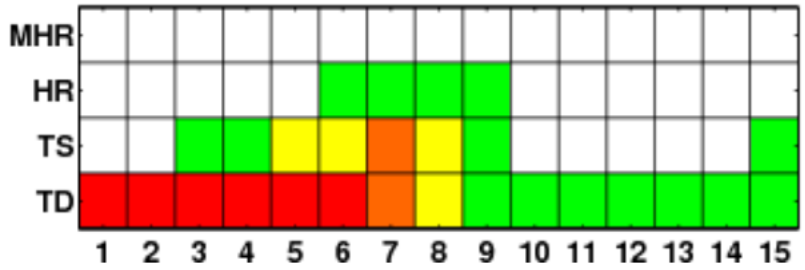




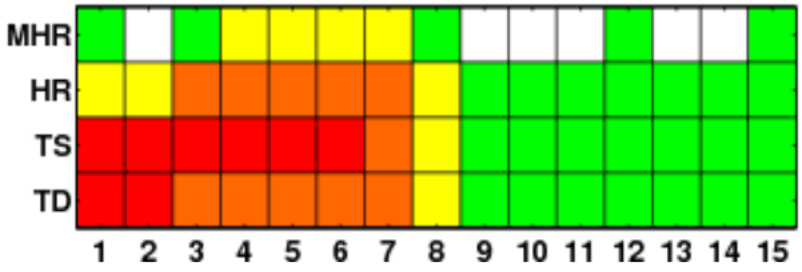
Calibrated synthetic ECMWF 1500 ensemble members



Main Development Region

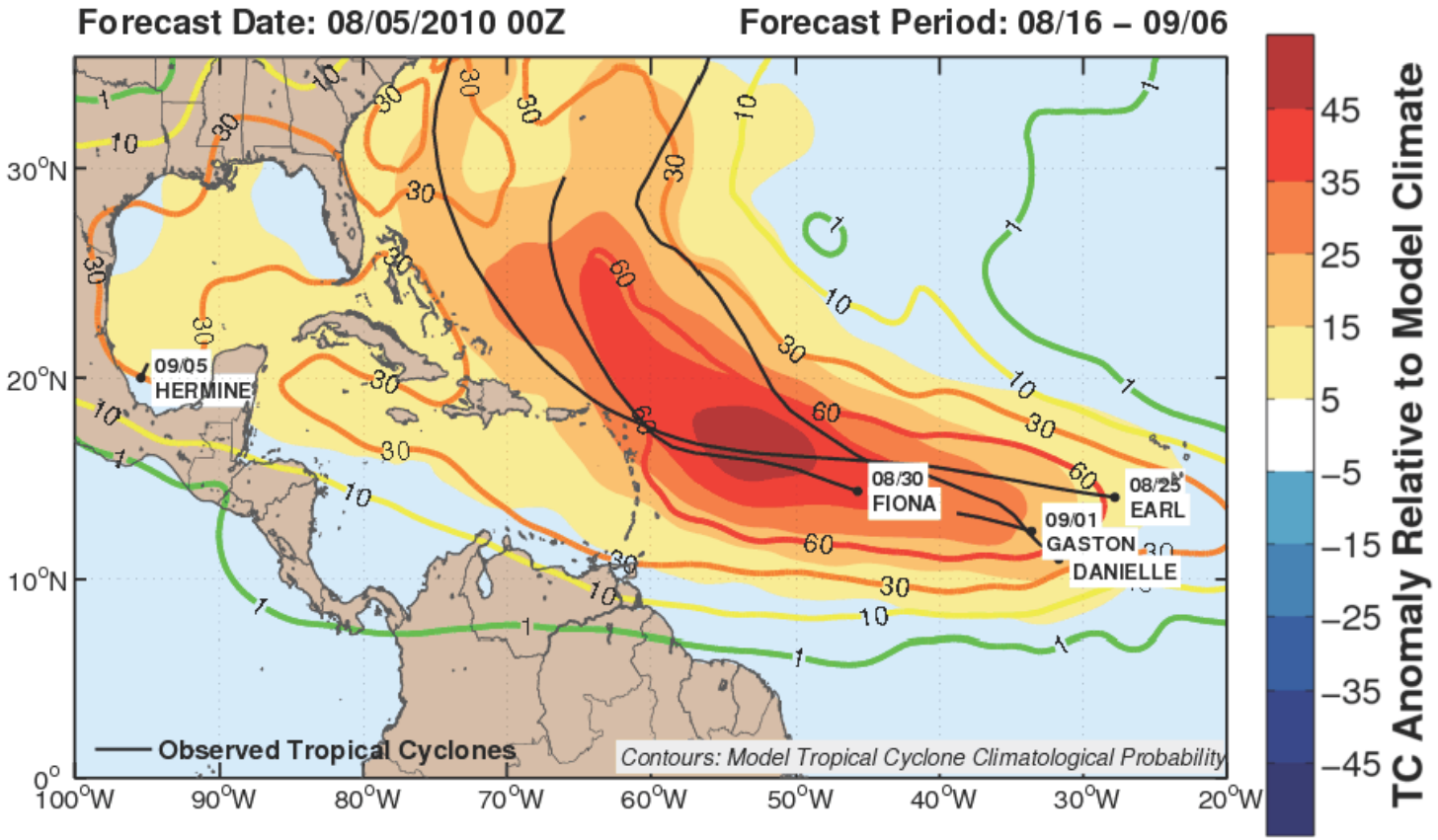


Main Development Region



Intensity Probability Color Key - 0.5 <= x < 10% 10 <= x < 30% 30 <= x < 60% 60 <= x <= 100%

Tropical cyclones: monthly outlooks



Observed Tropical Cyclones in Black

- Contours show bias-calibrated probability of a hurricane for specified forecast period and shading denotes anomaly relative to climate