Research Trends in Load Forecasting

and Their Implications to Energy Trading

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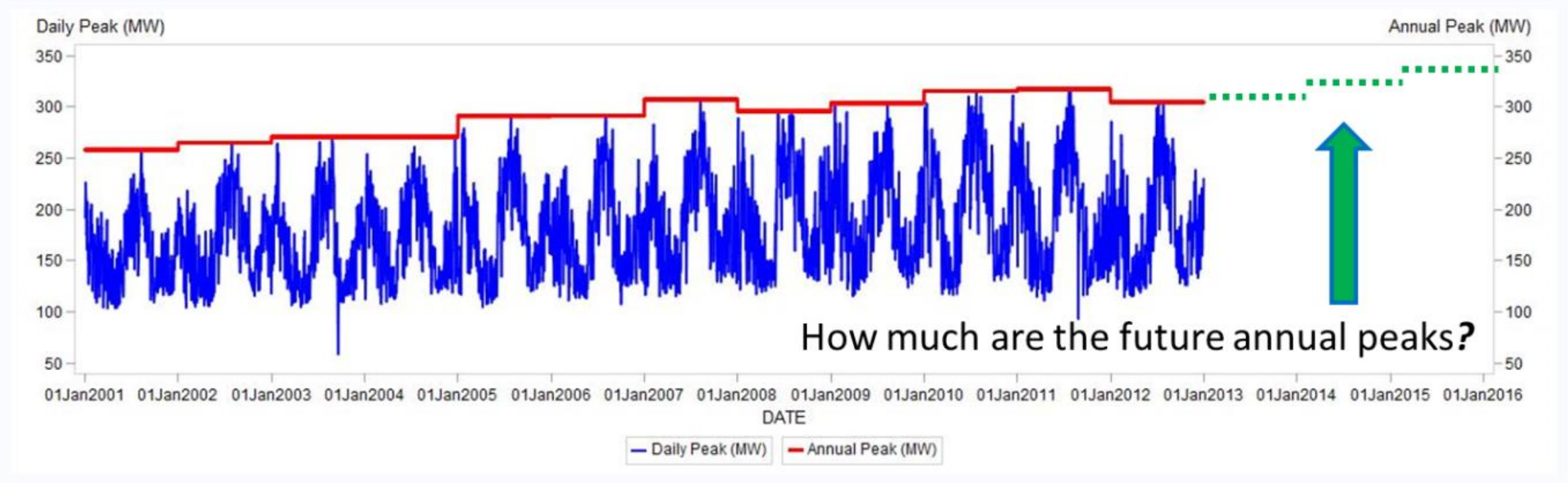
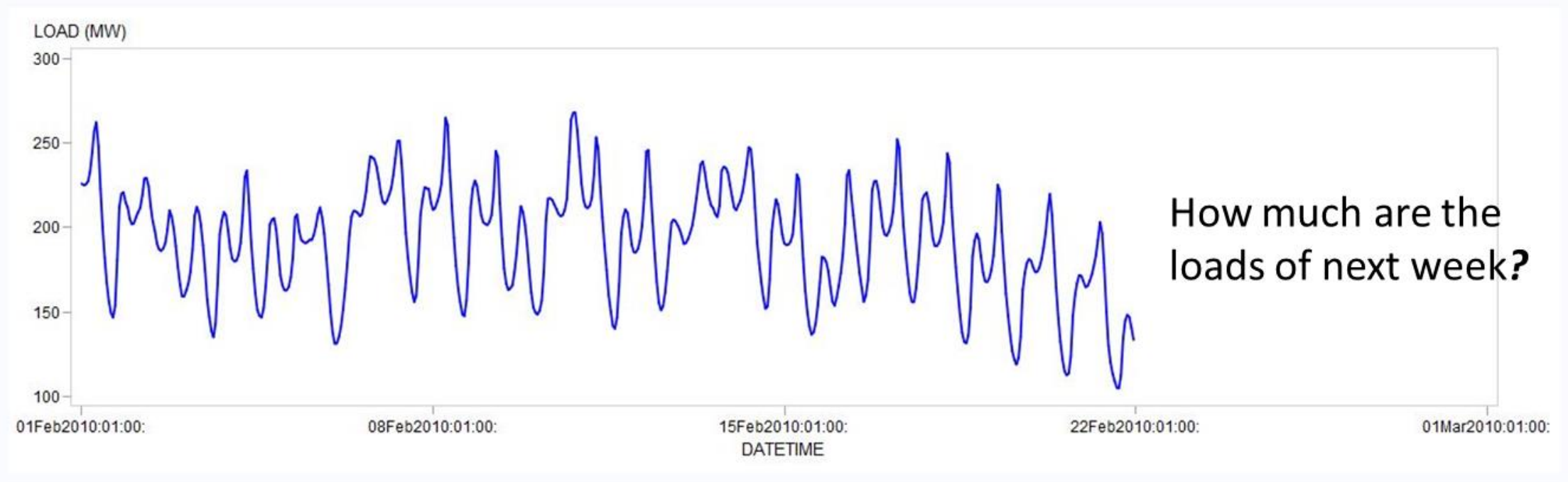


Tao Hong, "Energy forecasting: past, present and future", Foresight, 2014



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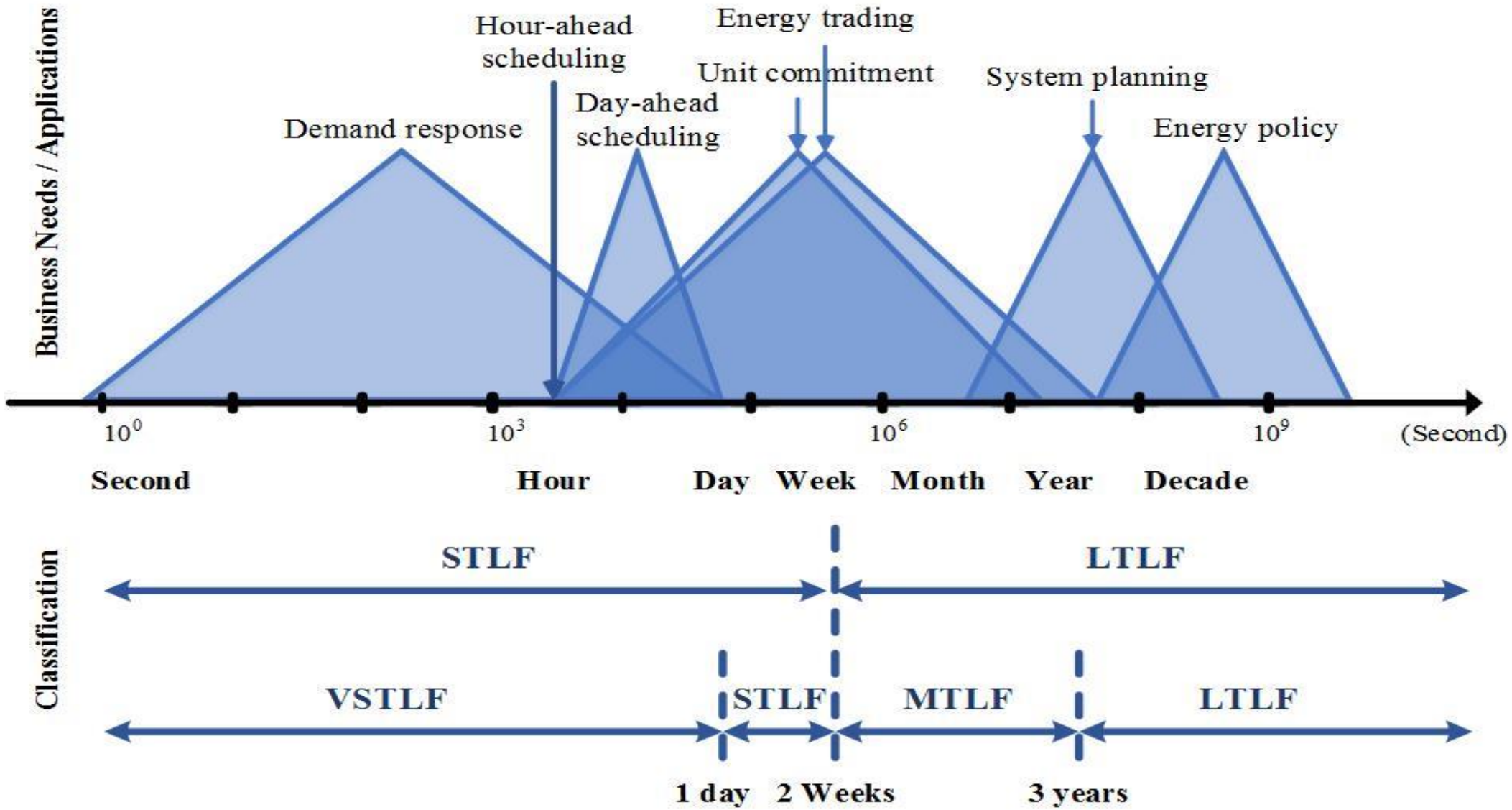
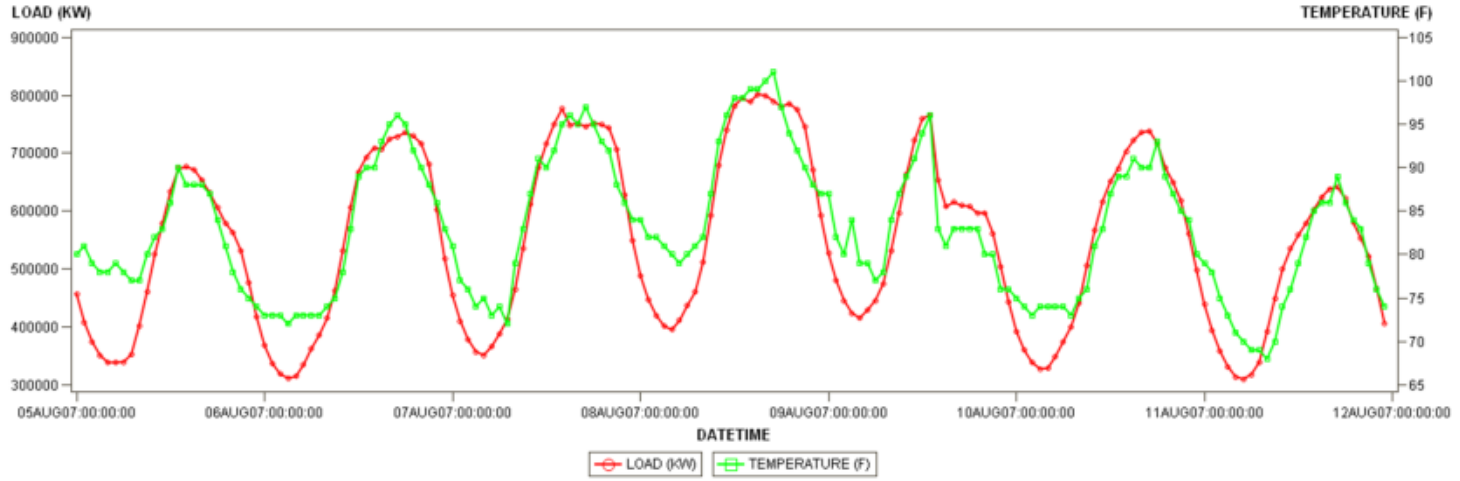


Tao Hong and Shu Fan, “Probabilistic electric load forecasting: A tutorial review”, IJF, 2016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800000
700000
600000
500000
400000
300000
105
100
95
90
85
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75
70
65
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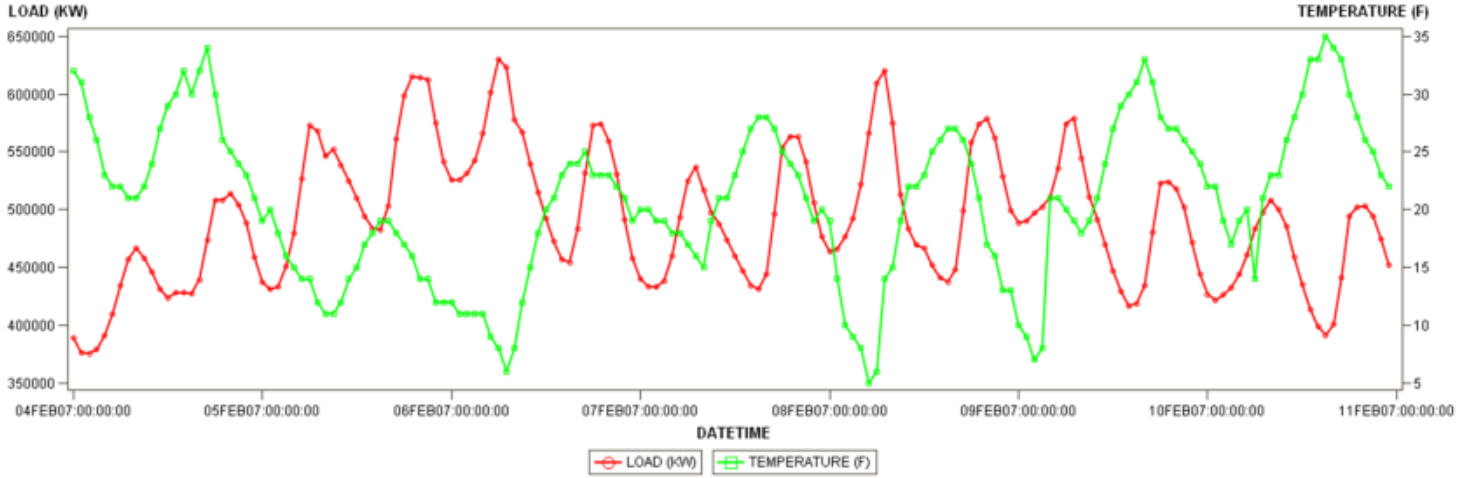
06AUG07:00:00:00
07AUG07:00:00:00
08AUG07:00:00:00
09AUG07:00:00:00
10AUG07:00:00:00
11AUG07:00:00:00
12AUG07:00:00:00
DATETIME
LOAD (KW)
TEMPERATURE (F)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TEMPERATURE (F)
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550000
500000
450000
400000
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30
25
20
15
10
5
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05FEB07:00:00:00
06FEB07:00:00:00
07FEB07:00:00:00
08FEB07:00:00:00
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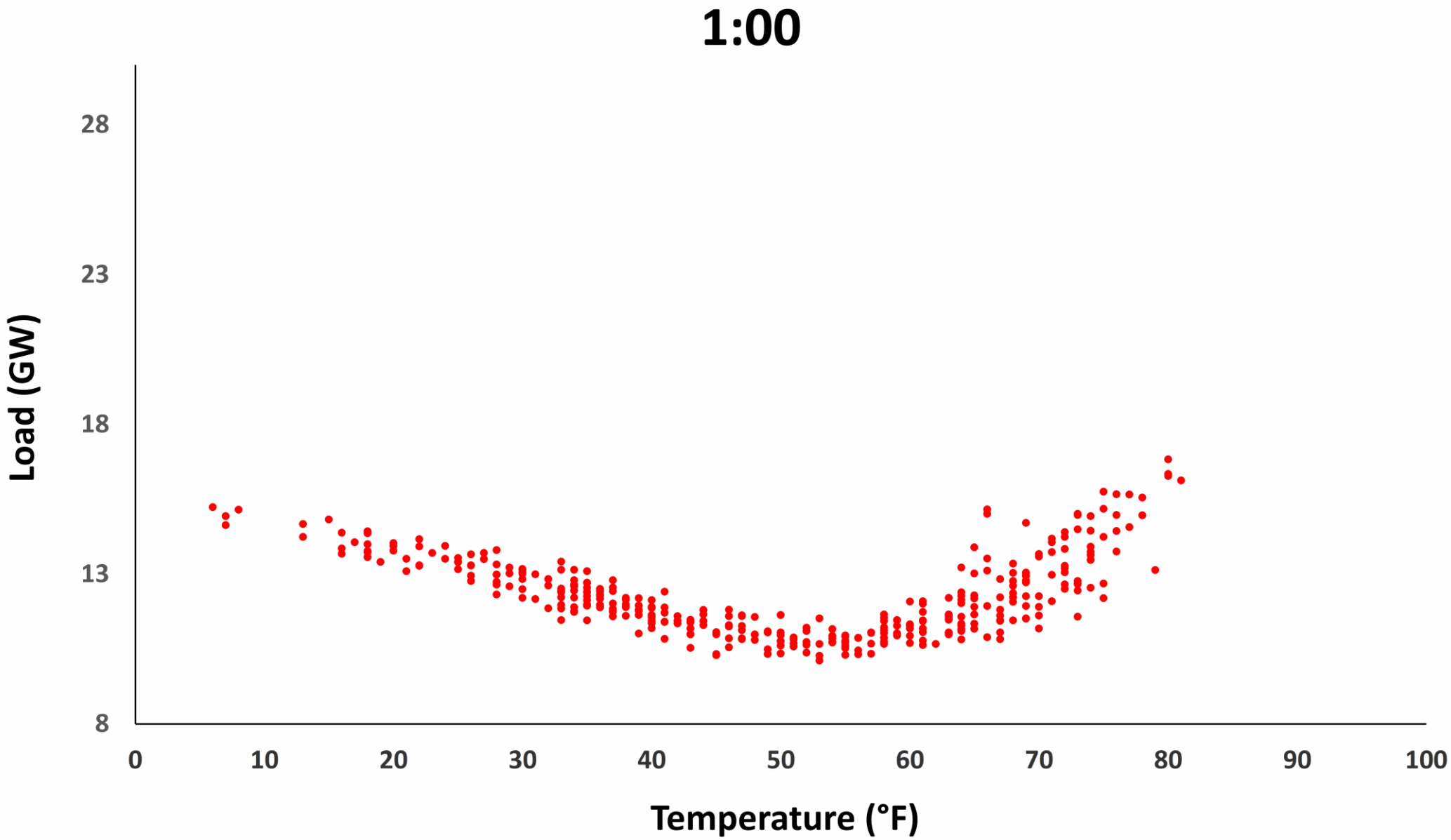
DATETIME
LOAD (KW)
TEMPERATURE (F)


1:00
Load (GW)
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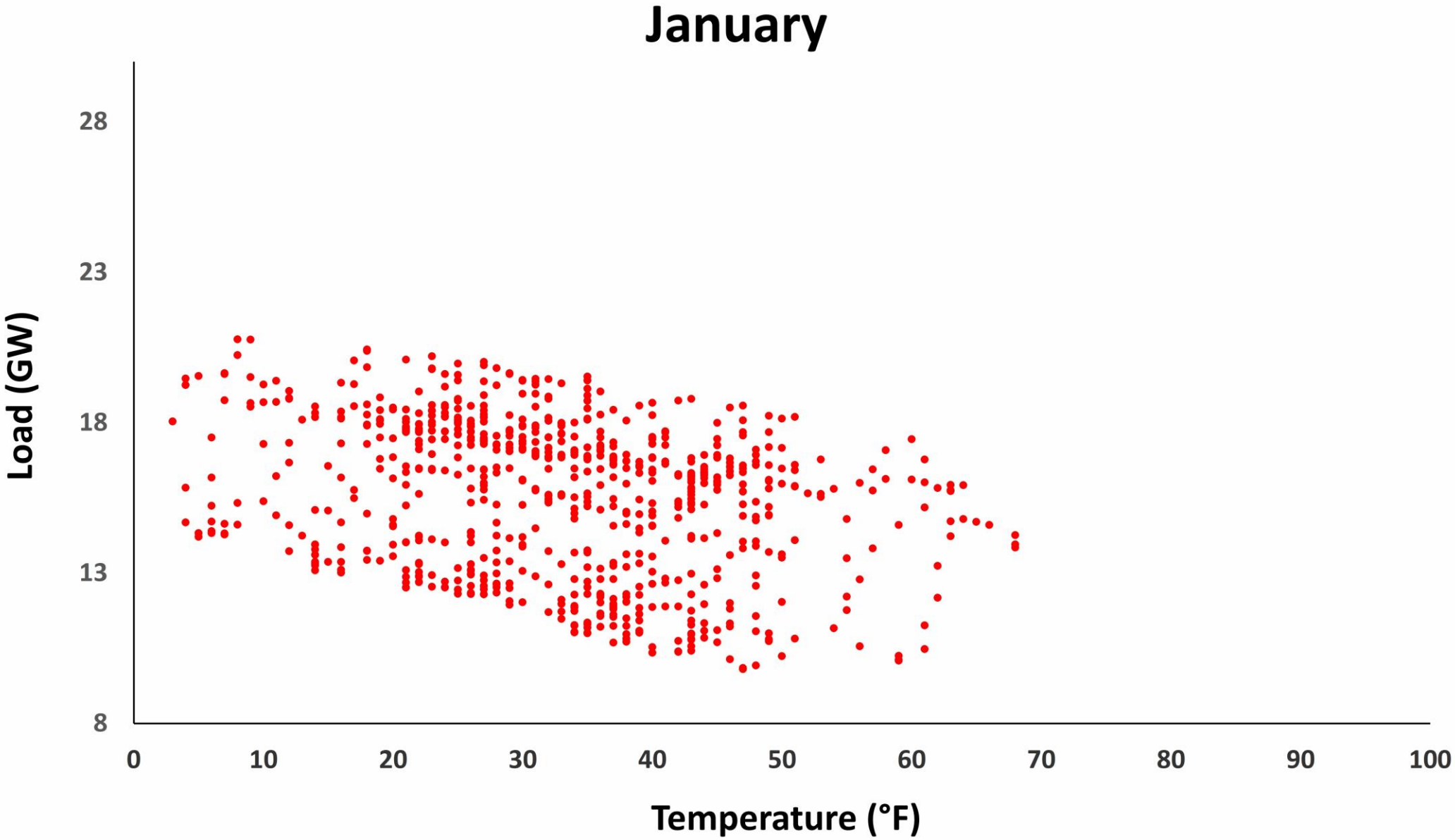
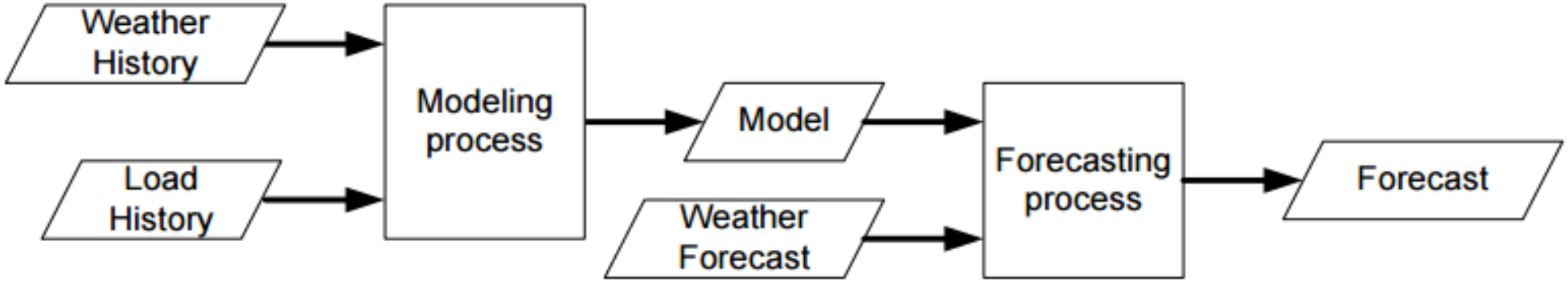
23
18
13
8
0
10
20
30
40
50
60
70
80
90
100
Temperature (°F)


January
Load (GW)
28
23
18
13
8
0
10
20
30
40
50
60
70
80
90
100
Temperature (°F)

- A load forecasting process



- Modeling process
  - Statistics: linear regression, Box-Jenkins, nonparametric regression
  - A.I.: ANN, fuzzy logic, neuro-fuzzy system, SVM
  - Others: hybrid approach, multi-stage approach

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~~Short~~ Long Temporal Lags

$$y_t = \beta_0 + \beta_1 Trend + \beta_2 M_t + \beta_3 W_t + \beta_4 H_t + \beta_5 W_t H_t + f(T_t) + \underbrace{\sum_d f(\tilde{T}_{(t,d)}) + \sum_h f(T_{t-h})}_{\text{recency effect terms}} .$$

$$\tilde{T}_{t,d} = \frac{1}{24} \sum_{h=24d-23}^{24d} T_{t-h}, \quad d = 1, 2, \ldots, 7$$

Pu Wang, Bidong Liu and Tao Hong, "Electric load forecasting with recency effect: a big data approach", IJF, 2016

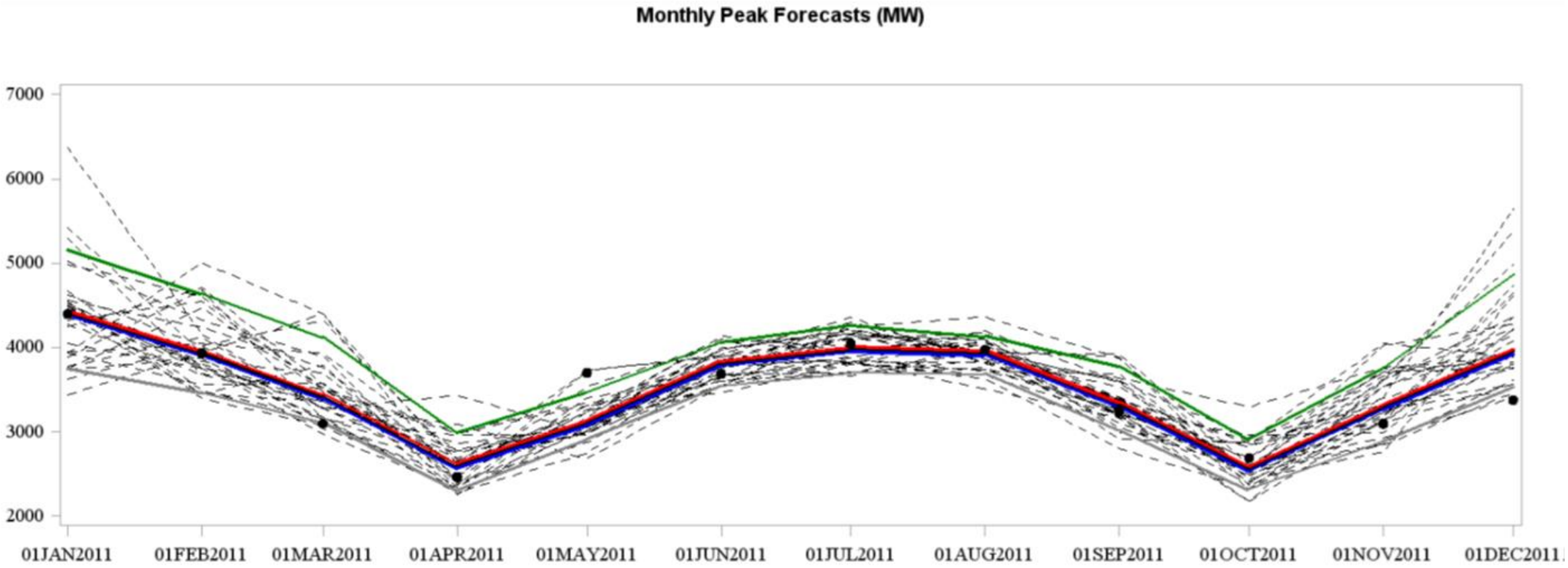
$h \setminus d$	0	1	2	3	4	5	6	7
0	4.89	4.10	4.09	4.16	4.23	4.13	4.12	4.25
1	4.55	3.92	3.91	3.97	4.05	3.95	3.96	4.08
2	4.34	3.81	3.80	3.87	3.94	3.85	3.85	3.97
3	4.20	3.76	3.74	3.81	3.88	3.79	3.79	3.91
4	4.09	3.71	3.70	3.76	3.84	3.75	3.74	3.86
5	4.00	3.68	3.67	3.73	3.81	3.72	3.71	3.83
6	3.93	3.65	3.64	3.71	3.78	3.70	3.69	3.81
7	3.86	3.63	3.62	3.69	3.76	3.68	3.67	3.80
8	3.81	3.60	3.60	3.67	3.75	3.67	3.66	3.78
9	3.77	3.59	3.58	3.65	3.73	3.66	3.65	3.78
10	3.74	3.58	3.57	3.64	3.72	3.65	3.64	3.77
11	3.73	3.57	3.55	3.63	3.71	3.64	3.63	3.76
12	3.71	3.56	**3.54**	3.62	3.69	3.63	3.62	3.75
13	3.69	3.56	3.54	3.62	3.68	3.62	3.62	3.74
14	3.67	3.57	3.55	3.63	3.69	3.63	3.63	3.76
15	3.66	3.58	3.57	3.64	3.70	3.64	3.64	3.77
16	3.67	3.60	3.58	3.66	3.71	3.66	3.66	3.79
17	3.67	3.62	3.61	3.68	3.73	3.68	3.68	3.81
18	3.67	3.64	3.63	3.71	3.75	3.70	3.70	3.83
19	3.68	3.67	3.65	3.73	3.77	3.72	3.71	3.86
20	3.68	3.69	3.68	3.75	3.79	3.74	3.73	3.88
21	3.69	3.71	3.70	3.77	3.80	3.76	3.76	3.90
22	3.70	3.73	3.72	3.78	3.81	3.78	3.77	3.92
23	3.72	3.74	3.73	3.78	3.82	3.79	3.79	3.94
24	3.73	3.76	3.75	3.79	3.83	3.80	3.80	3.95
25	3.74	3.76	3.77	3.80	3.84	3.81	3.81	3.96
26	3.75	3.78	3.79	3.81	3.85	3.83	3.82	3.98
27	3.76	3.80	3.81	3.83	3.86	3.84	3.84	4.00

~~Single Model~~ Forecast Combination

	GEFCom14	*ISO New England*									
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
Simple	4.54%	2.67%	2.80%	2.53%	2.60%	2.82%	2.70%	2.76%	2.71%	2.63%	2.10%
TA	4.52%	2.67%	2.79%	2.54%	2.60%	2.82%	2.70%	2.76%	2.70%	2.63%	2.10%
WA	4.53%	2.67%	2.80%	2.54%	2.60%	2.83%	2.70%	2.77%	2.70%	2.63%	2.10%
OLS	4.65%	2.71%	2.72%	2.50%	2.64%	2.82%	2.72%	2.70%	2.74%	2.67%	2.14%
LAD	4.57%	2.72%	2.70%	2.51%	2.65%	2.83%	2.72%	2.73%	2.76%	2.68%	2.14%
PW	4.63%	2.68%	2.71%	2.51%	2.61%	2.81%	2.69%	2.68%	2.74%	2.63%	2.12%
CLS	4.55%	2.66%	2.82%	2.52%	2.60%	2.83%	2.70%	2.74%	2.70%	2.65%	2.11%
IRMSE	4.54%	2.67%	2.80%	2.53%	2.60%	2.82%	2.70%	2.76%	2.71%	2.63%	2.10%
BI-C	4.74%	2.81%	2.88%	2.61%	2.78%	2.93%	2.80%	2.91%	2.84%	2.84%	2.25%
Ind1	**4.80%**	2.93%	3.09%	2.75%	2.91%	2.97%	2.91%	3.07%	2.88%	2.99%	2.29%
Ind2	5.12%	2.85%	**3.15%**	2.67%	2.81%	2.98%	2.82%	2.90%	3.01%	2.83%	2.24%
Ind3	4.86%	2.89%	2.76%	2.70%	2.82%	3.01%	2.96%	3.01%	2.87%	2.81%	2.34%
Ind4	5.44%	**2.78%**	3.17%	**2.60%**	**2.77%**	2.91%	**2.94%**	**2.95%**	**2.90%**	**2.81%**	**2.32%**
Ind5	4.76%	2.91%	3.02%	2.71%	2.92%	**3.05%**	2.87%	3.11%	2.82%	2.91%	2.28%
Ind6	4.79%	2.89%	3.18%	2.67%	2.79%	3.00%	2.79%	2.94%	2.94%	2.83%	2.30%
Ind7	4.76%	2.90%	2.82%	2.72%	2.85%	3.07%	2.97%	3.07%	2.87%	2.83%	2.37%
Ind8	5.21%	2.86%	3.21%	2.64%	2.77%	2.92%	2.91%	2.96%	3.00%	2.83%	2.31%

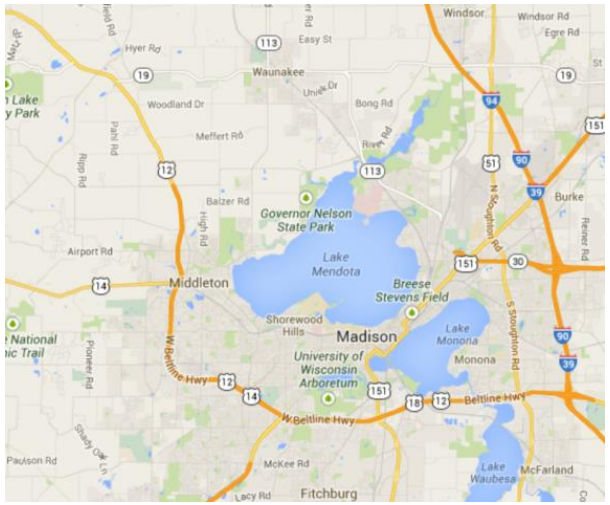
Jakub Nowotarski, Bidong Liu, Rafal Weron and Tao Hong, "Improving short term load forecast accuracy via combining sister forecasts", Energy, 2016

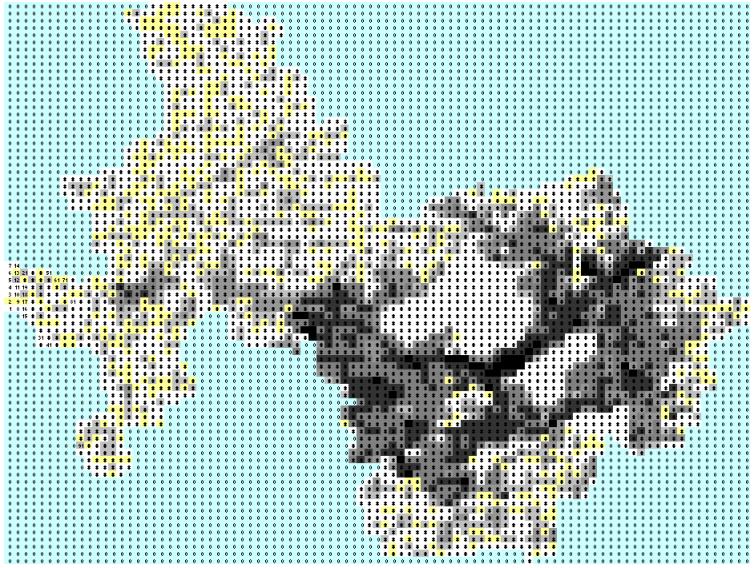
~~Point~~ Probabilistic Forecasting

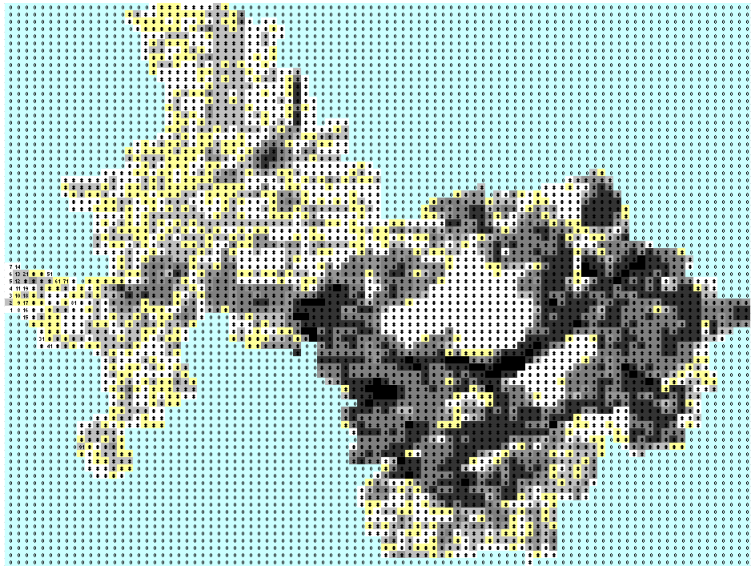


Tao Hong, Jason Wilson and Jingrui Xie, "Long term probabilistic load forecasting and normalization with hourly information", TSG, 2014

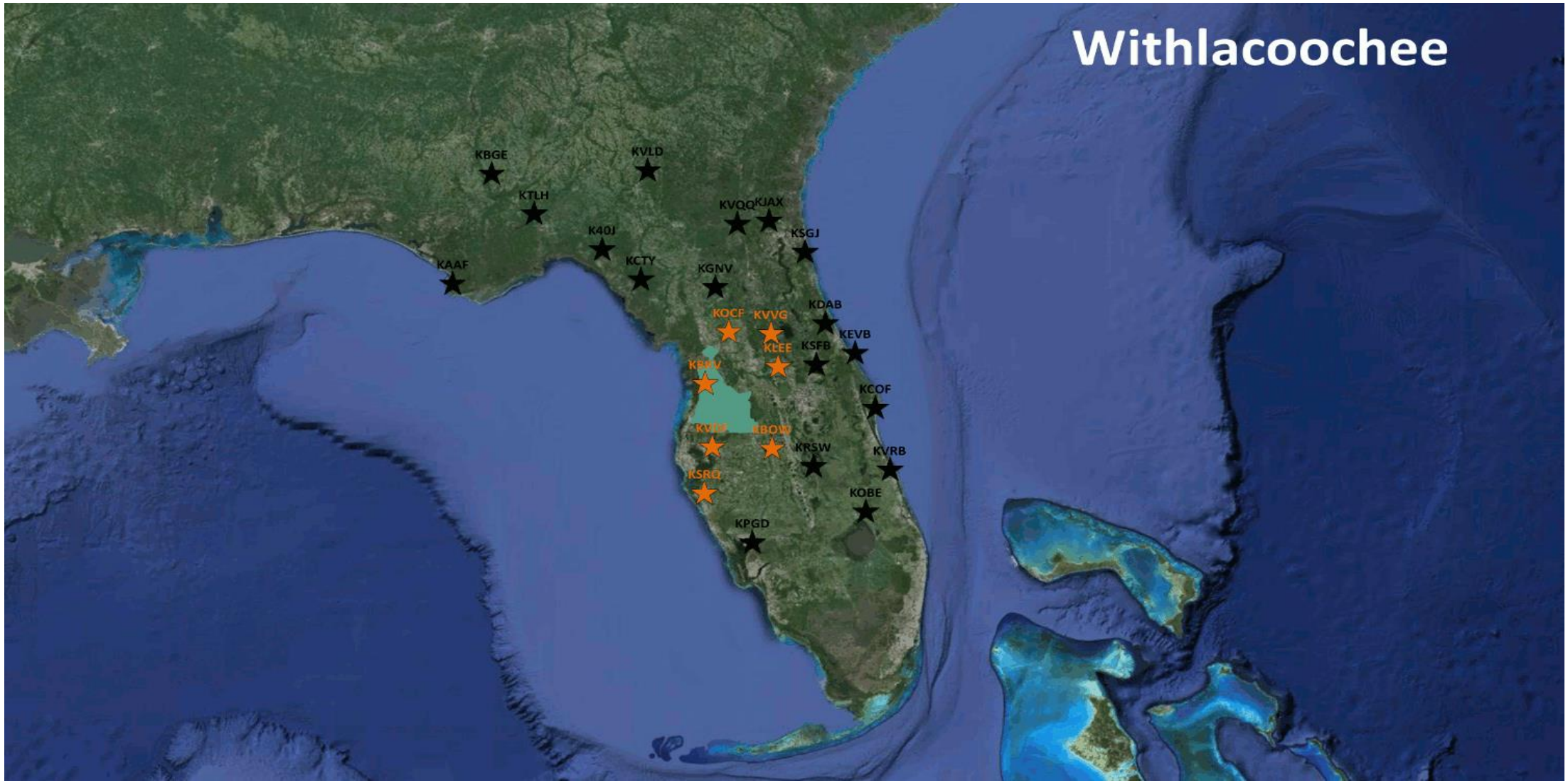
~~Aggregated Level~~ Hierarchical Forecasting





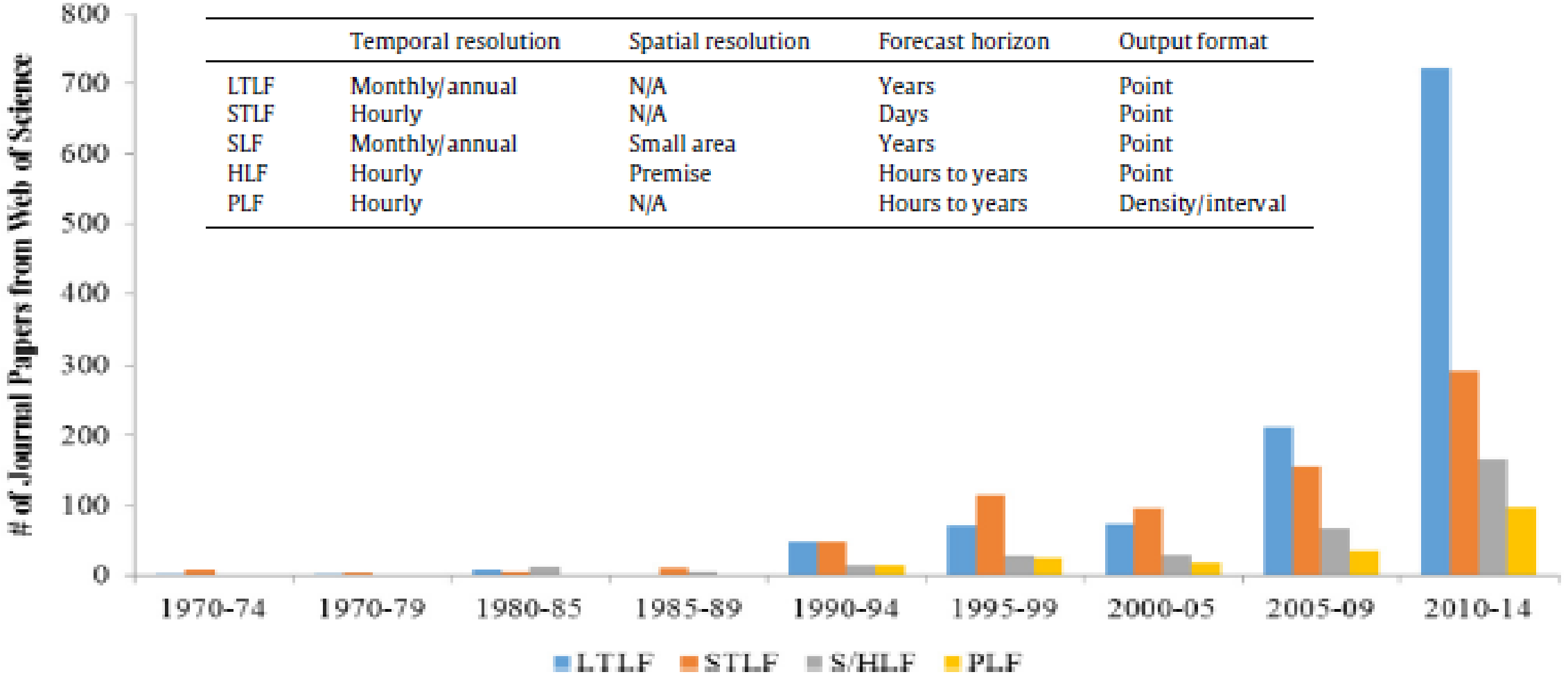


Tao Hong, "Long-Term Spatial Load Forecasting Using Human Machine Co-construct Intelligence Framework". NCSU, 2008



Tao Hong, Pu Wang and Laura White, "Weather station selection for electric load forecasting", IJF, 2015

	Temporal resolution	Spatial resolution	Forecast horizon	Output format
LTLF	Monthly/annual	N/A	Years	Point
STLF	Hourly	N/A	Days	Point
SLF	Monthly/annual	Small area	Years	Point
HLF	Hourly	Premise	Hours to years	Point
PLF	Hourly	N/A	Hours to years	Density/interval



Tao Hong and Shu Fan, “Probabilistic electric load forecasting: A tutorial review”, IJF, 2016

Implications

- More accurate ☺
- More reliable ☺
- More resolution ☺
- More certain ☺
- More validated ☺
- More customized ☺
- More control ☺
- More pressure ☹☹☹

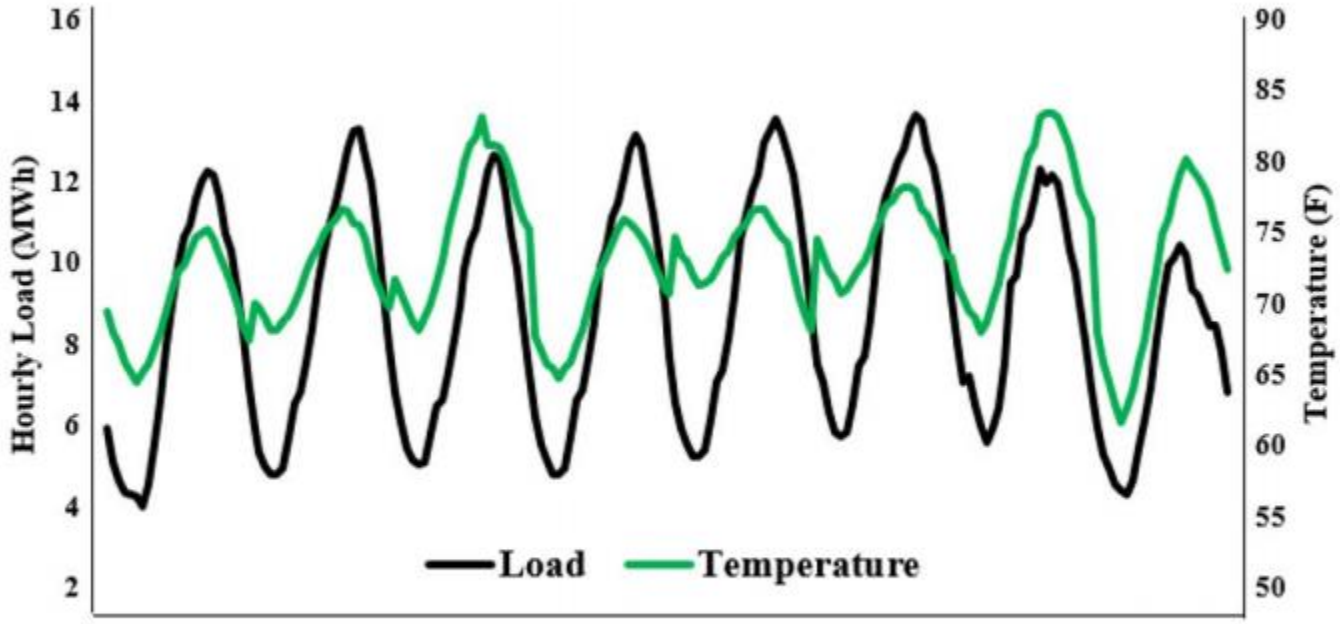
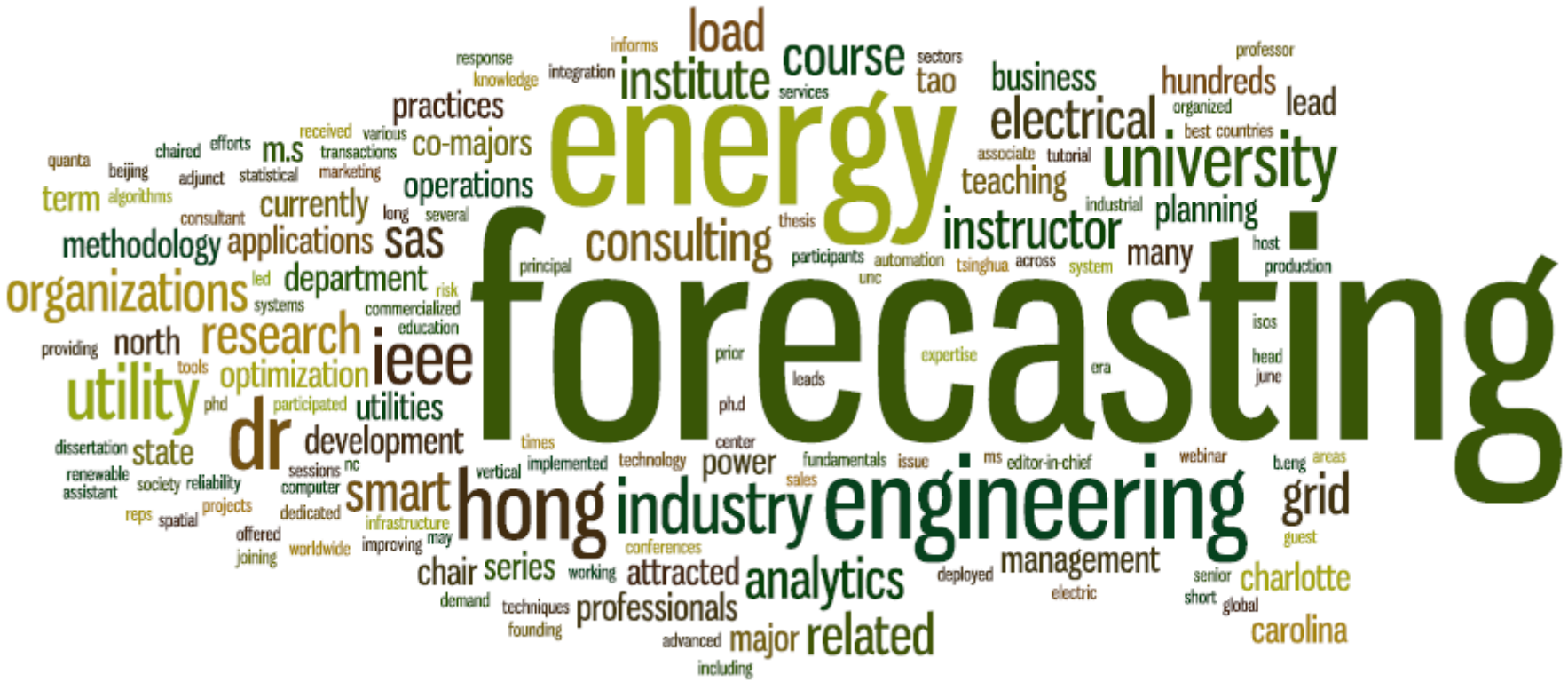


Fig. 12. Hourly load and temperature (14 July 2013–21 July 2013).

Jingrui Xie, Tao Hong and Joshua Stroud, "Long term retail energy forecasting with consideration of residential customer attrition", TSG, 2015

Key References

- Tao Hong and Shu Fan, Probabilistic electric load forecasting: A tutorial review, International Journal of Forecasting, vol. 32, no. 3, pp 914-938, July–September 2016
- Tao Hong, Pierre Pinson, Shu Fan, Hamidreza Zareipour, Alberto Troccoli and Rob J. Hyndman, Probabilistic energy forecasting: Global Energy Forecasting Competition 2014 and beyond, International Journal of Forecasting, vol.32, no.3, pp 896-913, July–September 2016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