



Supplement of

Probabilistic and machine learning methods for uncertainty quantification in power outage prediction due to extreme events

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Figure S1. Power outages caused by Hurricane Isaias (2020) in New York



Figure S2. Power outages caused by Hurricane Michael (2018) in Florida



Figure S3. Power outages caused by Hurricane Harvey (2017) in Texas

CDF1	1	0.39	-0.16	0.08	0.14	0.12	0.09	0.23	0.1	0.08	-0.01	0.24	0.24	-0.26	0.19	-0.15	-0	-0.1	0.18	-0.09	-0.09	0.03	0.06	-0.1	0.16		
CDF2	0.39	1	0.23	0.35	0.3	0.15	0.08	0.11	-0.12	-0.08	-0.19	0.31	0.31	-0.14	0	-0.12	-0.18	-0.09	0.1	0.06	0.18	-0.04	0.17	-0.09	-0.09		
CDF3	-0.16	0.23	1	0.34	0.29	0.21	0.14	-0.06	-0.31	-0.15	-0.04	-0.06	-0.06	0.31	-0.28	-0.11	-0.01	-0.07	-0.42	0.18	0.29	-0.24	-0.05	-0.12	-0.23		
SPI1	0.08	0.35	0.34	1			0.48	0.49	-0.07	-0.09	-0.21	0.08	0.08	0.16	-0.06	-0.08	-0.18	-0.01	0.09	0.13	0.19	0.19	0.11	0.09	-0.07		
SPI3	0.14	0.3	0.29	0.73	1	0.9	0.76	0.48	0.09	0.05	0.05	-0.1	-0.1	0.1	-0.02	-0.09	0.05	-0.04	-0.11	0.02	-0.07	-0.11	0.04	0.12	-0.04		
SPI6	0.12	0.15	0.21	0.59	0.9	1	0.84	0.58	0.3	0.24	0.28	-0.27	-0.26	0.06	0.07	-0.04	0.28	-0.08	-0.1	-0.1	-0.26	-0.14	-0.13	0.18	0.11		
SPI12	0.09	0.08	0.14	0.48	0.76	0.84	1	0.48	0.32	0.25	0.32	-0.31	-0.31	0.07	0.14	-0	0.32	-0.12	0	-0.23	-0.3	-0.06	-0.12	0.28	0.08		- 1.00
day7	0.23	0.11	-0.06	0.49	0.48		0.48	1		0.46	0.25	-0.25	-0.25	-0.04	0.3	-0.05	0.27	-0.2	0.25	-0.18	-0.26	0.11	-0.13	0.28	0.43		- 0.75
Vmax	0.1	-0.12	-0.31	-0.07	0.09	0.3	0.32			0.89		-0.48	-0.48	-0.03	0.4	0.07	0.49	-0.14	0.17	-0.25	-0.52	-0.17	-0.19	0.35			
Duration	0.08	-0.08	-0.15	-0.09	0.05	0.24	0.25	0.46	0.89	1	0.47	-0.46	-0.46	0.01	0.29	0.06	0.47	-0.14	0	-0.18	-0.43	-0.34	-0.22	0.24	0.6		0.50
Pop_Density	-0.01	-0.19	-0.04	-0.21	0.05	0.28	0.32	0.25		0.47	1	-0.55	-0.55	0.03	0.16	0.22	0.97	-0.08	-0.17	-0.45	-0.52	-0.31	-0.42	0.17	0.17		- 0.25
Mean_Elevation	0.24	0.31	-0.06	0.08	-0.1	-0.27	-0.31	-0.25	-0.48	-0.46	-0.55	1	1	-0.4	0.12	-0.44	-0.54	-0.1	0.31	0.2	0.3	0.2	0.33	-0.5	-0.13		
Median_Elevation	0.24	0.31	-0.06	0.08	-0.1	-0.26	-0.31	-0.25	-0.48	-0.46	-0.55	1	1	-0.4	0.11	-0.44	-0.54	-0.1	0.31	0.2	0.3	0.2	0.33	-0.5	-0.13		- 0.00
Root_Zone	-0.26	-0.14	0.31	0.16	0.1	0.06	0.07	-0.04	-0.03	0.01	0.03	-0.4	-0.4	1	-0.32	0.09	0.07	0.07	-0.34	0.1	0.2	0.03	0.1	0.27	-0.11		-0.26
Treed_area	0.19	0	-0.28	-0.06	-0.02	0.07	0.14	0.3	0.4	0.29	0.16	0.12	0.11	-0.32	1	-0.18	0.18	-0.22	0.63	-0.28	-0.26	0.1	-0.28	0.24	0.31		0.25
Water	-0.15	-0.12	-0.11	-0.08	-0.09	-0.04	-0	-0.05	0.07	0.06	0.22	-0.44	-0.44	0.09	-0.18	1	0.17	0.3	-0.03	0.22	-0.03	-0.01	-0.23	0.32	-0.05		0.50
Developed	-0	-0.18	-0.01	-0.18	0.05	0.28	0.32	0.27	0.49	0.47	0.97	-0.54	-0.54	0.07	0.18	0.17	1	-0.09	-0.16	-0.48	-0.5	-0.29	-0.41	0.18	0.18		
Barren	-0.1	-0.09	-0.07	-0.01	-0.04	-0.08	-0.12	-0.2	-0.14	-0.14	-0.08	-0.1	-0.1	0.07	-0.22	0.3	-0.09	1	-0	0.25	0.28	0.09	0.02	0.12	-0.16		0.75
Forest	0.18	0.1	-0.42	0.09	-0.11	-0.1	0	0.25	0.17	0	-0.17	0.31	0.31	-0.34	0.63	-0.03	-0.16	-0	1	-0.19	0.04	0.56	-0.01	0.27	0.19		1.00
Scrub	-0.09	0.06	0.18	0.13	0.02	-0.1	-0.23	-0.18	-0.25	-0.18	-0.45	0.2	0.2	0.1	-0.28	0.22	-0.48	0.25	-0.19	1	0.44	-0.08	0.14	-0.2	-0.04		
Grassland	-0.09	0.18	0.29	0.19	-0.07	-0.26	-0.3	-0.26	-0.52	-0.43	-0.52	0.3	0.3	0.2	-0.26	-0.03	-0.5	0.28	0.04	0.44	1	0.22	0.31	-0.07	-0.31		
Pasture	0.03	-0.04	-0.24	0.19	-0.11	-0.14	-0.06	0.11	-0.17	-0.34	-0.31	0.2	0.2	0.03	0.1	-0.01	-0.29	0.09	0.56	-0.08	0.22	1	0.29	0.22	-0.06		
Crops_cultivated	0.06	0.17	-0.05	0.11	0.04	-0.13	-0.12	-0.13	-0.19	-0.22	-0.42	0.33	0.33	0.1	-0.28	-0.23	-0.41	0.02	-0.01	0.14	0.31	0.29	1	-0.05	-0.08		
Wetlands	-0.1	-0.09	-0.12	0.09	0.12	0.18	0.28	0.28	0.35	0.24	0.17	-0.5	-0.5	0.27	0.24	0.32	0.18	0.12	0.27	-0.2	-0.07	0.22	-0.05	1	0.15		
Fraction Outages	0.16	-0.09	-0.23	-0.07	-0.04	0.11	0.08	0.43	0.62	0.6	0.17	-0.13	-0.13	-0.11	0.31	-0.05	0.18	-0.16	0.19	-0.04	-0.31	-0.06	-0.08	0.15	1		
	CDF1	CDF2	CDF3	SPI1	SP13	SPI6	SP112	day7	Vmax	Duration	Pop_Density	Mean_Elevation	Median_Elevation	Root_Zone	Treed_area	Water	Developed	Barren	Forest	Scrub	Grassland	Pasture	Crops_cultivated	Wetlands	Fraction Outages		

Figure S4. Spearman correlation coefficient[1] for the variables listed in Table 1.

S1: Variation of Hurricane Winds across Cities

Wind speed is an important factor causing outages, and any uncertainty in wind speed estimates could lead to errors in outage predictions. We investigated the variation in wind speeds across cities. We estimated the coefficient of variation (COV) of wind speeds for each city in the states of New Jersey and New York during hurricane Isaias (2020), Florida during hurricane Michael (2018), and Texas during Hurricane Harvey (2017). To compute COV, we first compute the 3-s wind gust at points spaced based on the tropical cyclone's wind profile[2] at the 0.025° x 0.025° resolution in each state. Then, we compute the mean and standard deviation of wind gusts in each city by accounting for the points occurring within a city. Finally, the COV is computed as the ratio of standard deviation and mean. The high value of the COV can indicate the high variability in wind speeds. Figure S5 illustrates the 3-s wind gust in New Jersey during hurricane Isaias (2020) for points spaced at 0.025° x 0.025°.

We studied how COV changes for different spacing of the points. The mean COV for wind gusts with 0.025° x 0.025° points spacing in New Jersey is 0.001, New York is 0.003, Florida is 0.02, and Texas is 0.02. The change in COV for all states is minimal when increasing the resolution from 0.05° to 0.025°. Thus, given the minimal change in COV, we do not compute COV for resolutions higher than 0.025°. The low values of COV for wind gusts indicate that wind gusts at the centroid of a city would be a reasonable estimate of wind gusts to determine the city-wide outages. Figure S6 shows the histograms showing each state's COV distribution for wind gusts.



Figure S5. 3-s wind gust wind speeds for points spaced at 0.025° x 0.025°



Figure S6. Distribution of Coefficient of Variation in 3-s wind gusts for (a) New Jersey (NJ) winds, (b) New York (NYS) winds, (c) Florida (FL) winds, (d) Texas (TX) winds

References

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