Weather Station Selection for Electric Load Forecasting

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(AEIC/WLRA 2015, Chicago, IL)

Weather Station Selection

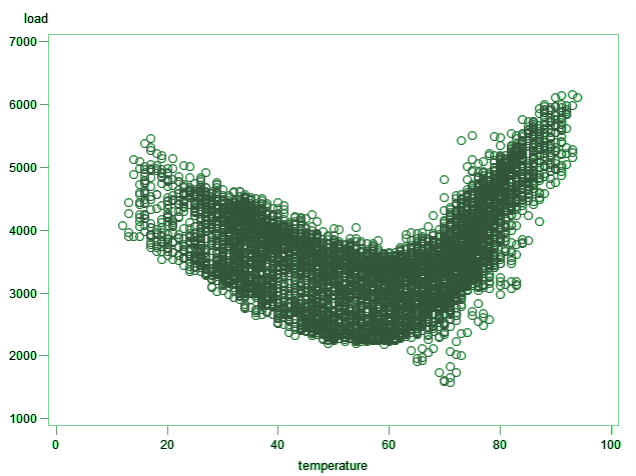
- Weather in load forecasting
- Two questions
- A counter-intuitive practice
- Tao’s three-step method
- Two case studies
- Seven-step implementation

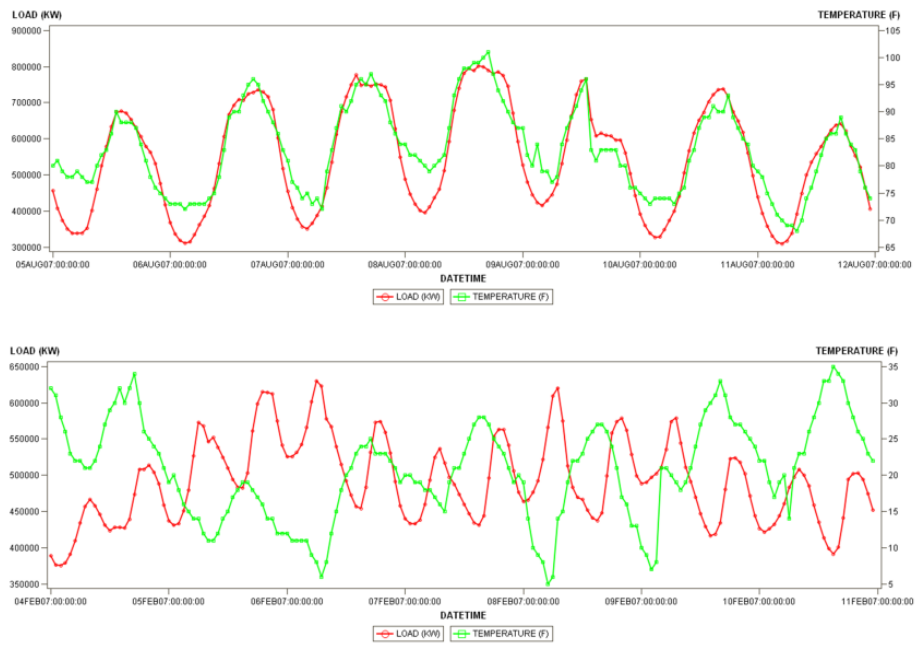
Weather in Load Forecasting

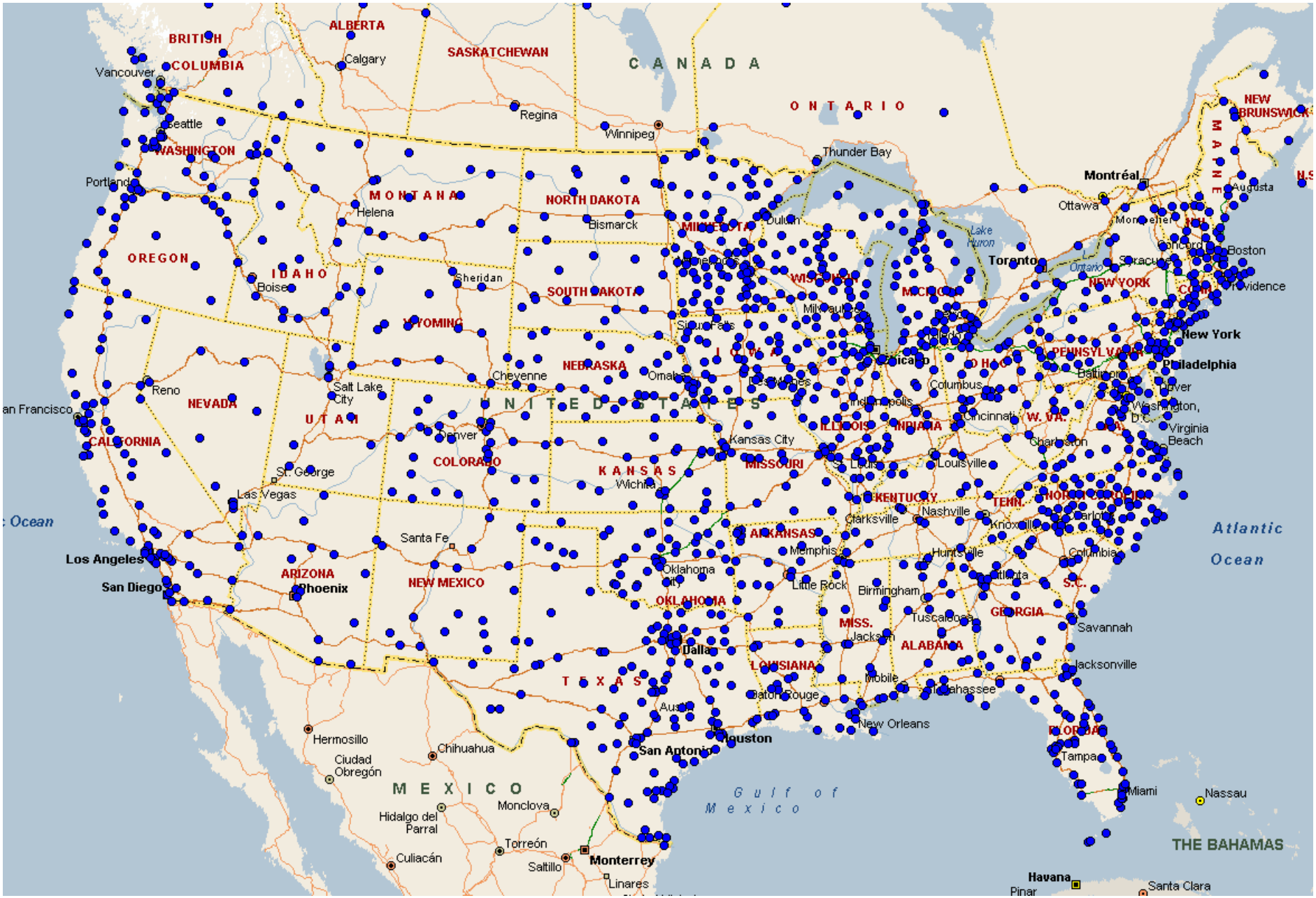
- Temperature, humidity, cloud cover, wind speed, rainfall …

  http://blog.drhongtao.com/2014/11/weather-climate-temperature.html

- Temperature



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M E X I C O
Hidalgo del Parral
Monclova
Torreón
Saltillo
Monterrey
Linares
Culiacán
Gulf of Mexico
Atlantic Ocean
Ocean

Two Questions

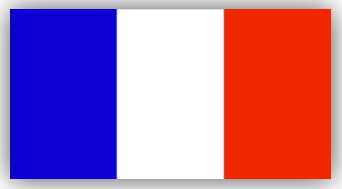
1. How Many?

2. Which?

A Counter-intuitive Practice

- Two steps
  1. Pick a number based on heuristics/feeling/sense/experience
  2. Identify the best weather station(s) subject to the constraint set in step 1)

GEFCom2012
Load Forecasting



Tao's Methodology

- Philosophy
  - Answering the two questions simultaneously
- Three steps
  1. Rating and ranking individual weather stations
  2. Combining weather stations
  3. Rating and ranking combined weather stations

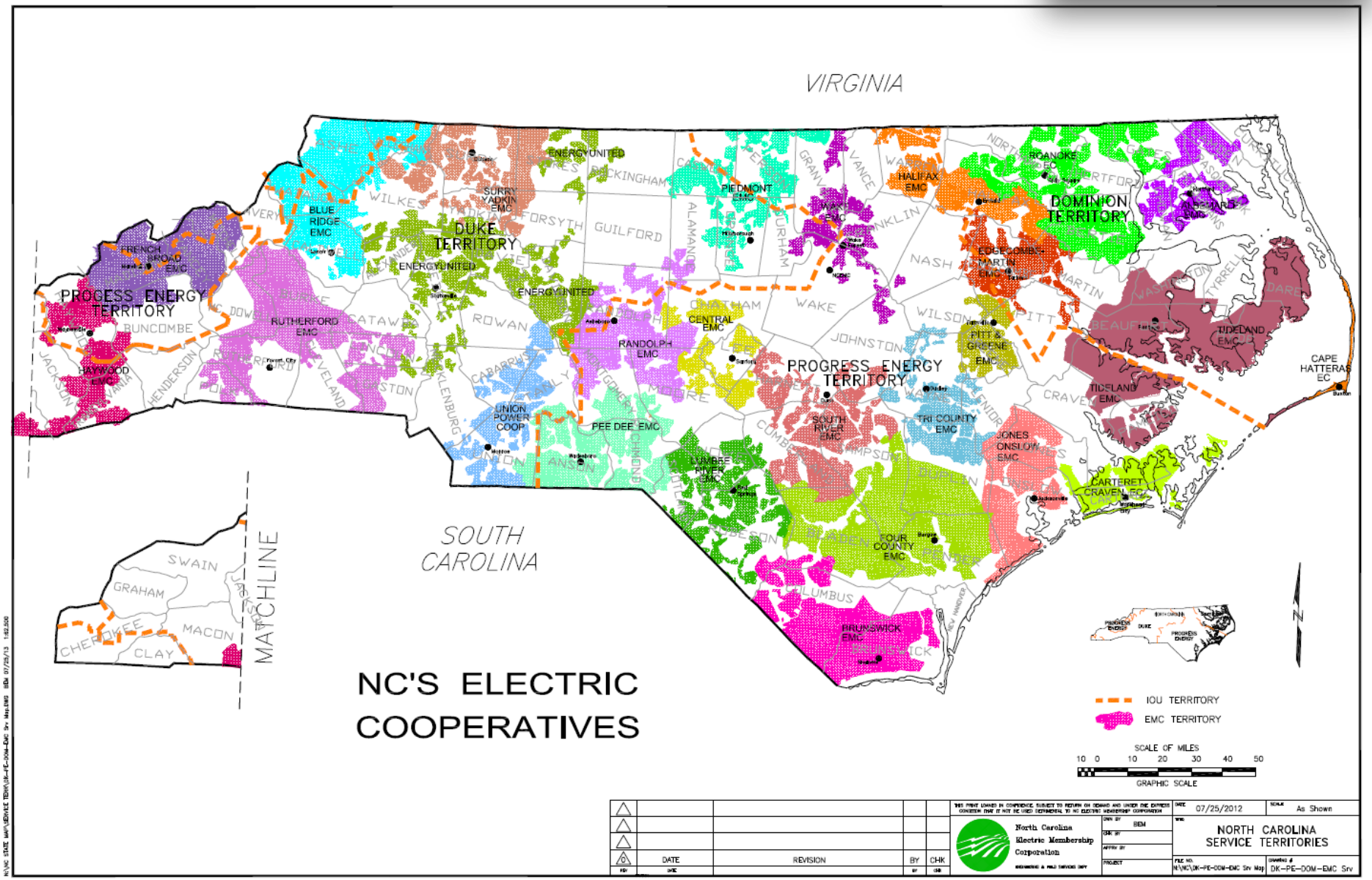
Two Case Studies

- NCEMC
  - 3 supply areas
  - 44 building blocks

North Carolina Electric Membership Corporation
A Touchstone Energy® Cooperative

- GEFCom2012
  - 1 aggregated zone
  - 20 low-level zones

GEFCom2012
Load Forecasting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SOUTH CAROLINA
MATCHLINE
PROGRESS ENERGY TERRITORY
DUKE TERRITORY
DOMINION TERRITORY
ENERGY UNITED
BLUE RIDGE EMC
SURRY YADKIN EMC
PIEDMONT EMC
HALIFAX EMC
ROANOKE EC
FRENCH BROAD EMC
RUTHERFORD EMC
HAYWOOD EMC
RANDOLPH EMC
CENTRAL EMC
EDGECOMBE-MARTIN EMC
PITT & GREENE EMC
TIDELAND EMC
TIDELAND EMC
CAPE HATTERAS EC
UNION POWER COOP
PEE DEE EMC
LUMBEE RIVER EMC
SOUTH RIVER EMC
TRI COUNTY EMC
JONES ONSLOW EMC
CARTERET CRAVEN EC
FOUR COUNTY EMC
BRUNSWICK EMC
NC'S ELECTRIC COOPERATIVES
IOU TERRITORY
EMC TERRITORY
SCALE OF MILES
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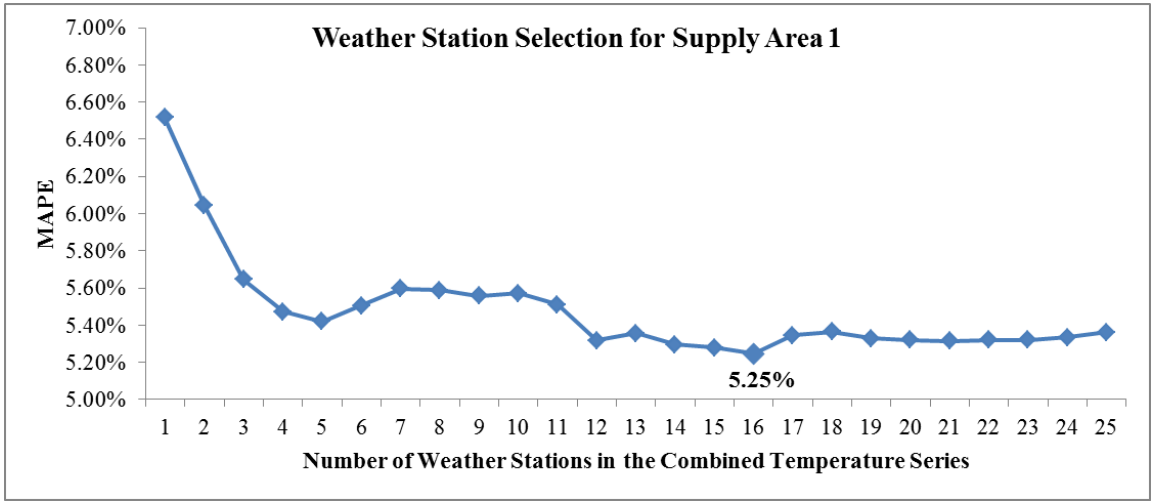
GRAPHIC SCALE
DATE
REVISION
BY
CHK
07/25/2012
As Shown
North Carolina Electric Membership Corporation
NORTH CAROLINA SERVICE TERRITORIES
DK-PE-DOM-EMC Srv

Weather stations ranked by the MAPE values for SA_1 (training: 2004–2005).

Rank	Name	MAPE
1	kpob	6.05%
2	kgsb	6.31%
3	kilm	6.44%
4	krdu	6.60%
5	knca	6.62%
6	krwi	6.64%
7	kpgv	6.66%
8	kewn	6.70%
9	kigx	7.16%
10	kmrh	7.17%
11	keyf	7.25%
12	kafp	7.38%
13	kcpc	7.40%
14	kasj	7.41%
15	khbi	7.48%
16	kgso	7.73%
17	khnz	7.75%
18	kecg	7.78%
19	kclt	7.91%
20	kipj	8.02%
21	korf	8.55%
22	khse	8.75%
23	kmwk	8.99%
24	kavl	9.66%
25	kgev	10.38%



Comparing the proposed method with the four alternatives (NCEMC case study).

		Proposed framework		Alternatives			
		Number of weather stations	Unconstrained selection	Best one	Best three	Best five	All
Supply area load	SA_1	16	**5.24%**	6.24%	5.92%	5.57%	5.32%
	SA_2	8	6.10%	7.03%	6.12%	**5.91%**	7.20%
	SA_3	18	**5.60%**	7.33%	6.35%	6.09%	6.13%
	Average (SAs)		**5.65%**	6.87%	6.13%	5.86%	6.22%
Regular building blocks	BB_2	5	**7.51%**	8.32%	7.64%	**7.51%**	8.06%
	BB_3	N/A	N/A	N/A	N/A	N/A	N/A
	BB_4	6	4.17%	5.09%	4.47%	**4.13%**	5.48%
	BB_6	12	7.33%	7.38%	7.18%	**7.10%**	7.82%
	BB_7	9	13.72%	14.26%	**13.24%**	13.34%	14.69%
	BB_{11}	17	**6.72%**	7.44%	6.76%	6.93%	7.25%
	BB_{12}	11	6.62%	6.90%	**6.55%**	6.89%	6.81%
	BB_{13}	23	6.31%	7.06%	6.51%	**6.28%**	6.43%
	BB_{14}	5	**5.21%**	5.61%	4.97%	**5.21%**	6.22%
	BB_{16}	9	**5.64%**	7.96%	6.45%	5.74%	6.10%
	BB_{17}	16	8.23%	8.66%	8.34%	**8.13%**	8.61%
	BB_{18}	14	**7.32%**	7.82%	7.64%	7.43%	7.82%
	BB_{19}	N/A	N/A	N/A	N/A	N/A	N/A
	BB_{20}	5	6.18%	**6.05%**	6.40%	6.18%	7.75%
	BB_{21}	6	6.68%	6.84%	6.52%	**6.41%**	7.96%
	BB_{22}	7	**6.49%**	7.46%	6.63%	6.56%	7.34%
	BB_{23}	16	7.06%	6.92%	7.12%	**6.85%**	7.44%
	BB_{26}	4	**5.70%**	5.94%	5.74%	**5.70%**	6.09%
	BB_{27}	8	6.51%	6.85%	**6.29%**	6.75%	6.88%
	BB_{28}	4	**6.33%**	7.07%	6.41%	6.72%	7.18%
	BB_{29}	3	**7.21%**	7.98%	**7.21%**	7.54%	7.69%
	BB_{30}	4	6.29%	6.89%	6.43%	**6.19%**	6.97%
	BB_{31}	23	6.77%	7.09%	7.02%	**6.72%**	6.84%
	BB_{32}	6	**5.54%**	6.52%	6.15%	5.70%	6.03%
	BB_{33}	N/A	N/A	N/A	N/A	N/A	N/A
	BB_{34}	10	**5.97%**	7.35%	6.49%	6.03%	6.33%
	BB_{35}	3	**5.33%**	5.91%	**5.33%**	5.38%	6.82%
	BB_{37}	15	6.27%	6.63%	**6.15%**	6.24%	6.42%
	BB_{38}	5	**6.07%**	6.42%	6.08%	6.10%	7.48%
	BB_{39}	13	**6.66%**	7.46%	7.65%	7.04%	7.30%
	BB_{40}	12	**6.09%**	7.42%	6.60%	6.19%	6.57%
	BB_{41}	23	**6.31%**	6.64%	6.39%	6.37%	6.46%
	BB_{42}	8	7.26%	7.25%	**6.86%**	6.91%	8.27%
	BB_{43}	5	**6.96%**	7.55%	7.17%	**6.96%**	7.48%
	BB_{44}	14	6.55%	6.93%	6.72%	**6.43%**	7.17%
	Average (regular BBs)		**6.66%**	7.24%	6.78%	6.68%	7.31%
Industrial building blocks	BB_1	15	266.89%	265.38%	263.64%	265.71%	267.34%
	BB_5	13	112.09%	116.07%	113.15%	112.99%	111.93%
	BB_8	2	18.21%	18.46%	18.78%	18.47%	18.29%
	BB_9	1	11.63%	11.63%	11.31%	11.24%	11.24%
	BB_{10}	5	26.98%	26.64%	26.65%	26.86%	27.31%
	BB_{15}	N/A	N/A	N/A	N/A	N/A	N/A
	BB_{24}	25	76.13%	75.73%	75.28%	75.20%	76.13%
	BB_{25}	1	40.48%	40.48%	40.35%	40.23%	40.13%
	BB_{36}	1	16.23%	16.54%	16.01%	16.04%	16.01%

Comparing the proposed method with the four alternatives (GEFCom2012 case study).

		Proposed framework		Alternatives			
		Number of weather stations	Unconstrained selection	Best one	Best three	Best five	All
	Z_{21}	11	**5.22%**	5.40%	5.40%	5.28%	**5.22%**
Regular Zones	Z_1	3	**7.01%**	7.53%	**7.01%**	7.31%	8.00%
	Z_2	6	**5.62%**	5.92%	5.64%	5.77%	5.94%
	Z_3	6	**5.62%**	5.92%	5.64%	5.77%	5.94%
	Z_5	3	9.88%	**9.01%**	9.88%	10.17%	10.81%
	Z_6	7	**5.55%**	5.84%	5.57%	5.71%	5.91%
	Z_7	6	**5.62%**	5.92%	5.64%	5.77%	5.94%
	Z_8	4	7.50%	7.54%	**7.48%**	7.71%	8.12%
	Z_{10}	6	6.70%	6.66%	**6.46%**	6.58%	7.21%
	Z_{11}	4	**7.70%**	7.72%	7.81%	8.01%	8.67%
	Z_{12}	4	6.78%	**6.74%**	**6.74%**	7.00%	7.90%
	Z_{13}	4	7.39%	**7.28%**	7.30%	7.39%	7.96%
	Z_{14}	5	**9.38%**	9.59%	9.44%	9.49%	9.84%
	Z_{15}	2	7.44%	**7.43%**	7.61%	7.66%	7.86%
	Z_{16}	7	**8.12%**	8.43%	8.33%	**8.12%**	8.51%
	Z_{17}	6	**5.26%**	5.93%	5.52%	5.35%	5.40%
	Z_{18}	1	6.72%	6.72%	**6.67%**	6.74%	6.90%
	Z_{19}	3	**7.90%**	8.17%	**7.90%**	8.18%	8.25%
	Z_{20}	6	5.74%	5.80%	**5.67%**	5.70%	5.93%
	Average (regular zones)		**7.00%**	7.12%	7.02%	7.14%	7.51%
Excluded Zones	Z_4	2	16.08%	15.72%	15.75%	15.78%	16.31%
	Z_9	9	139.16%	137.59%	137.50%	137.30%	139.13%

7-step Implementation

1. Label individual weather stations
2. Calculate MAPE on training data
3. Sort individual weather stations
4. Combine weather stations
5. Forecast validation period
6. Calculate MAPE on validation data
7. Sort combined weather stations

Further Readings

Blog

http://blog.drhongtao.com/2014/11/weather-climate-temperature.html
http://blog.drhongtao.com/2014/09/weather-station-selection-for-electric-load-forecasting.html

Paper

Tao Hong, Pu Wang and Laura White, “Weather Station Selection for Electric Load Forecasting”, International Journal of Forecasting, vol.31, no.2., pp 286-295, April - June, 2015

Questions?

For more information, please contact

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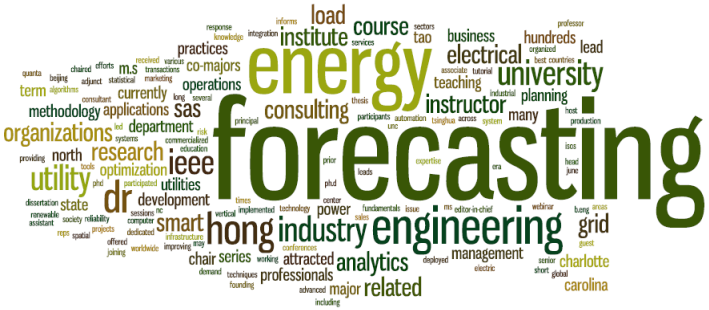
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