



Transferring Science to Practice: Nearly Two Decades of Producing Seasonal Forecasts for the Energy Trading Industry

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The Weather Company, an IBM Business
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Energy Futures Prices are Strongly Dependent on Weather

Commodity	Supply	Demand
Natural Gas	Mostly Wx-Independent	Mostly Temperature
Power (Electricity)	Solar/Wind/Hydro & Traditional Sources	Mostly Temperature



Prices rose sharply Tuesday due to (1) expected higher demand from upcoming pattern change to colder temperatures in the northern US and (2) new reports that showed supply was lower than expected after hot summer

Natural Gas Futures Prices

In the Beginning...A Brush with Infamy

- ✓ Enron created first weather derivatives market in 2000
- ✓ We provided forecasts for them and got \$ based on
- ✓ ~~Still waiting~~ ^{Still waiting} for them to pay their final bill....



Enron Forecasting Payout

	ATL	BOS	ORD	CVG	IAH	LIT	DCA	LGA	PHL	SAC	PHX	total	Grand total
Nov-00													
6-10 day direction	341	341	341	341	284	341	341	341	284	341	0	3,295	
6-10 day accuracy	103	167	278	183	105	146	145	152	142	62	19	1,503	
BOM direction	341	219	341	341	0	341	341	341	341	44	0	2,649	
BOM accuracy	80	238	237	141	106	86	161	203	197	136	73	1,658	
Seasonal direction	341	341	341	85	256	341	85	341	341	0	0	2,472	
Seasonal accuracy	0	156	9	0	0	0	0	114	88	182	0	550	
Base												2,000	14,126
Dec-00													
6-10 day direction	284	341	341	341	341	341	341	341	341	0	0	3,011	
6-10 day accuracy	112	243	85	155	140	99	115	234	227	174	70	1,656	
BOM direction	341	341	341	341	341	341	341	341	341	0	0	3,068	
BOM accuracy	81	236	113	78	132	82	86	191	167	241	26	1,434	
Seasonal direction	341	341	0	341	341	341	341	341	341	341	341	3,409	
Seasonal accuracy	329	340	263	332	341	267	341	314	329	187	138	3,180	
Base												2,000	17,759
Jan-01													
6-10 day direction	301	0	301	301	33	301	234	301	167	301	341	2,580	
6-10 day accuracy	155	264	272	276	62	157	216	202	268	216	151	2,240	
BOM direction	0	44	306	341	0	219	341	131	341	341	341	2,404	
BOM accuracy	50	222	222	222	74	222	222	212	222	272	221	2,522	

Seasonal Forecasting Milestones at TWC/IBM

April 2000: First US seasonal temperature forecast issued, based solely on NCAR CCM 3.6.6 climate model, to address needs in newly-deregulated energy markets

November 2002: First European seasonal temperature forecast issued

October 2009: First successful leveraging of solar cycle to skew forecasts colder in US/Europe

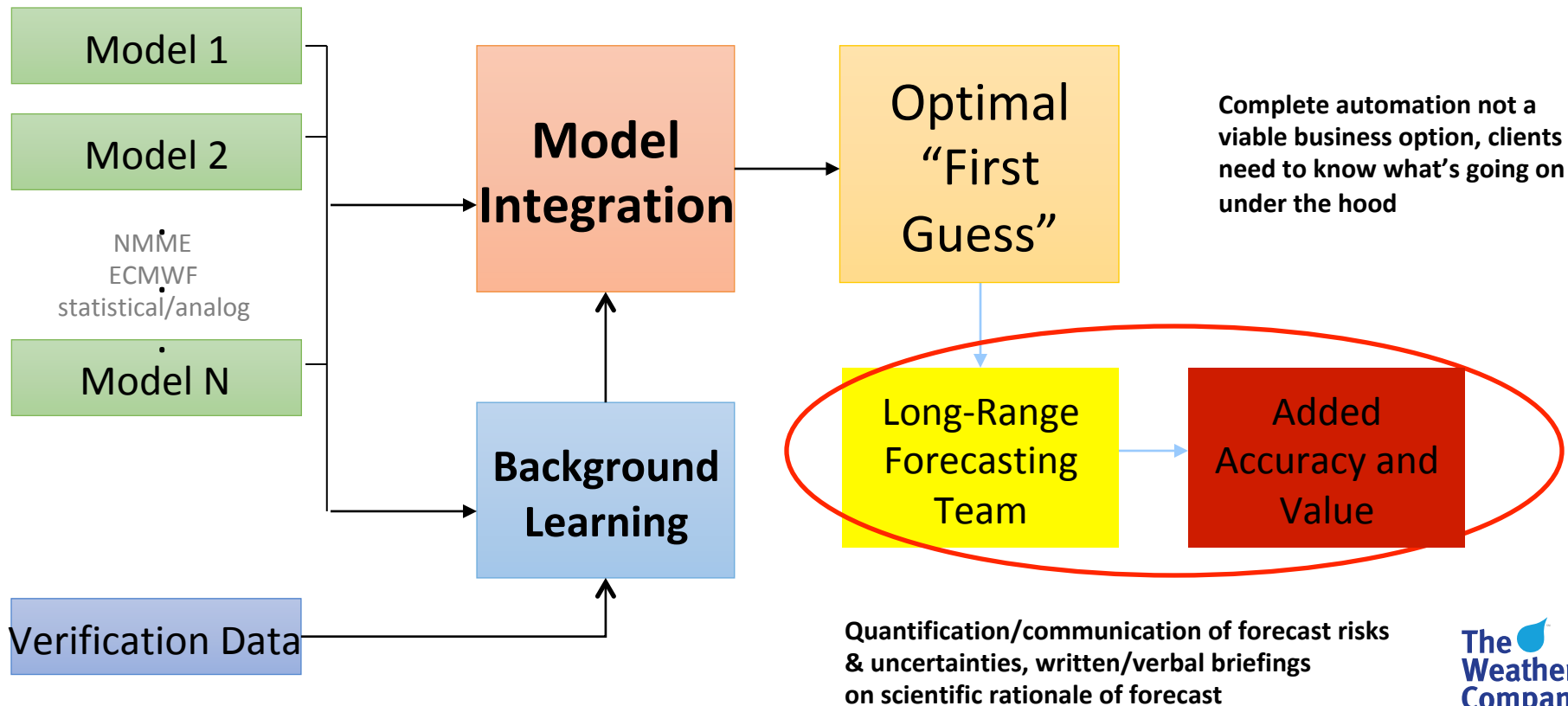
January 2013: First successful leveraging of SSW event to improve month 1 and month 2 forecasts

March 2015: Expanded to cover Asian temps/precip

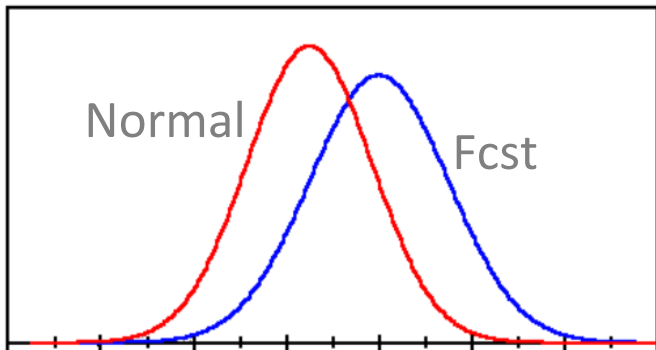
January 2017: First global seasonal forecast issued, available via API

April 2018: Expanded to cover India

Seasonal Forecasting at TWC/IBM: Optimal Combination of Dynamical/Statistical Models + Experience/Expertise



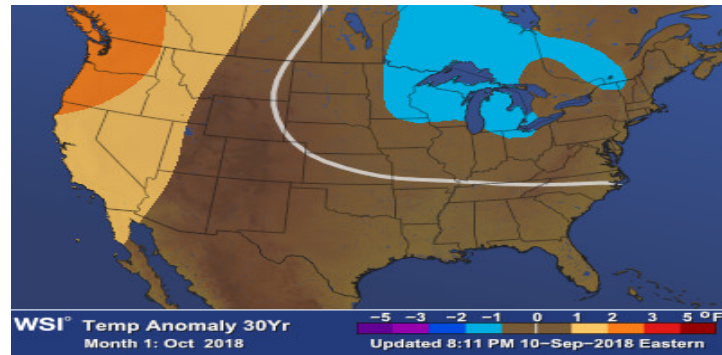
Market Needs Often Trump Scientific Judgment



How we should produce seasonal fcsts:

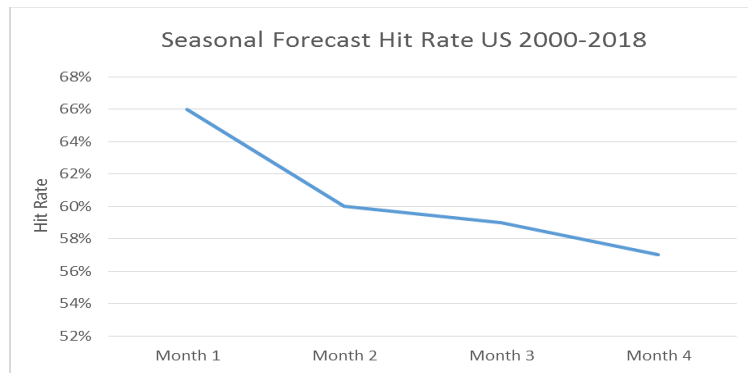
Probabilistic 3-month aggregates

Verification for clients done
via crude “hit rate” metric



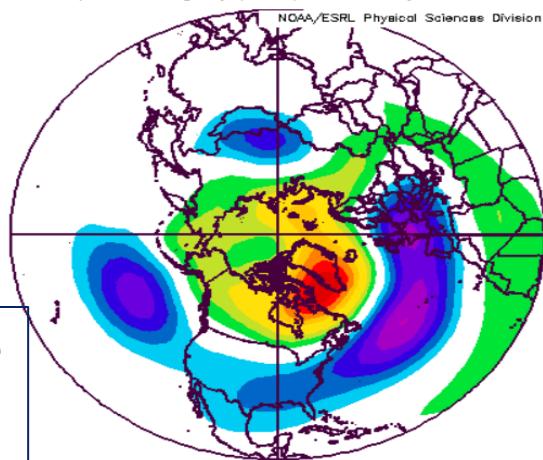
What clients demand:

Deterministic monthly forecasts



A Tale of Two Cold Winters

NCEP/NCAR Reanalysis
500mb Geopotential Height (m) Composite Anomaly 1981–2010 climo

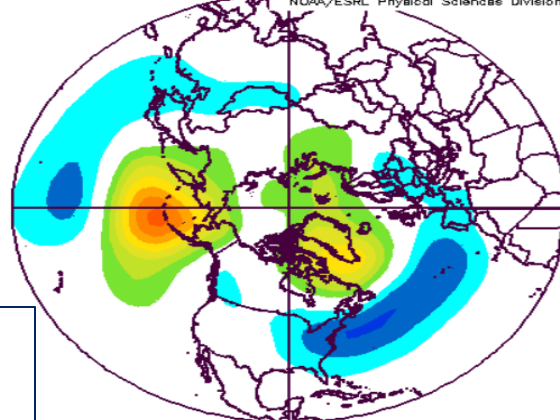


Dec to Feb: 2010

**500 mb GPH anomalies
Winter 2009-10**

Moderate
El Nino
E QBO

NCEP/NCAR Reanalysis
500mb Geopotential Height (m) Composite Anomaly 1981–2010 climo



Dec to Feb: 2011

**500 mb GPH anomalies
Winter 2010-11**

Strong
La Nina
W QBO

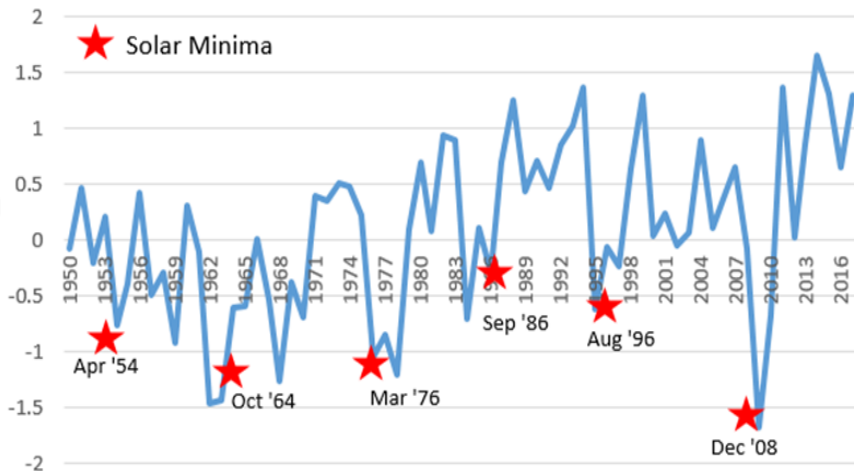
- ✓ Back-to-back very cold winters E US and W Eur with sharply differing ENSO
- ✓ N Atl pattern blocked up both winters after a decade of “anti-blocking”

What gives?

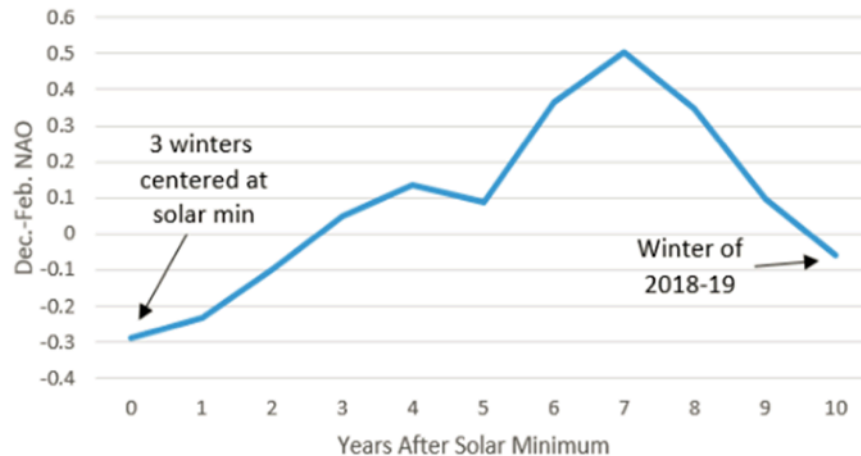
Solar – The Black Sheep of Seasonal Forecasting



Winter NAO



NAO, 3-Consecutive-Winter Aggregate 1950-2018



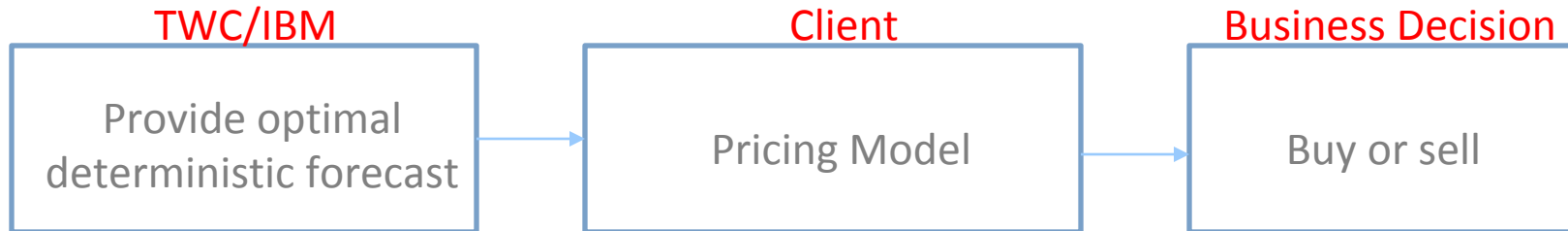
NAO for 3 winters centered on solar mins (18 years): -0.29

NAO for other winters (50 years): +0.24

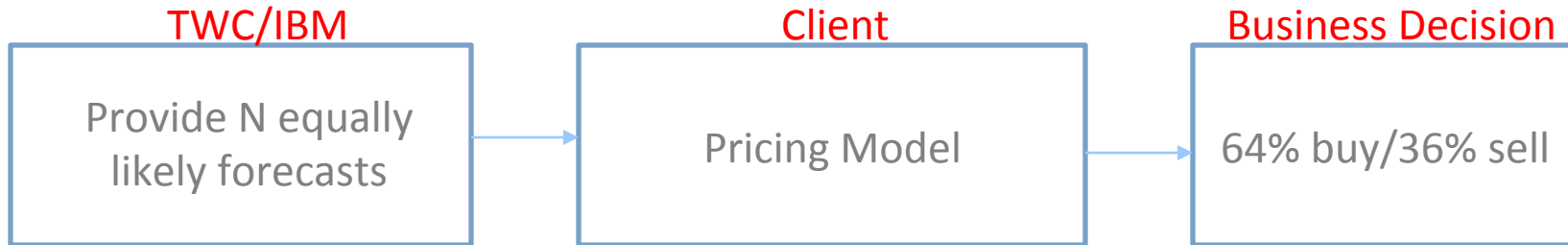
99.4% of random 18-year NAO samples (without replacement) had NAO > -0.29

Working Towards Acceptance of Probabilistic

Old Deterministic Paradigm

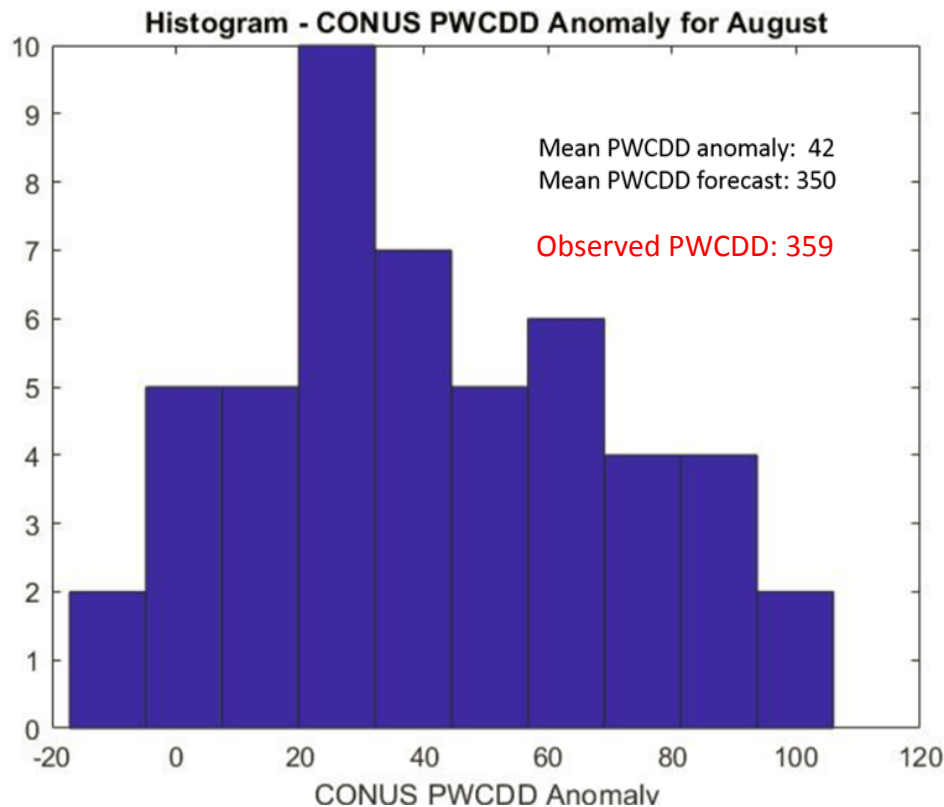


New Probabilistic Paradigm



Prob. business outcomes easier to digest than prob. weather forecasts!

New Probabilistic Output – Heating/Cooling Degree Days



Sample population-weighted cooling degree-days (PWCDD) forecast for August derived from July 1 climate model forecasts

Each realization has a different impact on demand/price

Clients seem more comfortable with ingesting full distribution of outcomes than in dealing with percentiles

Summary

- ✓ TWC/IBM has been producing seasonal forecasts for energy trading clients in US/Europe/Asia since 2000
- ✓ Blend NMME/ECMWF and proprietary statistical models to produce forecasts, but human expert judgment/handholding still required
- ✓ Solar impacts on vortex strength have been leveraged successfully, more focus from research community?
- ✓ Little acceptance/uptake of probabilistic content until recently



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