Supplementary Information for "Conductance Model for Extreme Events : Impact of Auroral Conductance on Space Weather Forecasts"

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1 Further Investigation of Oval Expansion during *Event 2*

In Section 3.1 of the main article, Figures 7 and 8 use magnetometer measurements to assess the impact of auroral conductance on the prediction of ground-based magnetic perturbations during Event 2 that occurred on December 14 - 16, 2006. In this section, we investigate the expansion of the auroral oval using photon radiance maps from the Defence Meteorological Satellite Program's (DMSP) Special Sensor Ultraviolet Spectrographic Imager (SSUSI). In Figure 1, we display radiance dial plots at four time instances observed by the DMSP F16 satellite. Correspondingly, these time instances are marked by colour on dB/dt measurement from Yellowknife (YKC) and Newport (NEW). During the early phase of the storm, SSUSI observations at 17:38:29 UT and 22:44:17 UT show the aurora confined sharply within MLat 60^0. As the event progresses, the main phase of the storm is characterized by an expansion of the auroral oval as seen in SSUSI observations at 02:08:09 UT and 06:14:36 UT. This expansion in the auroral oval corresponds with the variation seen in the dB/dt at the latitudinally higher YKC which is within the polar cap during the main phase of the storm and observes minimal disturbances, and the latitudinally lower NEW which observes dB/dt spikes during the same period when the auroral oval expands to the lower 50s MLat.

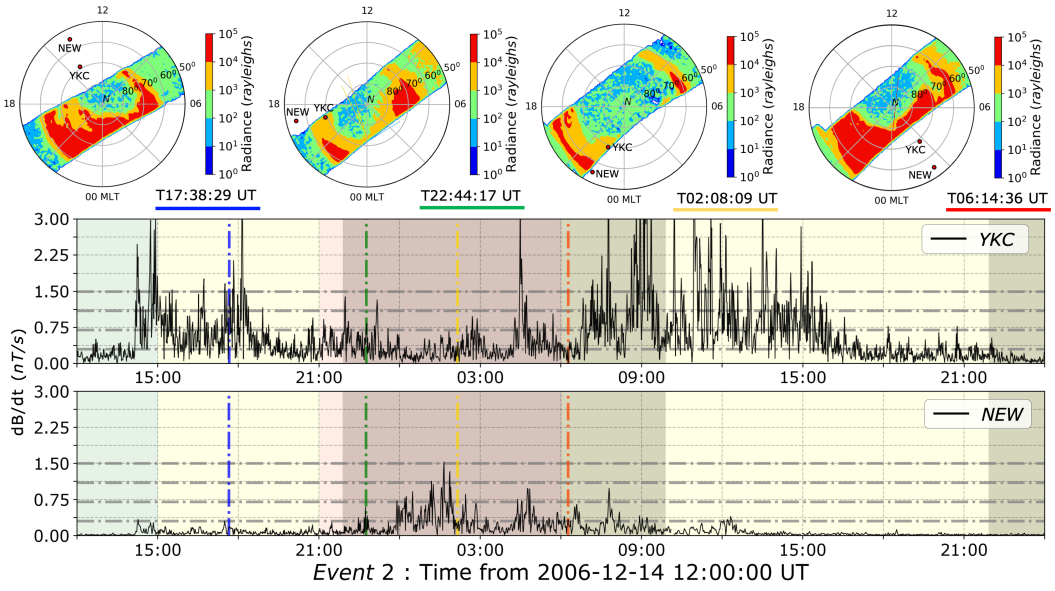

Figure 1. Expansion of the auroral oval as seen through DMSP SSUSI auroral radiance maps and the magnetometer stations at Yellowknife (YKC) and Newport (NEW). The SSUSI dial plots on top are demarcated by blue, green, yellow and red dot-dashed lines in the line plots, in increasing order of their timestamps. Line plots show raw dB/dt observations at a 1-minute cadence at YKC (top) and NEW (bottom). The background of the line plots are coloured by Kp, similarly to Figure 5 in the main paper. The dark shaded background regions are times when the respective magnetometer was on the nightside.

2 Comparison of dB/dt and ΔB Performance Metrics

The performance metrics calculated for multiple dB/dt and ΔB thresholds have been presented in the following. The metrics used has been listed in Table 2 of the main article. The format of these tables are similar to Tables 4 and 5 of the main article; for more details about those tables, please refer to Sections 3.2 and 3.3 of the main paper. For convenience, the tables have been coloured differently: In the tables listing dB/dt performance, green is used to denote best performance and red is used to denote worst. In ΔB tables, blue is used to denote best performance while orange is used to denote worst.

Usage of the auroral oval and CMEE amounts to an increase in False Negatives (F) in both ΔB and dB/dt predictions, while improving the rest of the quantities (H, M, N). Due to this reason, the FAR values are higher for oval runs, which results in less predictive score using the TSS metric. The new model (without the oval) has more misses (M) than the older model (without the oval), when predicting ΔB. For dB/dt predictions, the amount of skill lost during quieter activity, when simulating using CMEE, is more than regained with massive improvements for extreme driving, as is seen by Tables 3 to 7.

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.7776	0.7801	0.8436	0.8114	0.8342	0.8555	0.8976	0.8973
POFD	0.0631	0.0615	0.0903	0.0744	0.0938	0.0892	0.1687	0.1697
FAR	0.0431	0.0419	0.0560	0.0484	0.0587	0.0547	0.0944	0.0950
MR	0.2997	0.2970	0.2367	0.2686	0.2481	0.2224	0.1817	0.1823
TS	0.7513	0.7544	0.8034	0.7793	0.7929	0.8152	0.8208	0.8201
F1	0.8580	0.8600	0.8910	0.8760	0.8845	0.8982	0.9016	0.9012
TSS	0.6572	0.6611	0.7073	0.6830	0.6932	0.7229	0.7239	0.7227
HSS	0.6645	0.6687	0.7225	0.6959	0.7080	0.7381	0.7263	0.7251

Table 1. Performance metrics table for predicted dB/dt at Threshold = **0.1 nT/s**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.5814	0.5628	0.6782	0.6638	0.6444	0.6829	0.7970	0.7979
POFD	0.0416	0.0345	0.0597	0.0477	0.0426	0.0613	0.1038	0.1164
FAR	0.0858	0.0744	0.1034	0.0861	0.0797	0.1053	0.1459	0.1606
MR	0.2499	0.2567	0.2070	0.2121	0.2207	0.2049	0.1473	0.1485
TS	0.5513	0.5384	0.6290	0.6248	0.6103	0.6321	0.7015	0.6922
F1	0.7108	0.7000	0.7723	0.7690	0.7580	0.7746	0.8246	0.8181
TSS	0.6644	0.6689	0.6896	0.7017	0.6996	0.6899	0.7068	0.6909
HSS	0.5642	0.5541	0.6370	0.6368	0.6240	0.6396	0.6987	0.6855

Table 2. Performance metrics table for predicted dB/dt at Threshold = **0.3 nT/s**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.4812	0.4840	0.5636	0.5922	0.5496	0.5989	0.7244	0.7451
POFD	0.0331	0.0302	0.0497	0.0435	0.0378	0.0543	0.0926	0.1076
FAR	0.1244	0.1138	0.1539	0.1315	0.1241	0.1576	0.2087	0.2294
MR	0.2065	0.2051	0.1821	0.1713	0.1850	0.1706	0.1284	0.1217
TS	0.4504	0.4557	0.5112	0.5434	0.5099	0.5385	0.6082	0.6098
F1	0.6211	0.6261	0.6765	0.7042	0.6754	0.7001	0.7564	0.7576
TSS	0.6692	0.6811	0.6640	0.6972	0.6909	0.6718	0.6629	0.6489
HSS	0.5069	0.5139	0.5622	0.5977	0.5661	0.5883	0.6458	0.6430

Table 3. Performance metrics table for predicted dB/dt at Threshold = **0.5 nT/s**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.3949	0.4278	0.4661	0.5305	0.4812	0.5441	0.6537	0.7057
POFD	0.0255	0.0260	0.0365	0.0387	0.0285	0.0442	0.0801	0.0936
FAR	0.1502	0.1427	0.1765	0.1667	0.1395	0.1821	0.2516	0.2667
MR	0.1847	0.1765	0.1681	0.1512	0.1630	0.1482	0.1208	0.1059
TS	0.3692	0.3994	0.4238	0.4796	0.4463	0.4853	0.5359	0.5615
F1	0.5393	0.5708	0.5953	0.6483	0.6172	0.6535	0.6978	0.7192
TSS	0.6651	0.6809	0.6553	0.6821	0.6974	0.6697	0.6277	0.6274
HSS	0.4451	0.4779	0.4983	0.5559	0.5264	0.5594	0.5975	0.6195

Table 4. Performance metrics table for predicted dB/dt at Threshold = **0.7 nT/s**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.2920	0.3310	0.3520	0.4380	0.3770	0.4440	0.5300	0.6230
POFD	0.0222	0.0235	0.0284	0.0372	0.0273	0.0434	0.0687	0.0914
FAR	0.2532	0.2408	0.2651	0.2748	0.2445	0.3041	0.3668	0.3957
MR	0.1395	0.1330	0.1299	0.1156	0.1254	0.1152	0.1015	0.0850
TS	0.2657	0.2995	0.3123	0.3756	0.3360	0.3719	0.4055	0.4425
F1	0.4198	0.4610	0.4760	0.5461	0.5030	0.5421	0.5770	0.6135
TSS	0.6073	0.6262	0.6049	0.6096	0.6301	0.5808	0.5317	0.5193
HSS	0.3533	0.3936	0.4056	0.4736	0.4341	0.4660	0.4924	0.5253

Table 5. Performance metrics table for predicted dB/dt at Threshold = **1.1 nT/s**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.2216	0.2490	0.2668	0.3557	0.2791	0.3406	0.4309	0.5554
POFD	0.0169	0.0194	0.0253	0.0319	0.0262	0.0378	0.0566	0.0784
FAR	0.3306	0.3358	0.3810	0.3674	0.3780	0.4182	0.4597	0.4775
MR	0.1089	0.1057	0.1041	0.0932	0.1026	0.0957	0.0852	0.0693
TS	0.1998	0.2211	0.2291	0.2948	0.2386	0.2736	0.3153	0.3684
F1	0.3330	0.3622	0.3728	0.4553	0.3853	0.4297	0.4795	0.5385
TSS	0.5605	0.5585	0.5150	0.5394	0.5194	0.4861	0.4551	0.4532
HSS	0.2855	0.3120	0.3179	0.3973	0.3297	0.3672	0.4094	0.4647

Table 6. Performance metrics table for predicted dB/dt at Threshold = **1.5 nT/s**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.1975	0.2070	0.2389	0.3264	0.2452	0.3153	0.3838	0.5207
POFD	0.0161	0.0155	0.0238	0.0287	0.0246	0.0356	0.0529	0.0754
FAR	0.3861	0.3659	0.4340	0.4041	0.4359	0.4649	0.5151	0.5275
MR	0.0957	0.0947	0.0919	0.0826	0.0913	0.0844	0.0779	0.0630
TS	0.1756	0.1849	0.2019	0.2673	0.2062	0.2475	0.2726	0.3293
F1	0.2988	0.3121	0.3359	0.4218	0.3418	0.3968	0.4284	0.4955
TSS	0.5181	0.5395	0.4741	0.5133	0.4728	0.4508	0.4070	0.4095
HSS	0.2573	0.2709	0.2874	0.3706	0.2926	0.3406	0.3639	0.4264

Table 7. Performance metrics table for predicted dB/dt at Threshold = **1.7 nT/s**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.7293	0.7918	0.8099	0.7879	0.8603	0.8373	0.8882	0.8740
POF	0.1882	0.2296	0.3074	0.2836	0.3388	0.3199	0.4442	0.4003
FAR	0.1013	0.1124	0.1422	0.1358	0.1467	0.1430	0.1792	0.1667
MR	0.4330	0.3823	0.3860	0.4040	0.3261	0.3540	0.3153	0.3249
TS	0.6739	0.7196	0.7140	0.7011	0.7494	0.7346	0.7439	0.7439
F1	0.8052	0.8370	0.8331	0.8243	0.8568	0.8470	0.8532	0.8532
TSS	0.4658	0.5053	0.4718	0.4602	0.5272	0.5030	0.5055	0.5085
HSS	0.4825	0.5256	0.4850	0.4772	0.5243	0.5097	0.4689	0.4891

Table 8. Performance metrics table for predicted ΔB at Threshold = **100 nT**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.6803	0.7440	0.7534	0.7460	0.8184	0.7842	0.8599	0.8432
POF	0.1186	0.1460	0.2487	0.2186	0.2743	0.2469	0.3823	0.3354
FAR	0.1166	0.1294	0.2000	0.1816	0.2025	0.1925	0.2519	0.2315
MR	0.3238	0.2836	0.3024	0.3003	0.2484	0.2745	0.2304	0.2376
TS	0.6242	0.6699	0.6340	0.6400	0.6776	0.6606	0.6668	0.6724
F1	0.7686	0.8023	0.7760	0.7805	0.8078	0.7956	0.8001	0.8041
TSS	0.5595	0.5870	0.4976	0.5181	0.5491	0.5329	0.5177	0.5309
HSS	0.5418	0.5843	0.5000	0.5200	0.5463	0.5348	0.4893	0.5158

Table 9. Performance metrics table for predicted ΔB at Threshold = **150 nT**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.6331	0.6846	0.7241	0.7128	0.7812	0.7466	0.8142	0.8045
POF	0.0711	0.1117	0.1697	0.1523	0.2059	0.1929	0.3183	0.2683
FAR	0.1107	0.1532	0.2063	0.1916	0.2263	0.2228	0.3025	0.2701
MR	0.2625	0.2424	0.2305	0.2339	0.1990	0.2206	0.1973	0.1941
TS	0.5869	0.6092	0.6093	0.6098	0.6359	0.6150	0.6017	0.6200
F1	0.7397	0.7571	0.7573	0.7576	0.7774	0.7616	0.7513	0.7654
TSS	0.6267	0.6043	0.5631	0.5744	0.5747	0.5566	0.5002	0.5358
HSS	0.5702	0.5784	0.5568	0.5638	0.5750	0.5548	0.4918	0.5335

Table 10. Performance metrics table for predicted ΔB at Threshold = **200 nT**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.5774	0.6071	0.6998	0.6692	0.7686	0.7180	0.7830	0.7887
POF	0.0527	0.0799	0.1231	0.1129	0.1504	0.1504	0.2621	0.2265
FAR	0.1208	0.1656	0.2095	0.2027	0.2277	0.2399	0.3352	0.3020
MR	0.2284	0.2208	0.1851	0.1984	0.1531	0.1805	0.1633	0.1535
TS	0.5350	0.5418	0.5903	0.5719	0.6267	0.5853	0.5613	0.5880
F1	0.6971	0.7028	0.7424	0.7277	0.7705	0.7384	0.7191	0.7406
TSS	0.6508	0.6136	0.6054	0.5989	0.6193	0.5796	0.5015	0.5445
HSS	0.5569	0.5524	0.5881	0.5717	0.6188	0.5729	0.5058	0.5502

Table 11. Performance metrics table for predicted ΔB Threshold = **250 nT**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.5553	0.5422	0.6254	0.6145	0.7021	0.6703	0.7393	0.7426
POF	0.0456	0.0562	0.0960	0.0866	0.1194	0.1229	0.2054	0.1949
FAR	0.1333	0.1624	0.2231	0.2087	0.2414	0.2555	0.3421	0.3294
MR	0.1993	0.2058	0.1812	0.1840	0.1531	0.1672	0.1491	0.1459
TS	0.5116	0.4906	0.5302	0.5287	0.5739	0.5450	0.5340	0.5441
F1	0.6769	0.6582	0.6930	0.6917	0.7292	0.7055	0.6962	0.7048
TSS	0.6674	0.6318	0.5956	0.6073	0.6055	0.5773	0.5088	0.5248
HSS	0.5562	0.5295	0.5546	0.5568	0.5930	0.5604	0.5190	0.5344

Table 12. Performance metrics table for predicted ΔB at Threshold = **300 nT**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.5076	0.4810	0.5711	0.5698	0.6345	0.6193	0.6904	0.6967
POF	0.0529	0.0507	0.0752	0.0725	0.1041	0.1052	0.1750	0.1696
FAR	0.1952	0.1970	0.2347	0.2285	0.2764	0.2834	0.3711	0.3616
MR	0.1826	0.1902	0.1662	0.1662	0.1491	0.1546	0.1389	0.1356
TS	0.4520	0.4302	0.4860	0.4875	0.5107	0.4975	0.4905	0.4995
F1	0.6226	0.6016	0.6541	0.6555	0.6761	0.6644	0.6582	0.6663
TSS	0.6222	0.6127	0.5991	0.6053	0.5744	0.5620	0.4900	0.5027
HSS	0.5082	0.4858	0.5345	0.5373	0.5497	0.5348	0.5014	0.5137

Table 13. Performance metrics table for predicted ΔB at Threshold = **350 nT**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.4602	0.4385	0.5123	0.5224	0.5687	0.5485	0.6440	0.6671
POF	0.0575	0.0523	0.0616	0.0658	0.0865	0.0901	0.1393	0.1429
FAR	0.2587	0.2500	0.2516	0.2602	0.2982	0.3146	0.3768	0.3745
MR	0.1701	0.1749	0.1568	0.1546	0.1445	0.1508	0.1289	0.1220
TS	0.3965	0.3826	0.4370	0.4413	0.4580	0.4382	0.4635	0.4767
F1	0.5679	0.5534	0.6082	0.6124	0.6283	0.6093	0.6335	0.6457
TSS	0.5712	0.5751	0.5916	0.5851	0.5573	0.5346	0.4943	0.5035
HSS	0.4585	0.4456	0.5015	0.5042	0.5135	0.4898	0.4994	0.5132

Table 14. Performance metrics table for predicted ΔB at Threshold = **400 nT**

Metric	SET A	SET B	SET C	SET D	SET E	SET F	SET G	SET H
POD	0.4211	0.4243	0.4589	0.4803	0.5230	0.4901	0.5855	0.6184
POF	0.0487	0.0482	0.0536	0.0601	0.0715	0.0690	0.1127	0.1246
FAR	0.2768	0.2732	0.2791	0.2930	0.3117	0.3181	0.3894	0.4003
MR	0.1552	0.1544	0.1472	0.1431	0.1343	0.1419	0.1236	0.1163
TS	0.3626	0.3660	0.3897	0.4005	0.4229	0.3989	0.4263	0.4377
F1	0.5322	0.5358	0.5608	0.5720	0.5944	0.5703	0.5978	0.6089
TSS	0.5680	0.5724	0.5737	0.5640	0.5541	0.5400	0.4870	0.4834
HSS	0.4360	0.4401	0.4641	0.4732	0.4928	0.4670	0.4797	0.4885

Table 15. Performance metrics table for predicted ΔB at Threshold = **450 nT**