Lightning Activity Report for Test_Dagpazari RES

Analyzed Period:

01-05-2024 - 31-05-2024

Centroid Coordinates:

Latitude: 36.76824

Longitude: 33.41431

Report Generated: 28-08-2025 13:57

This report provides comprehensive lightning and storm activity analysis for wind farm operations and safety assessment. Each section includes detailed explanations to help you understand the data and make informed decisions about turbine safety

Turbine Information

This table contains detailed information about all turbines in the wind farm.

Turbine	Lat	Lng	Unit Power (MWm)	Unit Power (MWe)	Tower Height (m)	Rotor Diameter (m)	Altitude (m)
T1	36.7719	33.4050	N/A	N/A	N/A	N/A	N/A
T2	36.7703	33.4075	N/A	N/A	N/A	N/A	N/A
T3	36.7686	33.4100	N/A	N/A	N/A	N/A	N/A
T4	36.7664	33.4125	N/A	N/A	N/A	N/A	N/A
T5	36.7642	33.4147	N/A	N/A	N/A	N/A	N/A
T6	36.7628	33.4175	N/A	N/A	N/A	N/A	N/A
T7	36.7728	33.4117	N/A	N/A	N/A	N/A	N/A
T8	36.7706	33.4142	N/A	N/A	N/A	N/A	N/A
T9	36.7617	33.4200	N/A	N/A	N/A	N/A	N/A
T10	36.7669	33.4192	N/A	N/A	N/A	N/A	N/A
T11	36.7658	33.4217	N/A	N/A	N/A	N/A	N/A
T12	36.7739	33.4164	N/A	N/A	N/A	N/A	N/A
T13	36.7747	33.4206	N/A	N/A	N/A	N/A	N/A
T14	36.7733	33.4011	N/A	N/A	N/A	N/A	N/A
T15	36.7597	33.4228	N/A	N/A	N/A	N/A	N/A

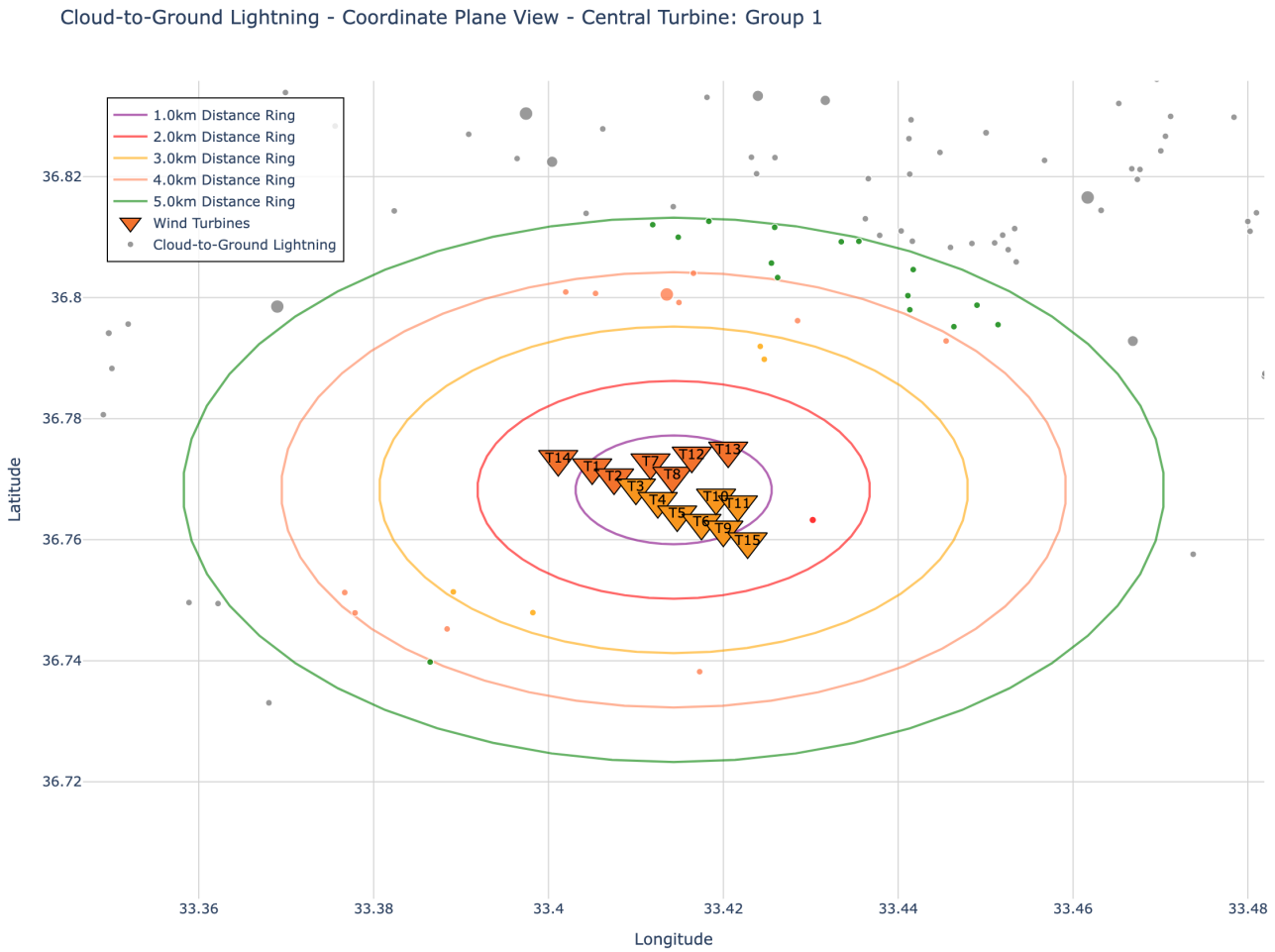
Turbine Group Information:

Total turbines: 15
Overall centroid: Lat 36.76824, Lng 33.41431
Analysis radius: 5.0 km from centroid

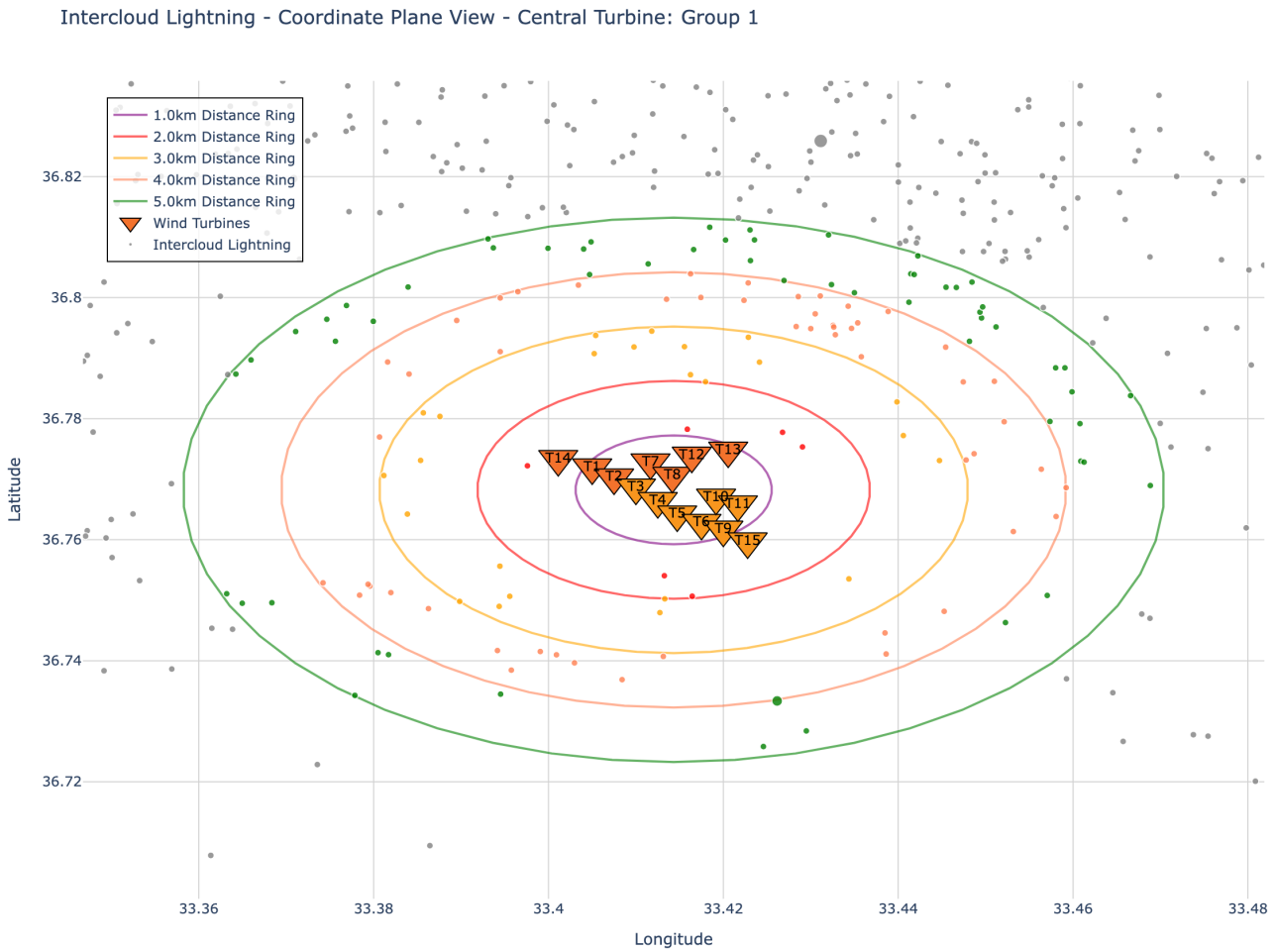
Map Interpretation Guide:

• Lightning circles: Size correlates with current magnitude (amperes) - larger circles = higher current
• Turbine colors: Color gradient correlates with risk score - blue (low) to red (high)
• Distance rings: Show proximity zones from turbine centroid (1km, 2km, 3km, 4km, 5km)
• Coordinate planes: X-axis = Latitude, Y-axis = Longitude
• Turbine markers: Inverted triangle symbols with turbine names
• Storm cells: Purple star symbols with 'S' label (if any)

Cloud-to-Ground Lightnings



Intercloud Lightnings



Turbine Risk Assessment

Group 1 Turbines

Turbine Name	Log Risk
T13	0.94
T12	0.91
T7	0.86
T8	0.83
T1	0.82
T2	0.81
T14	0.81
T3	0.79
T10	0.77
T11	0.77
T4	0.75
T5	0.73
T9	0.72
T6	0.71
T15	0.70

Daily Lightning Breakdown by Distance Rings

Area covered within 5.0 km radius: 78.5 km²

Total lightnings within 5.0 km radius: 171 events

Total lightning density: 2.177 events/km²

(Calculation: 171 total lightnings / 78.5 km² area)

Daily lightning density: 0.070 events/km²/day

(Calculation: 171 total lightnings / 78.5 km² area / 31 days in the month)

Daily Analysis:

This section shows lightning events organized by date and distance from turbines.
Higher counts in closer rings (1-2km) indicate elevated risk to turbine operations.

Date: 01-05-2024 (Total: 6 lightning events)

3.0-4.0km: 1 total (0 CG, 1 IC)
4.0-5.0km: 5 total (0 CG, 5 IC)

Date: 02-05-2024 (Total: 160 lightning events)

1.0-2.0km: 6 total (0 CG, 6 IC)
2.0-3.0km: 28 total (4 CG, 24 IC)
3.0-4.0km: 61 total (11 CG, 50 IC)
4.0-5.0km: 65 total (12 CG, 53 IC)

Date: 22-05-2024 (Total: 5 lightning events)

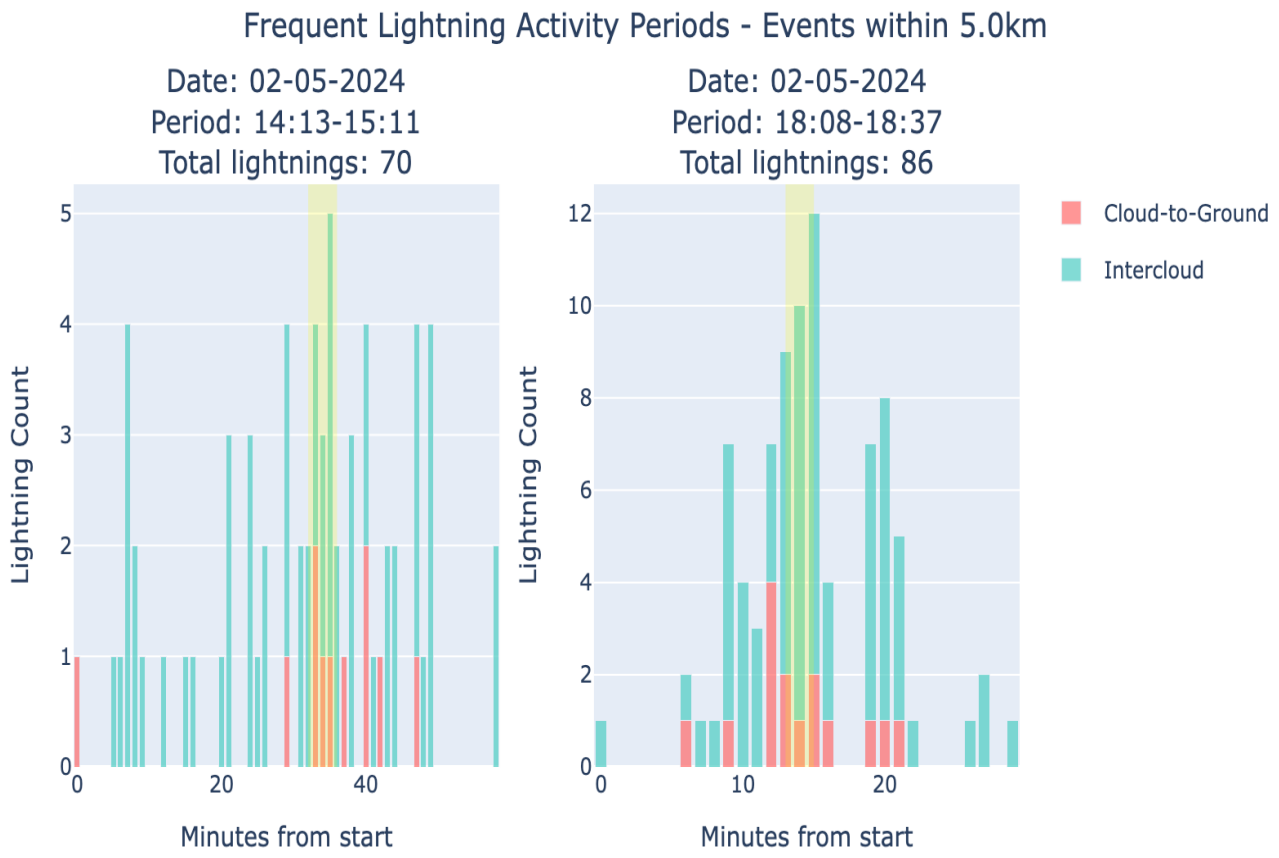
1.0-2.0km: 1 total (1 CG, 0 IC)
3.0-4.0km: 1 total (0 CG, 1 IC)
4.0-5.0km: 3 total (3 CG, 0 IC)

Frequent Lightning Activity Report

01-05-2024 - 31-05-2024

Lightning Activity Overview:

The chart below shows lightning activity patterns over time, helping identify high-risk periods and concentrated storm events. Peaks indicate intense lightning activity requiring attention.
For detailed information go to the "Frequent Lightning Activity Period Detection Algorithm" section in the appendix.



Storm Cells Analysis Summary

01-05-2024 - 31-05-2024

Storm Cells Overview:

The following pages show storm cell boundaries organized by day during the analysis period.
Each cell represents a storm system with defined boundaries and storm severity levels.

Storm Cells Summary:

Total storm cells: 7

Severity breakdown:

- Low: 7 cells

Average direction: 251.3°

Average speed: 15.4 km/h

Daily Storm Breakdown:

- 02-05-2024: 7 storm cells

Complete Storm Cells List:

No.	Severity	Effective Time	Expire Time
1	Low	02-05-2024 14:37	02-05-2024 15:22
2	Low	02-05-2024 14:37	02-05-2024 15:22
3	Low	02-05-2024 14:37	02-05-2024 15:22
4	Low	02-05-2024 18:25	02-05-2024 19:10
5	Low	02-05-2024 18:25	02-05-2024 19:10
6	Low	02-05-2024 18:25	02-05-2024 19:10
7	Low	02-05-2024 18:25	02-05-2024 19:10

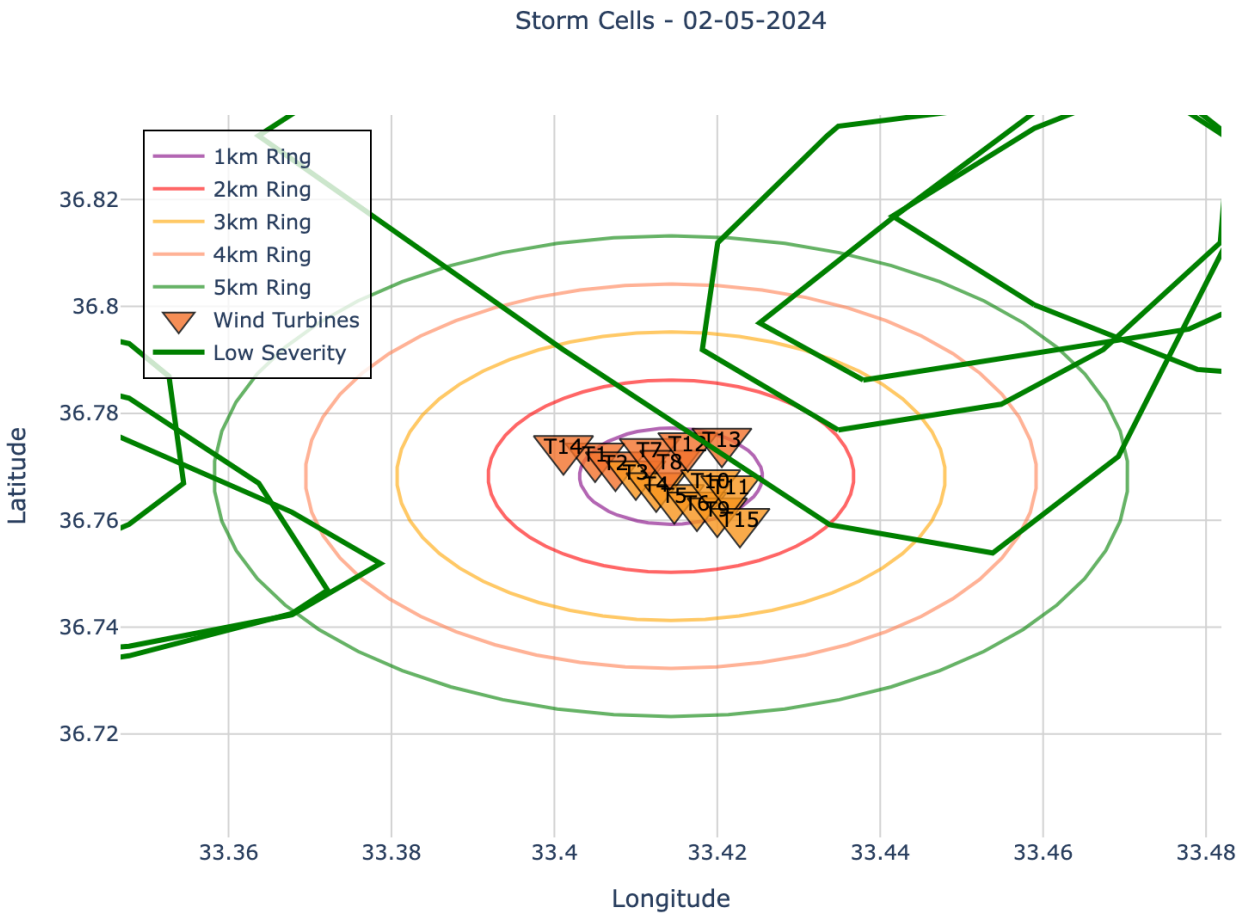
Storm Cells - 02-05-2024

Date: 02-05-2024

Number of storm cells: 7

Severity breakdown:

- Low: 7 cells



Detailed Lightning Event Data:

The table below lists all lightning events affecting this turbine group, sorted by risk level (cloud-to-ground strikes first, then by proximity). Row colors indicate distance zones.

Table Interpretation:

- Row colors: Match distance ring colors - indicates proximity to turbines
- Proximity: Distance from turbine group centroid in kilometers
- Current: Lightning current magnitude in amperes
- Height: Lightning height above ground in meters
- Lightning Type: Cloud-to-ground = highest risk, Intercloud = lower risk

Lightning Types:

- Cloud-to-Ground: Direct strikes to ground - highest damage potential
- Intercloud: Lightning between clouds - lower direct risk to turbines

#	Time (UTC)	Lat	Lng	Current (amps)	Height (m)	Lightning Type	Proximity (km)
1	22-05-2024 14:43:10	36.76326	33.43023	-9824	0	cloud-to-ground	1.52
2	02-05-2024 14:46:10	36.78981	33.42468	-3927	0	cloud-to-ground	2.57
3	02-05-2024 14:53:51	36.74794	33.39821	-2531	0	cloud-to-ground	2.67
4	02-05-2024 18:21:41	36.79193	33.42422	-3231	0	cloud-to-ground	2.78
5	02-05-2024 14:55:29	36.75138	33.38911	-5115	0	cloud-to-ground	2.93
6	02-05-2024 18:27:08	36.79618	33.42849	-4301	0	cloud-to-ground	3.35
7	02-05-2024 15:00:49	36.73818	33.41729	-3135	0	cloud-to-ground	3.35
8	02-05-2024 14:13:12	36.79918	33.41492	-6240	0	cloud-to-ground	3.44
9	02-05-2024 14:53:51	36.74525	33.38840	-2558	0	cloud-to-ground	3.44
10	02-05-2024 18:20:11	36.80053	33.41353	26669	0	cloud-to-ground	3.59
11	02-05-2024 18:20:11	36.80068	33.40538	-7196	0	cloud-to-ground	3.69
12	02-05-2024 18:14:27	36.80092	33.40197	-3720	0	cloud-to-ground	3.80
13	02-05-2024 14:42:24	36.75127	33.37669	-5763	0	cloud-to-ground	3.85
14	02-05-2024 18:22:37	36.79284	33.44548	-3400	0	cloud-to-ground	3.90
15	02-05-2024 14:47:29	36.74791	33.37787	-5032	0	cloud-to-ground	3.96
16	02-05-2024 18:20:11	36.80402	33.41658	-6266	0	cloud-to-ground	3.98
17	02-05-2024 16:33:16	36.73979	33.38646	-6052	0	cloud-to-ground	4.02
18	02-05-2024 14:46:11	36.80331	33.42621	-7448	0	cloud-to-ground	4.04

#	Time (UTC)	Lat	Lng	Current (amps)	Height (m)	Lightning Type	Proximity (km)
19	02-05-2024 18:29:52	36.79799	33.44133	-4864	0	cloud-to-ground	4.09
20	02-05-2024 14:50:31	36.79519	33.44637	-1644	0	cloud-to-ground	4.14
21	02-05-2024 18:17:15	36.80570	33.42550	-3575	0	cloud-to-ground	4.28
22	02-05-2024 14:48:28	36.80032	33.44111	-3981	0	cloud-to-ground	4.29
23	02-05-2024 18:28:54	36.79553	33.45142	-4751	0	cloud-to-ground	4.49
24	02-05-2024 18:24:35	36.79875	33.44901	-4853	0	cloud-to-ground	4.59
25	02-05-2024 18:21:41	36.80998	33.41484	-4971	0	cloud-to-ground	4.64
26	22-05-2024 14:30:15	36.80463	33.44172	-7216	0	cloud-to-ground	4.73
27	02-05-2024 18:23:26	36.81204	33.41192	-3931	0	cloud-to-ground	4.87
28	22-05-2024 14:32:47	36.80923	33.43349	-5122	0	cloud-to-ground	4.87
29	02-05-2024 18:23:45	36.81161	33.42587	-4176	0	cloud-to-ground	4.93
30	22-05-2024 14:32:47	36.80930	33.43550	-4887	0	cloud-to-ground	4.94
31	02-05-2024 18:20:11	36.81260	33.41834	-5374	0	cloud-to-ground	4.95
32	02-05-2024 18:08:37	36.77825	33.41588	-2830	5687	intercloud	1.12
33	02-05-2024 18:21:05	36.77532	33.42905	3449	5982	intercloud	1.53
34	02-05-2024 14:44:49	36.77774	33.42677	-3396	6609	intercloud	1.53
35	02-05-2024 14:45:14	36.77220	33.39759	-1949	5928	intercloud	1.55
36	02-05-2024 14:56:21	36.75404	33.41325	-2314	6189	intercloud	1.58
37	02-05-2024 15:00:49	36.75066	33.41644	-3693	19270	intercloud	1.96
38	02-05-2024 14:21:55	36.78610	33.41796	-1735	4228	intercloud	2.01
39	02-05-2024 14:57:43	36.75022	33.41330	-1951	10669	intercloud	2.01
40	02-05-2024 18:22:08	36.78726	33.41624	-3794	5762	intercloud	2.12
41	02-05-2024 14:37:52	36.74794	33.41274	-3314	12149	intercloud	2.26
42	02-05-2024 14:56:21	36.75563	33.39444	-1981	5844	intercloud	2.26
43	02-05-2024 15:00:49	36.75352	33.43436	2793	19366	intercloud	2.42
44	02-05-2024 18:16:59	36.78933	33.42413	3599	3006	intercloud	2.50
45	02-05-2024 18:20:52	36.77720	33.44059	-3153	5041	intercloud	2.54
46	02-05-2024 14:57:01	36.75064	33.39557	-2973	19994	intercloud	2.57
47	02-05-2024 14:21:11	36.79189	33.41555	-2372	6816	intercloud	2.63
48	02-05-2024 14:46:10	36.77309	33.38537	-4251	14590	intercloud	2.63
49	02-05-2024 18:20:44	36.79074	33.40523	-3657	5052	intercloud	2.63
50	02-05-2024 18:19:04	36.79184	33.40978	3064	4000	intercloud	2.66
51	02-05-2024 18:22:09	36.78036	33.38758	4646	13890	intercloud	2.74
52	02-05-2024 14:37:52	36.76423	33.38386	3670	5781	intercloud	2.75
53	02-05-2024 18:24:35	36.77307	33.44472	-3317	15217	intercloud	2.76
54	02-05-2024 14:53:51	36.74898	33.39436	-1744	6481	intercloud	2.78
55	02-05-2024 18:22:05	36.78276	33.43986	-1919	16968	intercloud	2.79
56	02-05-2024 18:18:14	36.79345	33.42286	-4654	7443	intercloud	2.90

#	Time (UTC)	Lat	Lng	Current (amps)	Height (m)	Lightning Type	Proximity (km)
57	02-05-2024 14:49:19	36.79446	33.41181	-1843	3216	intercloud	2.92
58	02-05-2024 18:19:04	36.78095	33.38568	3536	4205	intercloud	2.92
59	02-05-2024 14:25:46	36.79375	33.40540	-5530	3000	intercloud	2.95
60	02-05-2024 14:34:49	36.77060	33.38117	-2293	7112	intercloud	2.96
61	02-05-2024 14:38:16	36.74980	33.38984	4751	9655	intercloud	2.99
62	02-05-2024 18:35:04	36.77317	33.44777	-1734	17373	intercloud	3.03
63	02-05-2024 14:51:36	36.74071	33.41313	-2317	10426	intercloud	3.06
64	02-05-2024 18:17:11	36.79107	33.39448	7407	7297	intercloud	3.09
65	02-05-2024 18:27:38	36.79022	33.43578	-2883	6174	intercloud	3.10
66	02-05-2024 18:21:55	36.77420	33.44868	2178	4211	intercloud	3.13
67	02-05-2024 18:19:39	36.77696	33.38067	2236	17155	intercloud	3.15
68	02-05-2024 18:29:00	36.79521	33.42833	4313	3040	intercloud	3.25
69	02-05-2024 14:48:56	36.74098	33.40091	3230	7738	intercloud	3.26
70	02-05-2024 14:37:53	36.74152	33.39906	-2286	6384	intercloud	3.27
71	02-05-2024 18:21:57	36.79488	33.43000	-2903	4010	intercloud	3.28
72	02-05-2024 18:27:38	36.79386	33.43281	-2604	7543	intercloud	3.29
73	02-05-2024 14:54:42	36.74861	33.38627	-2708	17048	intercloud	3.32
74	02-05-2024 16:35:27	36.73964	33.40297	-5035	11735	intercloud	3.34
75	02-05-2024 15:02:15	36.74459	33.43849	-1709	7145	intercloud	3.40
76	02-05-2024 18:22:01	36.79513	33.43263	-2864	6135	intercloud	3.41
77	02-05-2024 14:34:49	36.78737	33.38405	-2967	6307	intercloud	3.43
78	02-05-2024 18:27:23	36.79542	33.43256	-3377	18715	intercloud	3.43
79	02-05-2024 14:51:36	36.75125	33.38197	-2493	6277	intercloud	3.45
80	02-05-2024 14:45:44	36.74168	33.39416	-4807	19534	intercloud	3.46
81	02-05-2024 18:28:08	36.79492	33.43466	-2256	17874	intercloud	3.48
82	02-05-2024 14:20:19	36.79973	33.41350	1999	6354	intercloud	3.50
83	02-05-2024 14:53:51	36.73688	33.40842	-1954	6824	intercloud	3.53
84	02-05-2024 18:28:53	36.79732	33.43051	-1254	5590	intercloud	3.54
85	02-05-2024 18:21:25	36.76135	33.45317	-3731	3505	intercloud	3.54
86	02-05-2024 18:23:40	36.80002	33.41743	-2565	5187	intercloud	3.54
87	02-05-2024 15:02:15	36.74815	33.44526	2507	16813	intercloud	3.55
88	02-05-2024 18:27:16	36.78607	33.44744	1462	9994	intercloud	3.55
89	02-05-2024 18:28:24	36.79955	33.42236	-2327	6165	intercloud	3.55
90	02-05-2024 14:42:25	36.75233	33.37958	3162	17845	intercloud	3.56
91	02-05-2024 14:42:25	36.75263	33.37936	5151	19374	intercloud	3.57
92	02-05-2024 14:28:06	36.79582	33.43537	-1669	4556	intercloud	3.59
93	02-05-2024 18:22:55	36.77949	33.45212	-2435	6948	intercloud	3.59
94	02-05-2024 14:47:08	36.73845	33.39575	2213	17302	intercloud	3.70

#	Time (UTC)	Lat	Lng	Current (amps)	Height (m)	Lightning Type	Proximity (km)
95	02-05-2024 15:02:15	36.74111	33.43862	3500	17093	intercloud	3.71
96	02-05-2024 14:51:36	36.75083	33.37839	-3312	17632	intercloud	3.74
97	02-05-2024 18:18:49	36.78935	33.38160	4846	5769	intercloud	3.74
98	02-05-2024 18:21:25	36.77164	33.45637	2670	4406	intercloud	3.76
99	02-05-2024 14:20:40	36.80016	33.42857	2937	18263	intercloud	3.77
100	01-05-2024 12:46:37	36.79181	33.44543	-2654	10853	intercloud	3.81
101	02-05-2024 18:29:32	36.79857	33.43428	-2475	3501	intercloud	3.81
102	02-05-2024 18:17:35	36.79622	33.38950	5140	7332	intercloud	3.82
103	02-05-2024 18:34:39	36.78616	33.45100	1417	6200	intercloud	3.83
104	02-05-2024 18:28:02	36.80027	33.43109	-2392	16242	intercloud	3.86
105	02-05-2024 18:20:25	36.80242	33.42284	-3526	18972	intercloud	3.88
106	02-05-2024 18:22:33	36.80206	33.40342	-2690	18483	intercloud	3.88
107	02-05-2024 18:23:22	36.76383	33.45806	-3941	7230	intercloud	3.93
108	02-05-2024 18:17:56	36.79994	33.39448	-2854	7935	intercloud	3.94
109	22-05-2024 14:28:53	36.79771	33.43885	2554	4390	intercloud	3.94
110	02-05-2024 14:42:25	36.75288	33.37421	2994	16004	intercloud	3.96
111	02-05-2024 18:23:15	36.80098	33.39650	-3381	3363	intercloud	3.97
112	02-05-2024 18:23:57	36.80392	33.41625	-3270	19255	intercloud	3.97
113	02-05-2024 15:11:03	36.76860	33.45921	-2924	17618	intercloud	4.00
114	02-05-2024 18:18:02	36.80283	33.42694	-1911	6438	intercloud	4.01
115	01-05-2024 14:51:11	36.73335	33.42615	-14221	5368	intercloud	4.02
116	01-05-2024 12:44:53	36.77954	33.45736	-2961	8693	intercloud	4.03
117	02-05-2024 18:22:45	36.80380	33.40470	-3153	7871	intercloud	4.05
118	02-05-2024 18:28:54	36.79277	33.44815	-2640	7289	intercloud	4.06
119	02-05-2024 18:21:57	36.80080	33.43499	4181	6792	intercloud	4.06
120	02-05-2024 14:22:19	36.80215	33.43237	-2095	16569	intercloud	4.10
121	02-05-2024 16:35:27	36.73448	33.39452	-4084	7182	intercloud	4.15
122	02-05-2024 14:20:02	36.80557	33.41140	-2325	6373	intercloud	4.16
123	02-05-2024 15:11:26	36.74631	33.45227	-1931	7355	intercloud	4.17
124	01-05-2024 12:39:10	36.77297	33.46089	-2470	16581	intercloud	4.18
125	02-05-2024 14:48:28	36.79923	33.44123	-3760	19201	intercloud	4.20
126	02-05-2024 15:00:49	36.74100	33.38170	3732	18756	intercloud	4.20
127	02-05-2024 18:22:37	36.77281	33.46126	-2582	17324	intercloud	4.21
128	02-05-2024 14:48:56	36.74133	33.38050	-2852	18883	intercloud	4.25
129	02-05-2024 18:27:42	36.75078	33.45705	-3810	13943	intercloud	4.27
130	02-05-2024 18:21:22	36.80610	33.42310	-1910	16259	intercloud	4.28
131	01-05-2024 12:39:10	36.77918	33.46079	-3034	17142	intercloud	4.31
132	02-05-2024 14:33:14	36.79608	33.37996	4781	19633	intercloud	4.35

#	Time (UTC)	Lat	Lng	Current (amps)	Height (m)	Lightning Type	Proximity (km)
133	02-05-2024 18:17:11	36.79278	33.37563	-6625	5301	intercloud	4.39
134	02-05-2024 14:20:02	36.80794	33.41660	2567	8329	intercloud	4.42
135	02-05-2024 18:28:54	36.79515	33.45119	-2365	17098	intercloud	4.44
136	02-05-2024 18:23:22	36.78443	33.45988	-4312	6118	intercloud	4.44
137	02-05-2024 18:28:54	36.79664	33.44953	-1936	16440	intercloud	4.45
138	02-05-2024 18:27:00	36.78840	33.45801	-3095	7379	intercloud	4.49
139	02-05-2024 14:48:05	36.79760	33.44935	-1887	5028	intercloud	4.52
140	02-05-2024 18:22:45	36.80802	33.40402	-3739	7660	intercloud	4.52
141	02-05-2024 18:30:38	36.78840	33.45907	1580	17376	intercloud	4.57
142	02-05-2024 14:47:29	36.74958	33.36836	-2616	5551	intercloud	4.59
143	02-05-2024 18:14:07	36.80175	33.38394	2978	3943	intercloud	4.60
144	02-05-2024 18:23:53	36.79846	33.44966	-3468	6986	intercloud	4.60
145	02-05-2024 14:19:29	36.80815	33.39994	1387	17784	intercloud	4.62
146	02-05-2024 18:18:26	36.80951	33.42025	6128	6102	intercloud	4.62
147	02-05-2024 15:02:15	36.72840	33.42949	3642	7051	intercloud	4.63
148	02-05-2024 18:23:57	36.80921	33.40487	-2752	4975	intercloud	4.63
149	02-05-2024 18:29:52	36.80392	33.44144	4541	6377	intercloud	4.64
150	02-05-2024 18:23:49	36.80171	33.44547	-2975	17530	intercloud	4.64
151	02-05-2024 18:35:04	36.80381	33.44183	3254	17167	intercloud	4.65
152	02-05-2024 14:34:16	36.80954	33.42356	-3243	6628	intercloud	4.67
153	02-05-2024 18:24:04	36.80168	33.44665	-2832	13919	intercloud	4.70
154	02-05-2024 14:39:37	36.79641	33.37464	2136	7186	intercloud	4.72
155	02-05-2024 14:39:37	36.79869	33.37689	2190	17112	intercloud	4.75
156	02-05-2024 15:01:41	36.72583	33.42458	-3788	10375	intercloud	4.80
157	01-05-2024 12:41:37	36.80822	33.39369	4056	17590	intercloud	4.81
158	02-05-2024 14:29:52	36.79439	33.37108	3026	3259	intercloud	4.82
159	02-05-2024 18:17:01	36.81163	33.41844	-3937	9058	intercloud	4.84
160	02-05-2024 18:24:38	36.81117	33.42305	-4353	19775	intercloud	4.84
161	02-05-2024 18:23:49	36.76895	33.46884	1509	15418	intercloud	4.86
162	02-05-2024 14:44:19	36.74949	33.36497	-2834	7168	intercloud	4.87
163	02-05-2024 14:49:54	36.80257	33.44844	-2667	9285	intercloud	4.88
164	02-05-2024 18:17:15	36.78970	33.36597	3548	3000	intercloud	4.92
165	02-05-2024 14:46:26	36.75107	33.36319	-3278	6083	intercloud	4.94
166	02-05-2024 18:15:06	36.78737	33.36424	-5664	7447	intercloud	4.94
167	02-05-2024 18:23:15	36.81036	33.43203	3613	4501	intercloud	4.94
168	02-05-2024 18:37:24	36.78379	33.46658	5511	17384	intercloud	4.97
169	02-05-2024 18:29:52	36.80689	33.44225	2994	6093	intercloud	4.97
170	02-05-2024 14:18:13	36.80969	33.39308	-4495	6675	intercloud	4.98

#	Time (UTC)	Lat	Lng	Current (amps)	Height (m)	Lightning Type	Proximity (km)
171	02-05-2024 16:34:00	36.73428	33.37785	-5364	4138	intercloud	4.98

Appendix

1. Risk Calculation Method

How Risk Scores Are Determined:
Risk scores combine lightning current magnitude and distance from turbines.
Higher scores indicate greater exposure and potential damage risk.
• Risk = P0 × (1 + α×Current/10000) × e^(-α×Distance)
• P0 = Base probability (1.0), α = Distance decay factor (0.5)
• Current = Lightning current magnitude in amperes
• Distance = Distance from turbine in kilometers
• Higher current and closer distance = Higher risk score
• Risk scores are summed for all lightning strikes affecting each turbine.
The log value of the calculated risk score is used to represent the risk level.

2. Risk Score Interpretation

Understanding Risk Score Values:

• Minimum Risk Score: ~0.001 (far distance, low current)
• Maximum Risk Score: ~2.500 (close distance, high current)
• Typical Range: 0.010 - 1.000 for most lightning events
• Log Scale: log10(risk_score + 1) used for visualization

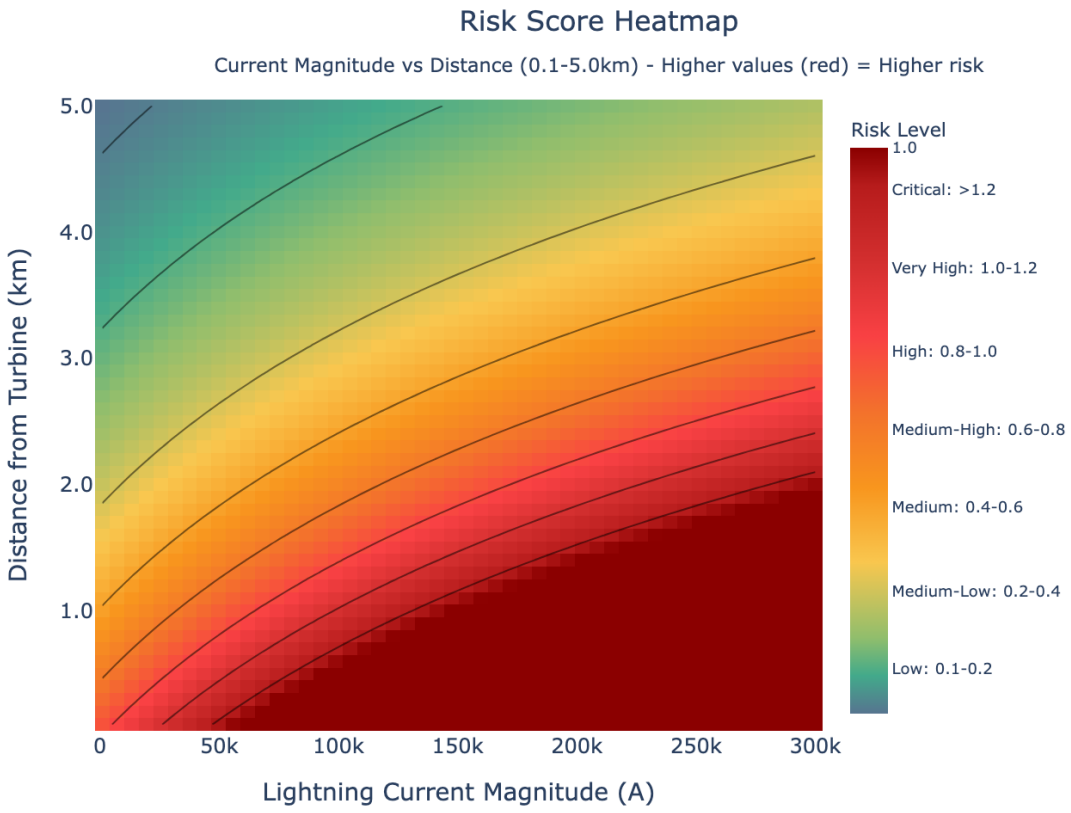
Risk Score Categories (Fixed Color Intervals):

• Very Low Risk (<0.1): Blue - Distant lightning with low current
• Low Risk (0.1-0.2): Teal - Moderate distance lightning
• Med-Low Risk (0.2-0.4): Green - Closer lightning
• Medium Risk (0.4-0.6): Yellow - Moderate risk lightning
• Med-High Risk (0.6-0.8): Orange - High risk lightning
• High Risk (0.8-1.0): Dark Orange - Very high risk lightning
• Very High Risk (1.0-1.2): Red - Extreme risk lightning
• Critical Risk (>1.2): Dark Red - Critical risk lightning

3. Risk Score Calculation Chart

Chart Reference Guide:

The following chart shows how distance and current magnitude affect risk scores.
Use this chart to interpret the risk scores in the main report.
• Red areas = High risk (close distance, high current)
• Yellow/Orange areas = Medium risk
• Blue/Green areas = Low risk (far distance, low current)



4. Centroid and Distance Ring Calculation

• Turbines are grouped by proximity (within 4km of each other)
• Group centroid = Average latitude and longitude of all turbines in the group
• Distance rings are drawn from the group centroid, not individual turbines
• Single isolated turbines get their own centroid (individual analysis)
• Distance calculations use Haversine formula for accurate geographic distances

5. Turbine Grouping Method

How Turbines Are Grouped for Analysis:

The system uses an intelligent clustering algorithm to group turbines based on geographic proximity.

Grouping Algorithm Process:

1. Proximity Analysis: All turbines are analyzed for pairwise distances using Haversine formula
2. Clustering Method: Uses DBSCAN (Density-Based Spatial Clustering) algorithm when available
3. Dynamic Distance Threshold: Configurable grouping radius: 5.0km (5000m)
4. Fallback Algorithm: If DBSCAN unavailable, uses iterative proximity grouping
5. Group Formation: Each group contains turbines that are mutually within the distance threshold

Group Types and Analysis:

• Multi-Turbine Groups: Multiple turbines within proximity range - analyzed as a cluster
• Single Turbine Groups: Isolated turbines beyond grouping threshold - individual analysis
• Centroid Calculation: Each group's center point calculated as mean of member coordinates
• Distance Ring Origin: All proximity calculations use group centroid as reference point

Benefits of Grouping Approach:

• Efficient Analysis: Reduces computational complexity for large wind farms
• Logical Clustering: Groups turbines that experience similar weather conditions
• Risk Assessment: Provides both group-level and individual turbine risk analysis
• Scalability: Algorithm adapts to wind farms of any size and turbine distribution

6. Frequent Lightning Activity Period Detection Algorithm

How Period Timespans Are Determined:

The algorithm uses a gap-based approach to identify concentrated lightning activity periods.

Step-by-Step Process:

1. Chronological Sorting: All lightning events are sorted by timestamp (local_time)
2. Gap Calculation: Time differences between consecutive lightning events are calculated
3. Period Boundary Detection:
   • When a gap between two consecutive events exceeds 30 minutes (configurable), it marks the end of one period and the start of another
   • This creates natural breaks in lightning activity
4. Period Validation:
   • Only periods with ≥10 lightning events (configurable) are considered significant
   • This filters out minor activity and focuses on major storm events
5. Timespan Definition:
   • Start time: Timestamp of the first lightning event in the period
   • End time: Timestamp of the last lightning event in the period
   • The period timespan is the actual duration from first to last event, not a fixed duration
6. Peak Sub-Period Detection:
   • Uses a 3-minute rolling average to smooth the data
   • Identifies peaks when activity exceeds mean + 1 standard deviation
   • These peak periods are highlighted in yellow on the histogram