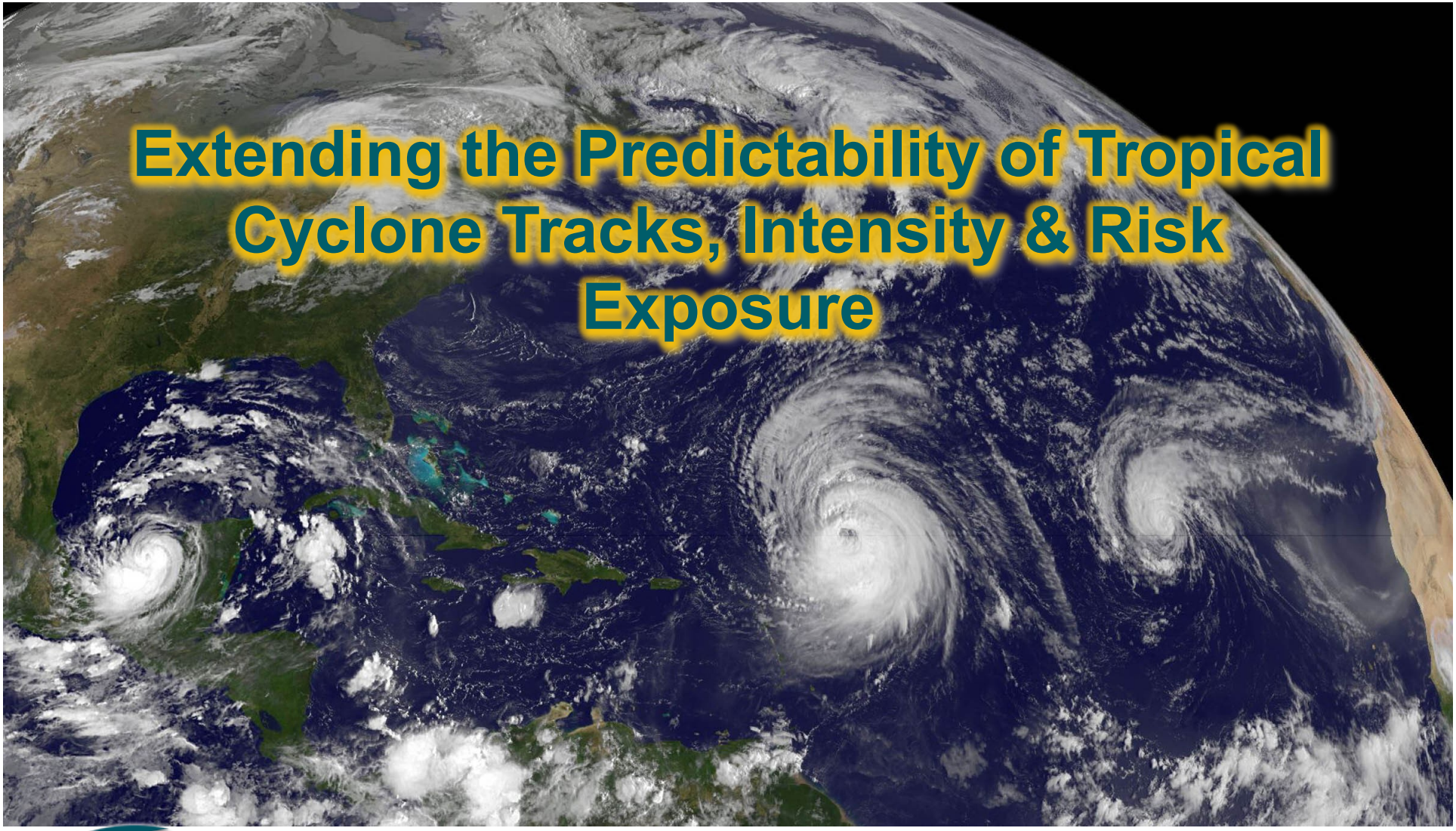
Extending the Predictability of Tropical Cyclone Tracks, Intensity & Risk Exposure



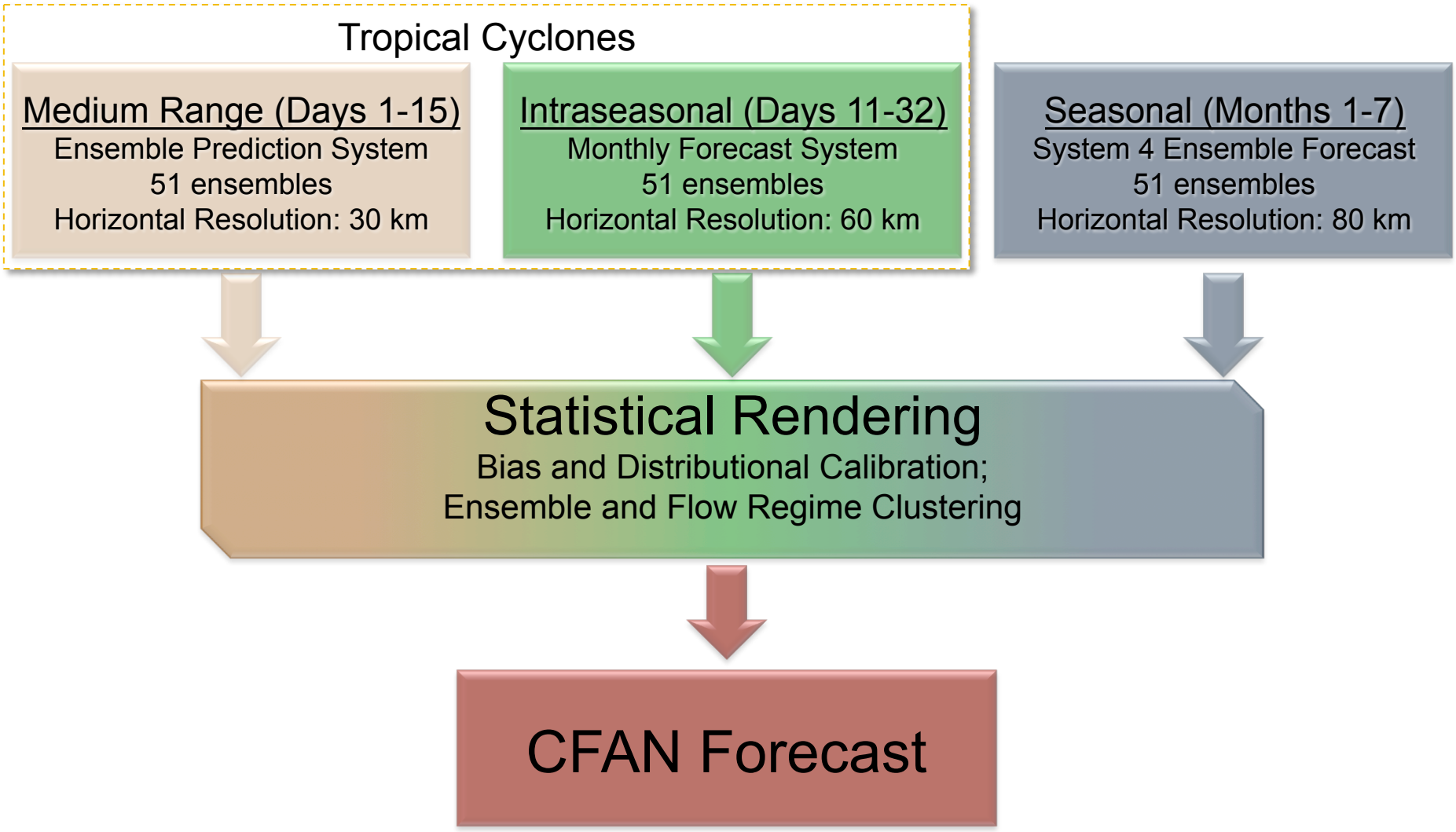
Earth Networks Energy Weather Seminar:
Summer/Hurricane Outlook 2012

Mark Jelinek – Lead Forecaster
CFAN

Today's Topics

- Advancing Tropical Cyclone Forecasts
  - Seeing them sooner
  - Maximizing track and intensity forecasts
  - Extending the risk exposure envelope
- Tropical Cyclone Dashboard
- Supporting Energy Trading Decisions
- Extreme Temperature Events
  - Seeing out to month
  - Extending lead-time and performance
- CFAN's OmniCast™ Solution

CFAN's Hierarchical Forecasting Philosophy



Extending Genesis Prediction

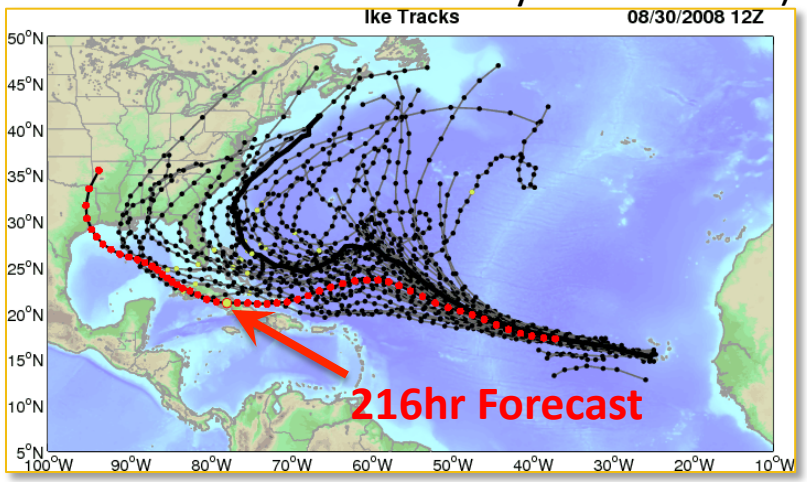
Current: 2011	CFAN 30% (60%)	NHC 30% (60%)
All TCs	6.2 (2.1)	1.6 (0.6)

Previous: 2010	CFAN 30% (60%)	NHC 30% (60%)
All TCs	4.1 (1.8)	1.6 (0.8)

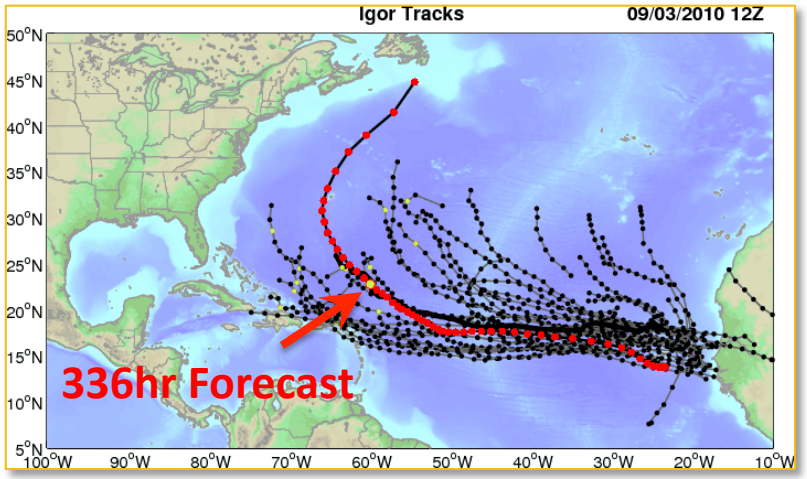
- TC genesis has been more predictable in 2011 compared to 2010
- Stronger systems, particularly hurricanes and major hurricanes have longer lead time predictability
- Lead times in excess of traditional 48 proven viable
- CFAN moderate risk forecasts exceeded NHC in 29 of 35 tropical cyclones in 2010 and 2011
- 2010-2011 CFAN False Alarm Ratio
  - 29% using moderate (30-60%) risk
  - 12% using high (60%+) risk

Pre-Genesis Track Forecasting: North Atlantic

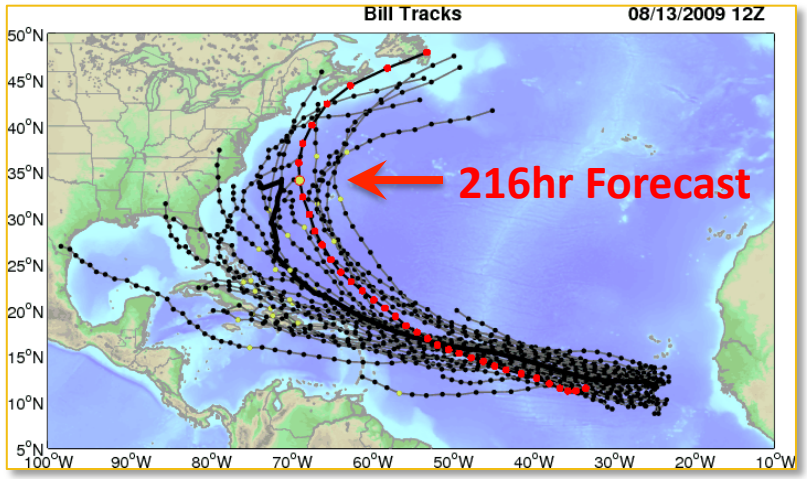
MHR Ike 2008 (2 Days Pre-Genesis 15 Days Pre-Landfall)



MHR Igor 2010 (5 Days Pre-Genesis)



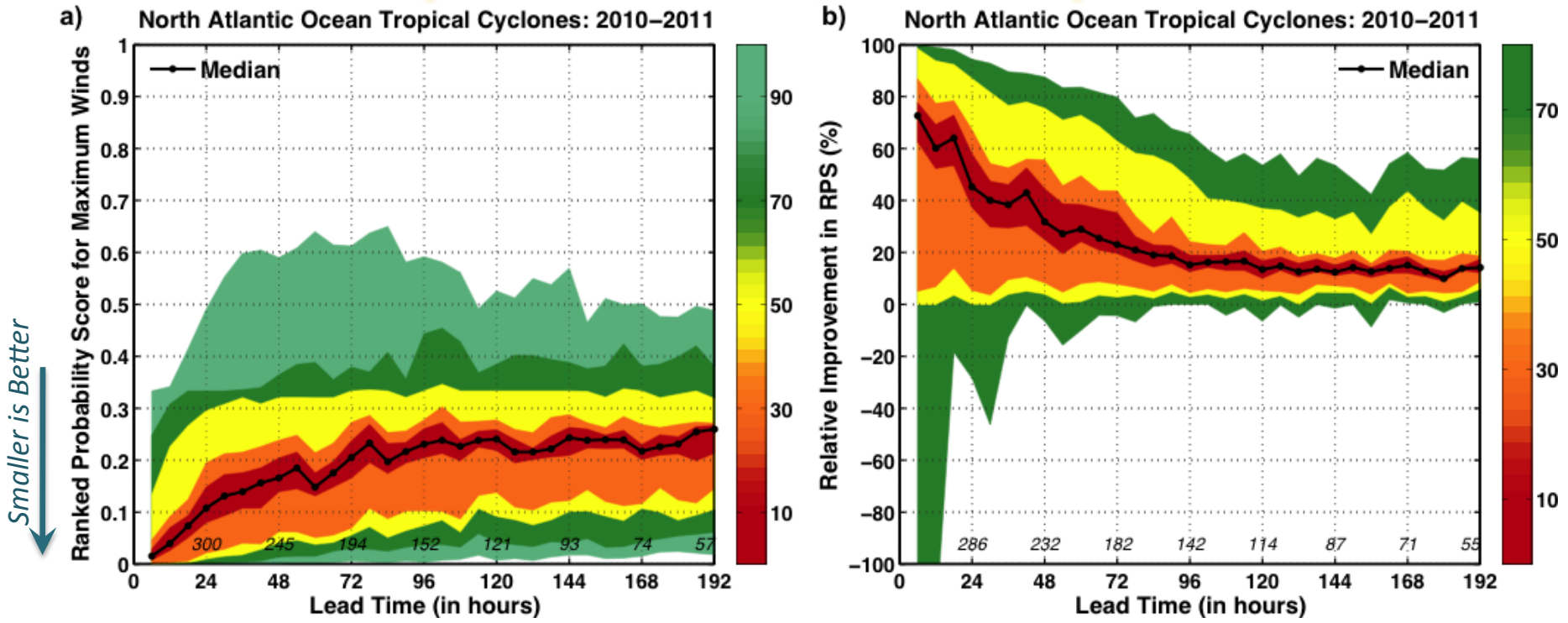
MHR Bill 2009 (2 Days Pre-Genesis)



- Clear ability to capture tropical cyclone track behavior in pre-genesis state
- Captures not only cross-track but along-track error which can represent up to 66% of track errors

Tropical Cyclones: Forecast Performance

ECMWF Intensity Forecasts → CFAN Improvement

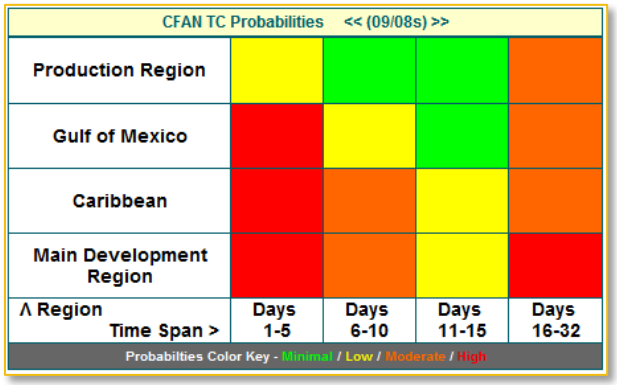


- Ranked probability scores for max winds using Saffir-Simpson scale: Tropical Depression, Tropical Storm, Hurricane, Major Hurricane
- CFAN's intensity correction yields significant improvement
- 3 additional days of consistent performance beyond NHC forecast window

Tropical Cyclones: Regional Outlook Skill

Brier Skill Scores 2008-2011

Regions	Days 1-5	Days 6-10
Production Region	**0.45 (0.47)**	**0.27 (0.14)**
Gulf of Mexico	**0.56 (0.39)**	**0.19 (0.19)**
Caribbean	**0.55 (0.42)**	**0.25 (0.21)**
Main Develop. Region	**0.52 (0.38)**	**0.14 (0.22)**
All Regions	**0.52 (0.42)**	**0.21 (0.19)**



Format: CFAN (ECMWF); **Statistically Significant Values at 90% level**
Note: Values > 0 Forecast Skillful Relative to Climatology

- CFAN has *outperformed ECMWF and climatology during the past four years for a majority of regions during Days 1-10*
- CFAN performance relative to ECMWF is attributed to appropriately identifying periods of higher (lower) than normal predictability while accounting for systematic model tendencies/errors

Tropical Cyclones: Monthly Outlooks

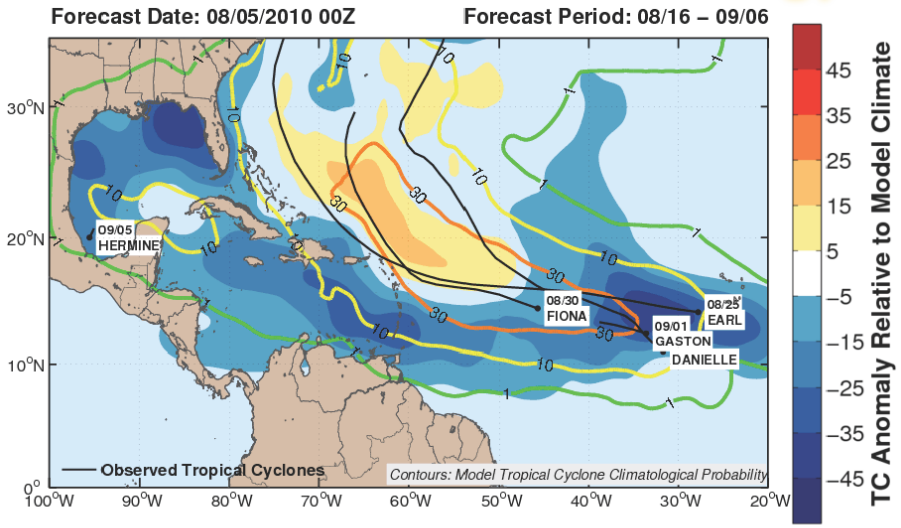
***Input**: ECMWF Monthly Forecast and Hindcasts*

→ Bias-track adjustment for TCs forming in the eastern Atlantic

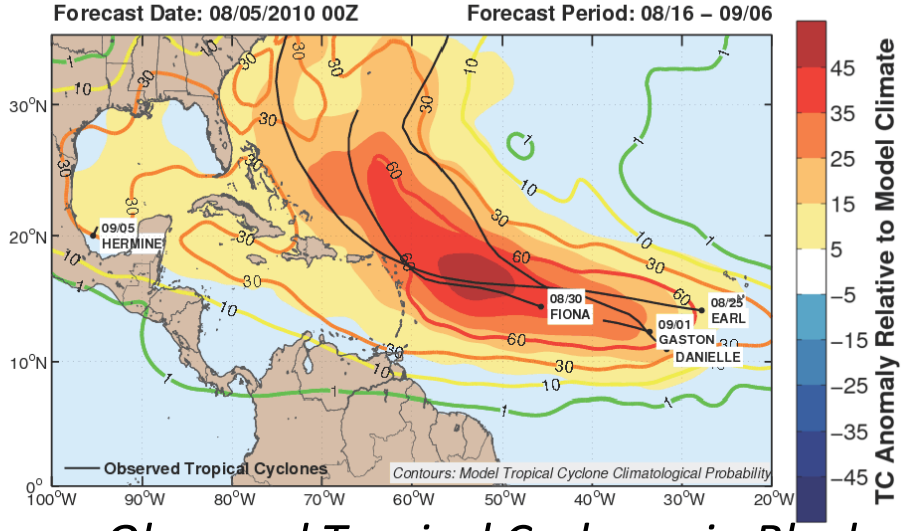
→ Determine prob. bias-correction from model and obs. climate

→ ***Output:** Bias-corrected track density probabilities and anomalies*

ECMWF Forecast - Climatology



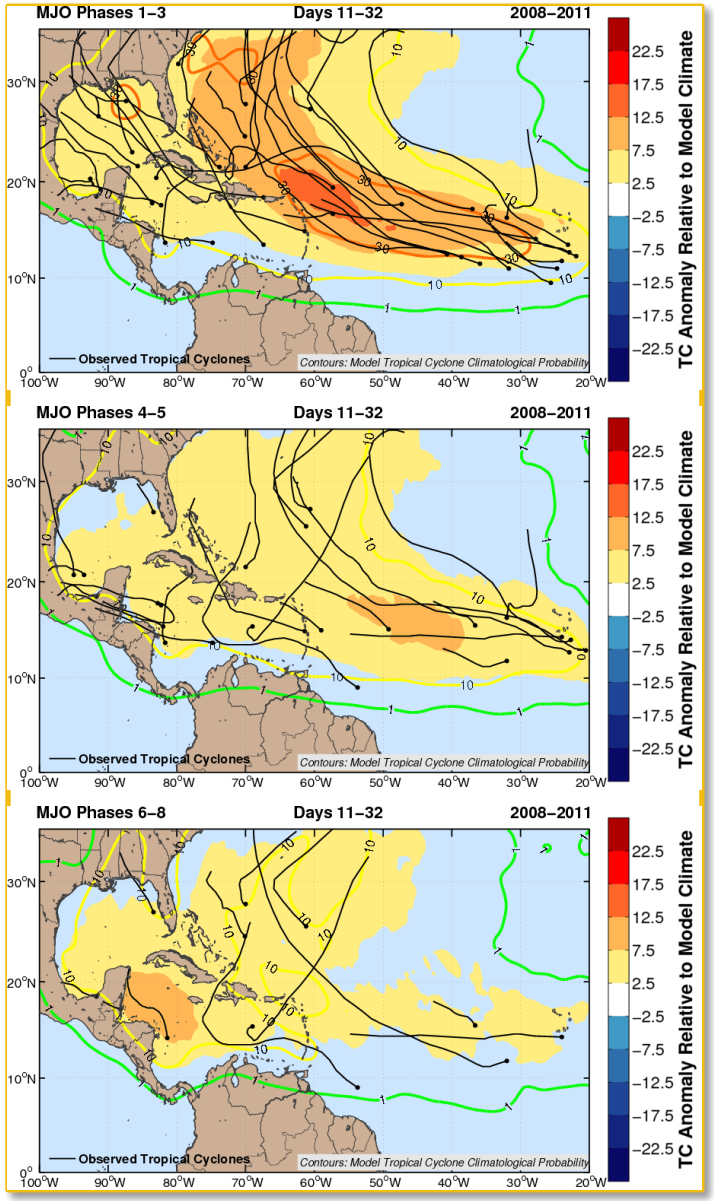
Hindcast Calibrated Forecast



Observed Tropical Cyclones in Black

- Contours show bias-calibrated probability of a tropical cyclone for specified forecast period and shading denotes anomaly relative to climate
- Forecast confidence assigned based on phase and amplitude of the Madden-Julian Oscillation

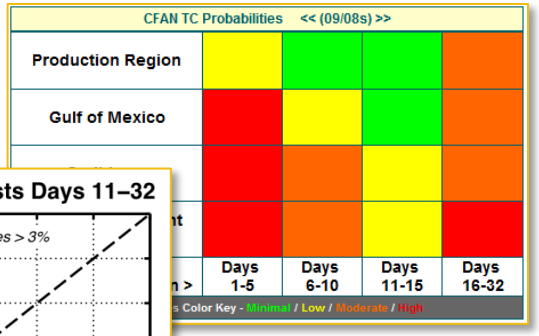
MJO Influence

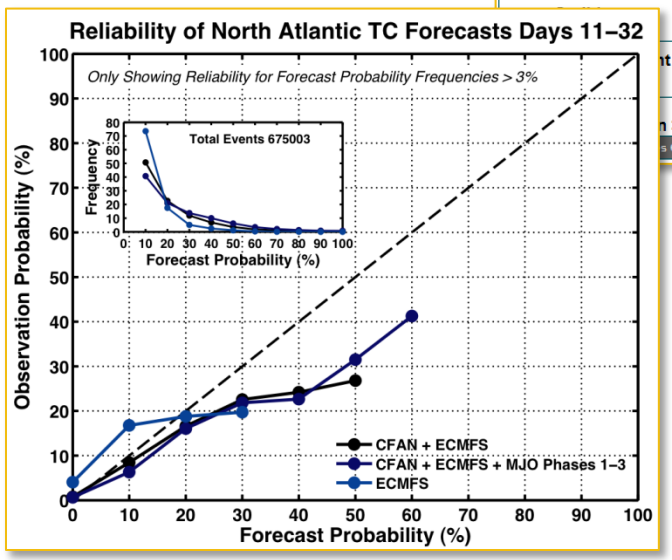


TC Anomaly: 11-32 Days

When active MJO (>1 SD) is centered in the **Indian Ocean** (**Western Hemisphere**) at model initialization, TC activity in the North Atlantic is **enhanced** (**suppressed**).

MJO phasing and intensity modulates 10-30% of TC probability forecasts for the Main Development Region and western Caribbean/southern Gulf of Mexico

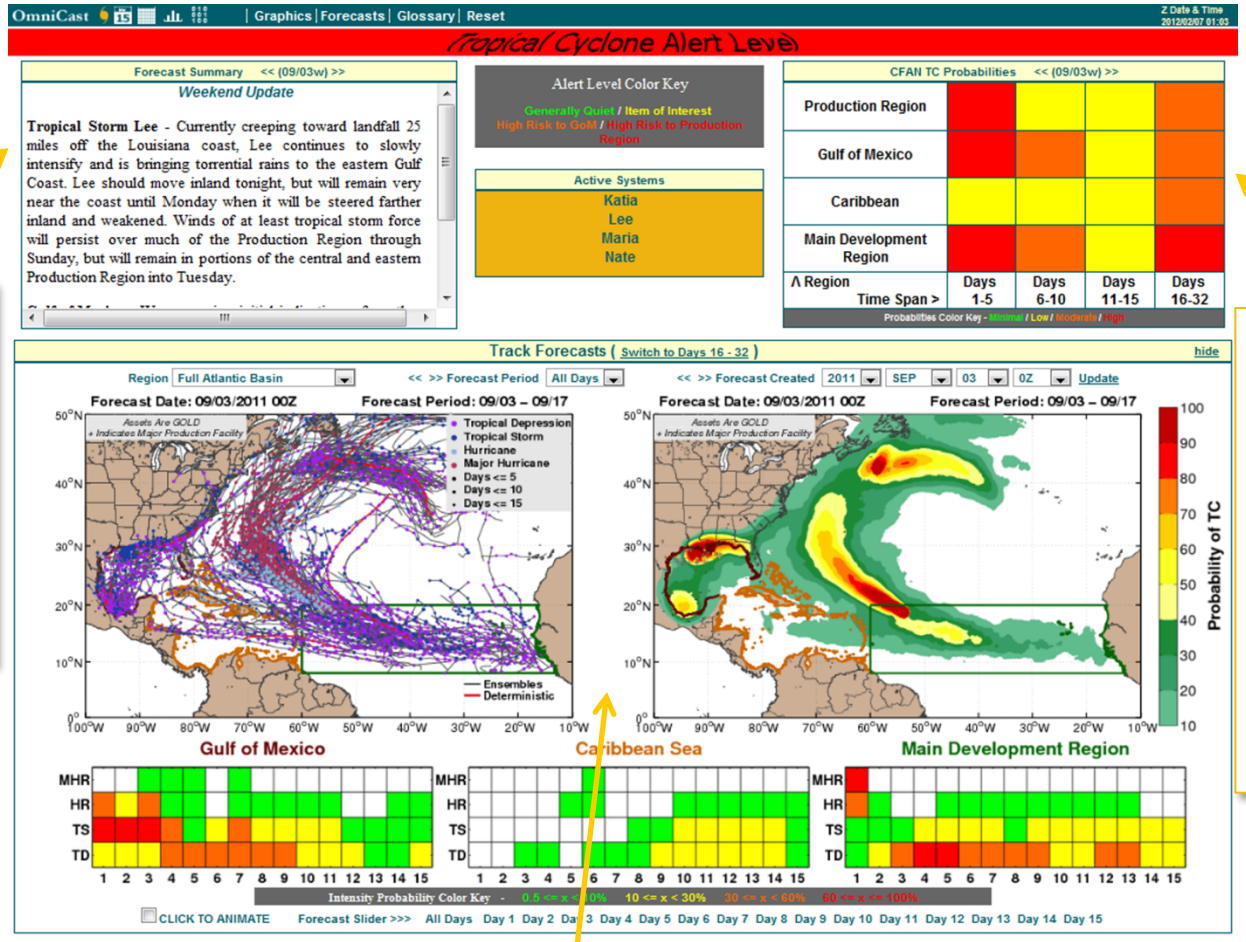




OmniCast – Decision Support

Summary text forecast for key system and regions.

Also provided via email.



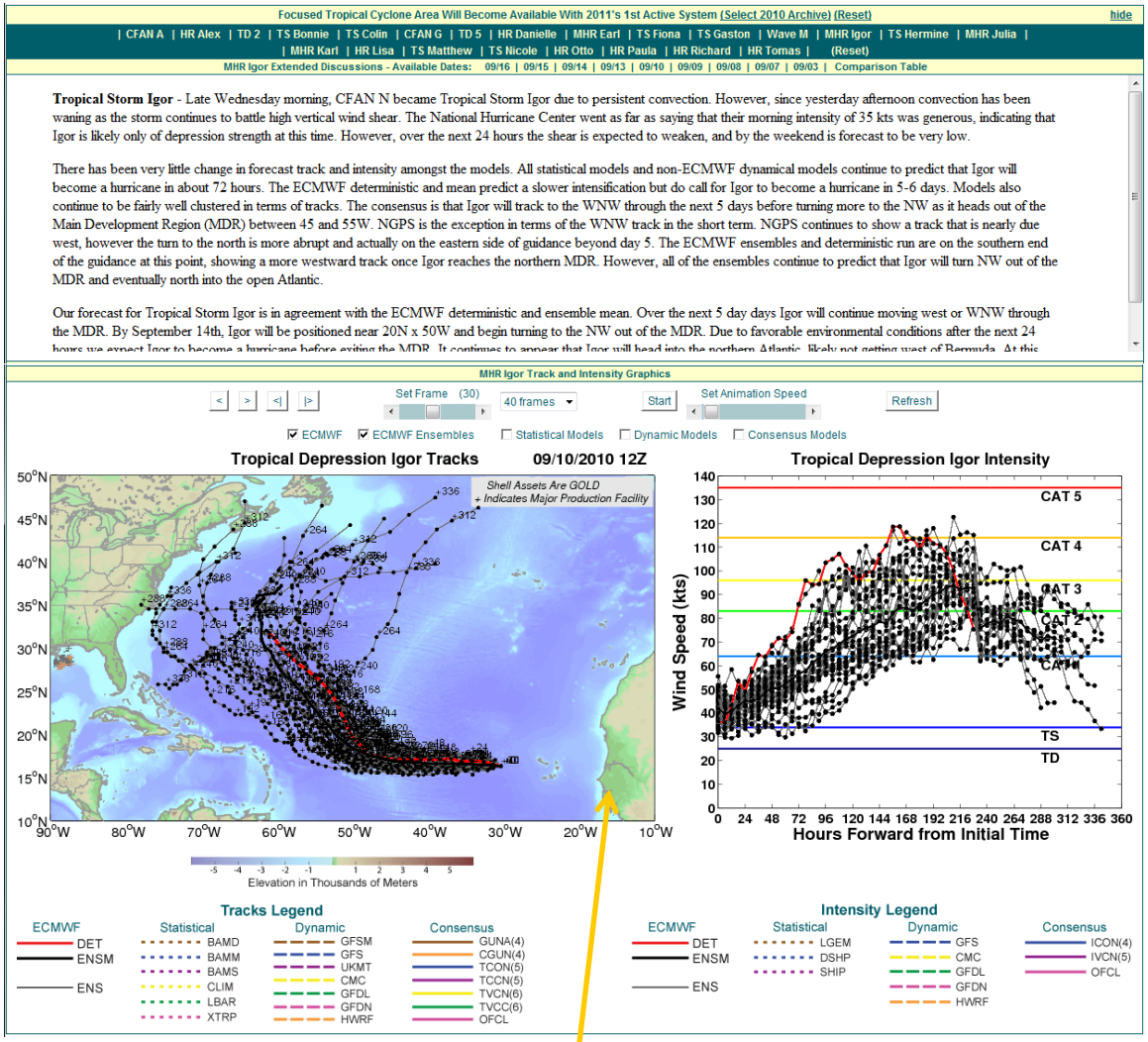
TC risk table provides quick-glance TC probabilities.

Divided by region, timeframe and risk level.

Basin-wide and regional zoom track/intensity projections as well as probability based projections.

OmniCast – Active System Detail

Extended discussion covers system details with regional and landfall risks

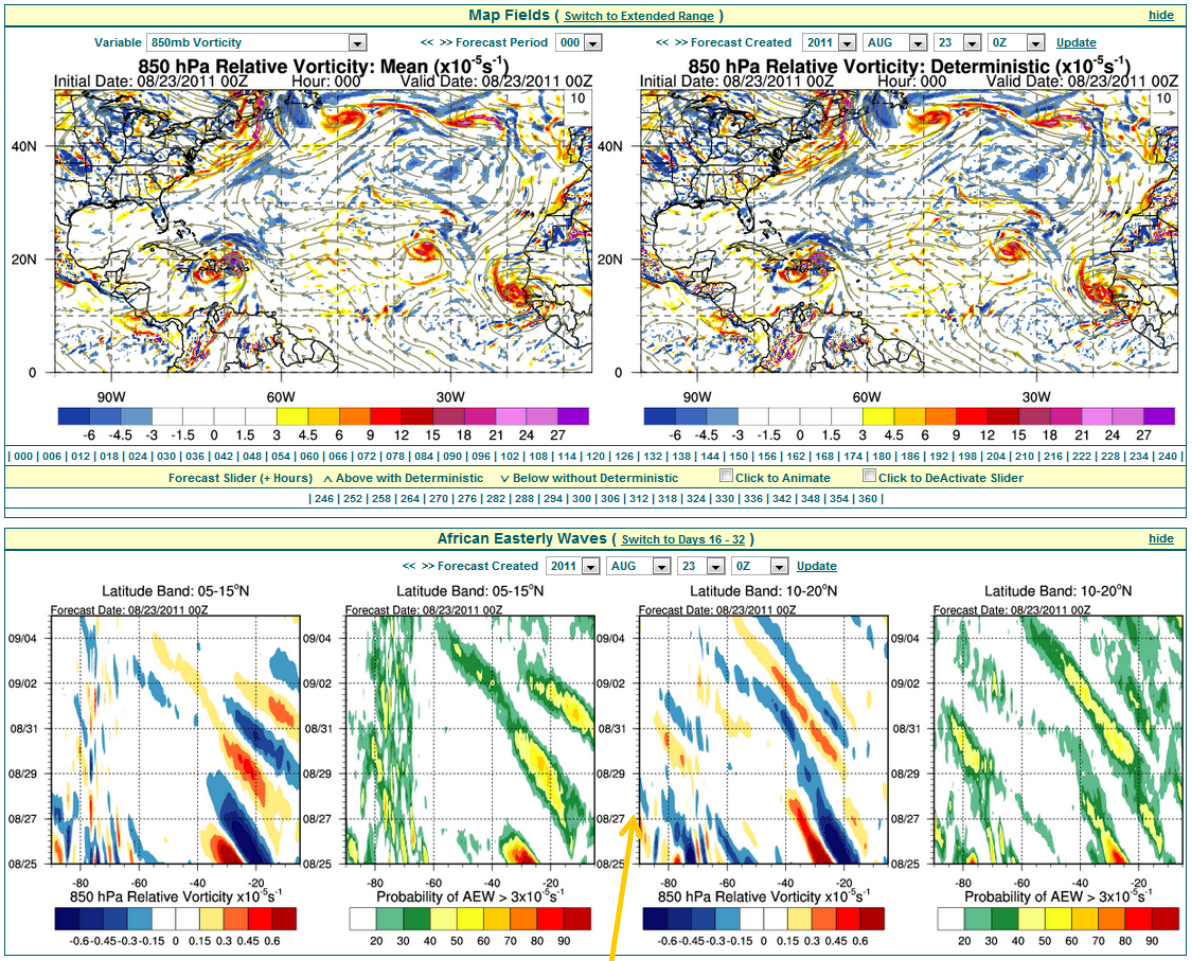


Highlights differences from NHC

Tropical cyclone graphics provide layer driven, multi-model forecasts for track and forecasts with animations.

OmniCast – Meteorologist Support

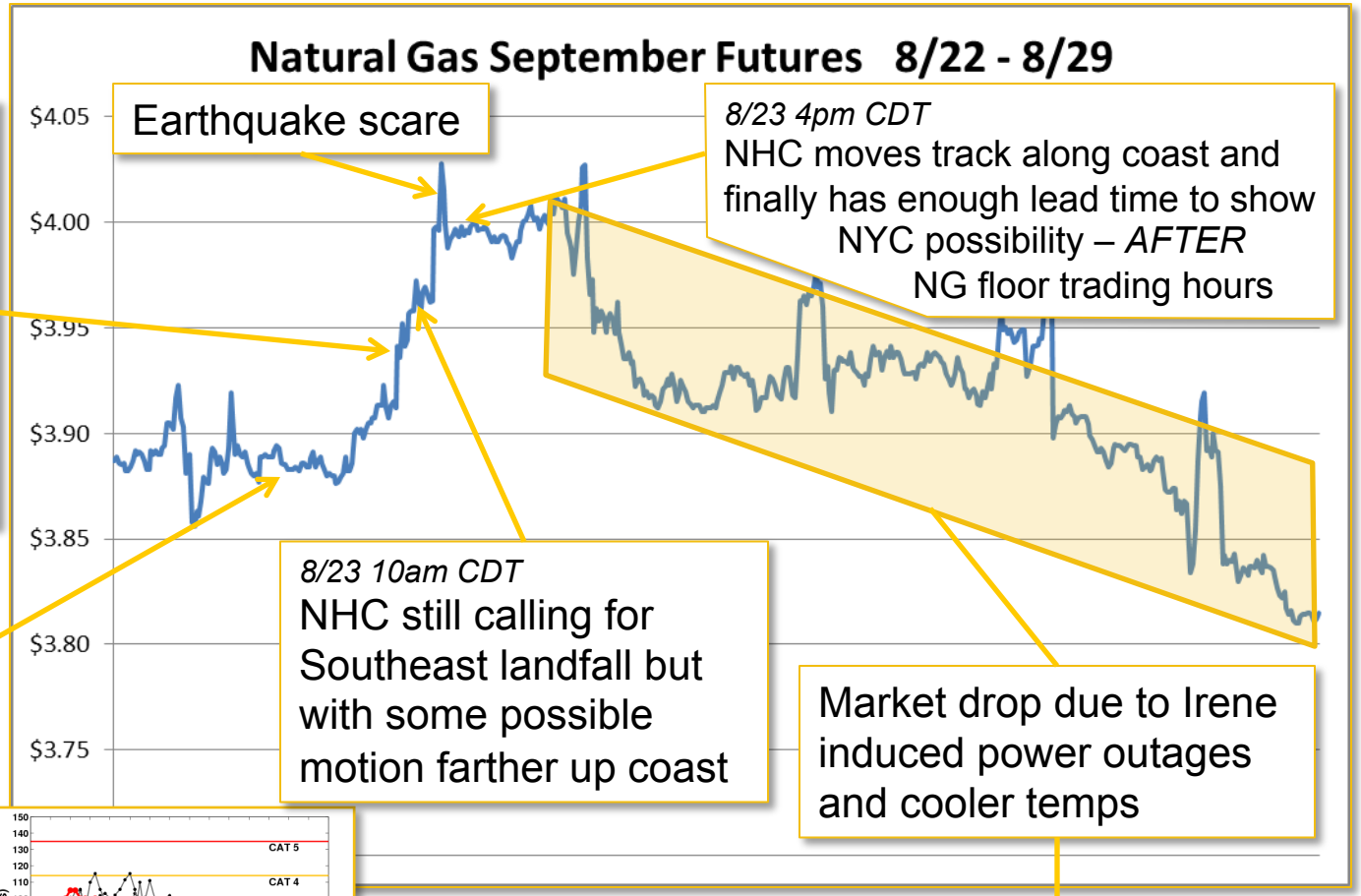
Critical meteorology fields at 6 hour intervals for both EPS and Deterministic



Sliders and animation as well as customizable four panel version

Sophisticated African Easterly Wave forecasting system captures positioning and intensity of primary source of most basin major hurricanes

CFAN Forecasts: Tropical Cyclones – Trading Decisions



8/23 9am CDT
CFAN Forecast Team daily forecast confirms East Coast with likely flooding, power outages and cooler temps
NHC still calling for Southeast landfall

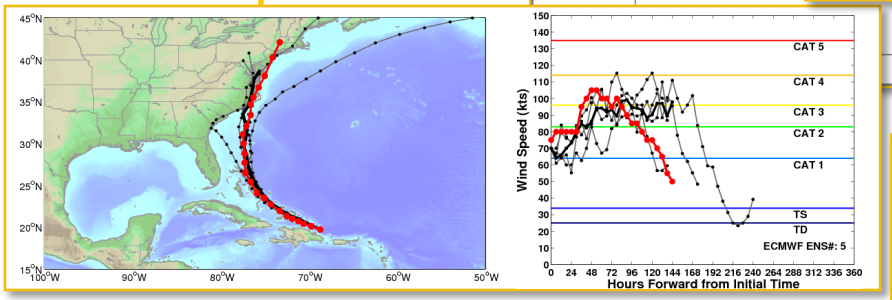
Earthquake scare

8/23 4pm CDT
NHC moves track along coast and finally has enough lead time to show NYC possibility – *AFTER* NG floor trading hours

8/22 1pm CDT
ECMWF solidifies forecast for East Coast track

8/23 10am CDT
NHC still calling for Southeast landfall but with some possible motion farther up coast

Market drop due to Irene induced power outages and cooler temps

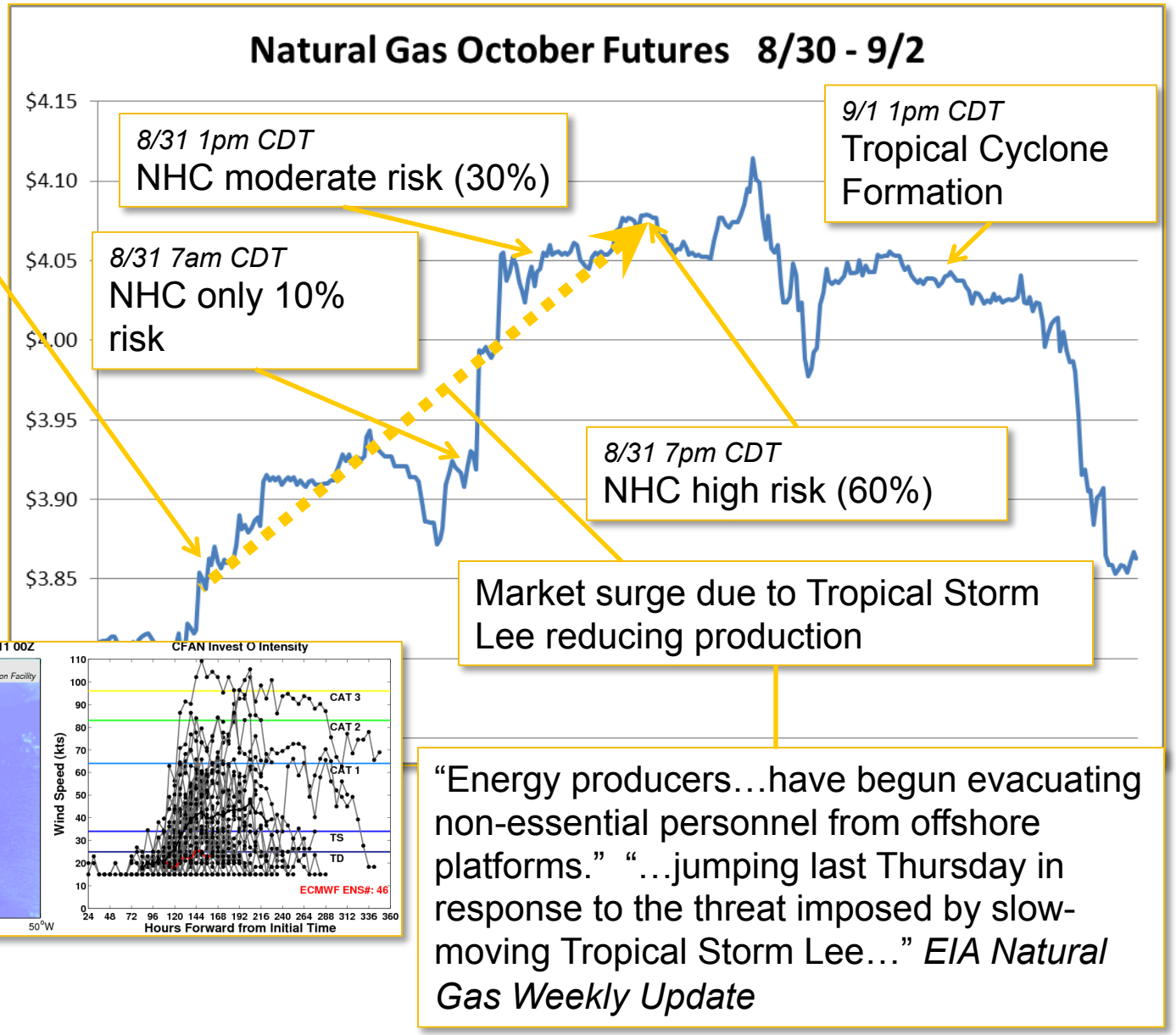


"…price declines resulted from forecasts for cooler weather and continued power outages from Hurricane Irene…" *EIA Natural Gas Weekly Update*

CFAN Forecasts: Tropical Cyclones – Trading Decisions

8/30 9am CDT
CFAN goes to high risk levels for Production Region based on ECMWF forecast

NHC has ***NO*** assignment of risk



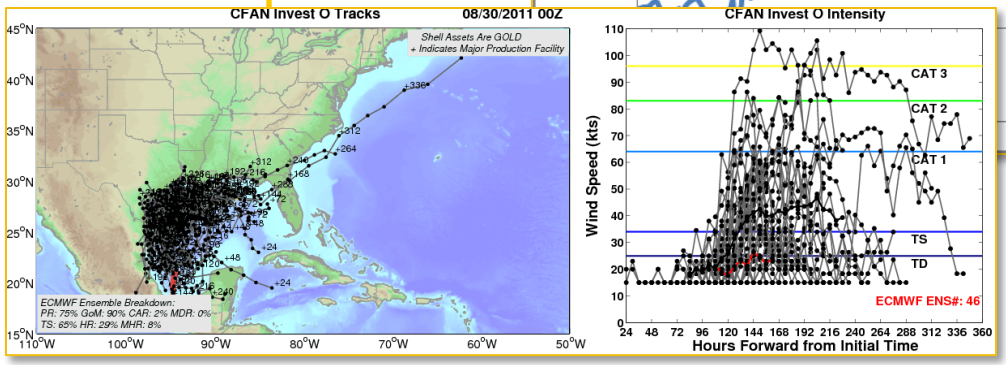
8/31 1pm CDT
NHC moderate risk (30%)

8/31 7am CDT
NHC only 10% risk

9/1 1pm CDT
Tropical Cyclone Formation

8/31 7pm CDT
NHC high risk (60%)

Market surge due to Tropical Storm Lee reducing production



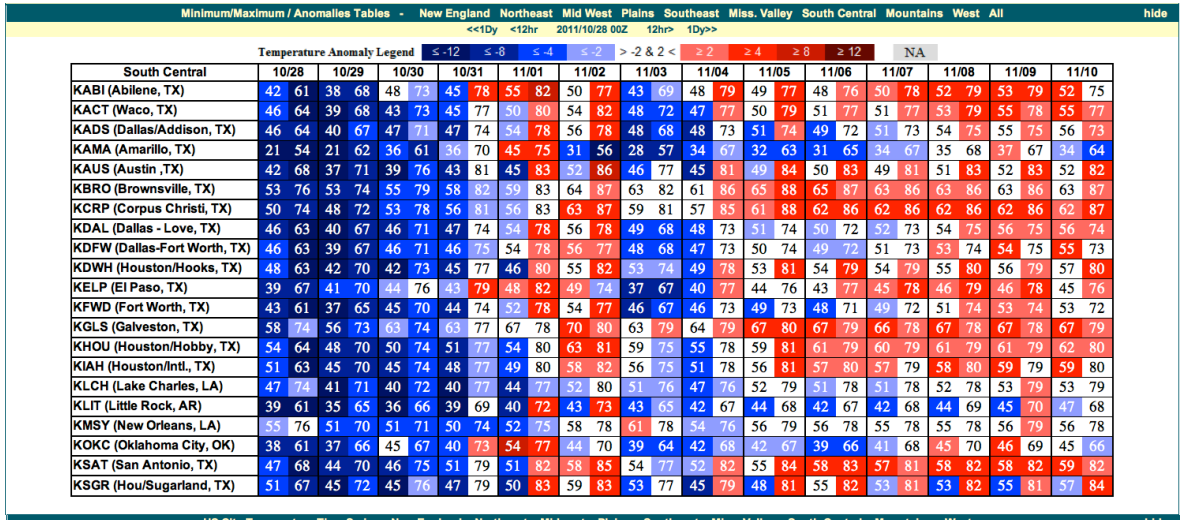
"Energy producers…have begun evacuating non-essential personnel from offshore platforms." "…jumping last Thursday in response to the threat imposed by slow-moving Tropical Storm Lee…" *EIA Natural Gas Weekly Update*

U.S. Daily Temperature Forecasts

Input: *ECMWF Variable Ensemble Prediction System* → Q-to-Q Mapping Developed from Hindcast Products → Variable Averaging Bias Correction Using Last 45 Days of Forecasts → ***Output:*** *Deterministic & Probabilistic Daily Max & Min Temp*

Deterministic:

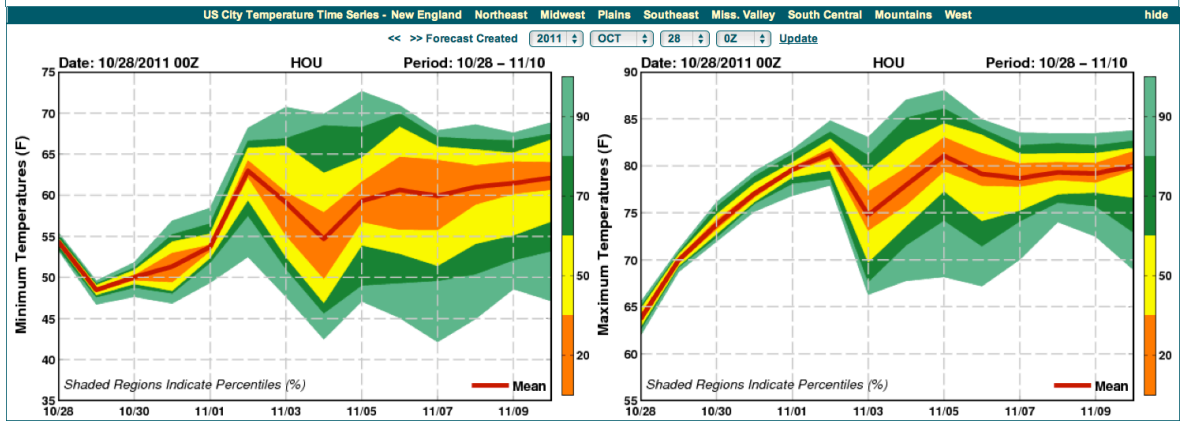
Daily Max/Min Temperature Forecasts for 105 U.S. Cities Based on Energy Trading Regions



South Central	10/28		10/29		10/30		10/31		11/01		11/02		11/03		11/04		11/05		11/06		11/07		11/08		11/09		11/10	
KABI (Abilene, TX)	42	61	38	68	48	73	45	78	55	82	50	77	43	69	48	79	49	77	48	76	50	78	52	79	53	79	52	75
KACT (Waco, TX)	46	64	39	68	43	73	45	77	50	80	54	82	48	72	47	77	50	79	51	77	51	77	53	79	55	78	55	77
KADS (Dallas/Addison, TX)	46	64	40	67	47	71	47	74	54	78	56	78	48	68	48	73	51	74	49	72	51	73	54	75	55	75	56	73
KAMA (Amarillo, TX)	21	54	21	62	36	61	36	70	45	75	31	56	28	57	34	67	32	63	31	65	34	67	35	68	37	67	34	64
KAUS (Austin ,TX)	42	68	37	71	39	76	43	81	45	83	52	86	46	77	45	81	49	84	50	83	49	81	51	83	52	83	52	82
KBRO (Brownsville, TX)	53	76	53	74	55	79	58	82	59	83	64	87	63	82	61	86	65	88	65	87	63	86	63	86	63	86	63	87
KCRP (Corpus Christi, TX)	50	74	48	72	53	78	56	81	56	83	63	87	59	81	57	85	61	88	62	86	62	86	62	86	62	86	62	87
KDAL (Dallas - Love, TX)	46	63	40	67	46	71	47	74	54	78	56	78	49	68	48	73	51	74	50	72	52	73	54	75	56	75	56	74
KDFW (Dallas-Fort Worth, TX)	46	63	39	67	46	71	46	75	54	78	56	77	48	68	47	73	50	74	49	72	51	73	53	74	54	75	55	73
KDWH (Houston/Hooks, TX)	48	63	42	70	42	73	45	77	46	80	55	82	53	74	49	78	53	81	54	79	54	79	55	80	56	79	57	80
KELP (El Paso, TX)	39	67	41	70	44	76	43	79	48	82	49	74	37	67	40	77	44	76	43	77	45	78	46	79	46	78	45	76
KFWD (Fort Worth, TX)	43	61	37	65	45	70	44	74	52	78	54	77	46	67	46	73	49	73	48	71	49	72	51	74	53	74	53	72
KGLS (Galveston, TX)	58	74	56	73	63	74	63	77	67	78	70	80	63	79	64	79	67	80	67	79	66	78	67	78	67	78	67	79
KHOU (Houston/Hobby, TX)	54	64	48	70	50	74	51	77	54	80	63	81	59	75	55	78	59	81	61	79	60	79	61	79	61	79	62	80
KIAH (Houston/Intl., TX)	51	63	45	70	45	74	48	77	49	80	58	82	56	75	51	78	56	81	57	80	57	79	58	80	59	79	59	80
KLCH (Lake Charles, LA)	47	74	41	71	40	72	40	77	44	77	52	80	51	76	47	76	52	79	51	78	51	78	52	78	53	79	53	79
KLIT (Little Rock, AR)	39	61	35	65	36	66	39	69	40	72	43	73	43	65	42	67	44	68	42	67	42	68	44	69	45	70	47	68
KMSY (New Orleans, LA)	55	76	51	70	51	71	50	74	52	75	58	78	61	78	54	76	56	79	56	78	55	78	55	78	56	79	56	78
KOKC (Oklahoma City, OK)	38	61	37	66	45	67	40	73	54	77	44	70	39	64	42	68	42	67	39	66	41	68	45	70	46	69	45	66
KSAT (San Antonio, TX)	47	68	44	70	46	75	51	79	51	82	58	85	54	77	52	82	55	84	58	83	57	81	58	82	58	82	59	82
KSGR (Hou/Sugarland, TX)	51	67	45	72	45	76	47	79	50	83	59	83	53	77	45	79	48	81	55	82	53	81	53	82	55	81	57	84

Probabilistic:

Daily Max/Min Temperature Interpercentile Plumes for Each City



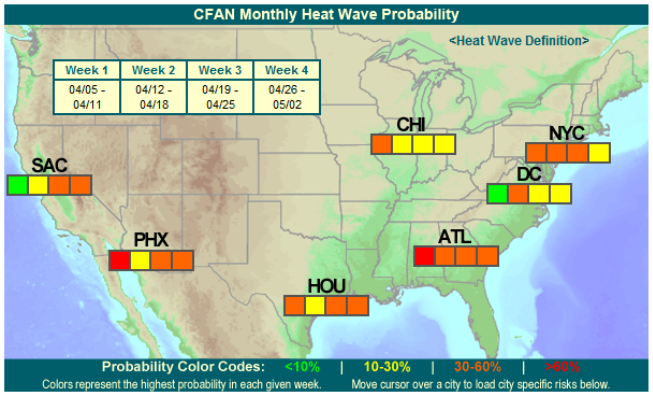
U.S. Monthly Forecasts

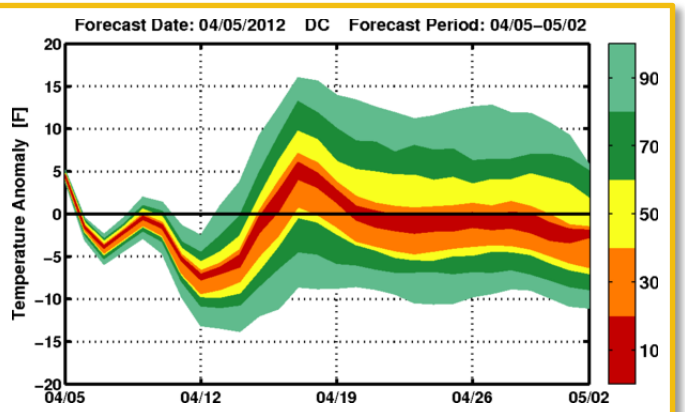
Input: *ECMWF Monthly Forecast and Hindcasts*

Theoretical Extreme Value Distribution from Hindcast Products

Output: *Probabilistic Extreme Temperature and Heat/Cold Wave Forecast*

Heat/Cold Wave Probability:





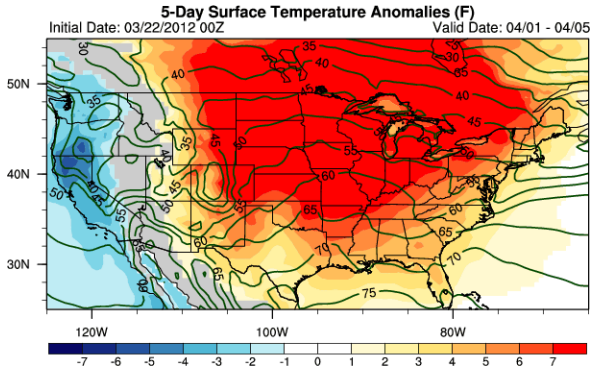
Weekly Departures from Normal and Probability of Exceedances

Output: *Regional Temperature Outlook w/ Forecast Confidence*

Regional & Averaged Outlooks:

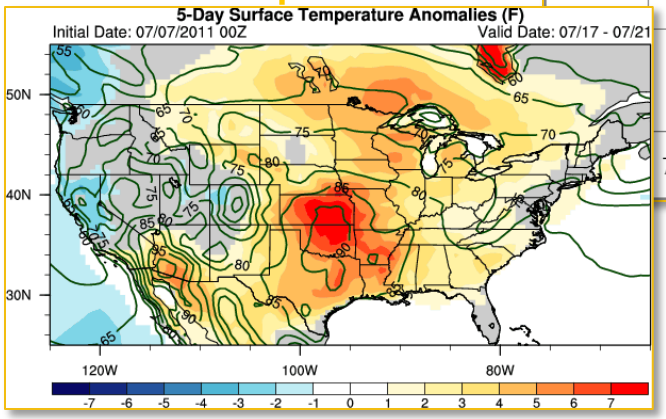
CFAN US Monthly Temperature Outlook << (03/22/2012) >>

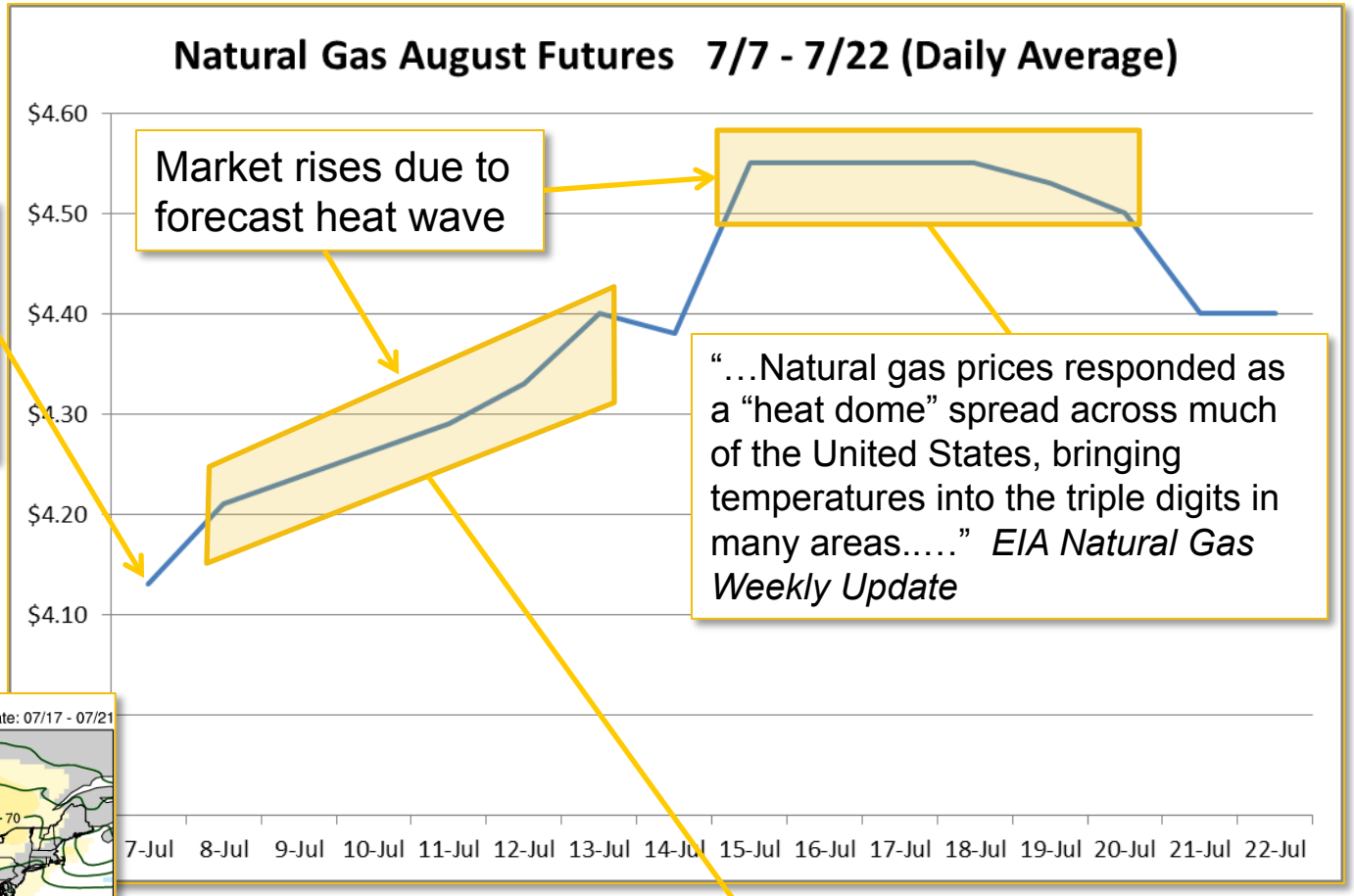
Regions / Weeks 1-4	Northeast	Southeast	Midwest	South Central	Northwest	Southwest
Week 1 03/22 - 03/28	High Confidence	High Confidence	High Confidence	High Confidence	High Confidence	High Confidence
Week 2 03/29 - 04/04	High Confidence	Moderate Confidence	High Confidence	High Confidence	Moderate Confidence	High Confidence
Week 3 04/05 - 04/11	Moderate Confidence	Moderate Confidence	*Low Confidence*	Moderate Confidence	*Low Confidence*	*Low Confidence*
Week 4 04/12 - 04/18	*Low Confidence*	Moderate Confidence	*Low Confidence*	Moderate Confidence	*Low Confidence*	Moderate Confidence
	Temperature Anomaly Legend	≤ -8	≤ -4	≤ -2	> -2 & 2 <	≥ 2	≥ 4	≥ 8



CFAN Forecasts: Monthly – Trading Decisions

7/13 7am CDT
CFAN Monthly Forecast captures major heat wave due 7/17-7/21 over vast area of US





Market rises due to forecast heat wave

"…Natural gas prices responded as a "heat dome" spread across much of the United States, bringing temperatures into the triple digits in many areas….." *EIA Natural Gas Weekly Update*

"Since last Thursday, expectations of higher temperatures with rising cooling load has likely been the chief catalyst propelling futures to a string of four consecutive days of price gains accounting for the bulk of the week's price increase." *EIA Natural Gas Weekly Update*

CFAN Forecasts: 15 Day – Trading Decisions

Only the CFAN MOS solution caught the timing and severity of the NYC vicinity heat wave and it did it over a week in advance

LaGuardia Station MOS Forecast

	Days in Advance>	8	7	6	5	4	3	2	1
	vModel								
7/21 Forecast	CFAN MOS (ECMWF)	97	95	97	95	97	99	98	99
	GFS Extended		91	91	94	93	92	93	95
	GFS						88	90	91
	NAM						88	91	88
7/22 Forecast	CFAN MOS (ECMWF)	97	98	99	103	105	104	104	104
	GFS Extended		94	96	96	98	97	98	98
	GFS						93	95	93
	NAM						96	97	96

Actual Temps	
July 21st	
NYC	97
LGA	96
EWR	103
July 22nd	
NYC	104
LGA	104
EWR	108

"Although natural gas prices fell at most points across the country, likely as a result of a general lessening of the previous week's heat dome, the **Northeast saw significant price spikes during the week**." *EIA Natural Gas Weekly Update*

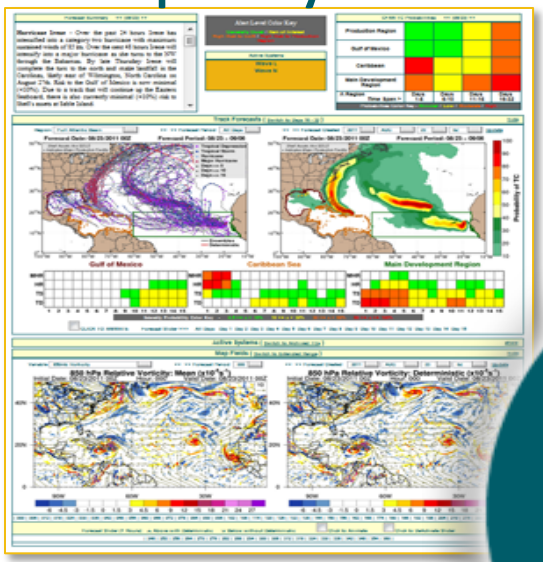
Huge local market spike in New York around heat wave

Spot Prices ($ per MMBtu)	Thu 14-Jul	Fri. 15-Jul	Mon. 18-Jul	Tue. 19-Jul	Wed. 20-Jul	Thu 21-Jul	Fri. 22-Jul	Mon. 25-Jul
Henry Hub	4.42	4.49	4.60	4.60	4.64	4.58	4.46	4.45
New York	4.75	4.82	5.45	6.73	9.13	13.41	6.39	5.00

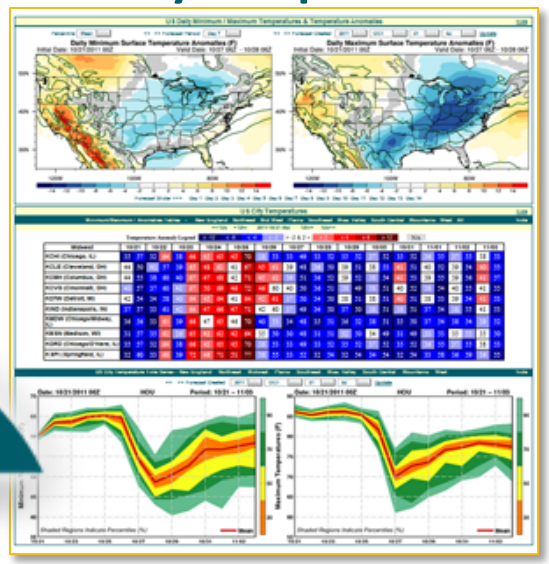
EIA Natural Gas Weekly Update

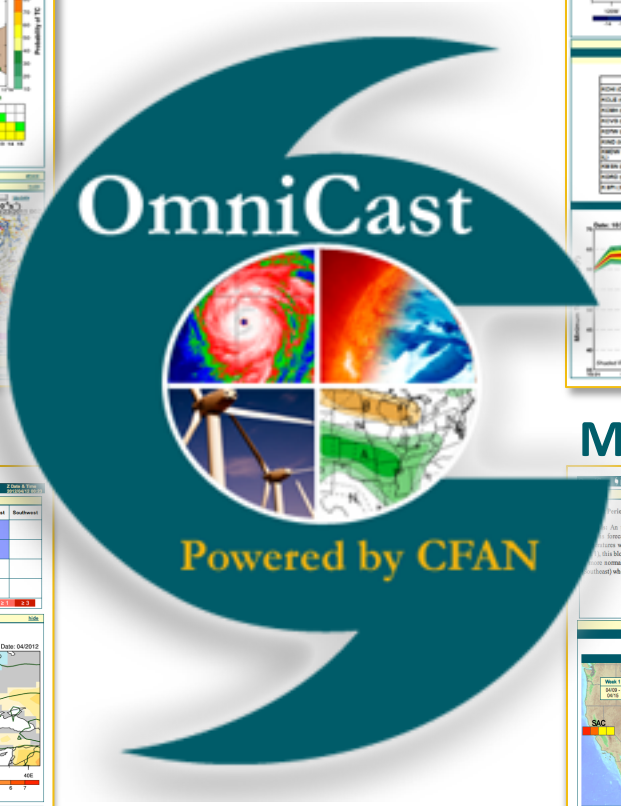
OmniCast – Bringing It Together

Tropical Cyclones

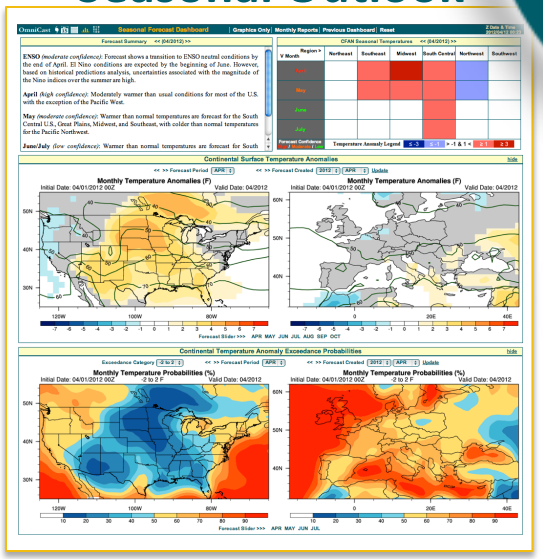


15-Day Temperatures





Seasonal Outlook



Monthly Temperatures