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Supplement of

Outlet glacier seasonal terminus prediction using interpretable machine learning

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S1 Data preparation plots for additional input variables in study

Figures S1-S9. We provide nine sample data preparation plots similar to Fig. 2 in the main text for the other input variables in this study. A figure for ice thickness is not included, as it is generated from bed elevation and surface elevation data post-interpolation.

S2 Model results for all glaciers in study

Figures S10-S53. We provide model output similar to Fig. 4 in the main text for the other 45 glaciers in this study. Figure captions are similar from figure to figure but we update the glacier name, GID, and the statistics of the model fit to the observations for each.

S3 Weather stations used in this study

Table C1. We provide a table showing the Danish Meteorological Institute weather station used for the air temperature time series by each glacier in this study, along with the distance between the station and the glacier.

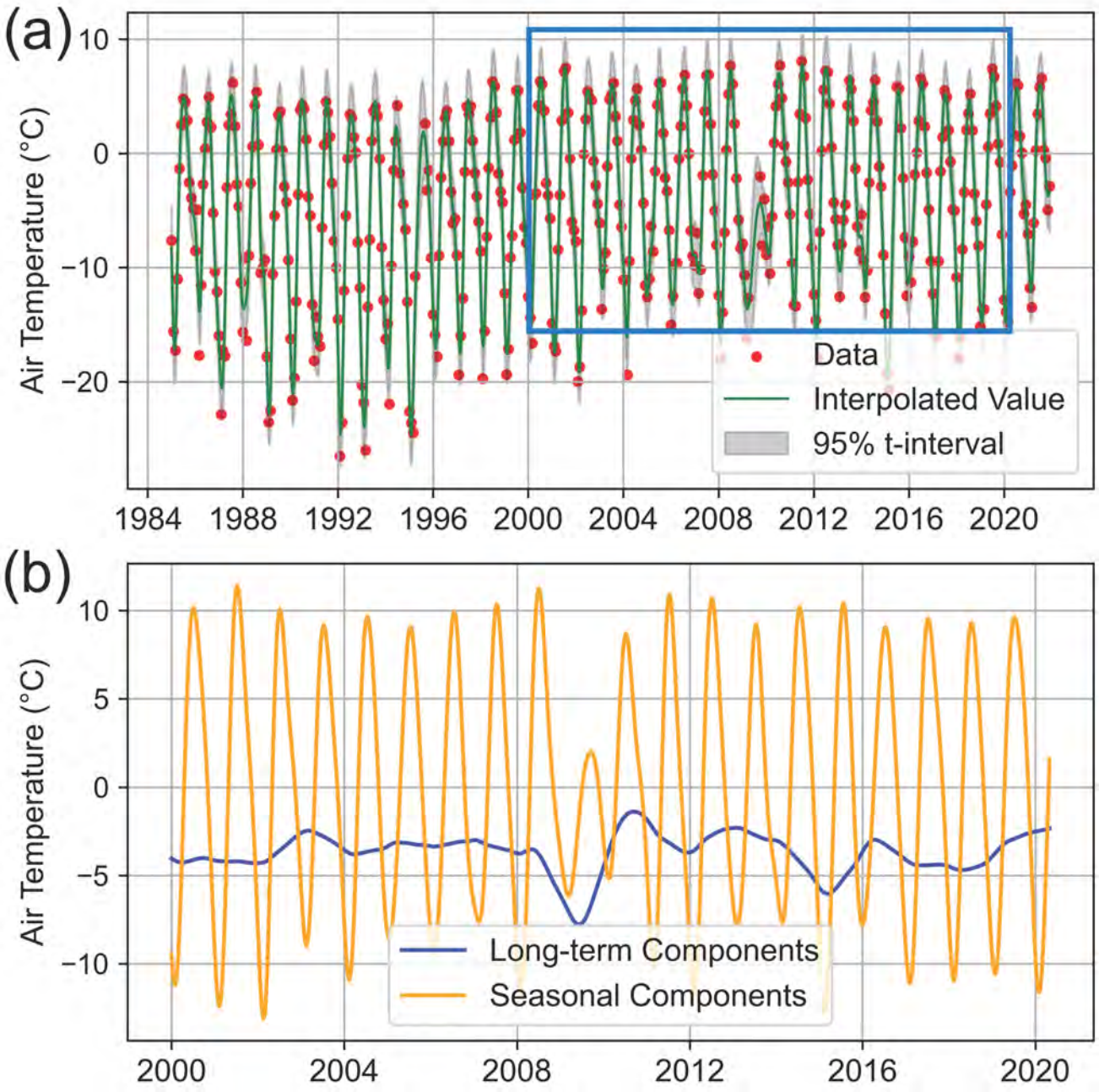

Figure S1. Sample data preparation for air temperature for Rink Isbræ (GID 1). (a) Approximation by localized penalized splines (ALPS) showing original data points in red, daily interpolation series in green, and the interpolation's 95% confidence interval in gray. Data used from 2000-2020 boxed in blue. (b) Long-term and seasonal trend components separated from the time series by single spectrum analysis (SSA). The SSA was conducted only on data from 2000-2020.

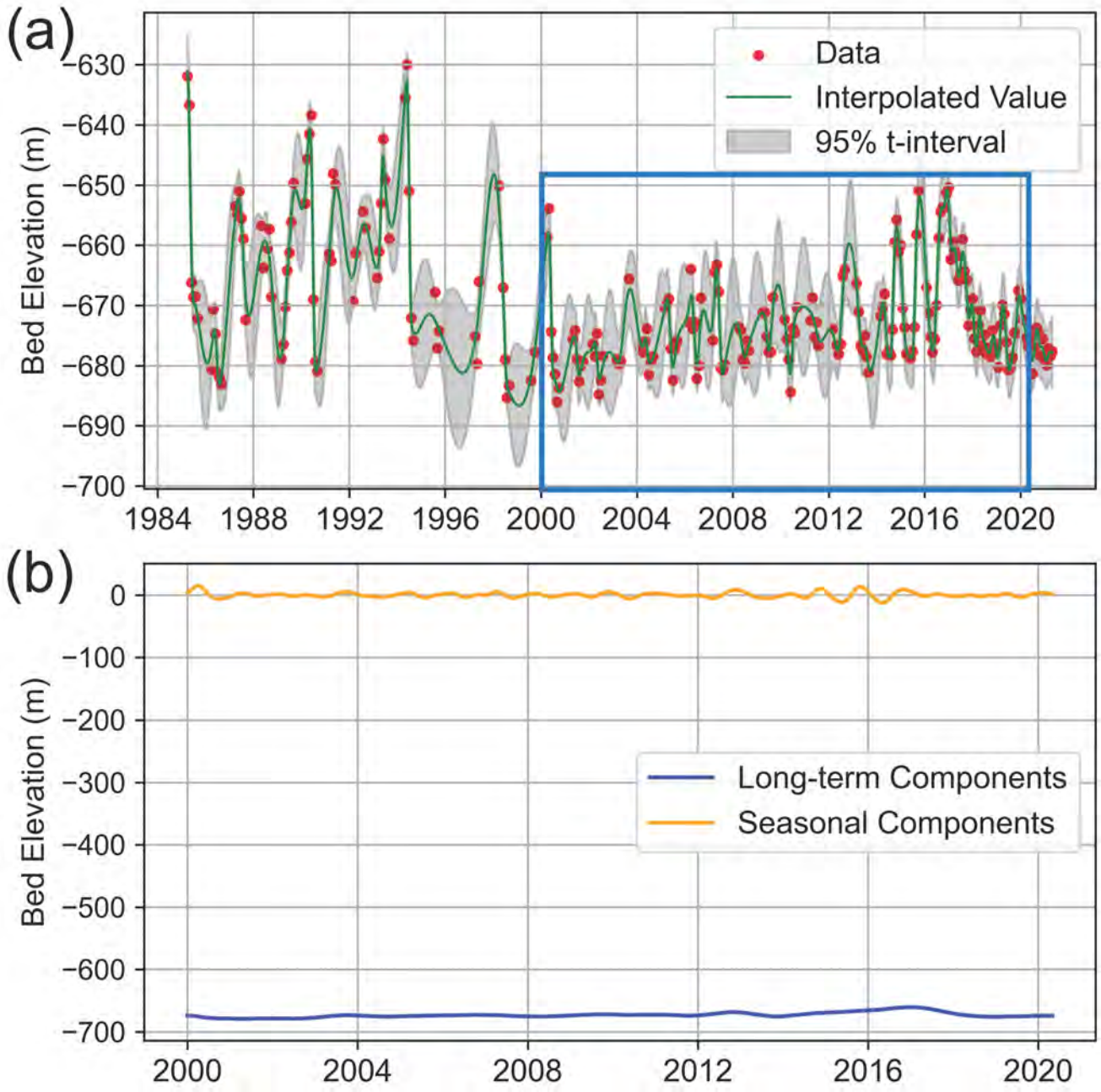

Figure S2. Same as for Fig. S1 but for air temperature.

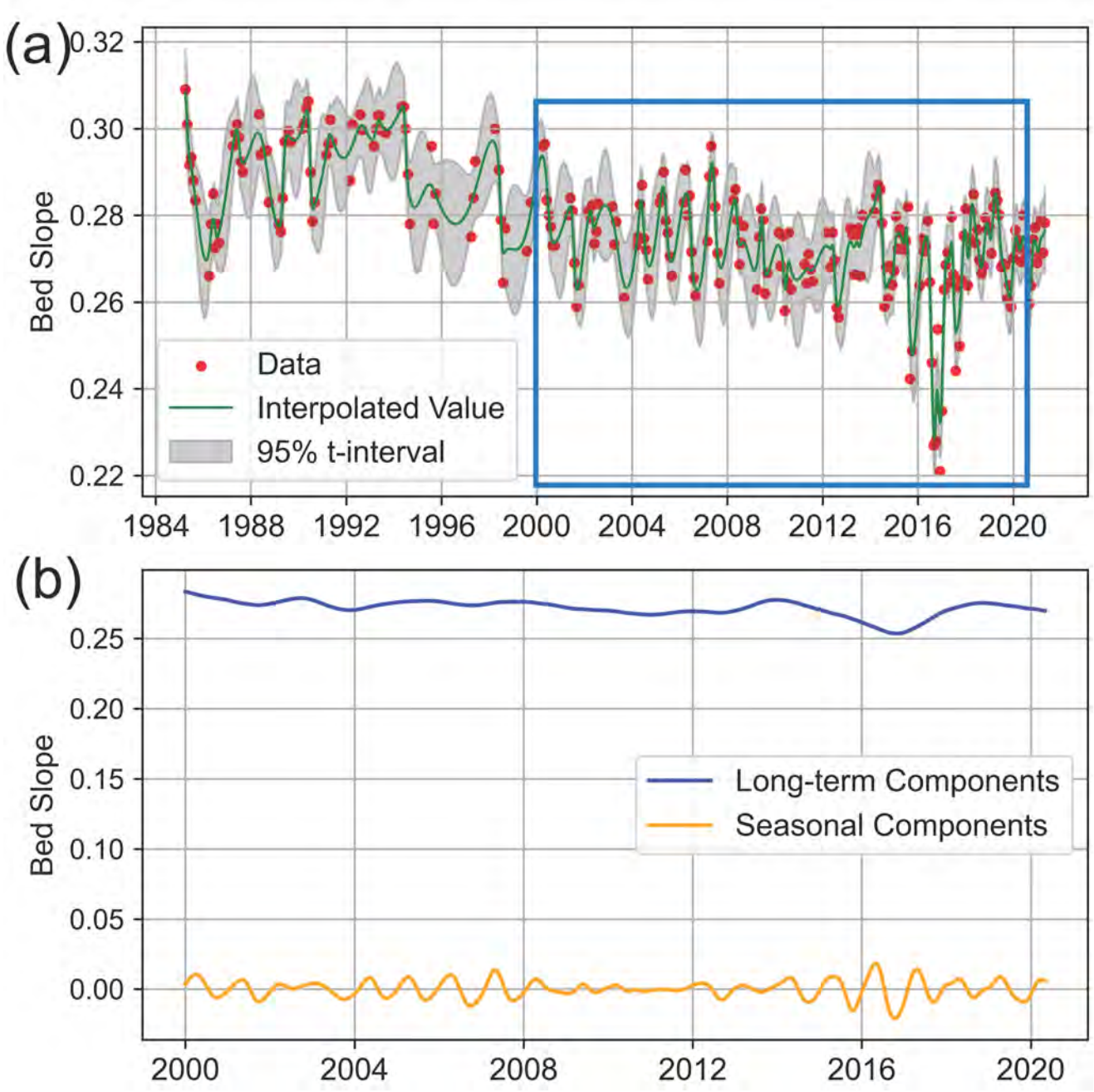

Figure S3. Same as for Fig. S1 but for bed slope.

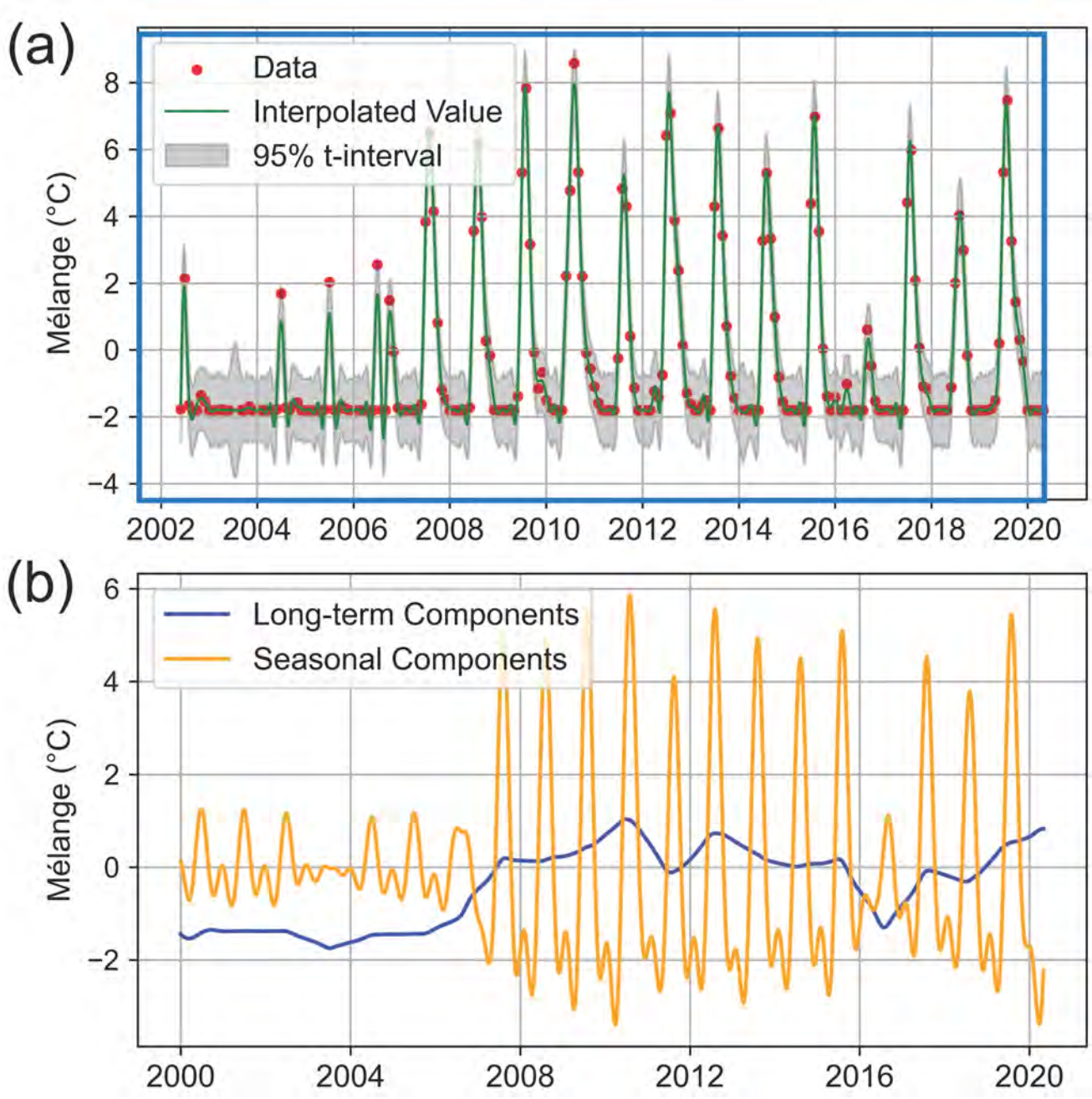

Figure S4. Same as for Fig. S1 but for mélange. Because the product used for a mélange proxy begins in 2002, we artificially extend the time series back two years by duplicating the entire year of 2002 data for 2001 and 2000.

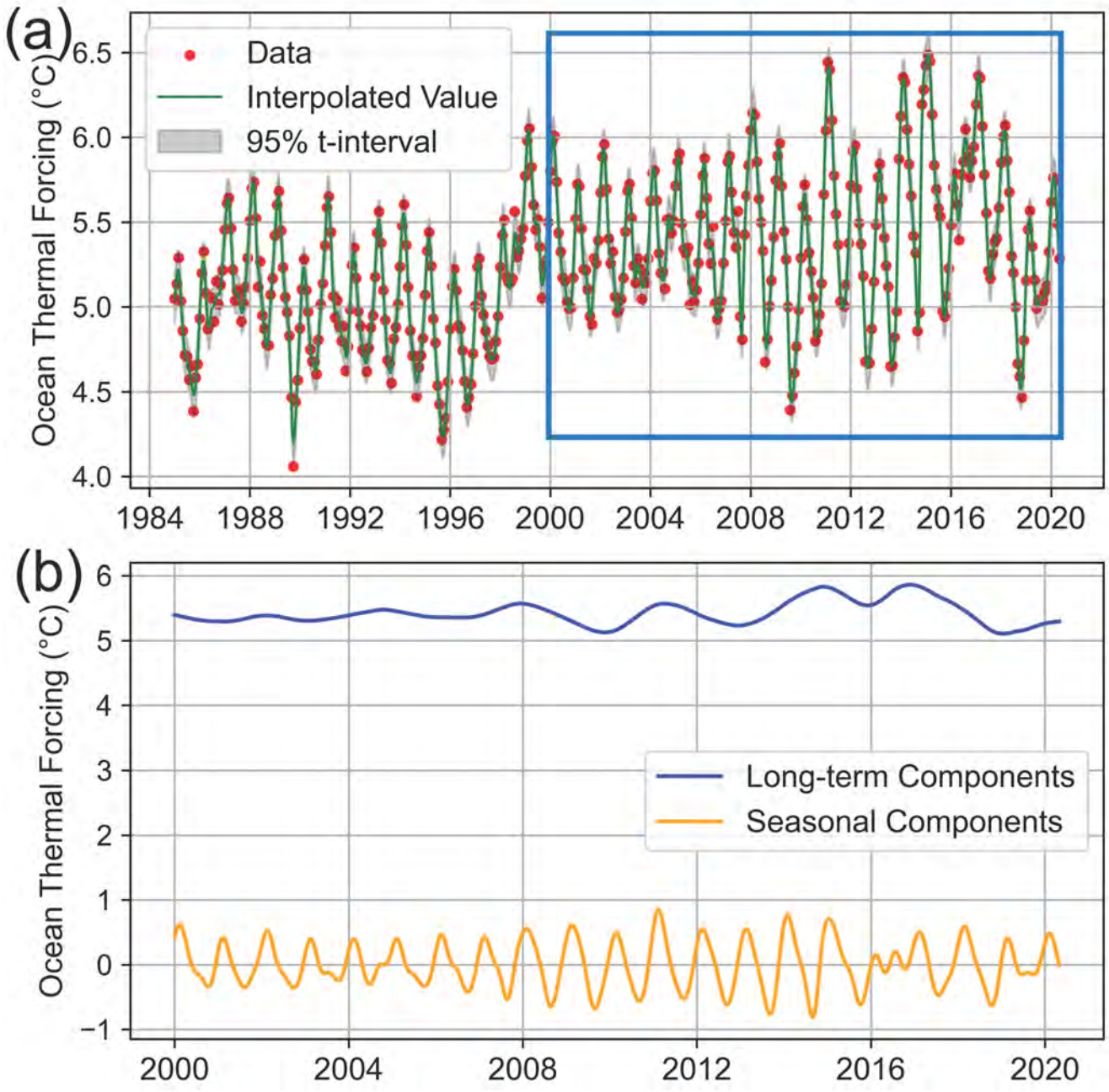

Figure S5. Same as for Fig. S1 but for ocean thermal forcing using the EN4 product.

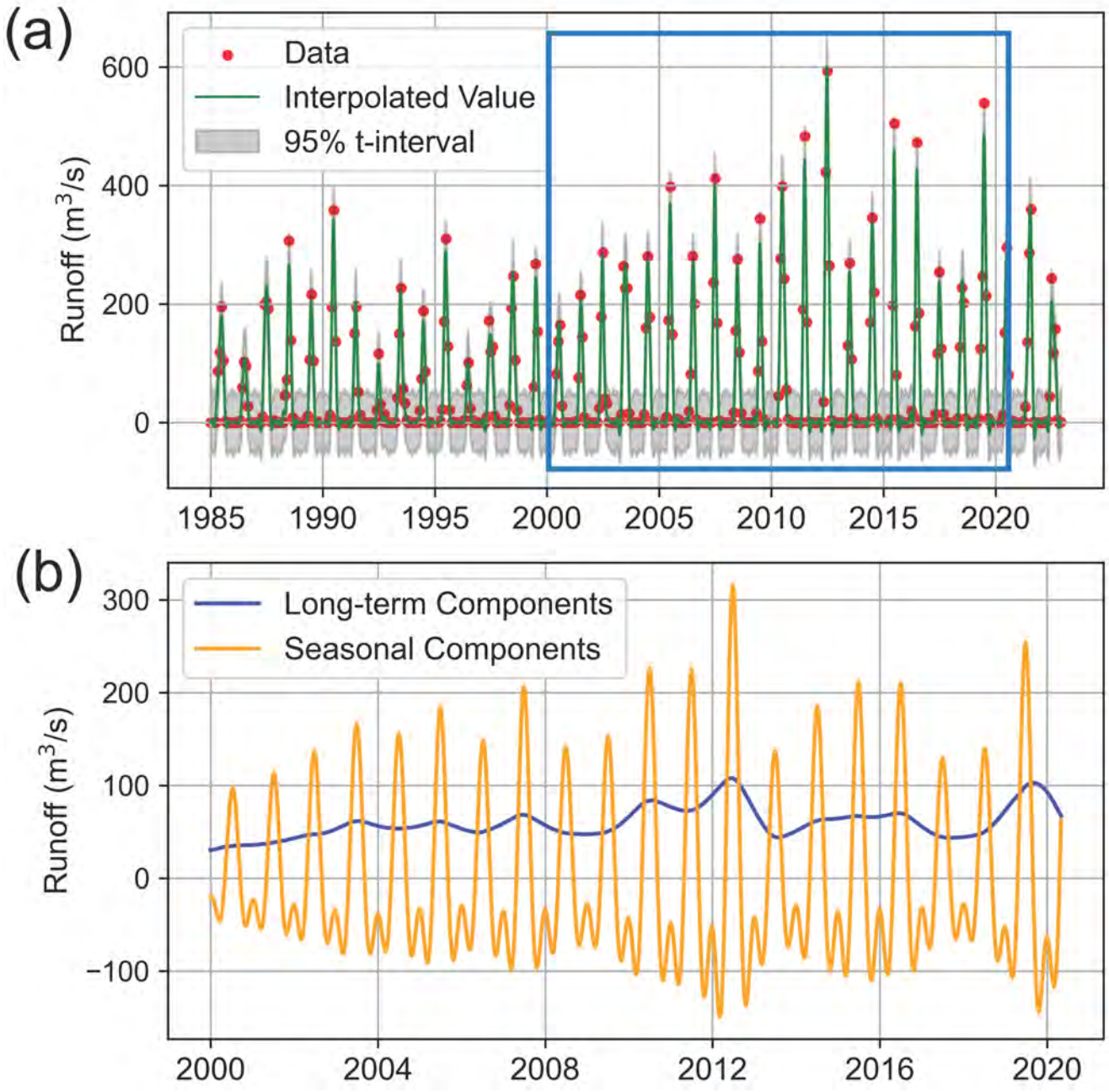

Figure S6. Same as for Fig. S1 but for runoff using the MAR product.

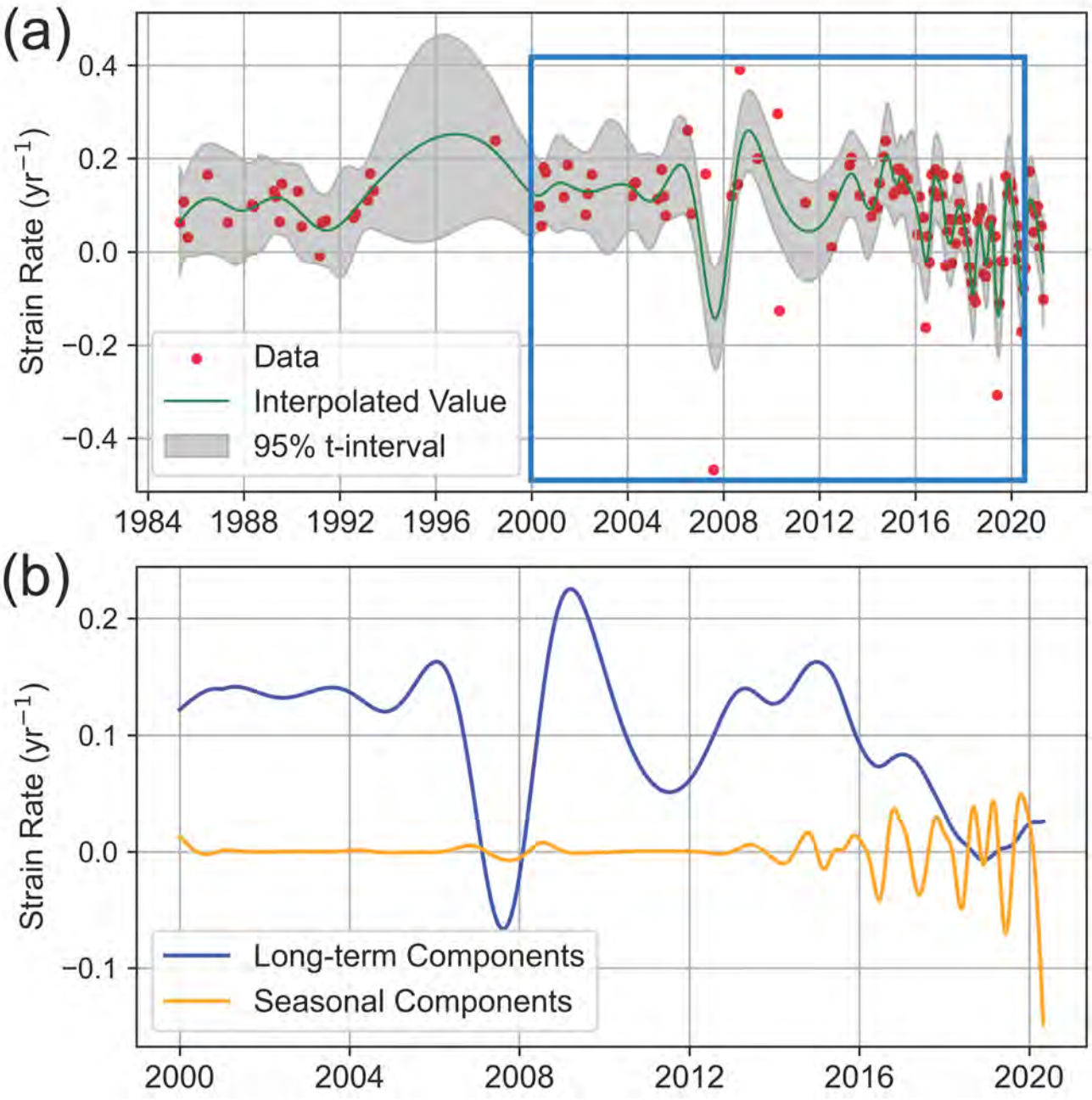

Figure S7. Same as for Fig. S1 but for strain rate.

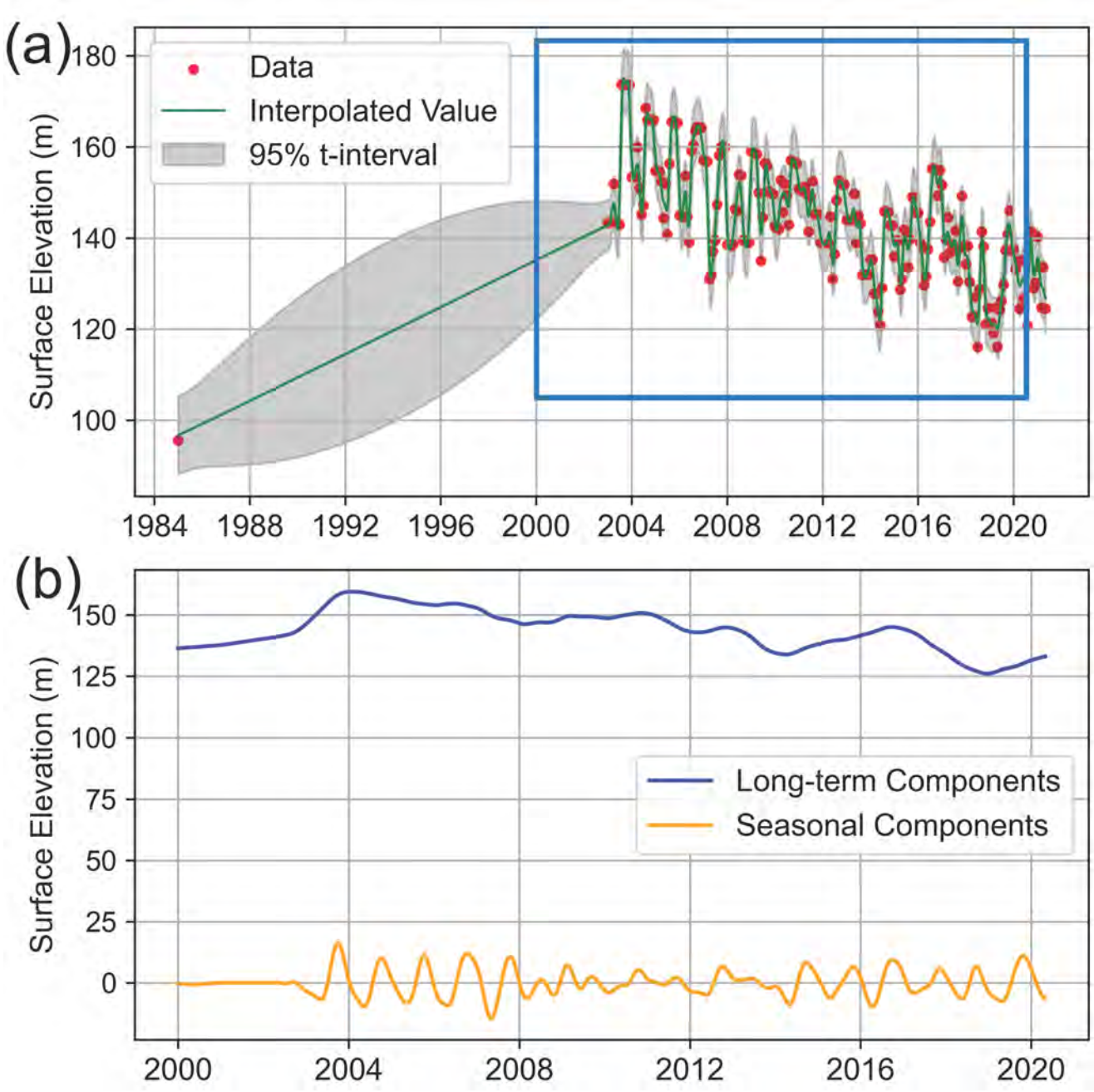

Figure S8. Same as for Fig. S1 but for surface elevation.

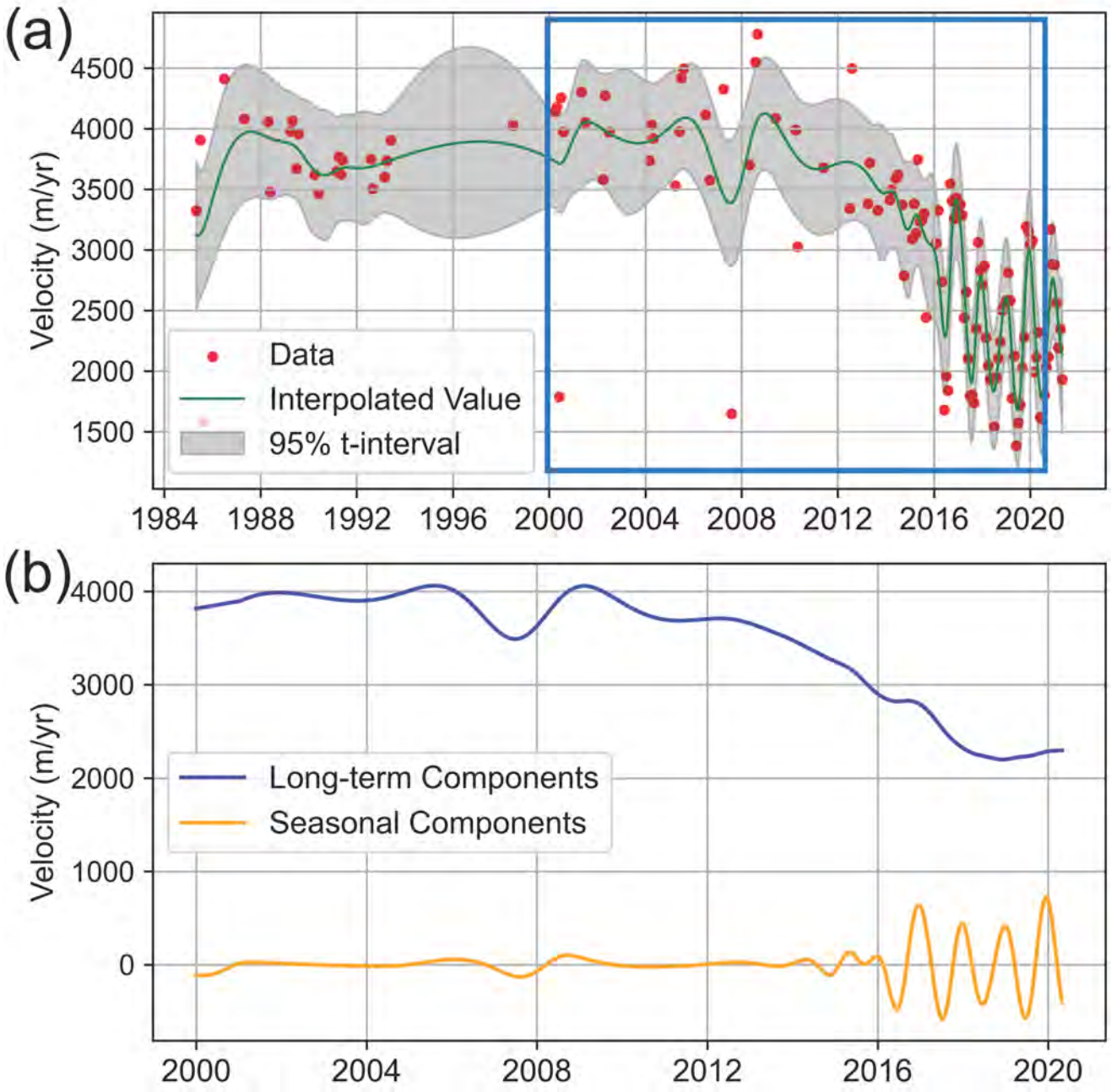

Figure S9. Same as for Fig. S1 but for velocity.

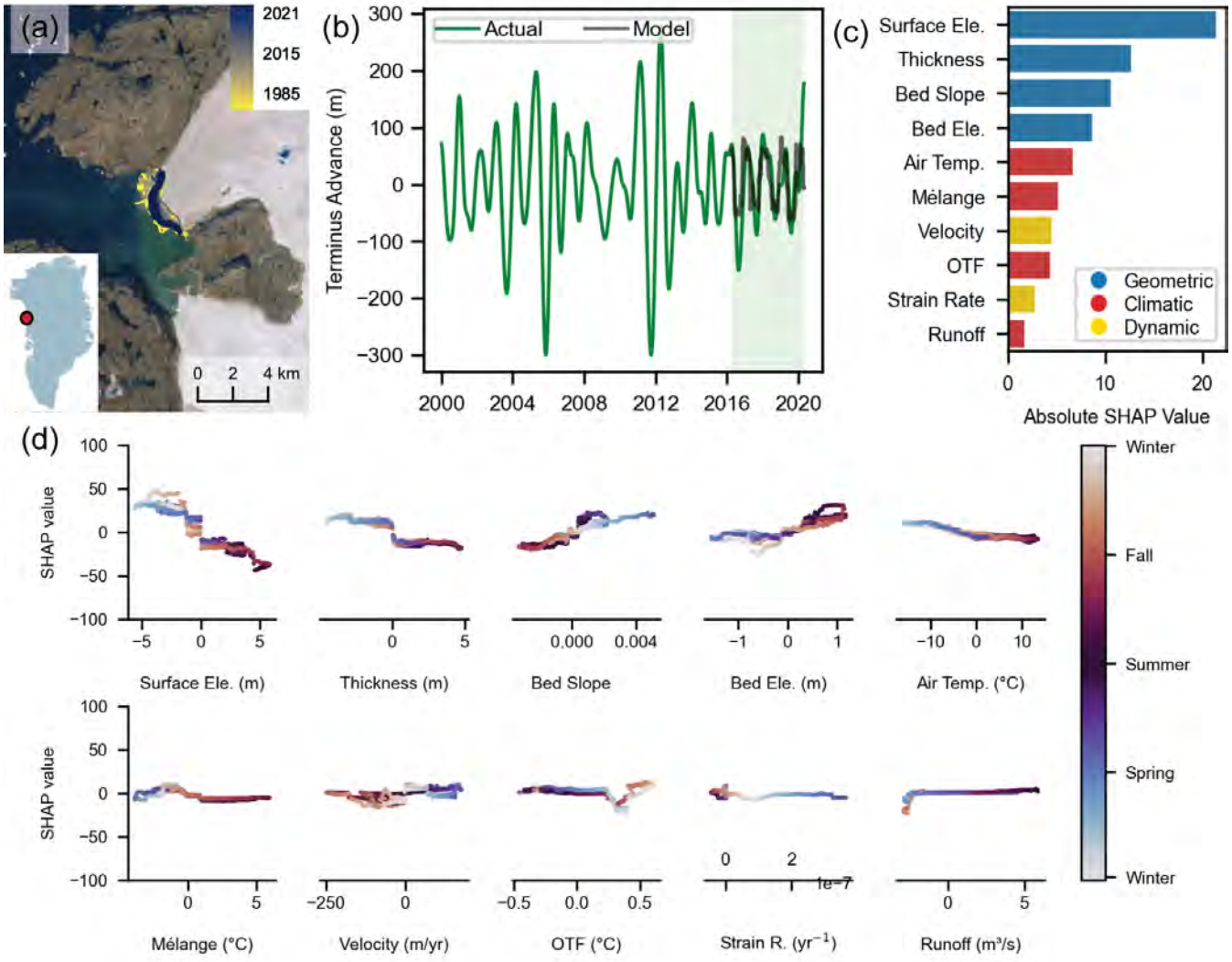

Figure S10. Model results for Nunatakassaap Sermia (GID 11). (a) Glacier location in Greenland and terminus traces colored by time. (b) Seasonal component of terminus change from 2000-2021 (green) with model prediction from Experiment 1 (black). (c) Absolute values of SHapley Additive exPlanations (SHAP) scores for each input variable, ranking variables by prediction importance. Variables are colored by variable group as indicated in the legend. (d) Relationship plots showing the variability of feature importance over a year. Data points are colored by time of year. Error scores for this model are NRMSE: 0.096 (RMSE: 65 m); Spearman: 0.885; R^2: 0.783; offset: 2.5 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

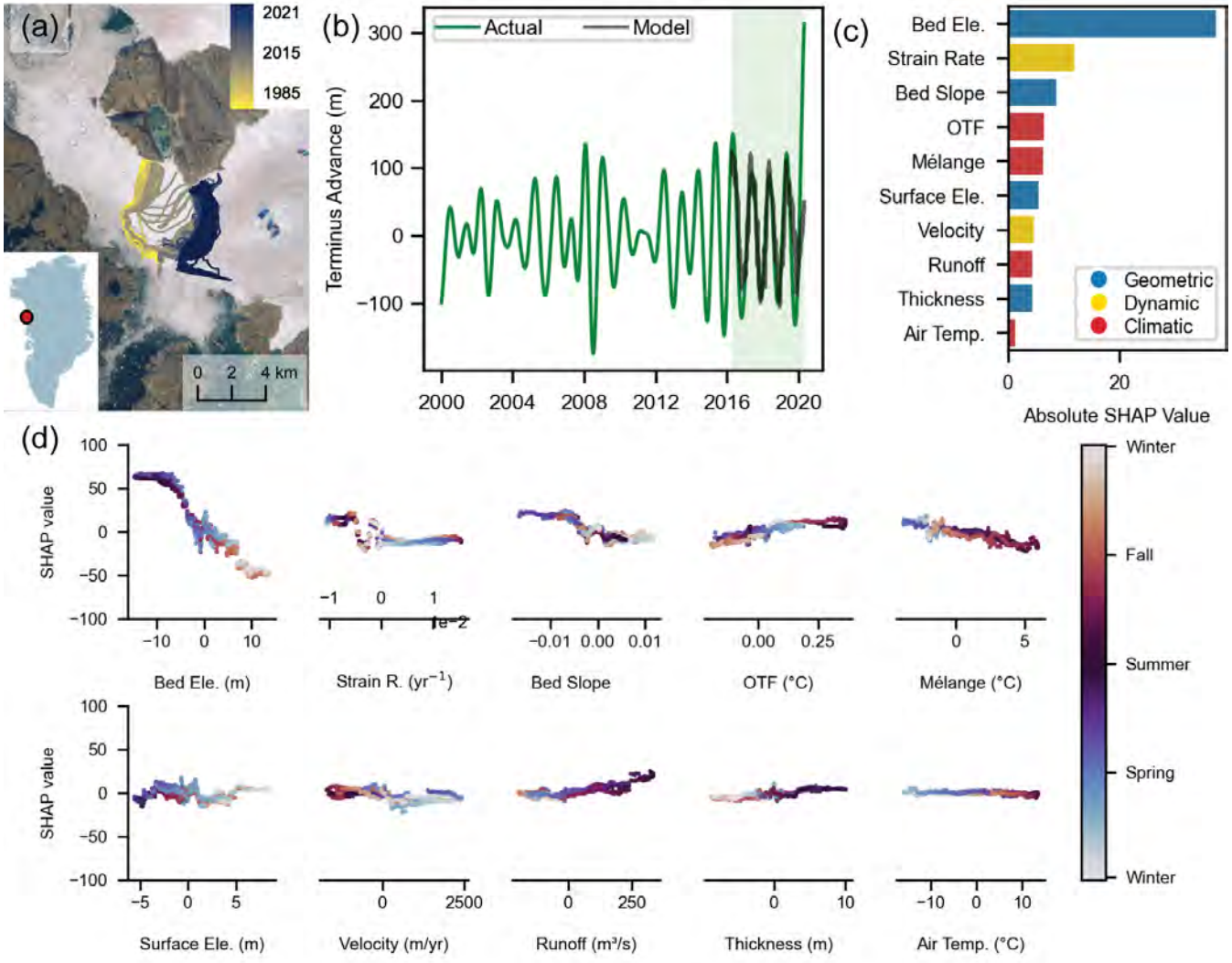

Figure S11. Same as for Fig. S10 but for Kakivfaat Sermiat (GID 14). Error scores for this model are NRMSE: 0.112 (RMSE: 55 m); Spearman: 0.739; R^2: 0.437; offset: 0.6 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

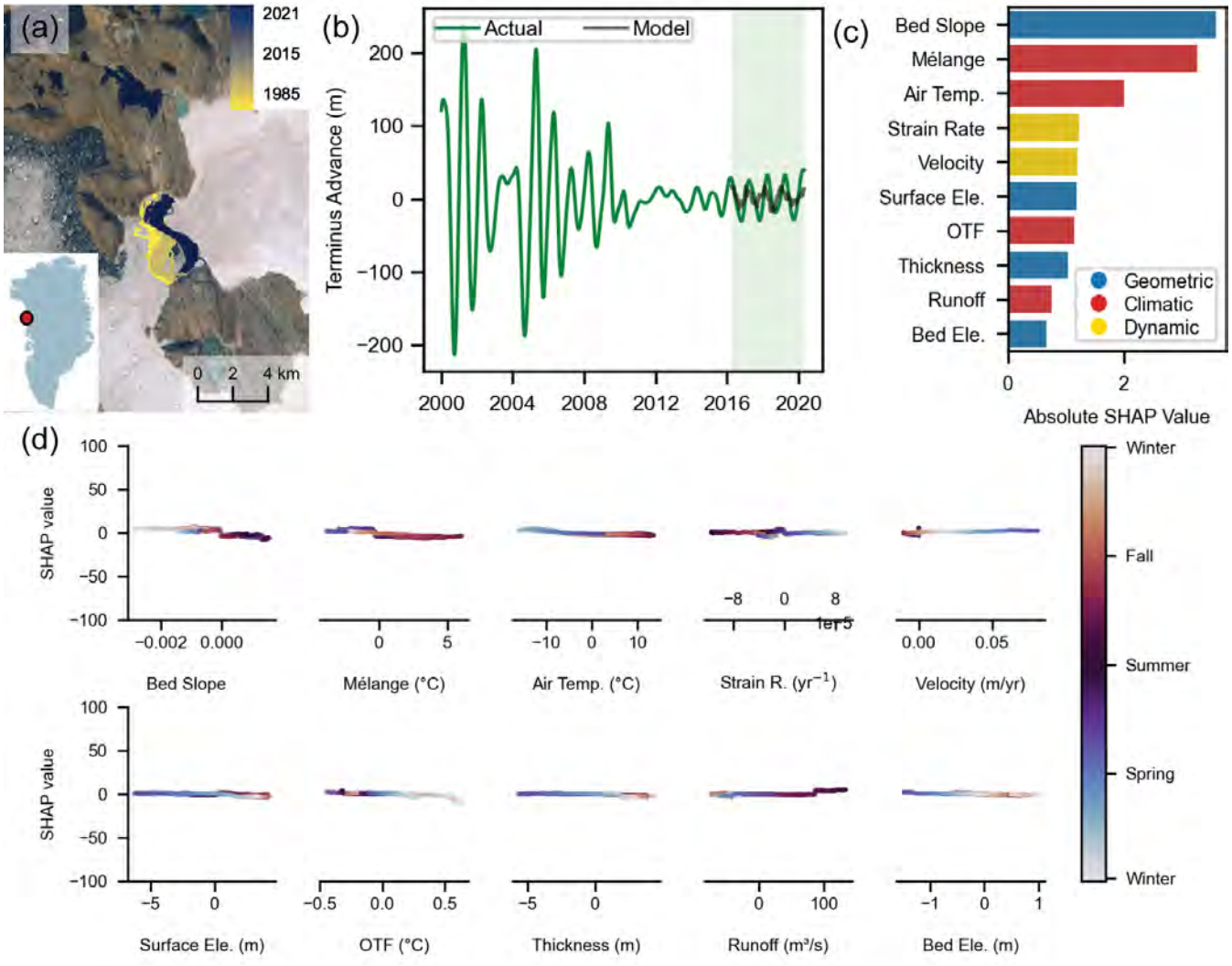

Figure S12. Same as for Fig. S10 but for Qeqertarsuup Sermia (GID 15). Error scores for this model are NRMSE: 0.221 (RMSE: 100 m); Spearman: 0.545; R^2: 0.250; offset: 10.7 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

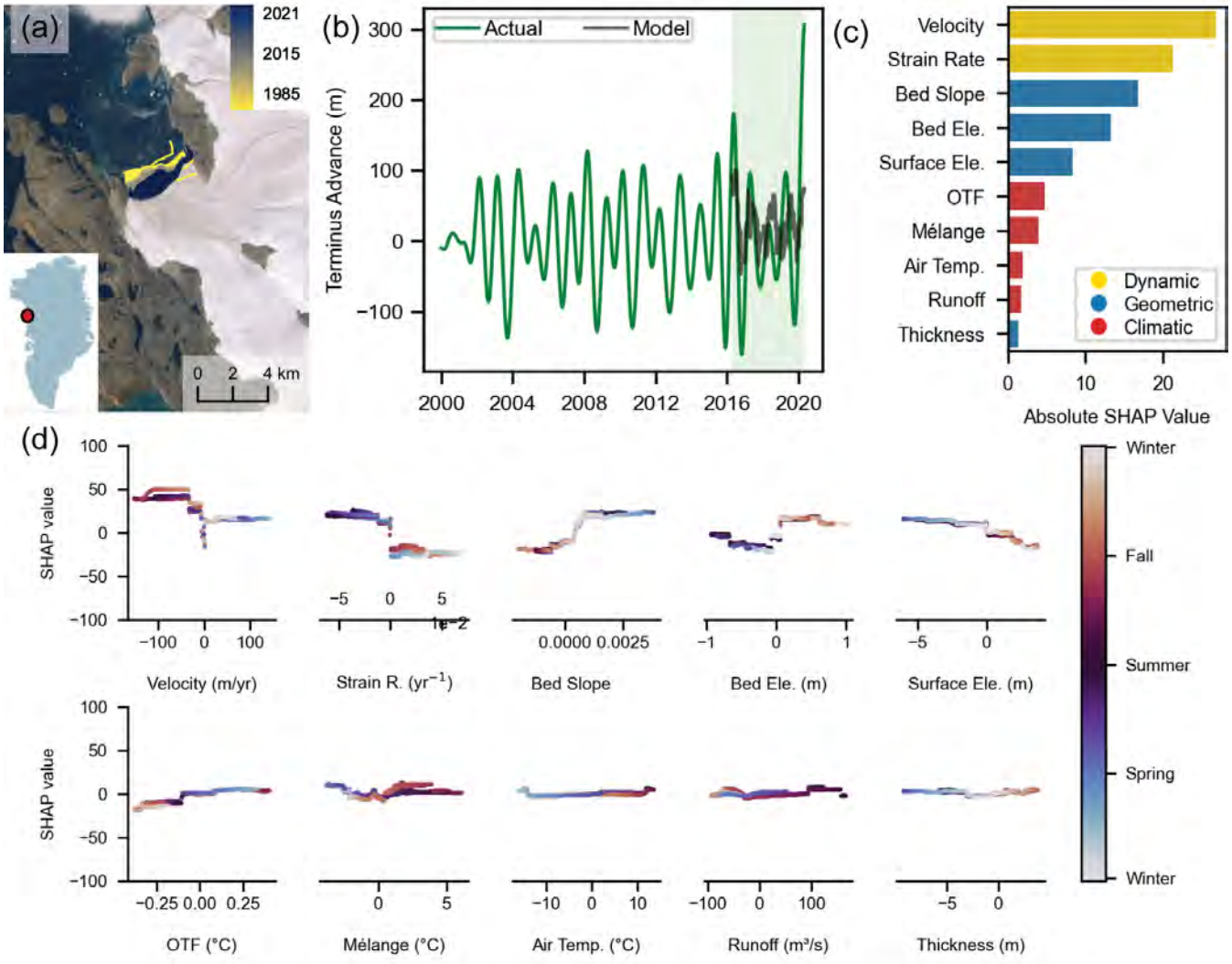

Figure S13. Same as for Fig. S10 but for Ussing Bræer (GID 16). Error scores for this model are NRMSE: 0.152 (RMSE: 71 m); Spearman: 0.452; R^2: 0.068; offset: 13.1 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

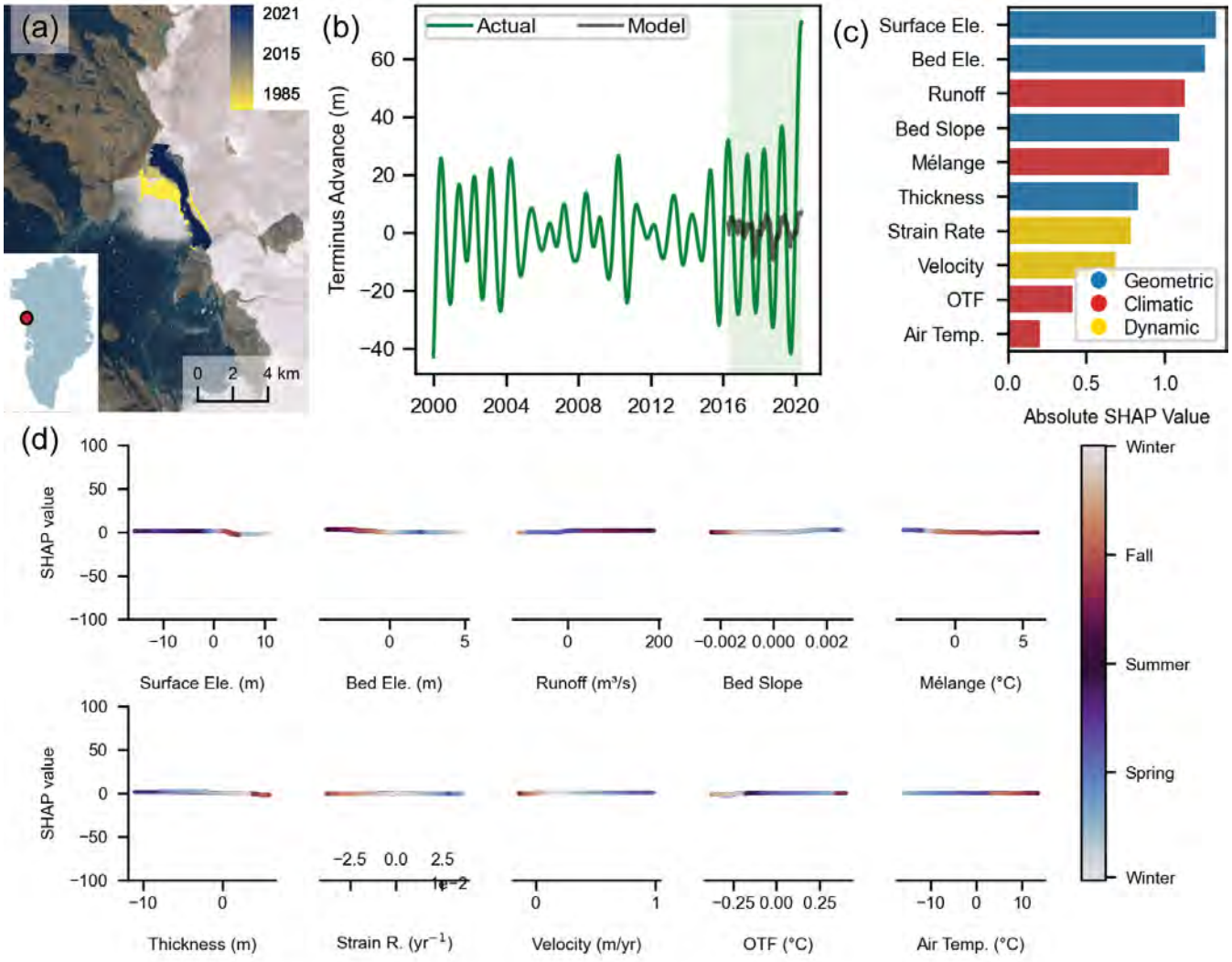

Figure S14. Same as for Fig. S10 but for Ussing Bræer N (GID 17). Error scores for this model are NRMSE: 0.194 (RMSE: 22 m); Spearman: 0.152; R^2: 0.019; offset: 20.2 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

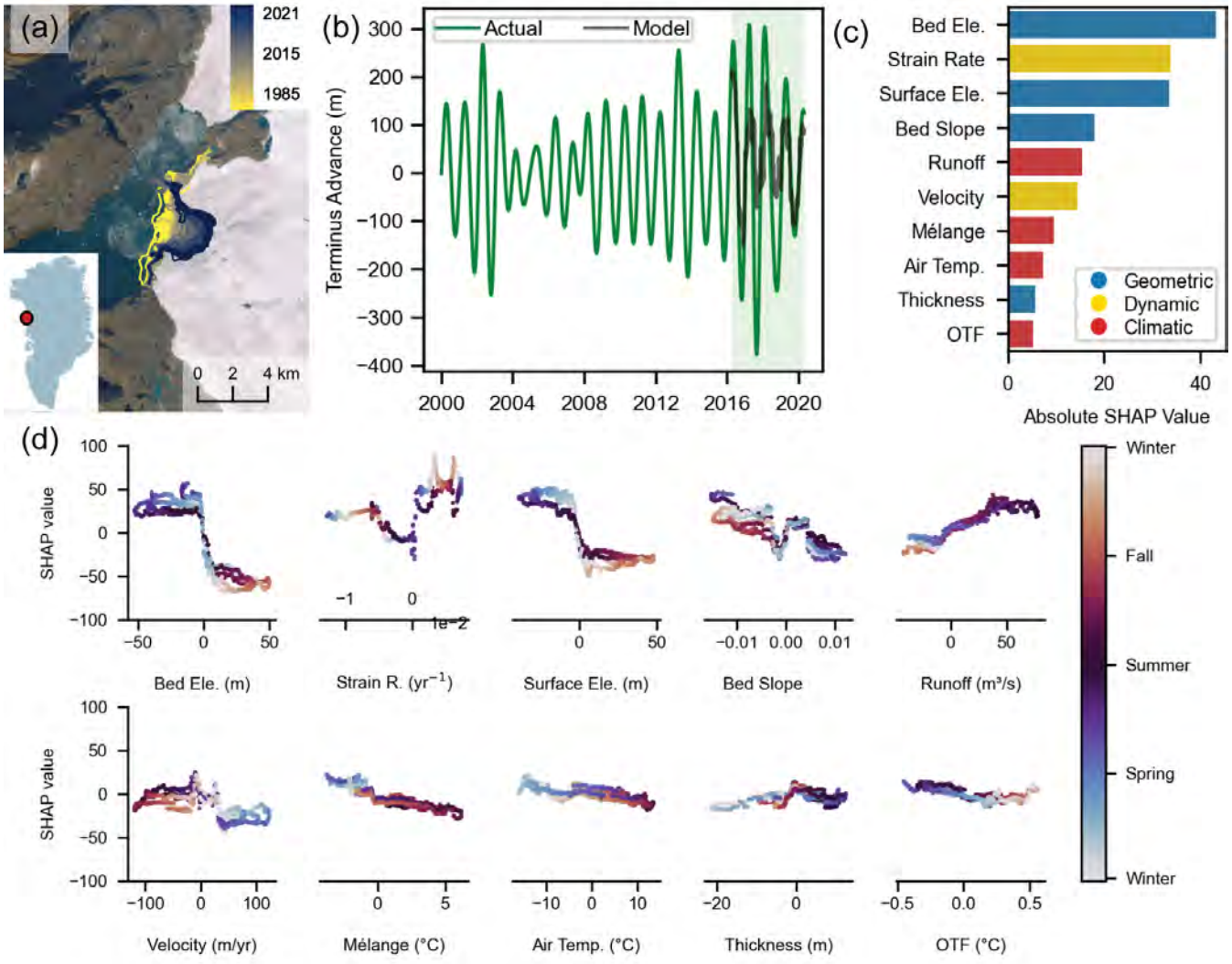

Figure S15. Same as for Fig. S10 but for Cornell Gletscher (GID 18). Error scores for this model are NRMSE: 0.164 (RMSE: 113 m); Spearman: 0.767; R^2: 0.437; offset: 7.0 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

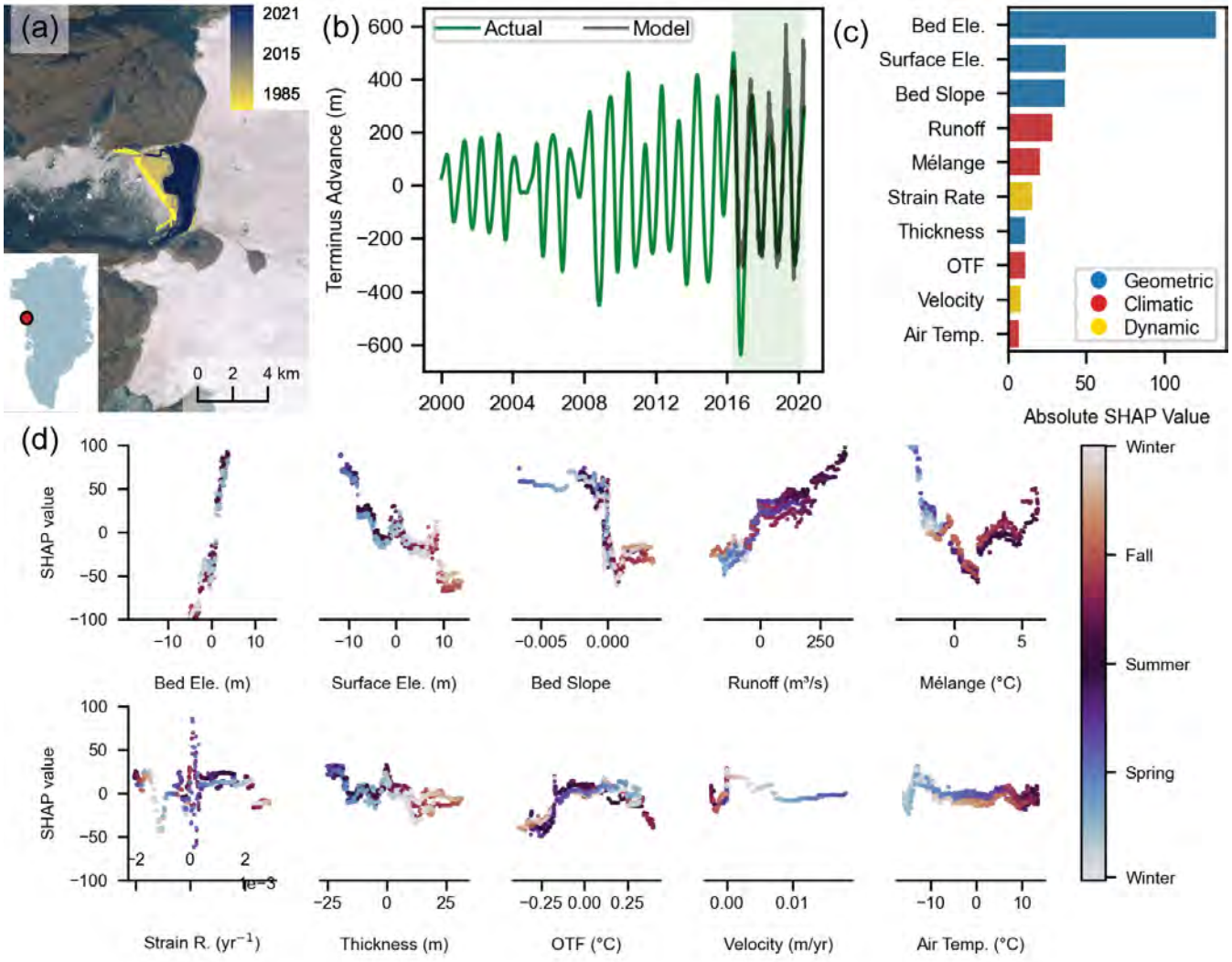

Figure S16. Same as for Fig. S10 but for Illullip Sermia (GID 20). Error scores for this model are NRMSE: 0.084 (RMSE: 96 m); Spearman: 0.915; R^2: 0.759; offset: 3.9 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

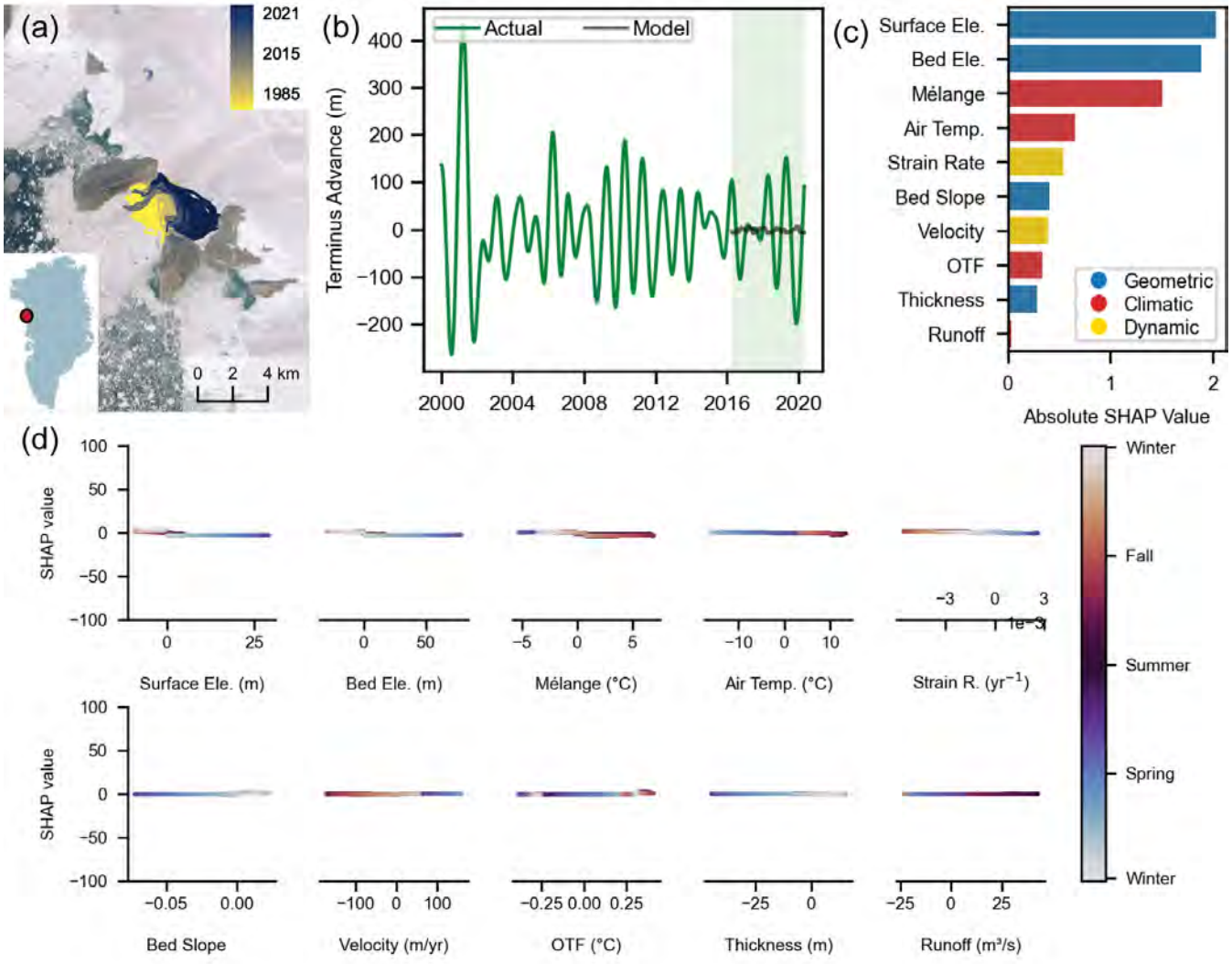

Figure S17. Same as for Fig. S10 but for Hayes N (GID 24). Error scores for this model are NRMSE: 0.190 (RMSE: 133 m); Spearman: 0.239; R^2: -0.017; offset: 14.6 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

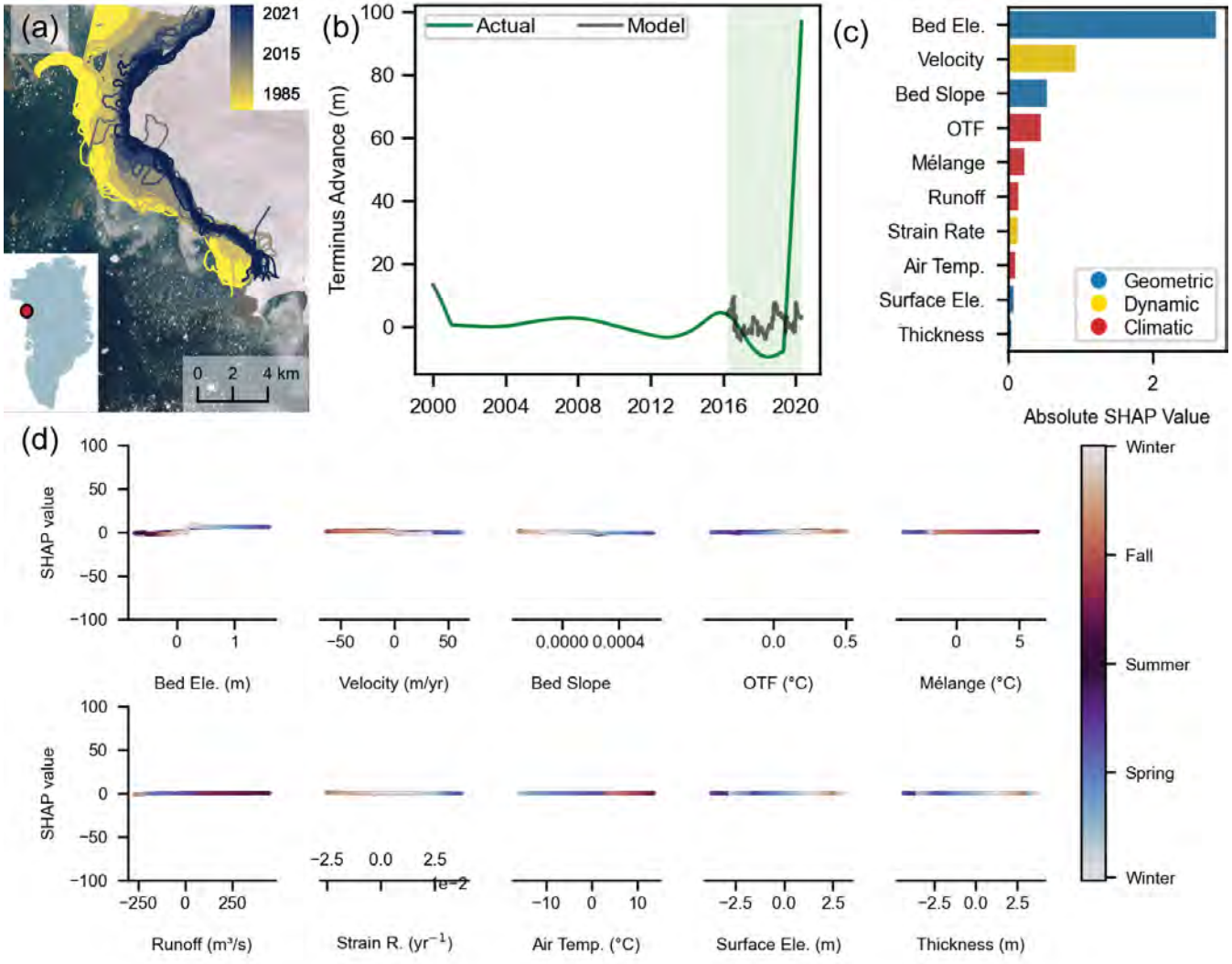

Figure S18. Same as for Fig. S10 but for Hayes Gletscher N' (GID 27). Error scores for this model are NRMSE: 0.144 (RMSE: 15 m); Spearman: 0.267; R^2: 0.007; offset: 13.2 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

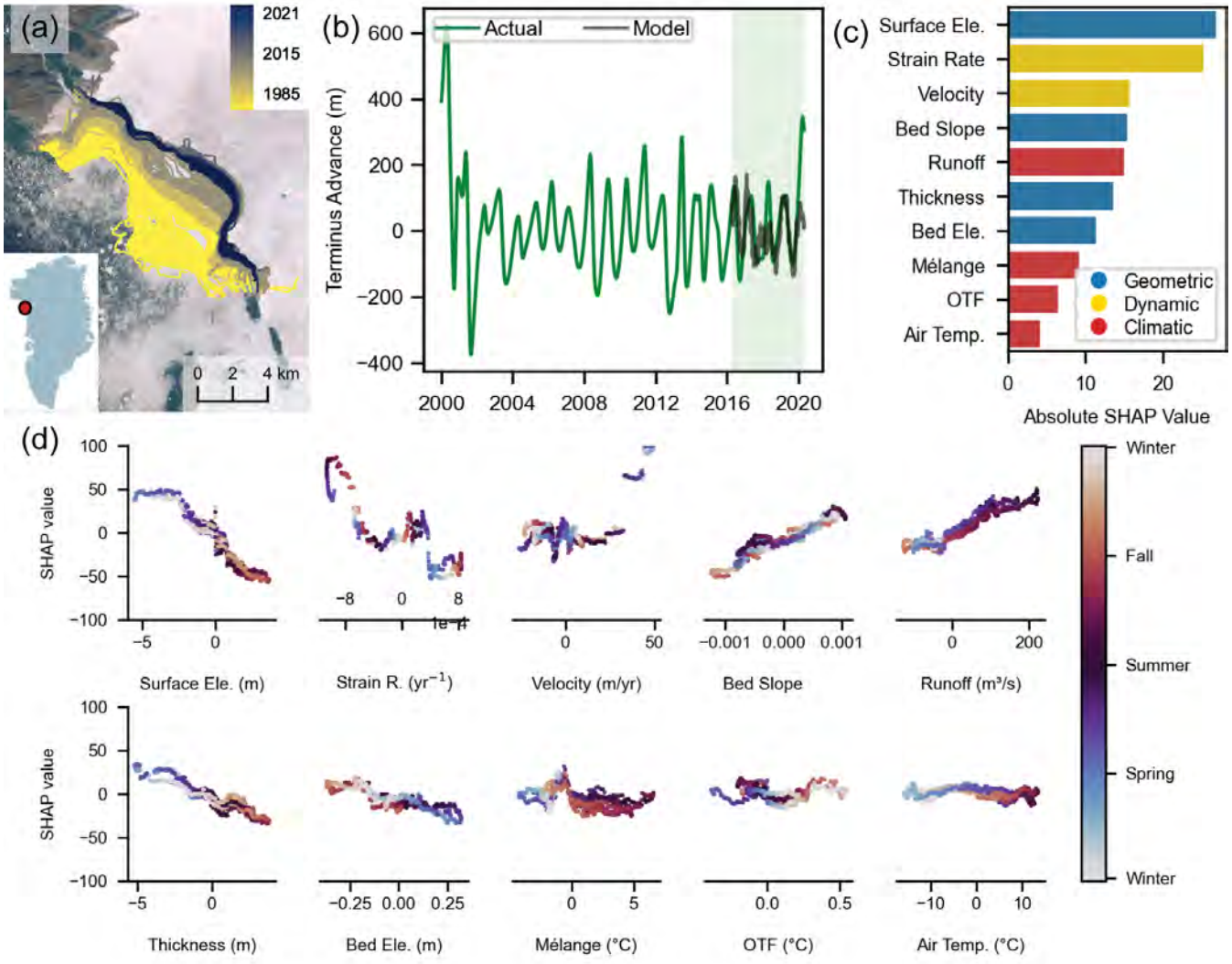

Figure S19. Same as for Fig. S10 but for Steenstrup Gletscher (GID 30). Error scores for this model are NRMSE: 0.132 (RMSE: 132 m); Spearman: 0.660; R^2: 0.266; offset: 3.8 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

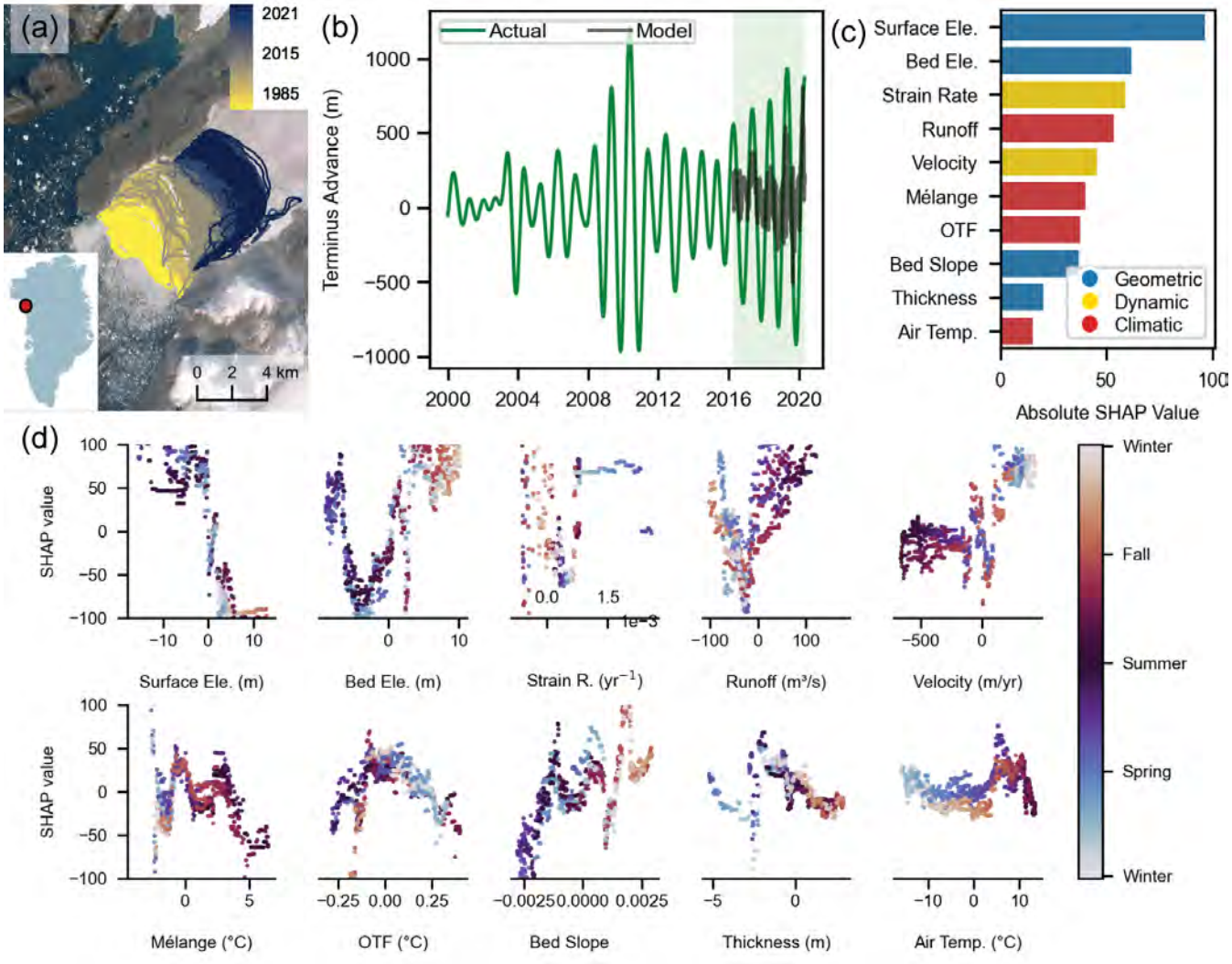

Figure S20. Same as for Fig. S10 but for Sverdrup Gletscher (GID 32). Error scores for this model are NRMSE: 0.234 (RMSE: 510 m); Spearman: 0.590; R^2: 0.199; offset: 9.6 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

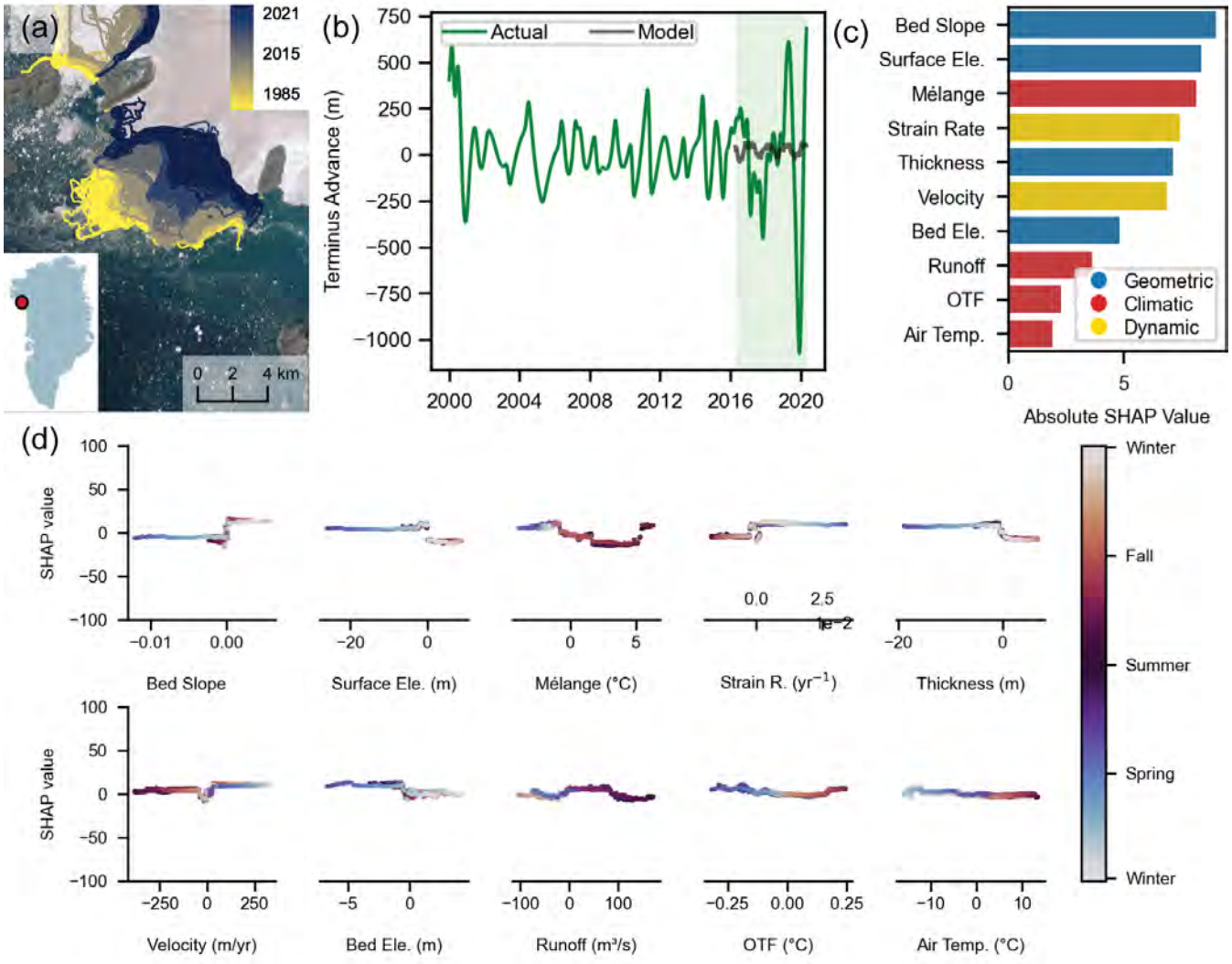

Figure S21. Same as for Fig. S10 but for Nansen Gletscher (GID 34). Error scores for this model are NRMSE: 0.145 (RMSE: 255 m); Spearman: 0.302; R^2: 0.034; offset: 11.7 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

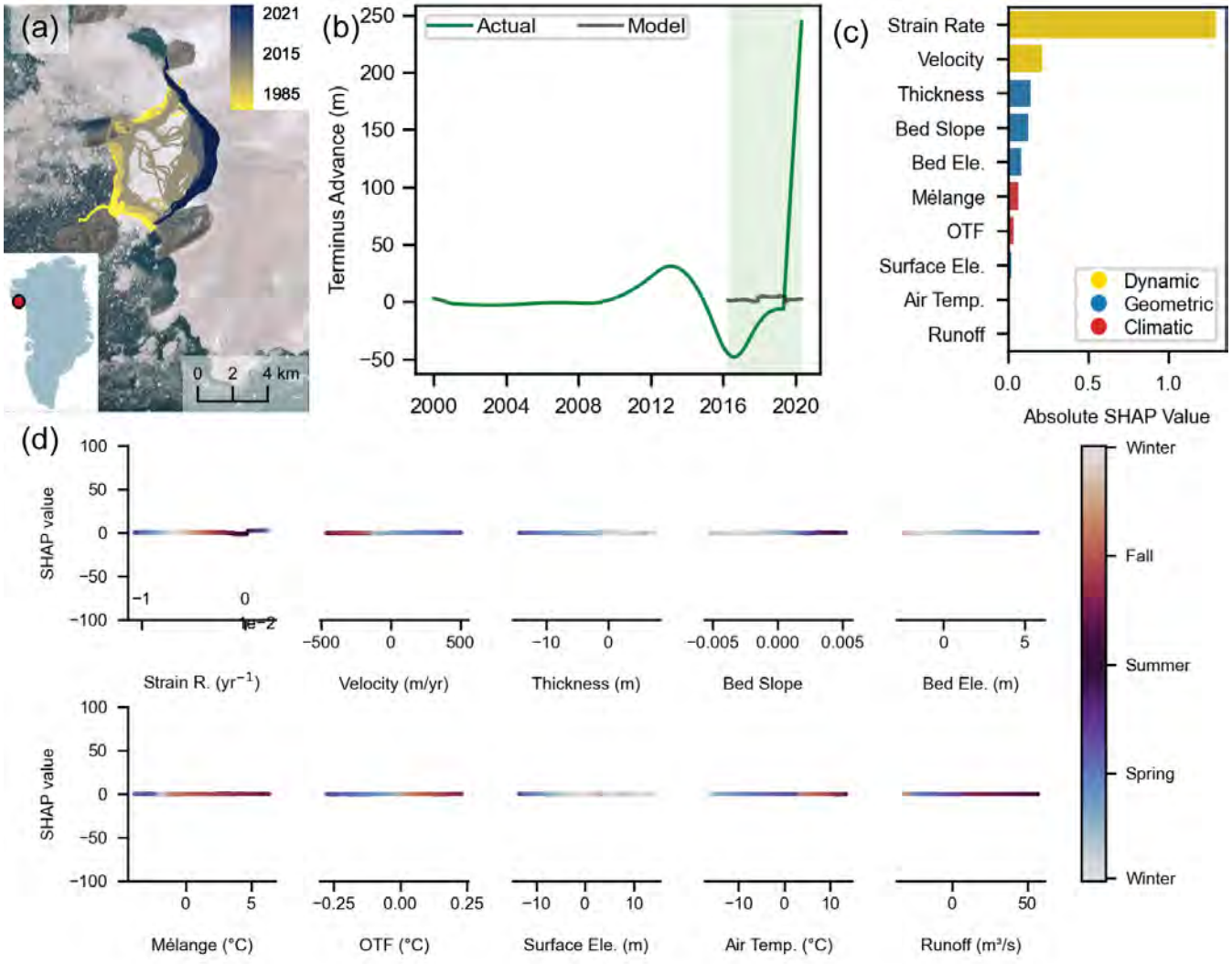

Figure S22. Same as for Fig. S10 but for Nordenskiöld Gletscher (GID 35). Error scores for this model are NRMSE: 0.169 (RMSE: 49 m); Spearman: 0.336; R^2: -0.018; offset: 14.7 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

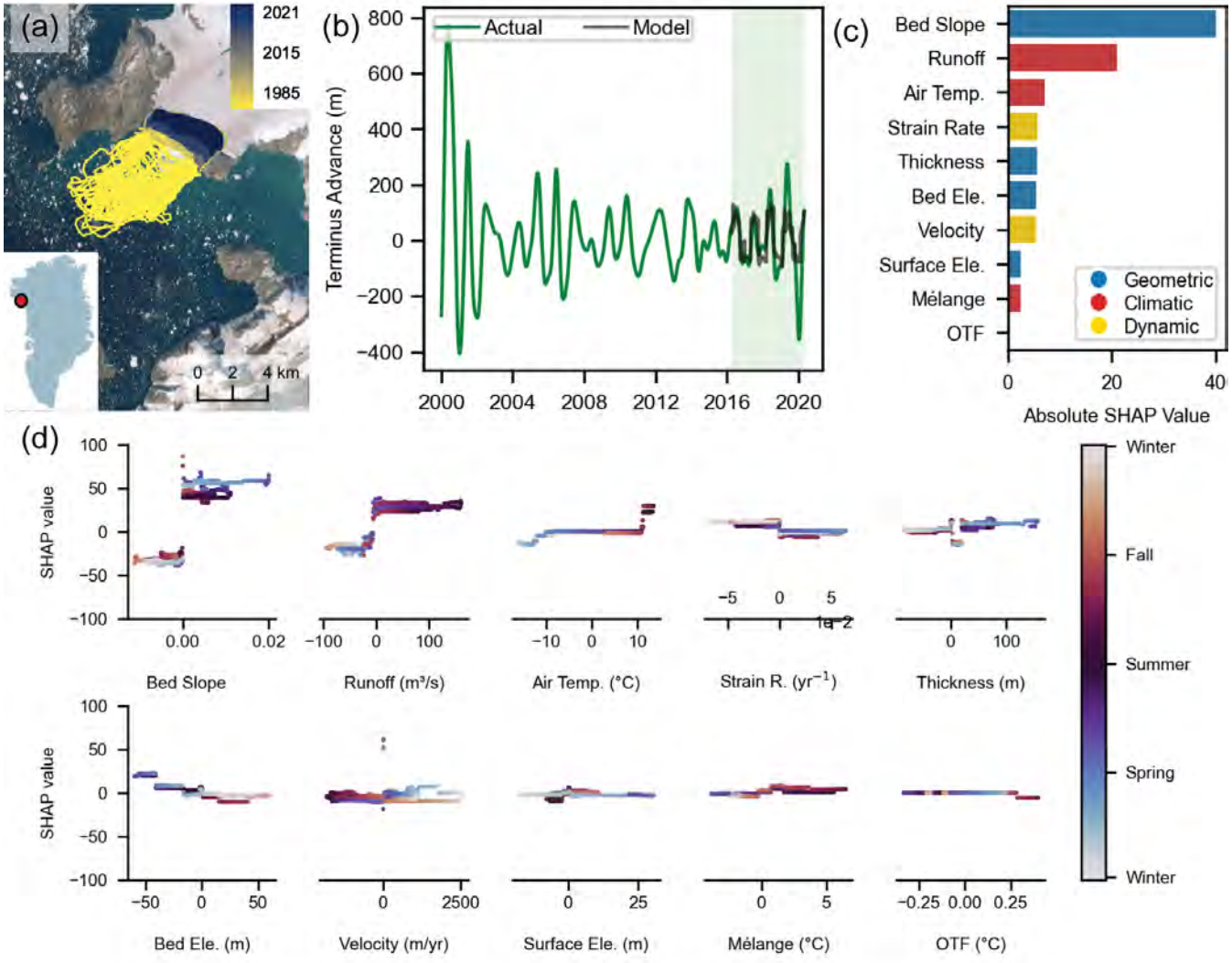

Figure S23. Same as for Fig. S10 but for Oscar Gletscher (GID 39). Error scores for this model are NRMSE: 0.098 (RMSE: 116 m); Spearman: 0.717; R^2: 0.453; offset: 10.5 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

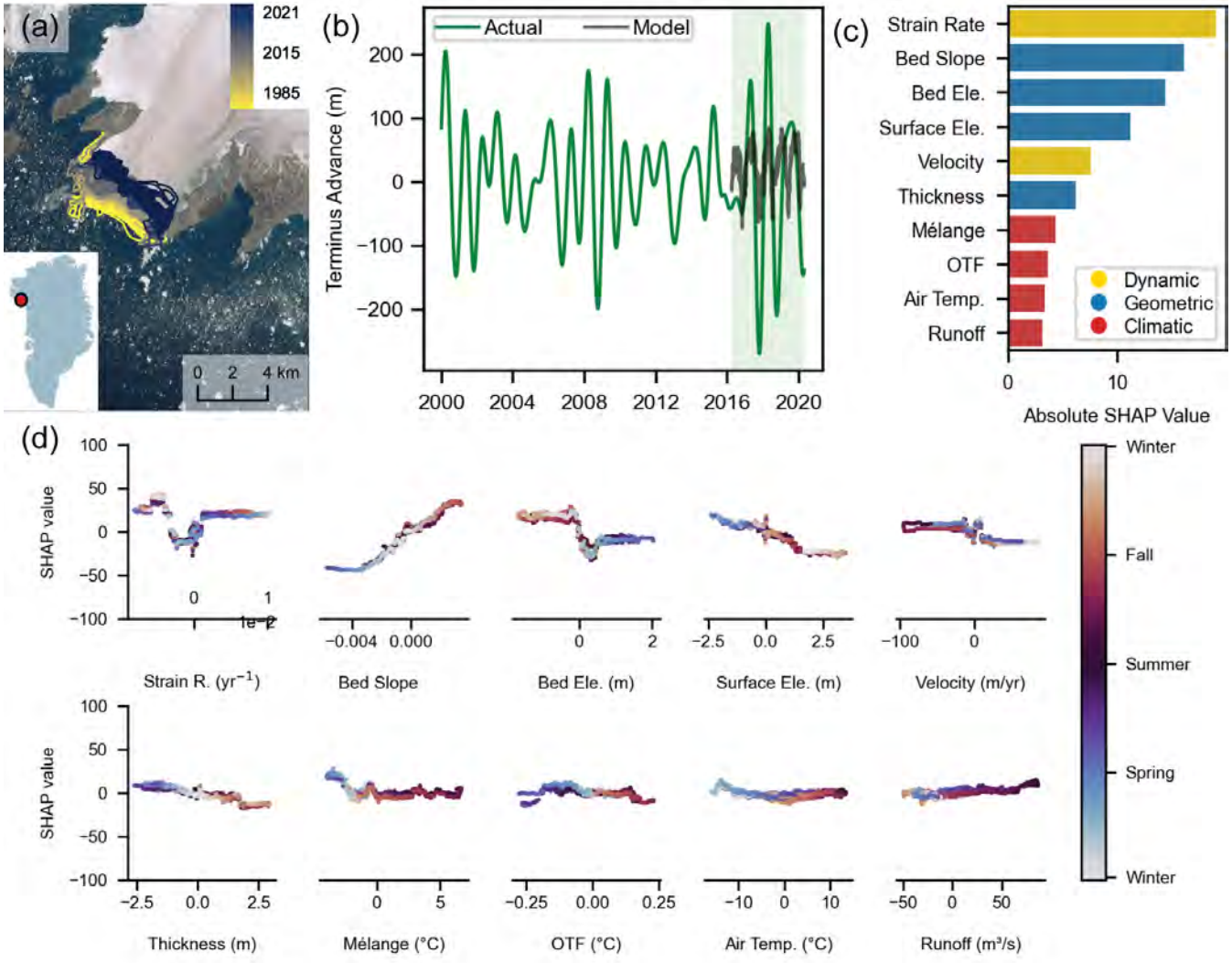

Figure S24. Same as for Fig. S10 but for Issuuarsuit Sermia (GID 42). Error scores for this model are NRMSE: 0.190 (RMSE: 99 m); Spearman: 0.411; R^2: 0.036; offset: 8.7 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

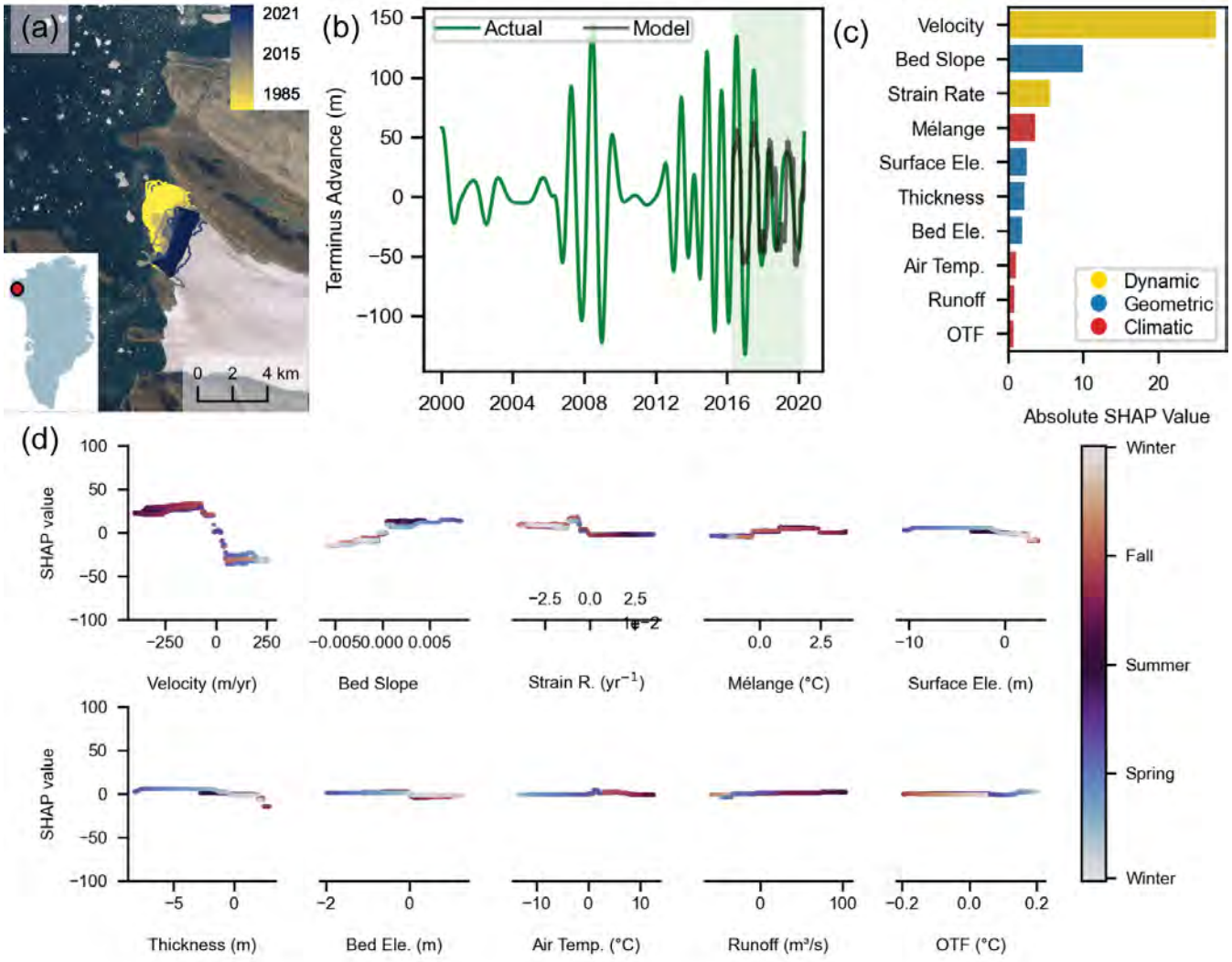

Figure S25. Same as for Fig. S10 but for Heilprin Gletscher (GID 72). Error scores for this model are NRMSE: 0.112 (RMSE: 31 m); Spearman: 0.813; R^2: 0.569; offset: 10.4 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

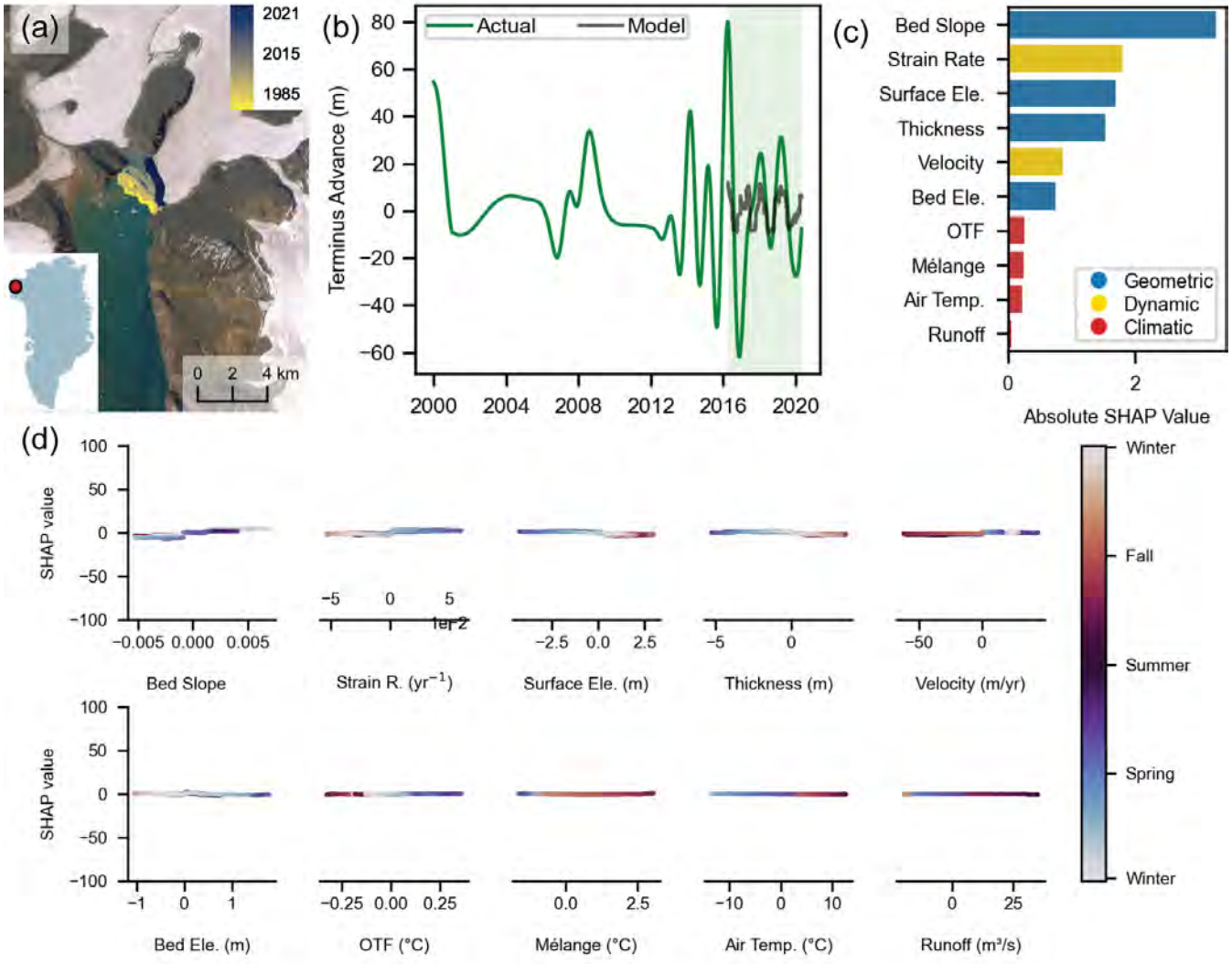

Figure S26. Same as for Fig. S10 but for Bowdoin Gletscher (GID 77). Error scores for this model are NRMSE: 0.144 (RMSE: 20 m); Spearman: 0.492; R^2: 0.153; offset: 13.0 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

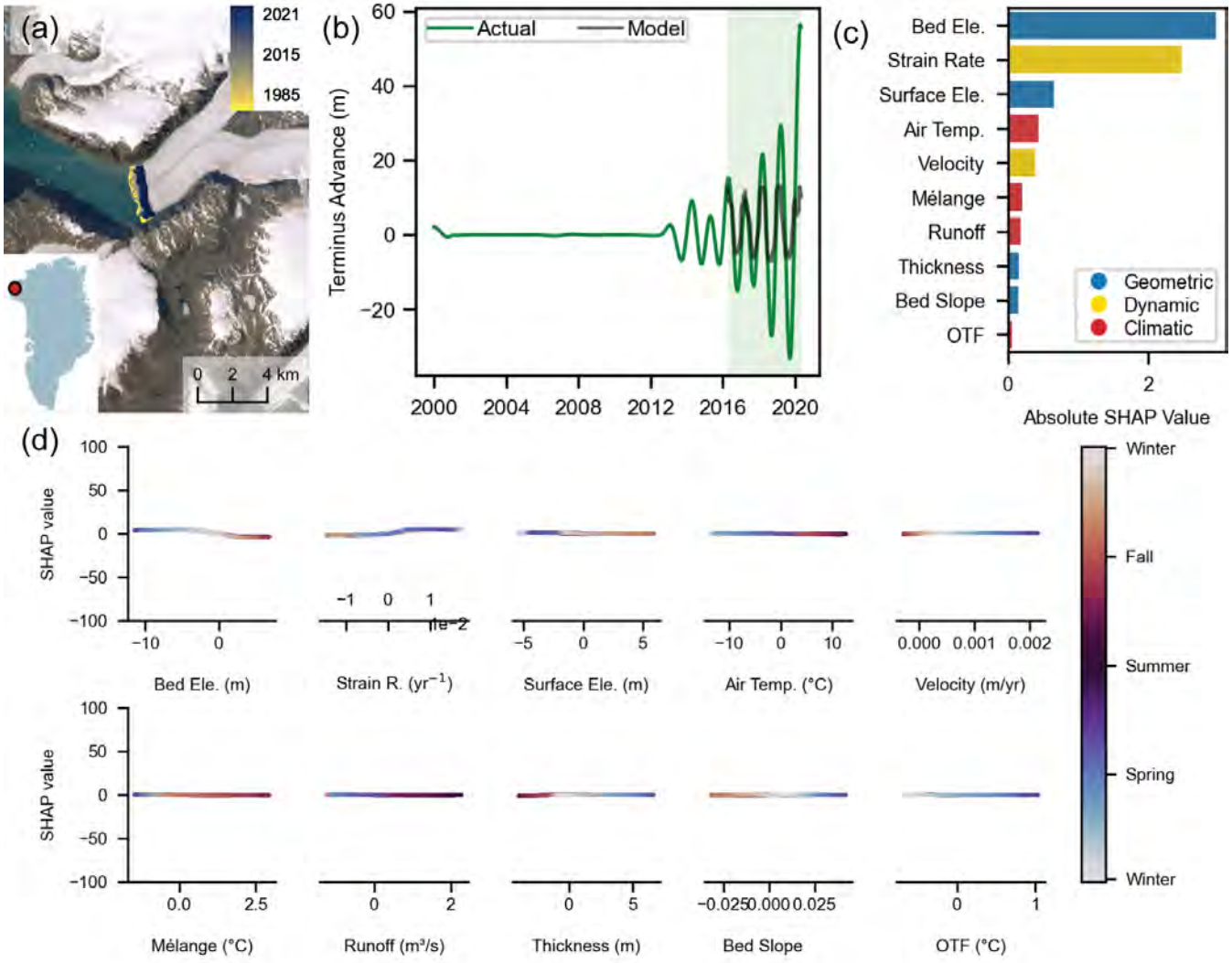

Figure S27. Same as for Fig. S10 but for Verhoeff Gletscher (GID 78). Error scores for this model are NRMSE: 0.125 (RMSE: 11 m); Spearman: 0.827; R^2: 0.421; offset: 5.1 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

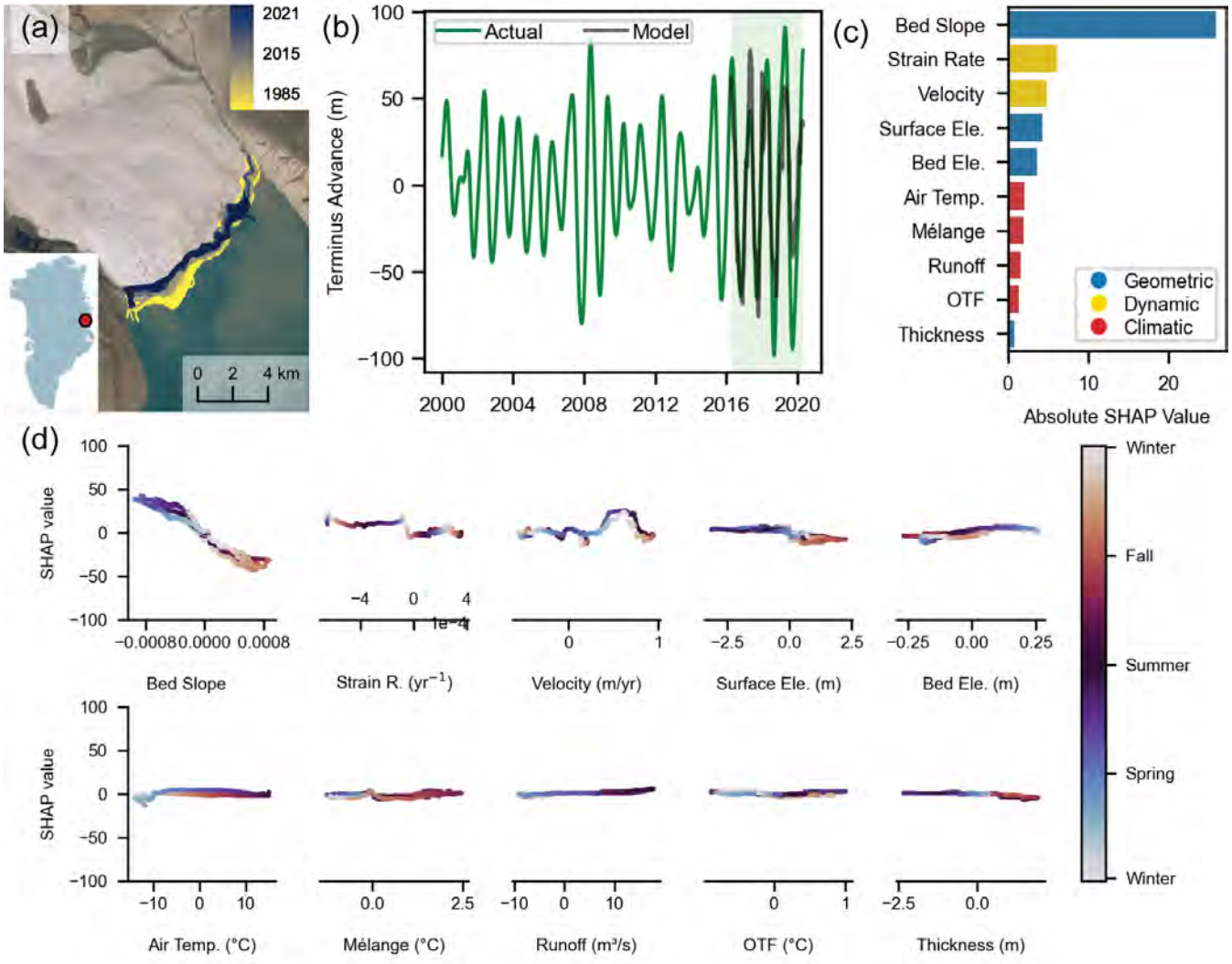

Figure S28. Same as for Fig. S10 but for Waltershausen Gletscher (GID 110). Error scores for this model are NRMSE: 0.123 (RMSE: 23 m); Spearman: 0.859; R^2: 0.727; offset: 1.5 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

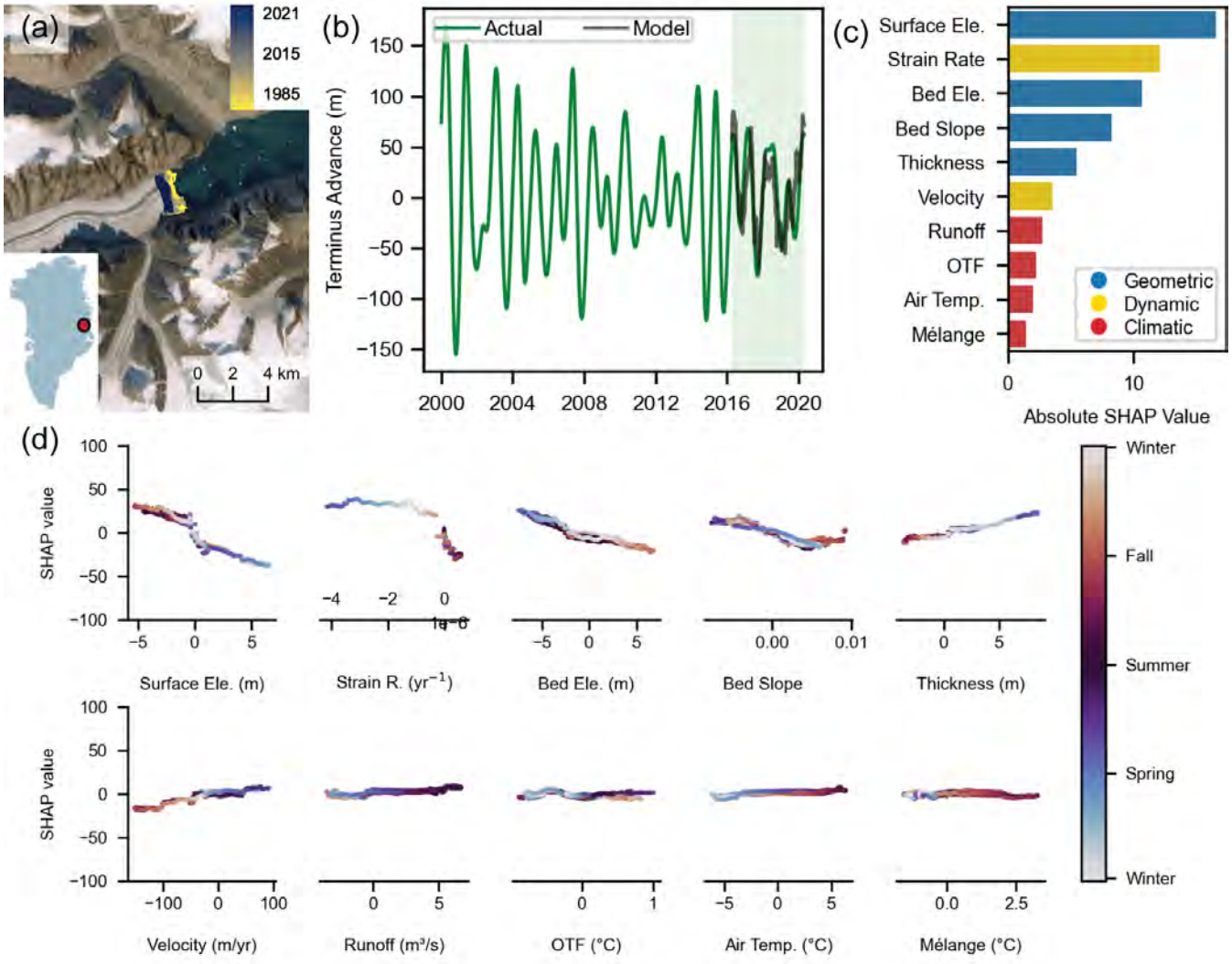

Figure S29. Same as for Fig. S10 but for Nordenskiöld Gletscher (GID 114). Error scores for this model are NRMSE: 0.141 (RMSE: 46 m); Spearman: 0.796; R^2: 0.619; offset: 2.1 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

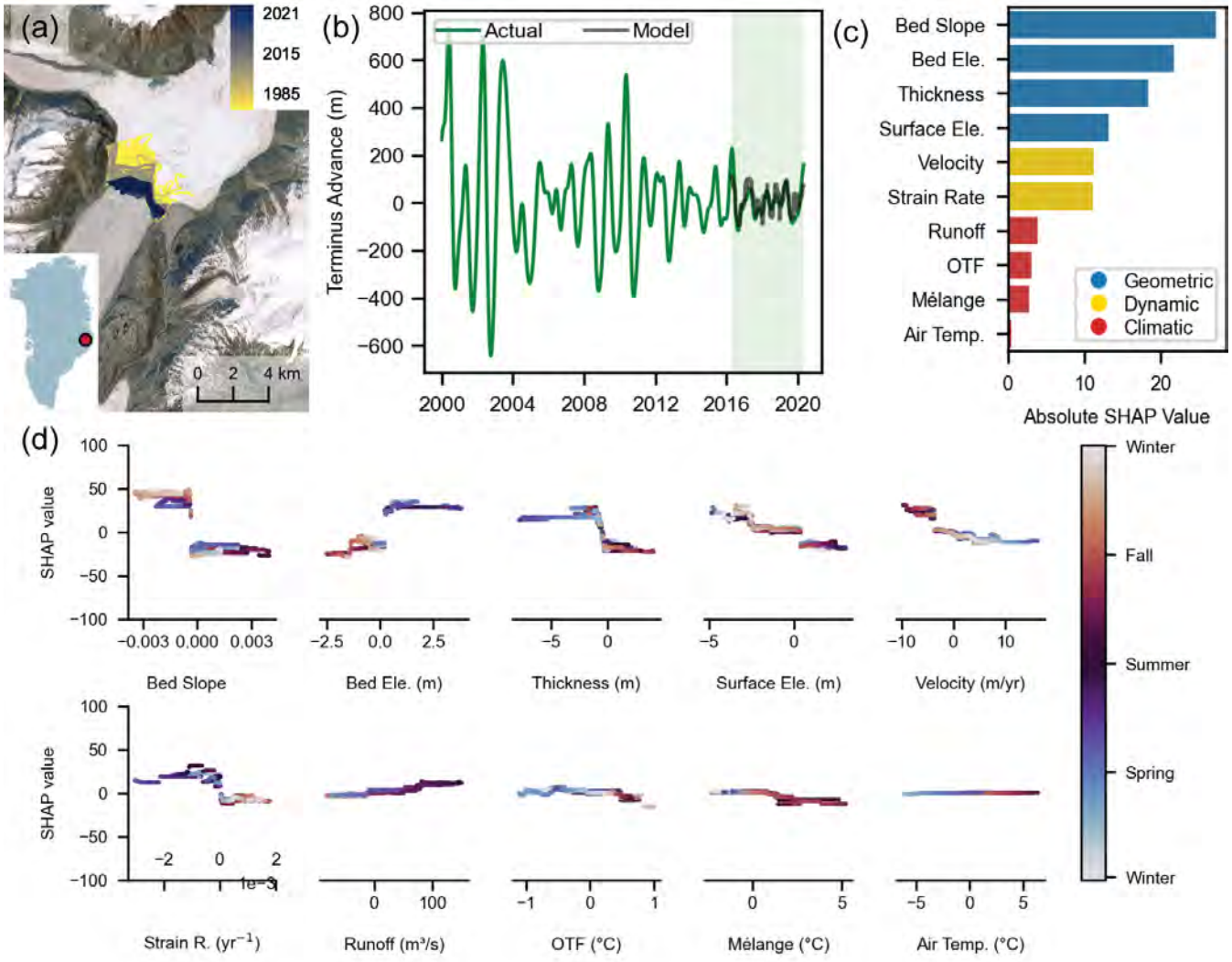

Figure S30. Same as for Fig. S10 but for Vestfjord Gletscher (GID 121). Error scores for this model are NRMSE: 0.094 (RMSE: 130 m); Spearman: 0.792; R^2: 0.514; offset: 13.6 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

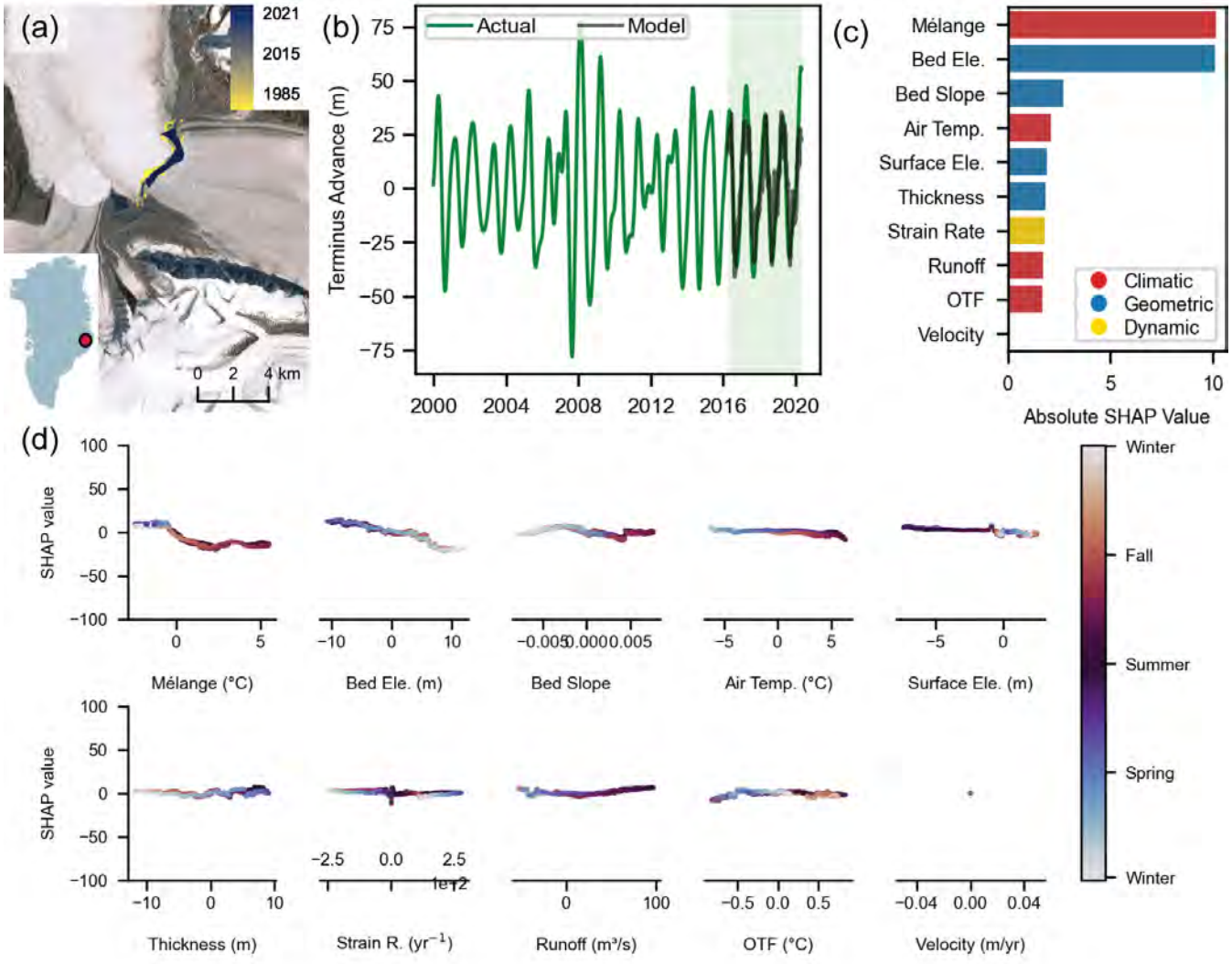

Figure S31. Same as for Fig. S10 but for Magga Dan Gletscher (GID 125). Error scores for this model are NRMSE: 0.106 (RMSE: 16 m); Spearman: 0.916; R^2: 0.772; offset: 0.8 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

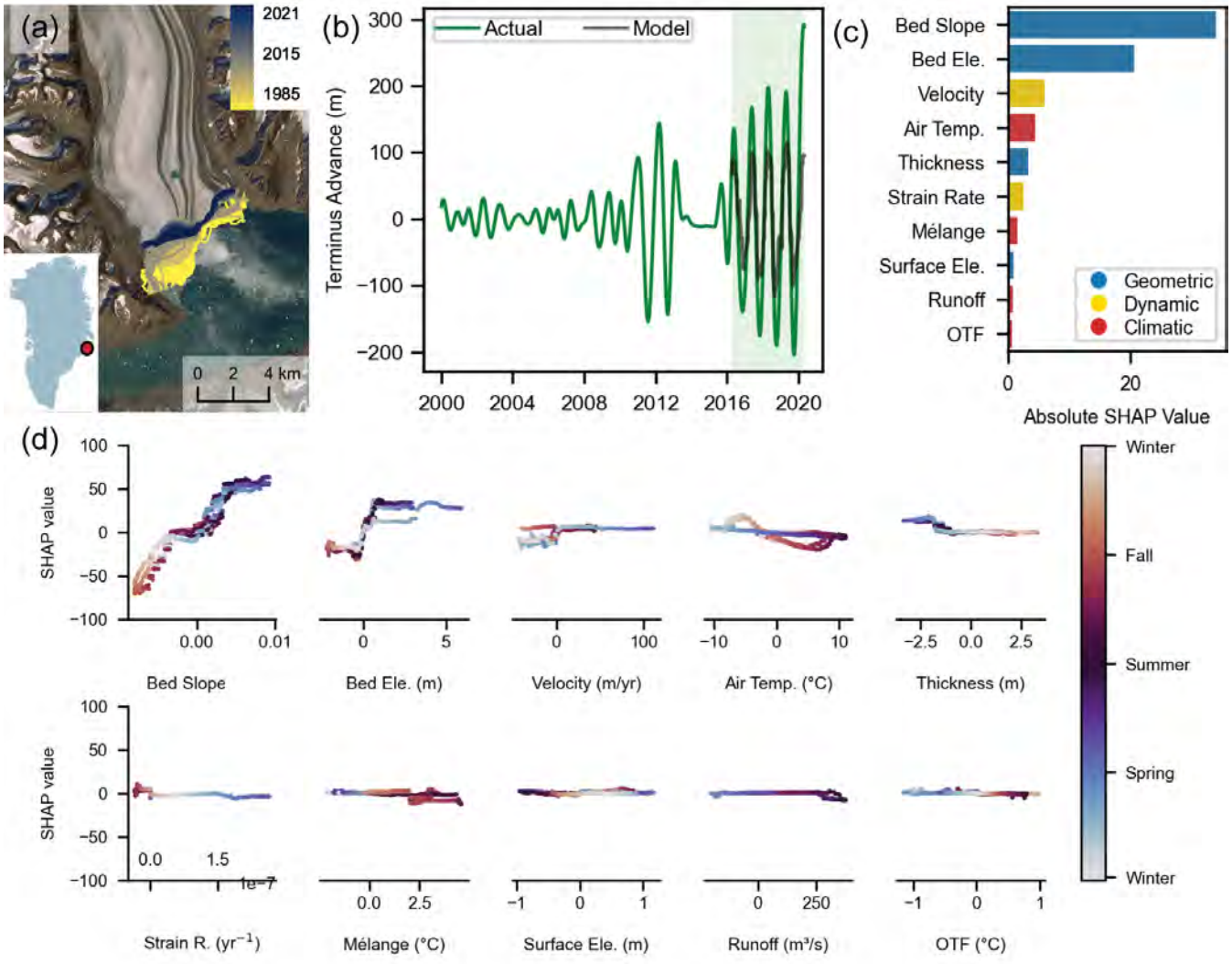

Figure S32. Same as for Fig. S10 but for Dendritgletscher (GID 132). Error scores for this model are NRMSE: 0.127 (RMSE: 63 m); Spearman: 0.906; R^2: 0.668; offset: 0.6 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

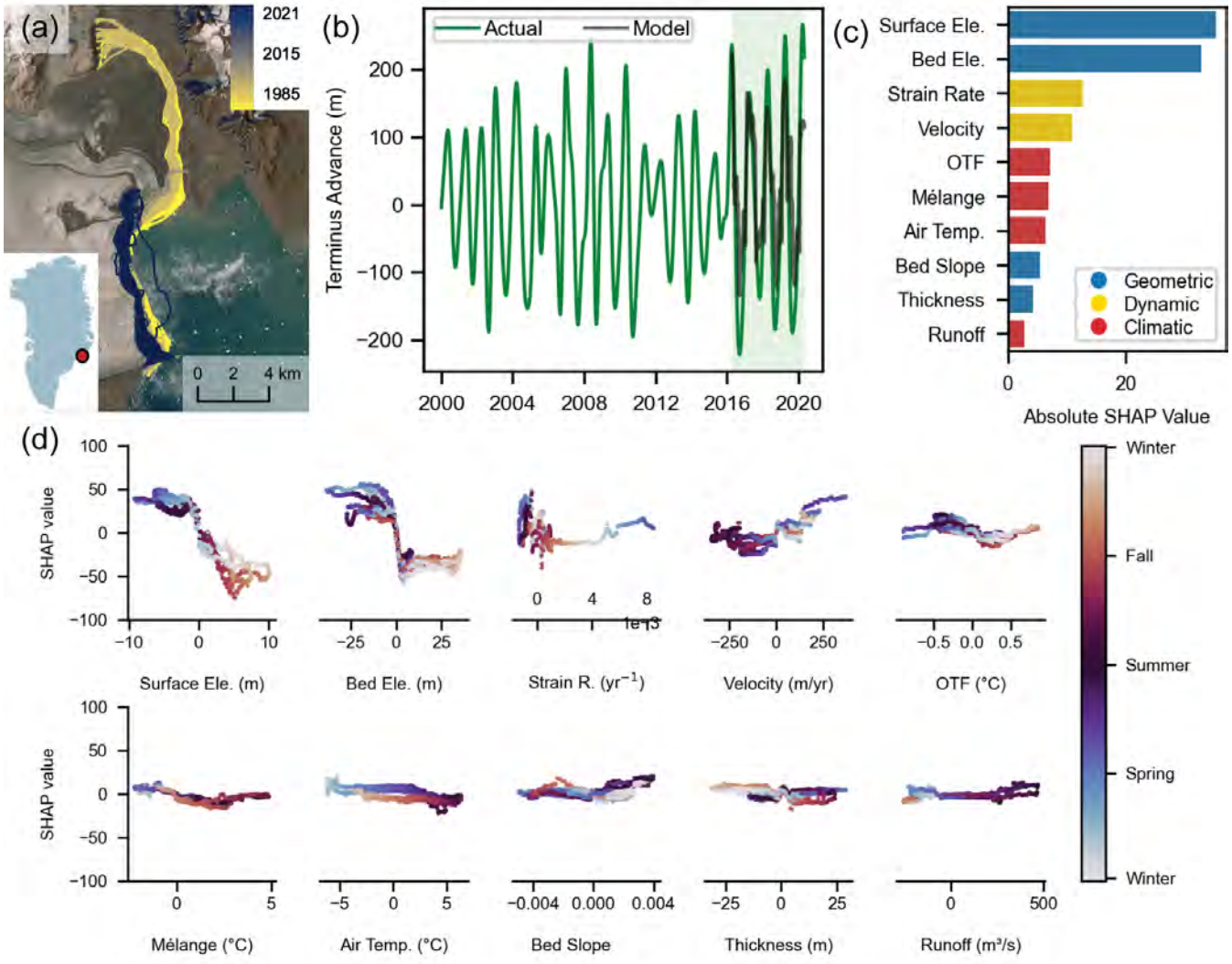

Figure S33. Same as for Fig. S10 but for Kong Christian IV Gletscher (GID 145). Error scores for this model are NRMSE: 0.153 (RMSE: 75 m); Spearman: 0.841; R^2: 0.624; offset: 2.5 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

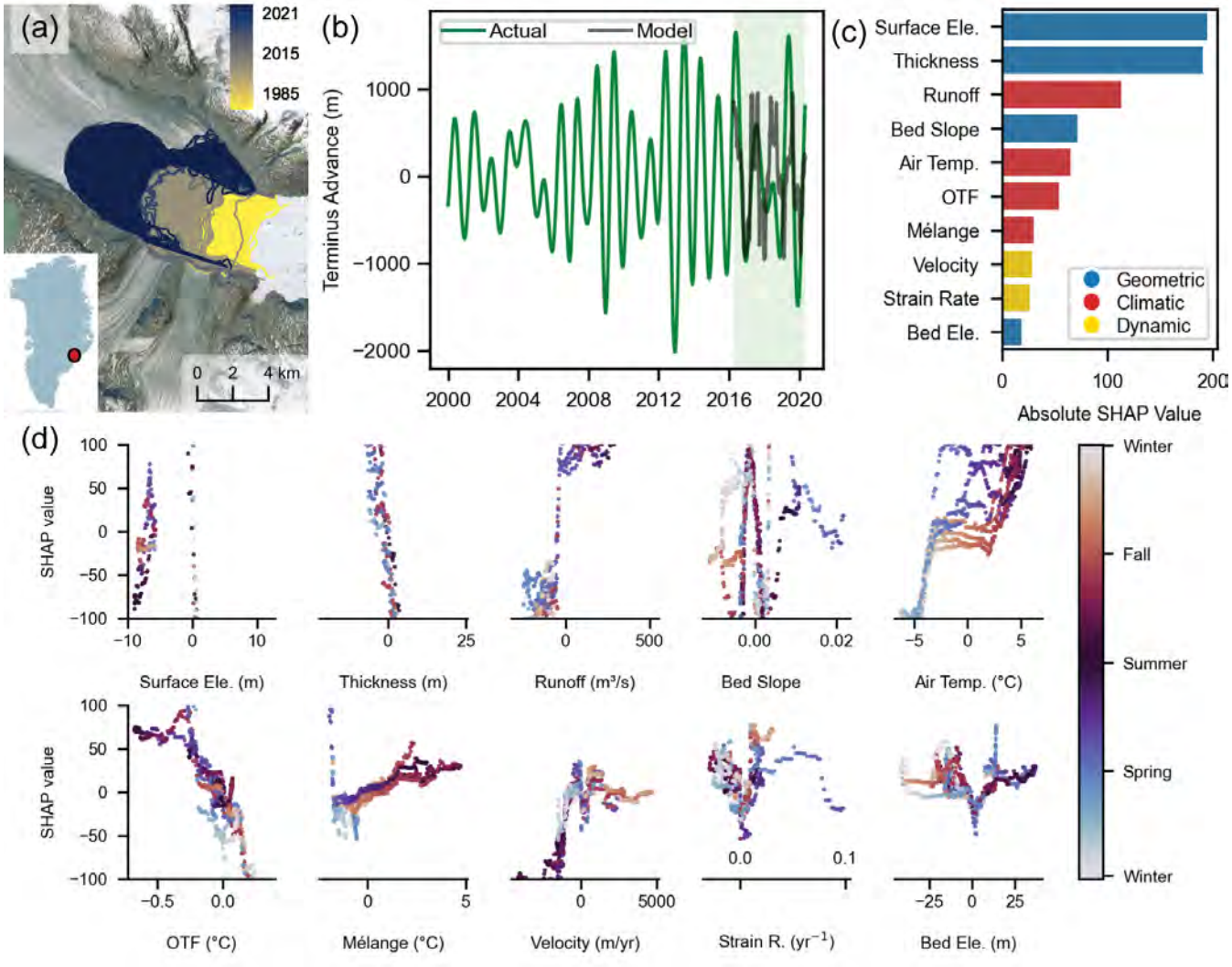

Figure S34. Same as for Fig. S10 but for Kangerlussuaq Gletscher (GID 152). Error scores for this model are NRMSE: 0.179 (RMSE: 668 m); Spearman: 0.593; R^2: 0.308; offset: 6.5 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

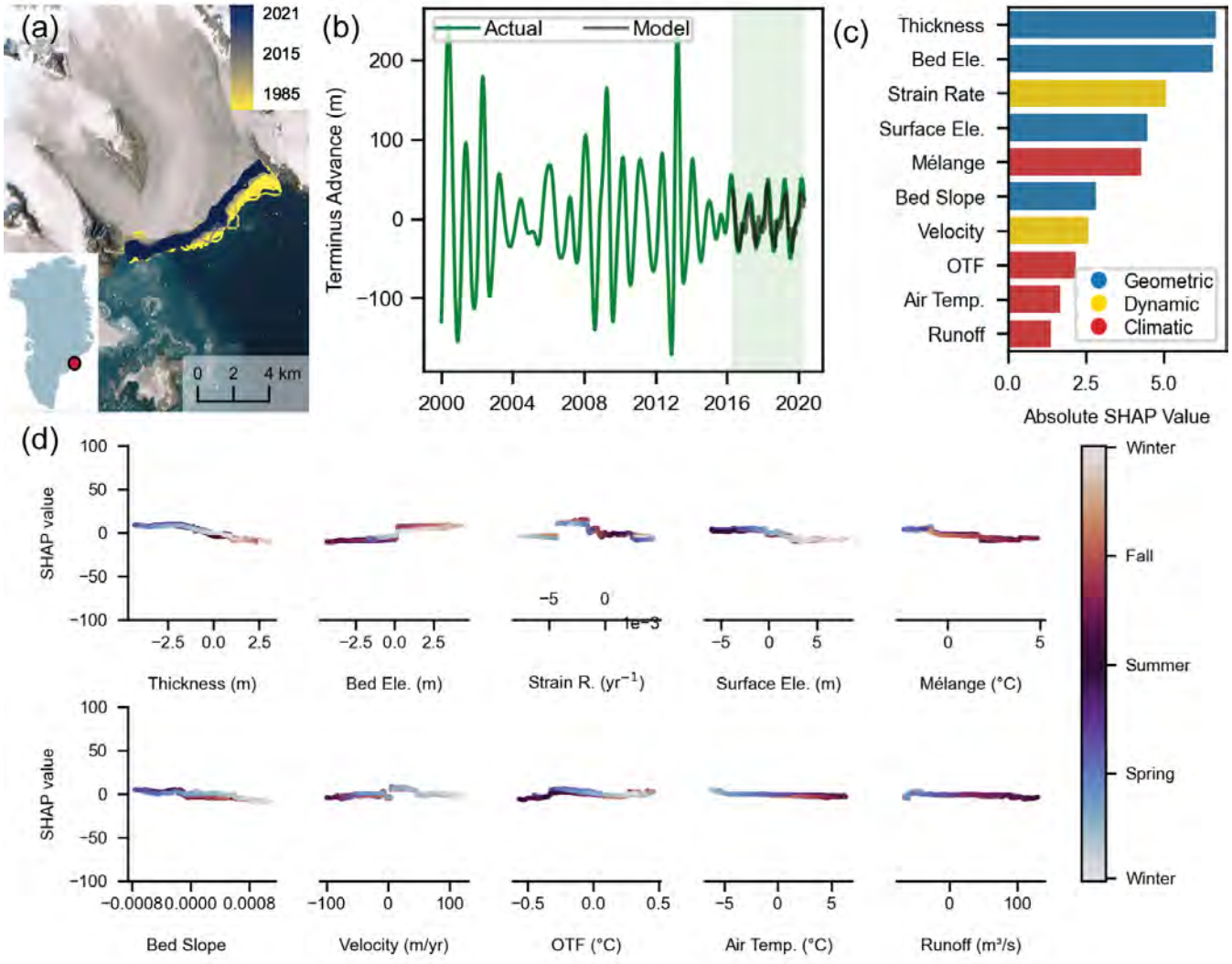

Figure S35. Same as for Fig. S10 but for Polaric Gletscher (GID 157). Error scores for this model are NRMSE: 0.105 (RMSE: 44 m); Spearman: 0.888; R^2: 0.773; offset: 6.9 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

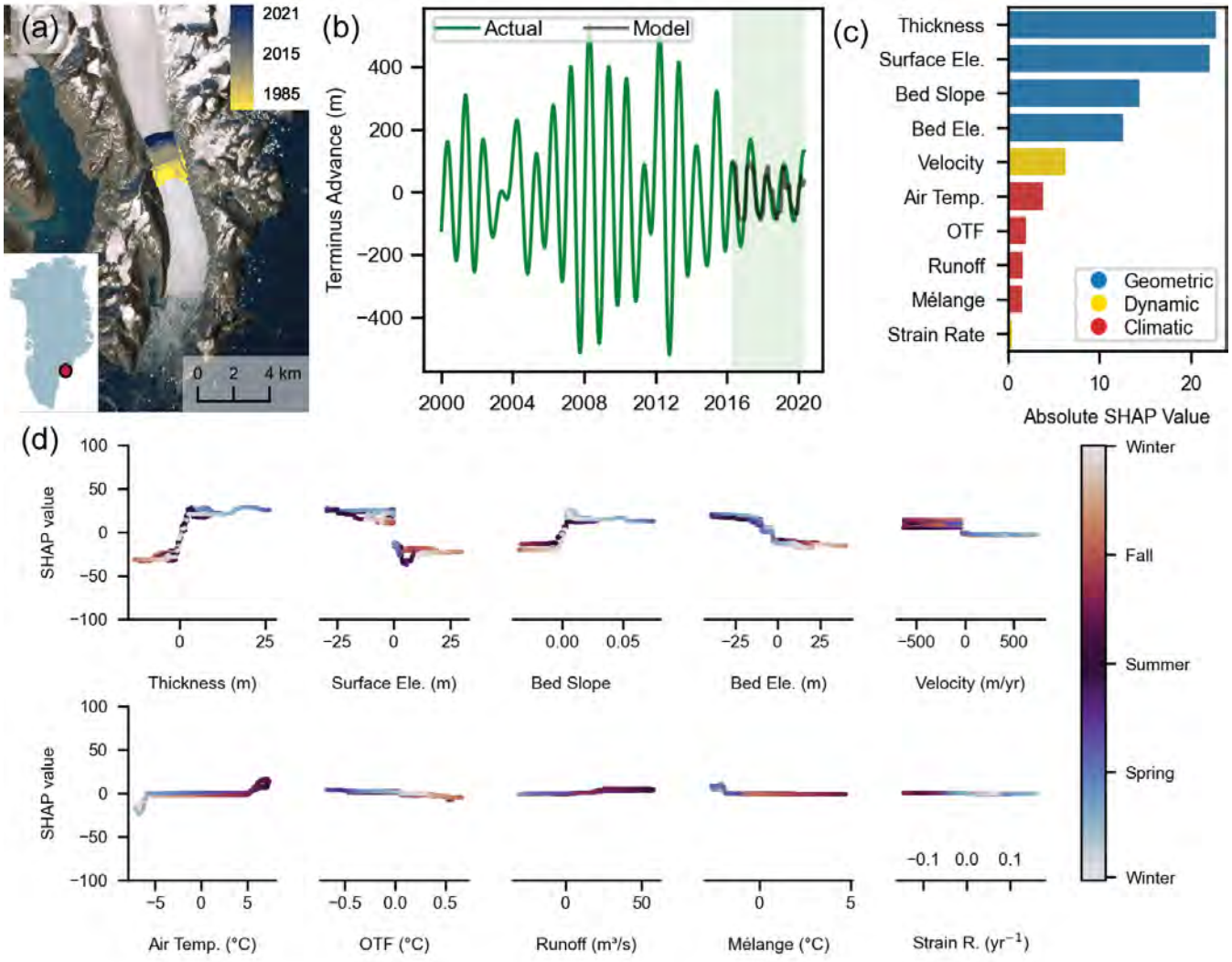

Figure S36. Same as for Fig. S10 but for Laube S (GID 167). Error scores for this model are NRMSE: 0.110 (RMSE: 116 m); Spearman: 0.852; R^2: 0.696; offset: 10.2 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

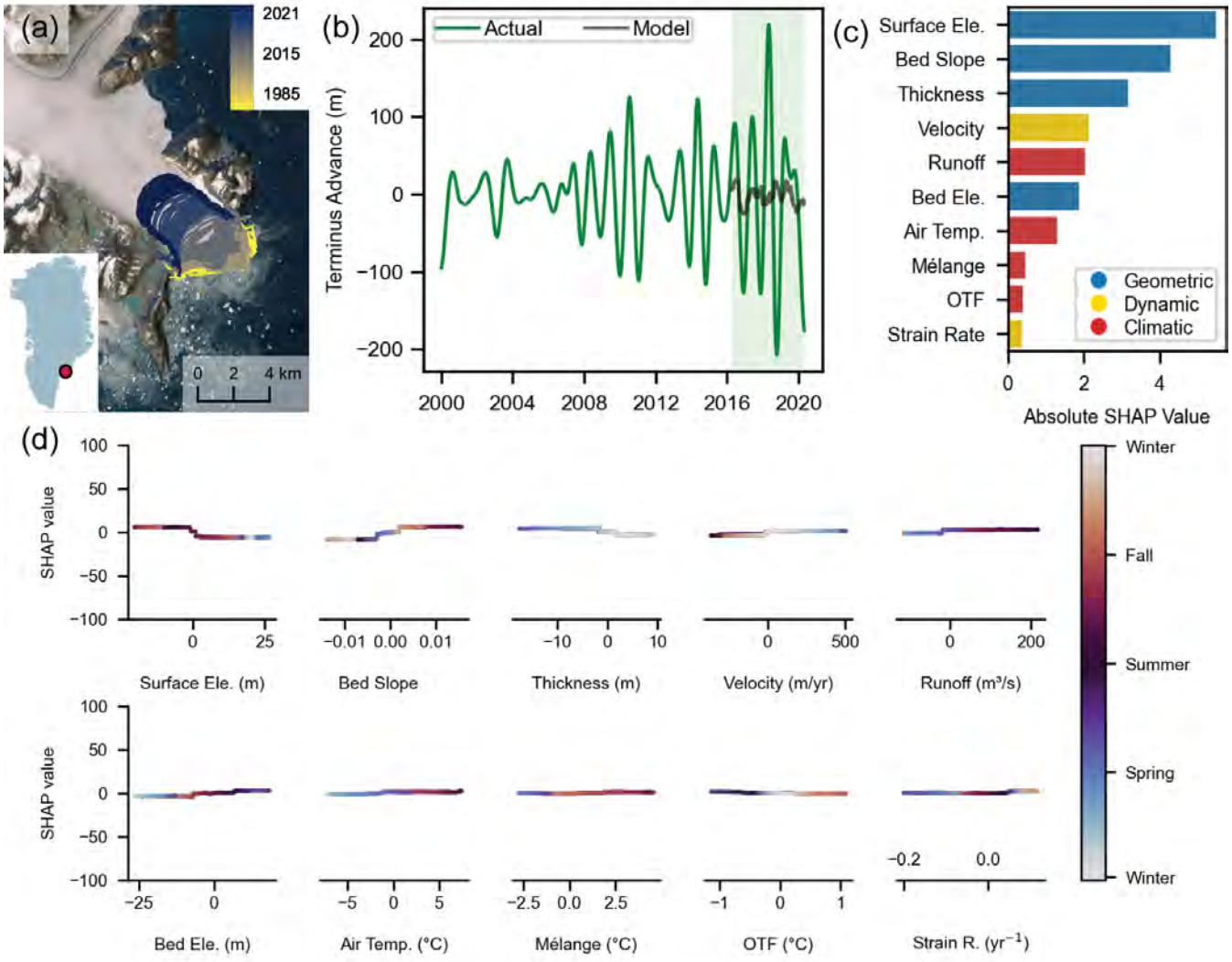

Figure S37. Same as for Fig. S10 but for Steenstrup Nodre Bræ (GID 171). Error scores for this model are NRMSE: 0.185 (RMSE: 79 m); Spearman: 0.264; R^2: 0.028; offset: 15.5 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

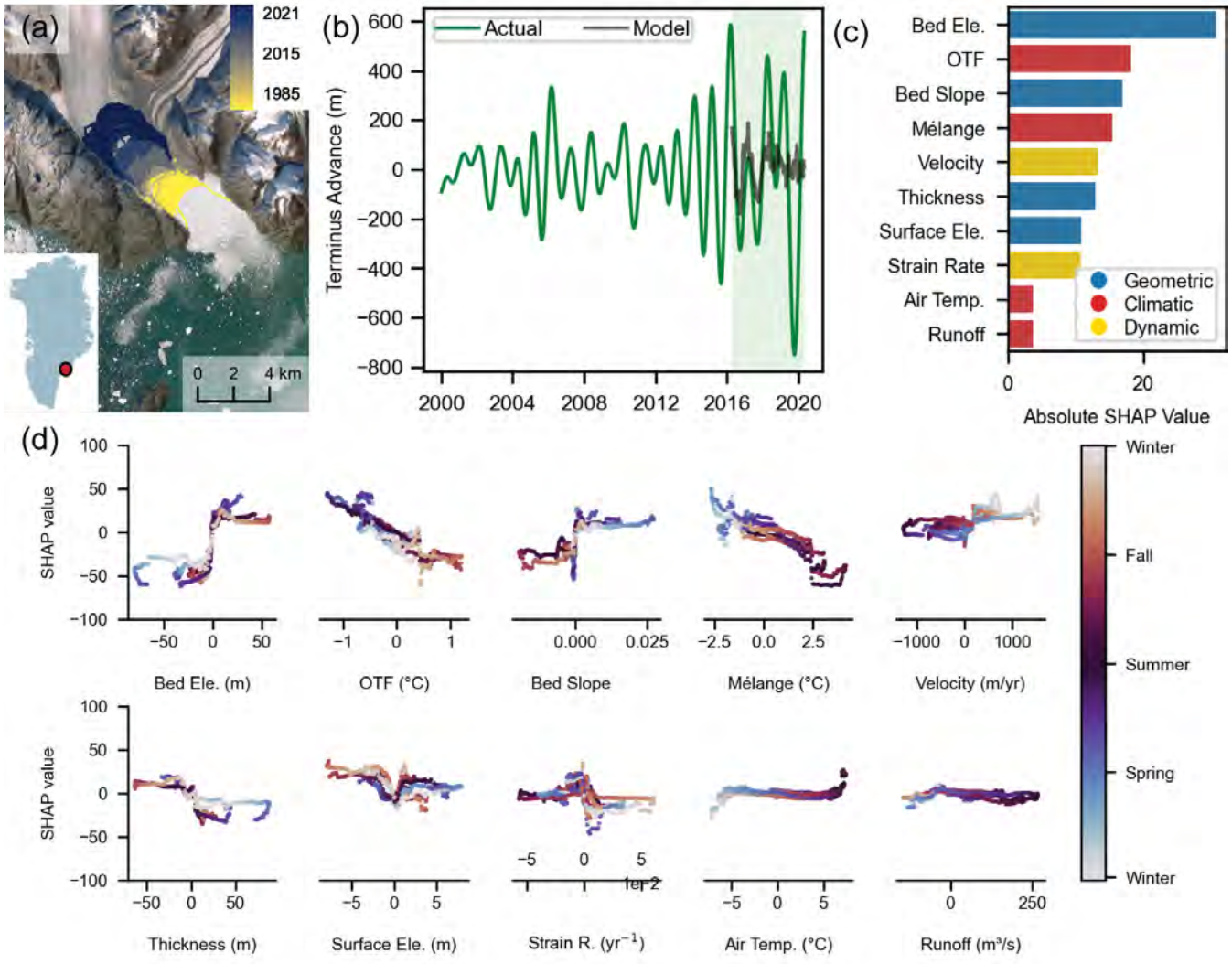

Figure S38. Same as for Fig. S10 but for Fenrisgletscher (GID 180). Error scores for this model are NRMSE: 0.181 (RMSE: 242 m); Spearman: 0.533; R^2: 0.120; offset: 7.4 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

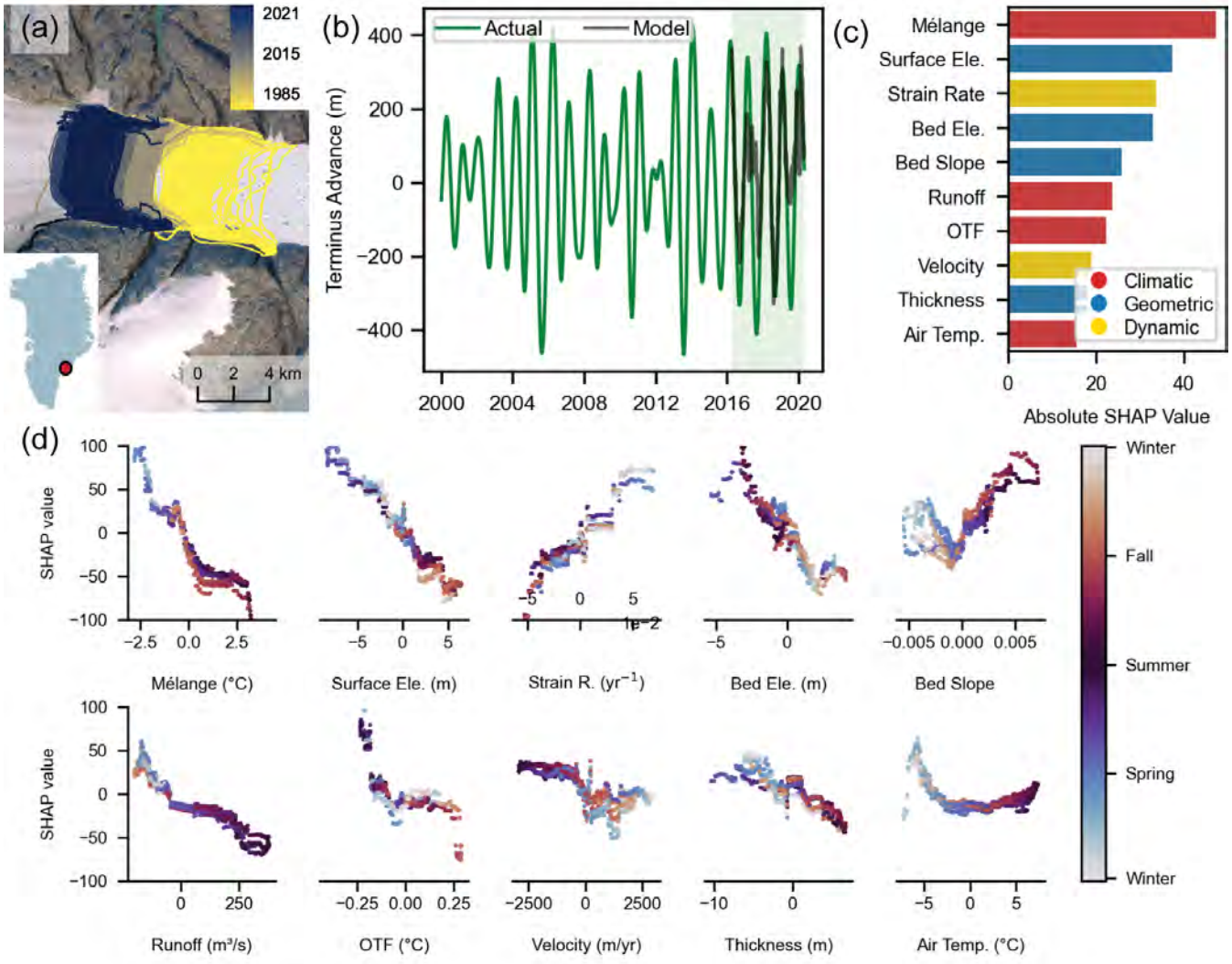

Figure S39. Same as for Fig. S10 but for Helheimgletscher (GID 181). Error scores for this model are NRMSE: 0.136 (RMSE: 122 m); Spearman: 0.871; R^2: 0.702; offset: 10.4 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

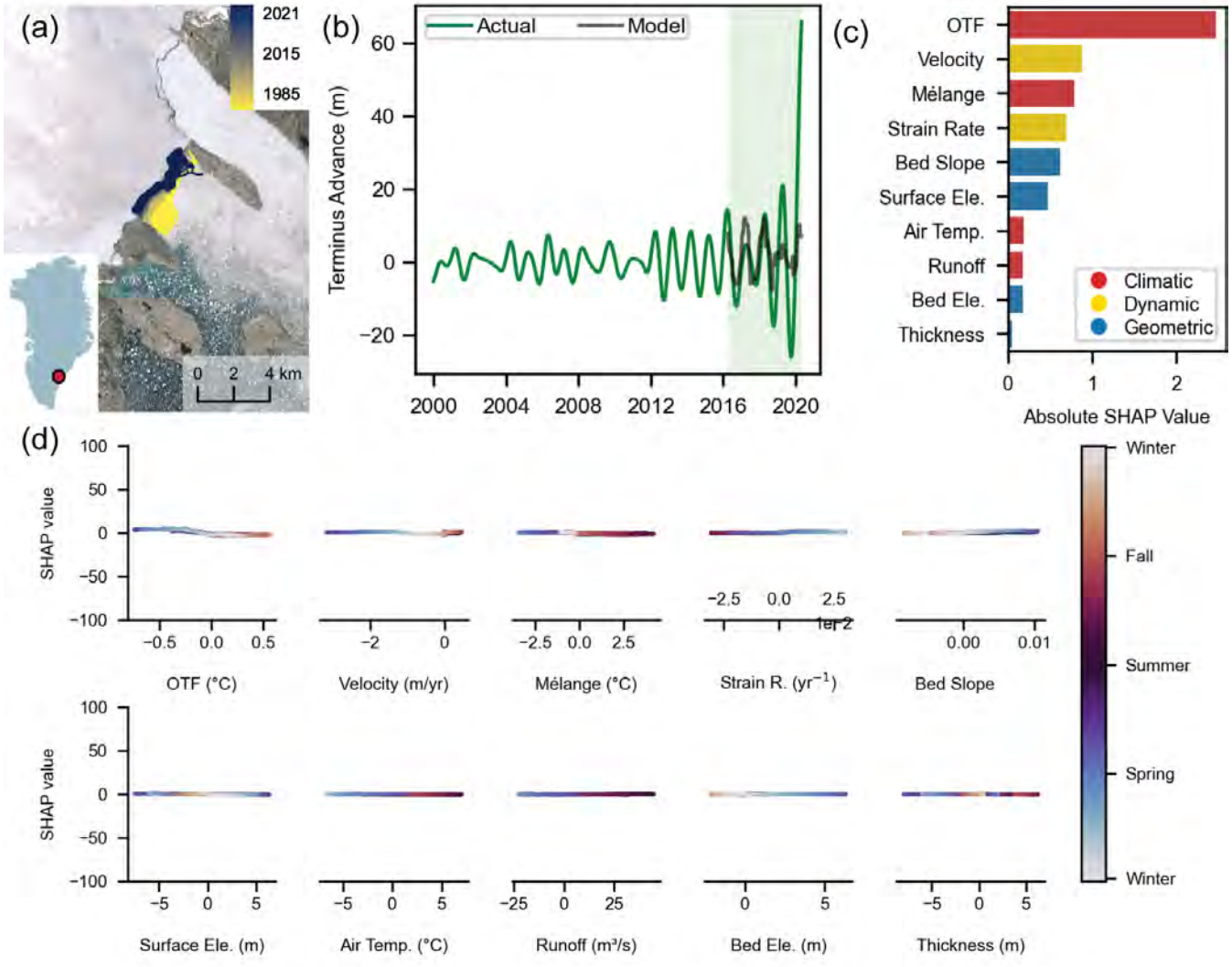

Figure S40. Same as for Fig. S10 but for Ikertivaq N (GID 186). Error scores for this model are NRMSE: 0.098 (RMSE: 9 m); Spearman: 0.681; R^2: 0.304; offset: 1.4 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

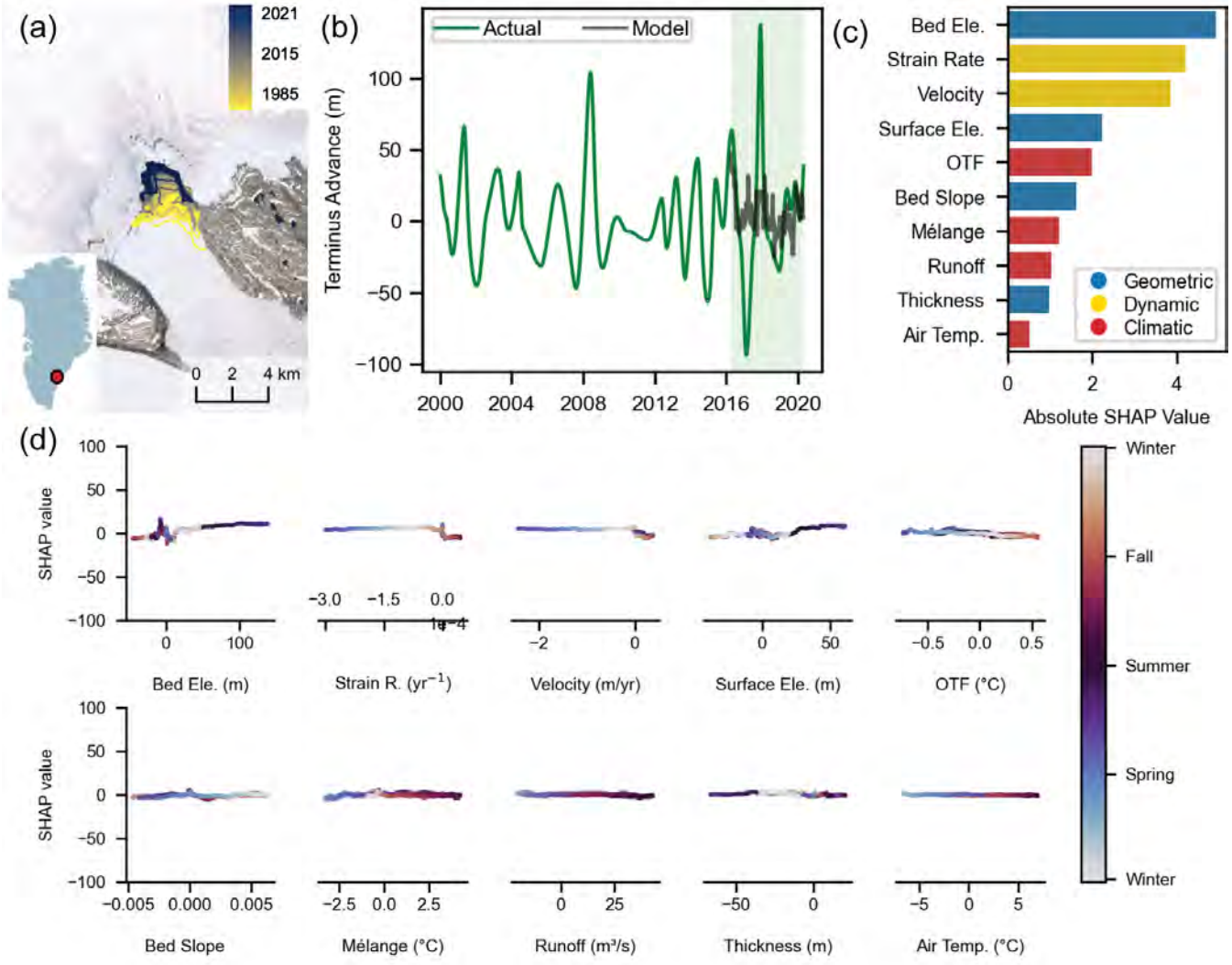

Figure S41. Same as for Fig. S10 but for Ikertivaq M (GID 187). Error scores for this model are NRMSE: 0.131 (RMSE: 30 m); Spearman: 0.387; R^2: 0.093; offset: 2.7 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

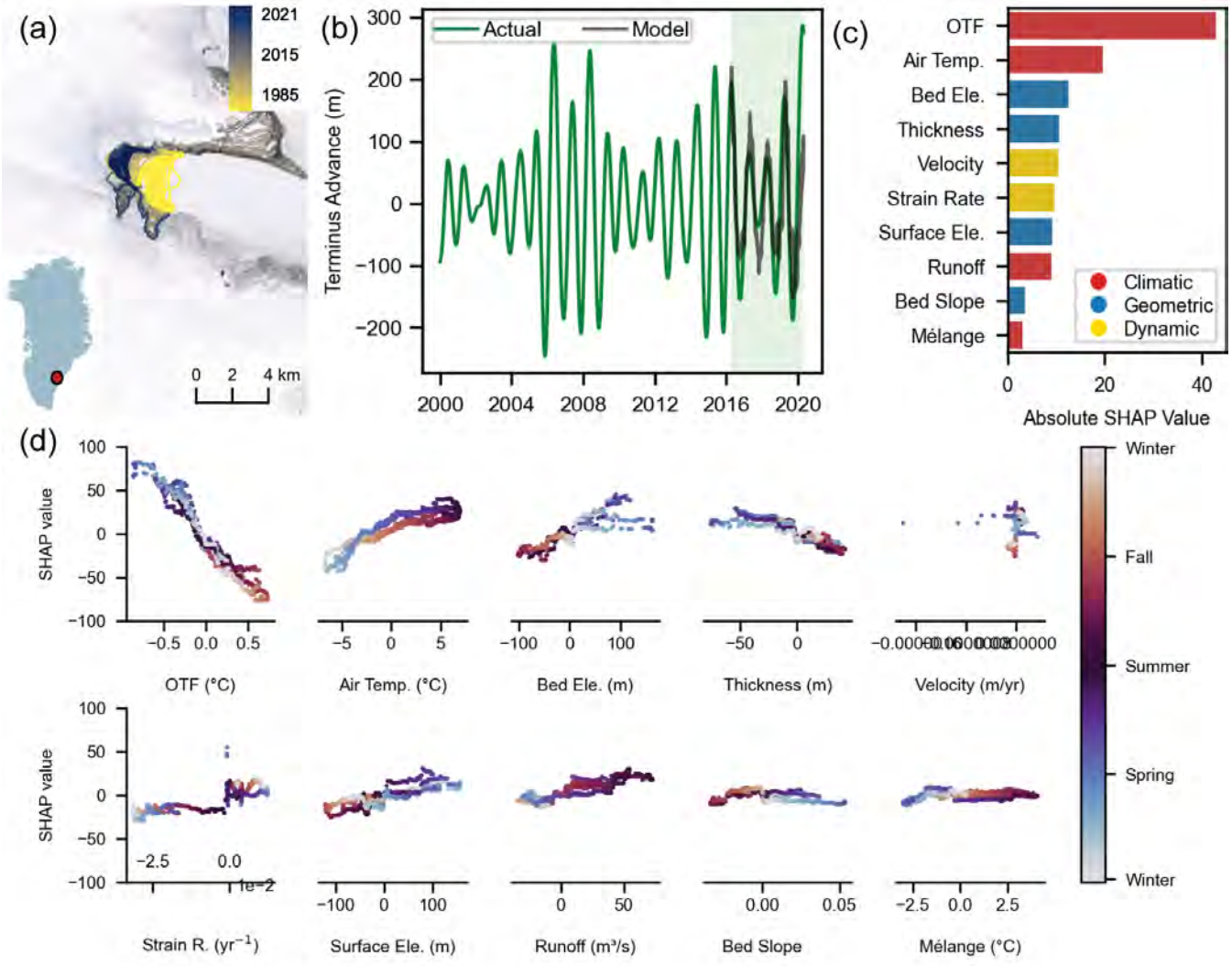

Figure S42. Same as for Fig. S10 but for Ikertivaq S (GID 189). Error scores for this model are NRMSE: 0.092 (RMSE: 49 m); Spearman: 0.902; R^2: 0.731; offset: 4.9 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

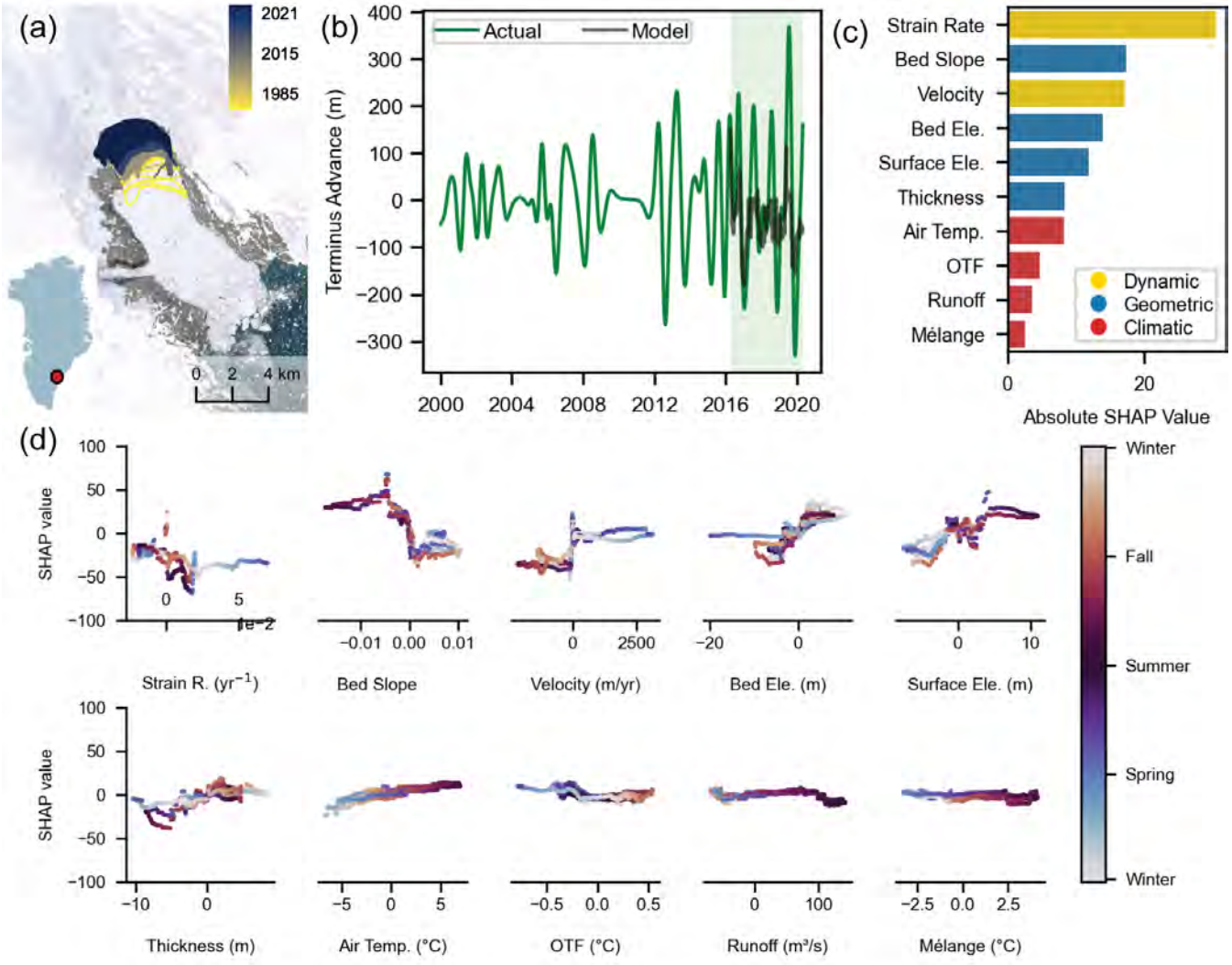

Figure S43. Same as for Fig. S10 but for Køge Bugt C (GID 196). Error scores for this model are NRMSE: 0.141 (RMSE: 99 m); Spearman: 0.745; R^2: 0.347; offset: 2.7 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

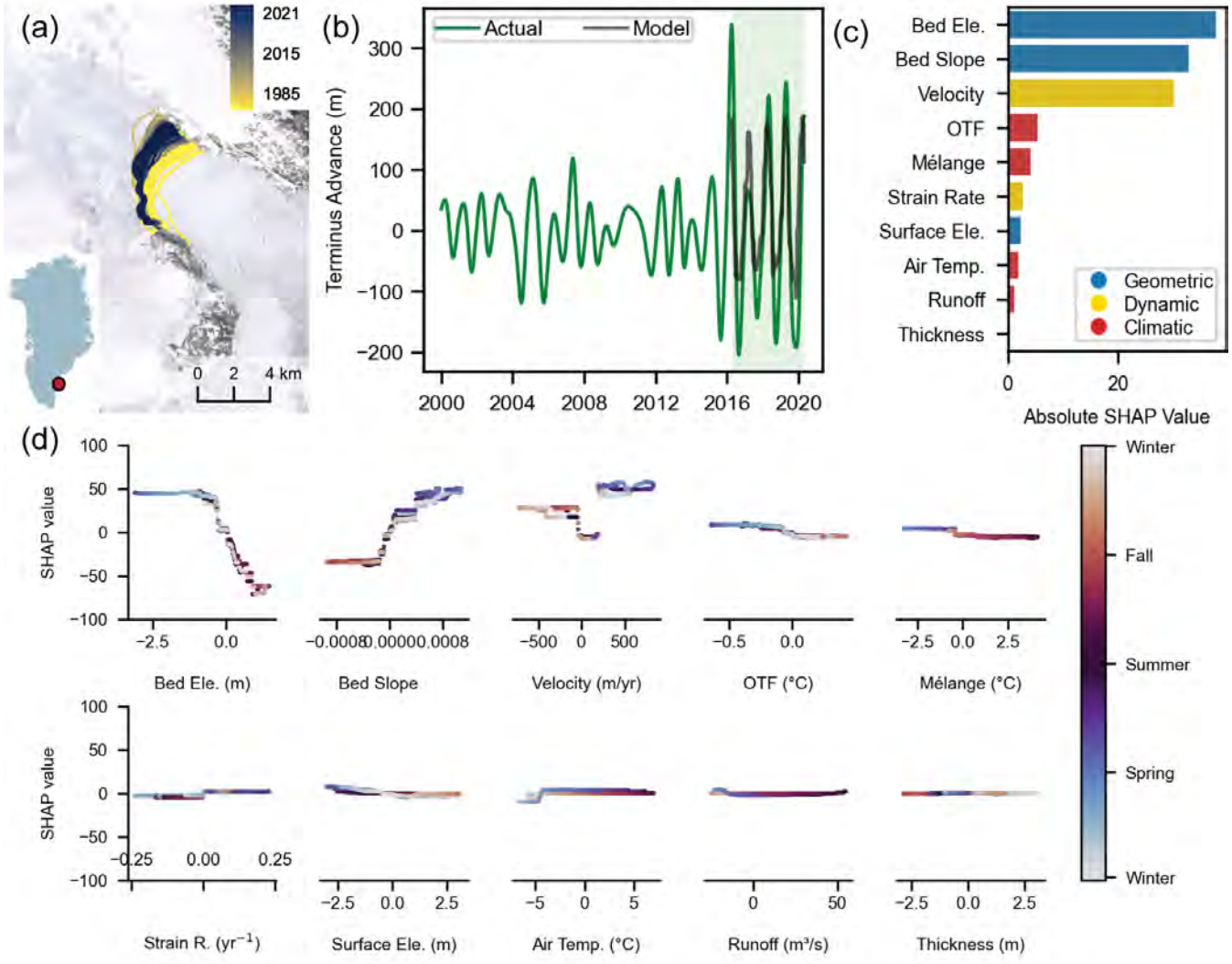

Figure S44. Same as for Fig. S10 but for Køge Bugt S (GID 197). Error scores for this model are NRMSE: 0.148 (RMSE: 80 m); Spearman: 0.821; R^2: 0.532; offset: 2.7 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

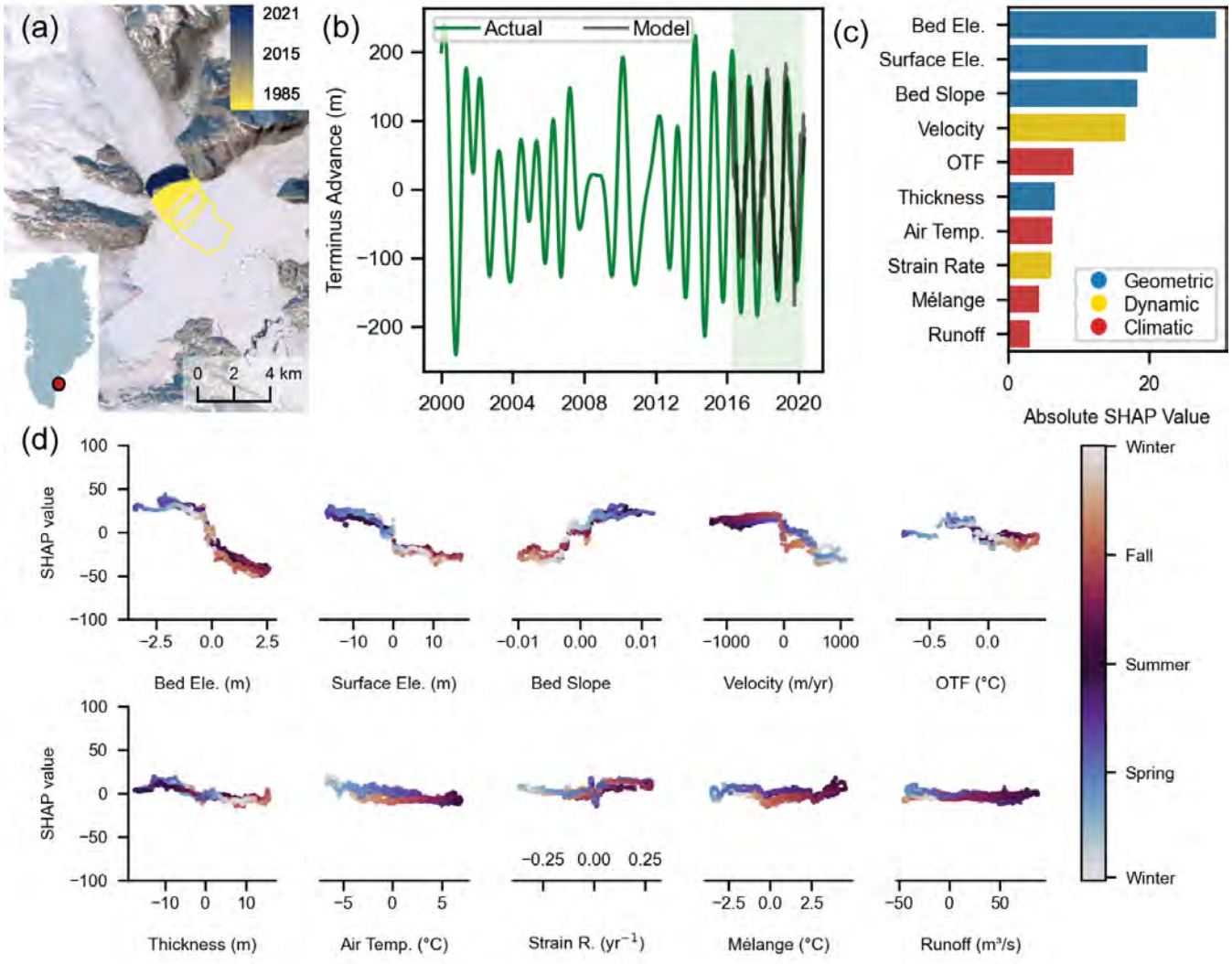

Figure S45. Same as for Fig. S10 but for Graulv (GID 210). Error scores for this model are NRMSE: 0.131 (RMSE: 63 m); Spearman: 0.869; R^2: 0.724; offset: 1.8 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

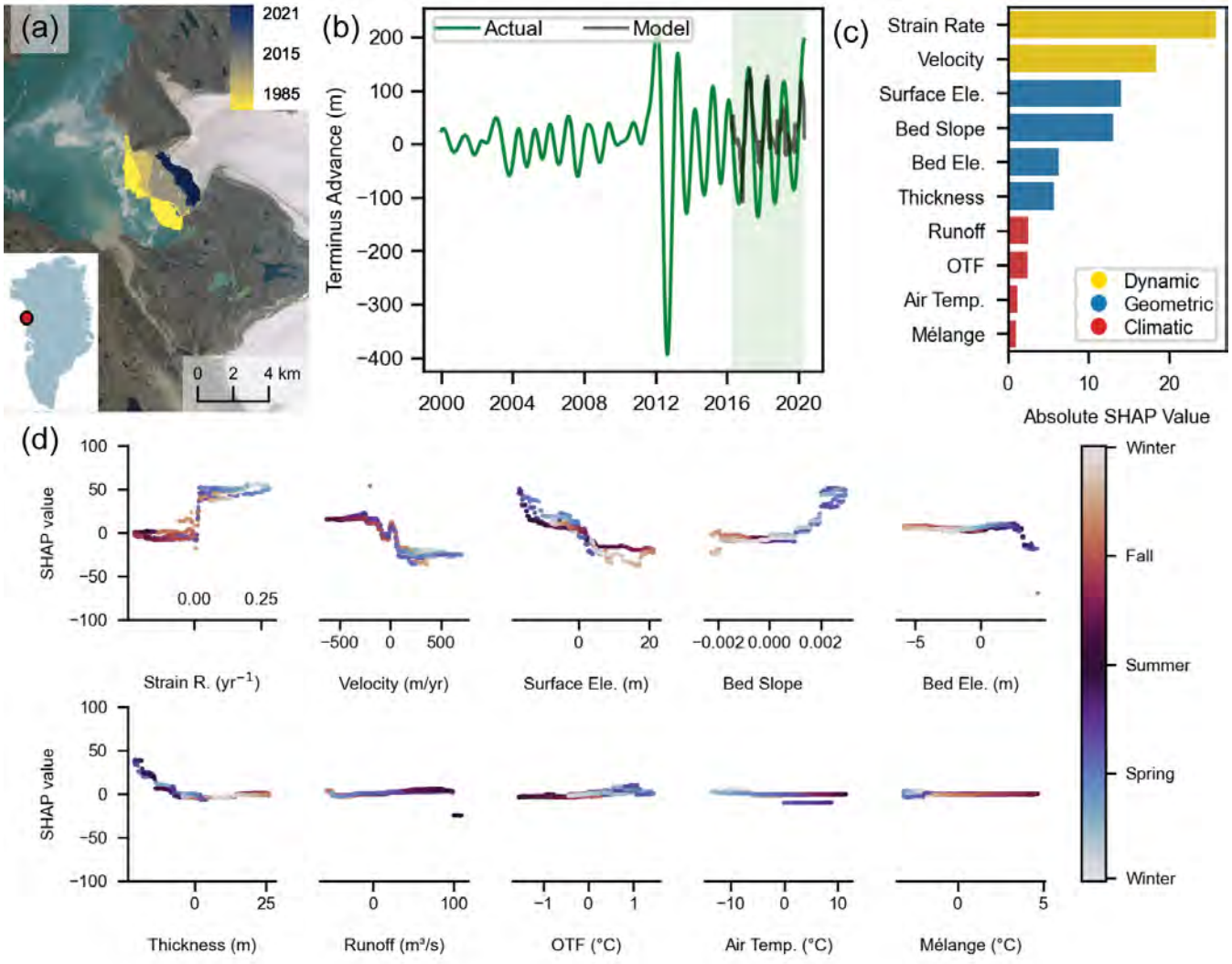

Figure S46. Same as for Fig. S10 but for Eqip Sermia (GID 280). Error scores for this model are NRMSE: 0.171 (RMSE: 106 m); Spearman: 0.775; R^2: 0.463; offset: 10.2 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

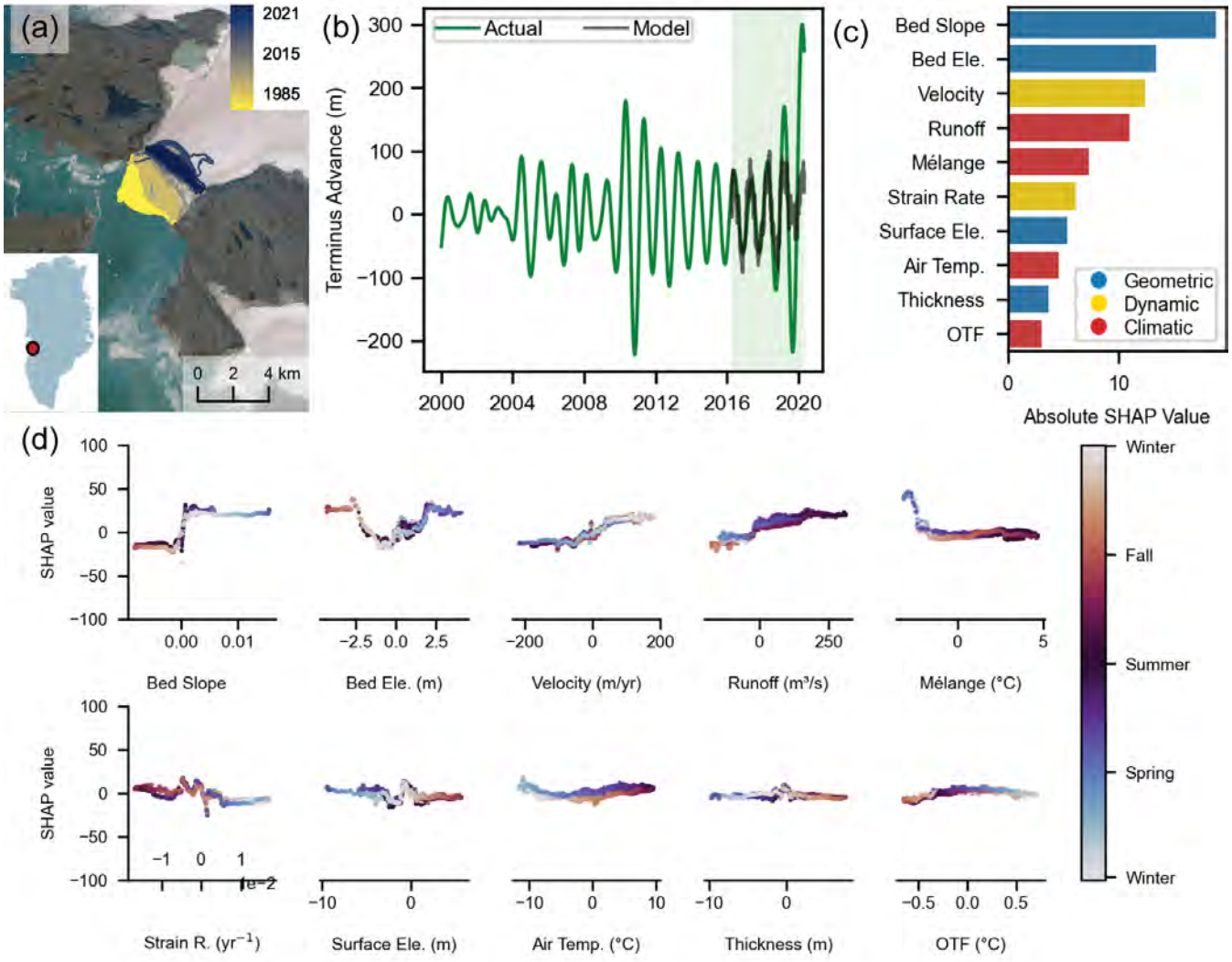

Figure S47. Same as for Fig. S10 but for Kangilerngata Sermia (GID 281). Error scores for this model are NRMSE: 0.107 (RMSE: 56 m); Spearman: 0.802; R^2: 0.363; offset: 0.5 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

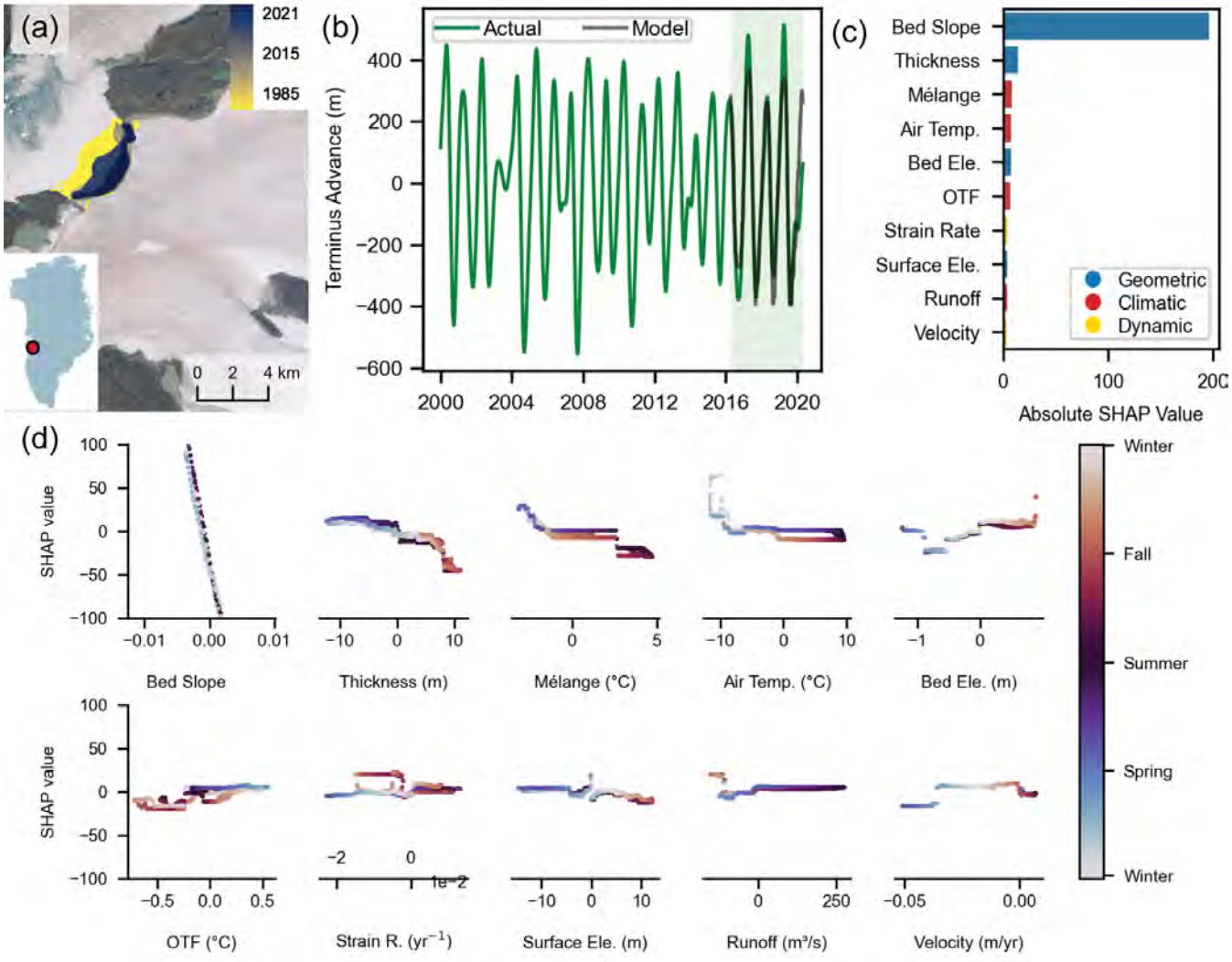

Figure S48. Same as for Fig. S10 but for Sermeq Kujalleq (GID 282). Error scores for this model are NRMSE: 0.068 (RMSE: 73 m); Spearman: 0.955; R^2: 0.878; offset: 7.2 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

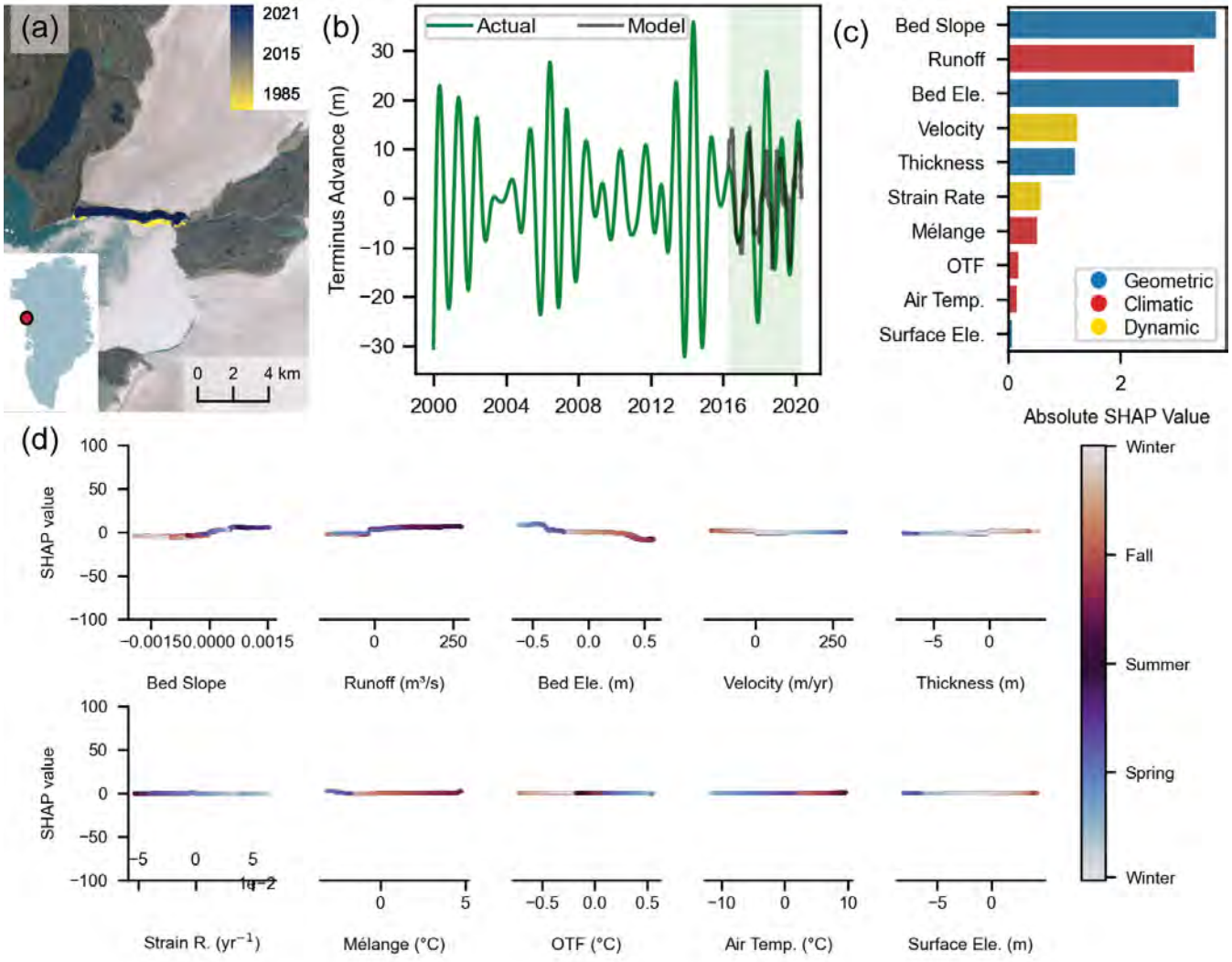

Figure S49. Same as for Fig. S10 but for Sermeq Avannarleq (GID 283). Error scores for this model are NRMSE: 0.147 (RMSE: 10 m); Spearman: 0.698; R^2: 0.410; offset: 12.4 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

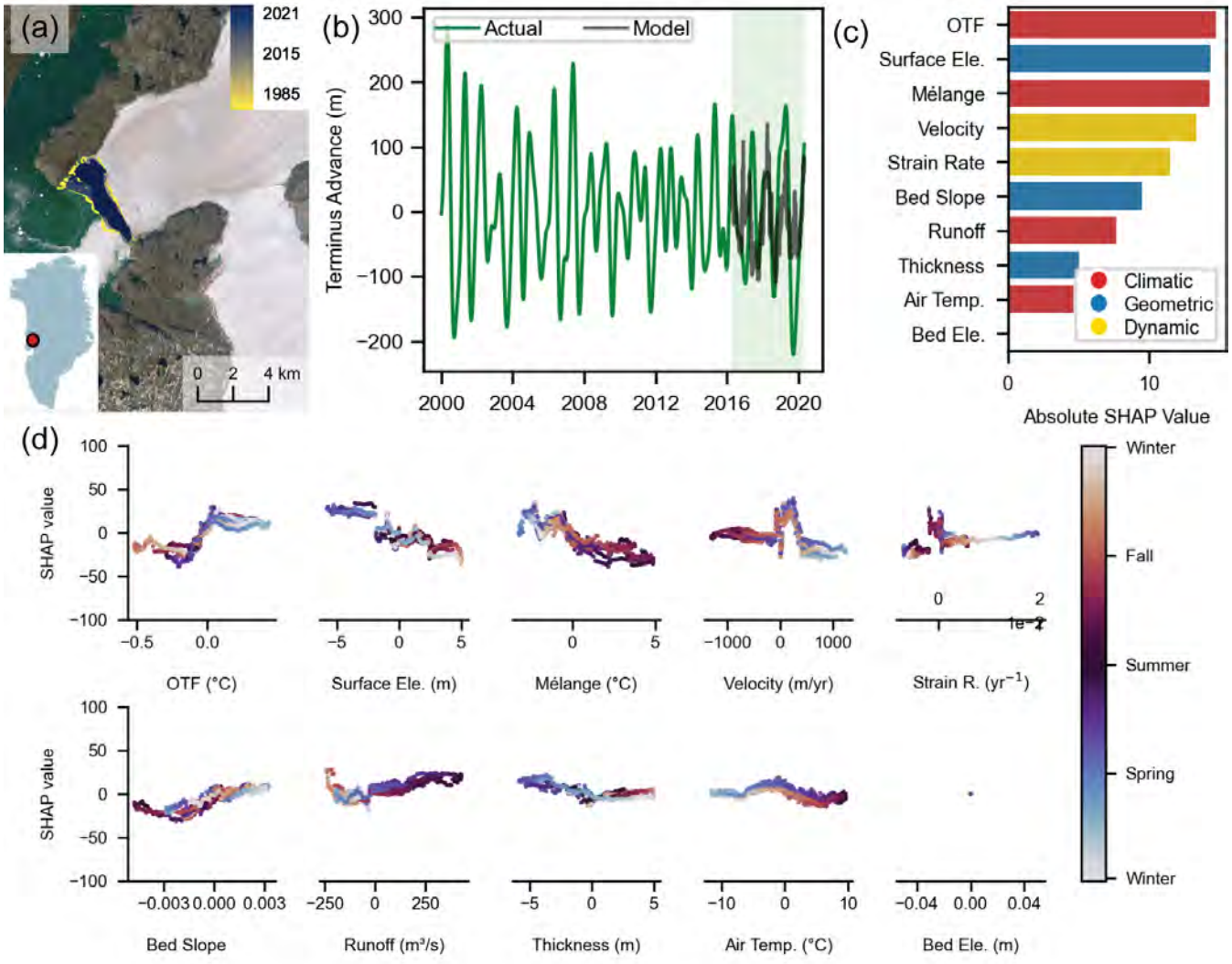

Figure S50. Same as for Fig. S10 but for Store Gletscher (GID 284). Error scores for this model are NRMSE: 0.192 (RMSE: 98 m); Spearman: 0.377; R^2: 0.574; offset: 5.8 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

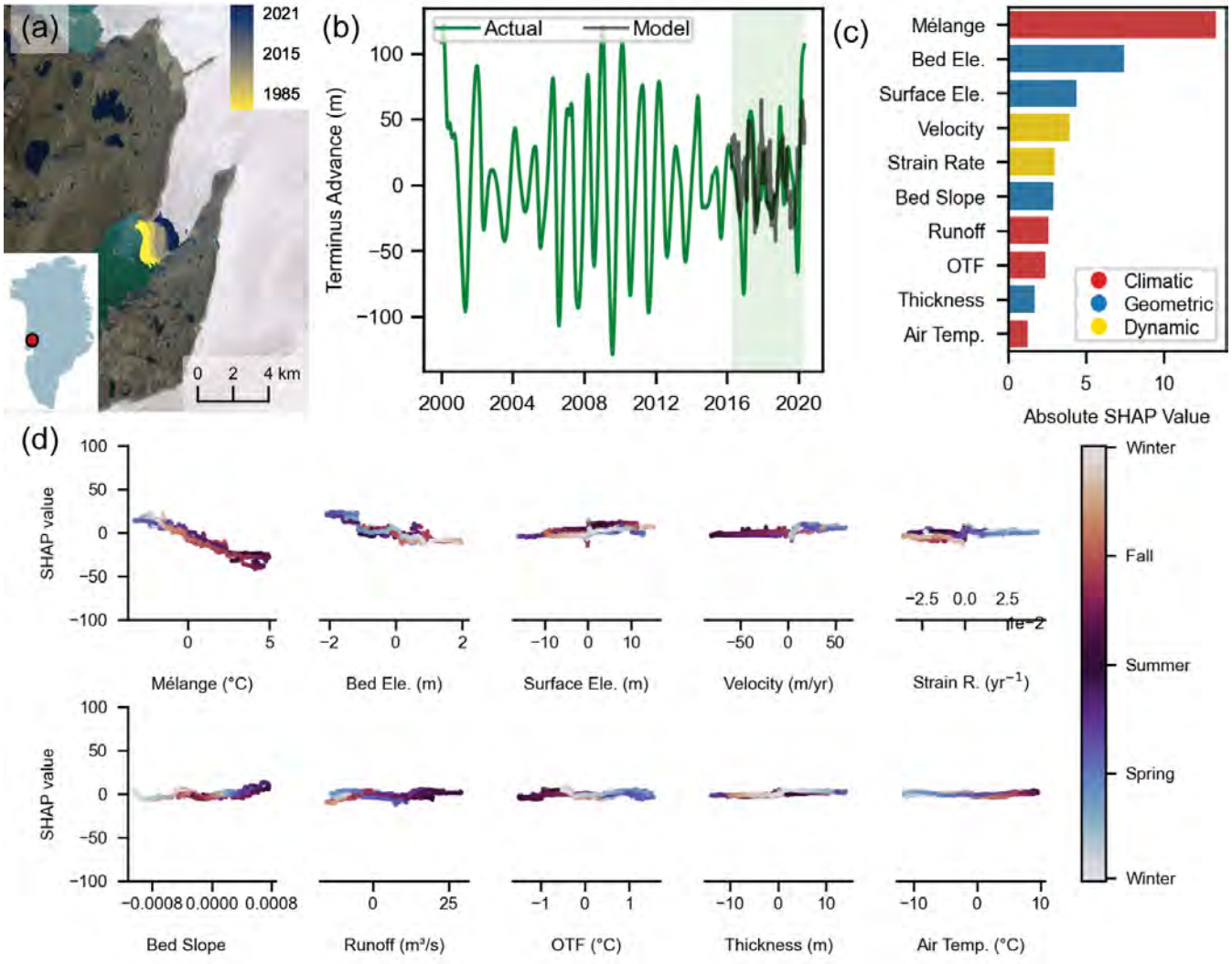

Figure S51. Same as for Fig. S10 but for Lille Gletscher (GID 285). Error scores for this model are NRMSE: 0.152 (RMSE: 38 m); Spearman: 0.175; R^2: 0.084; offset: 6.0 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

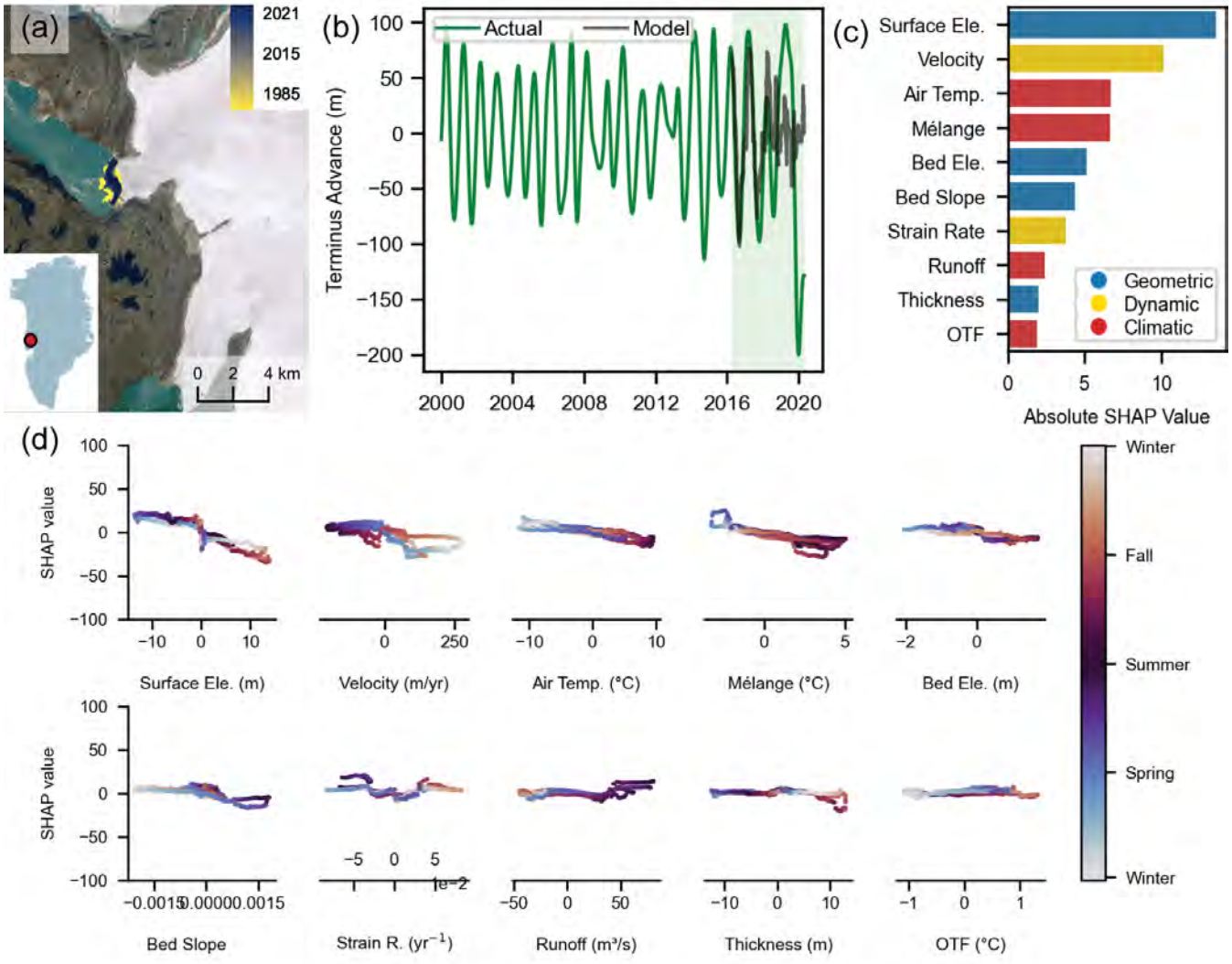

Figure S52. Same as for Fig. S10 but for Sermilik (GID 286). Error scores for this model are NRMSE: 0.189 (RMSE: 56 m); Spearman: 0.440; R^2: 0.138; offset: 4.2 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

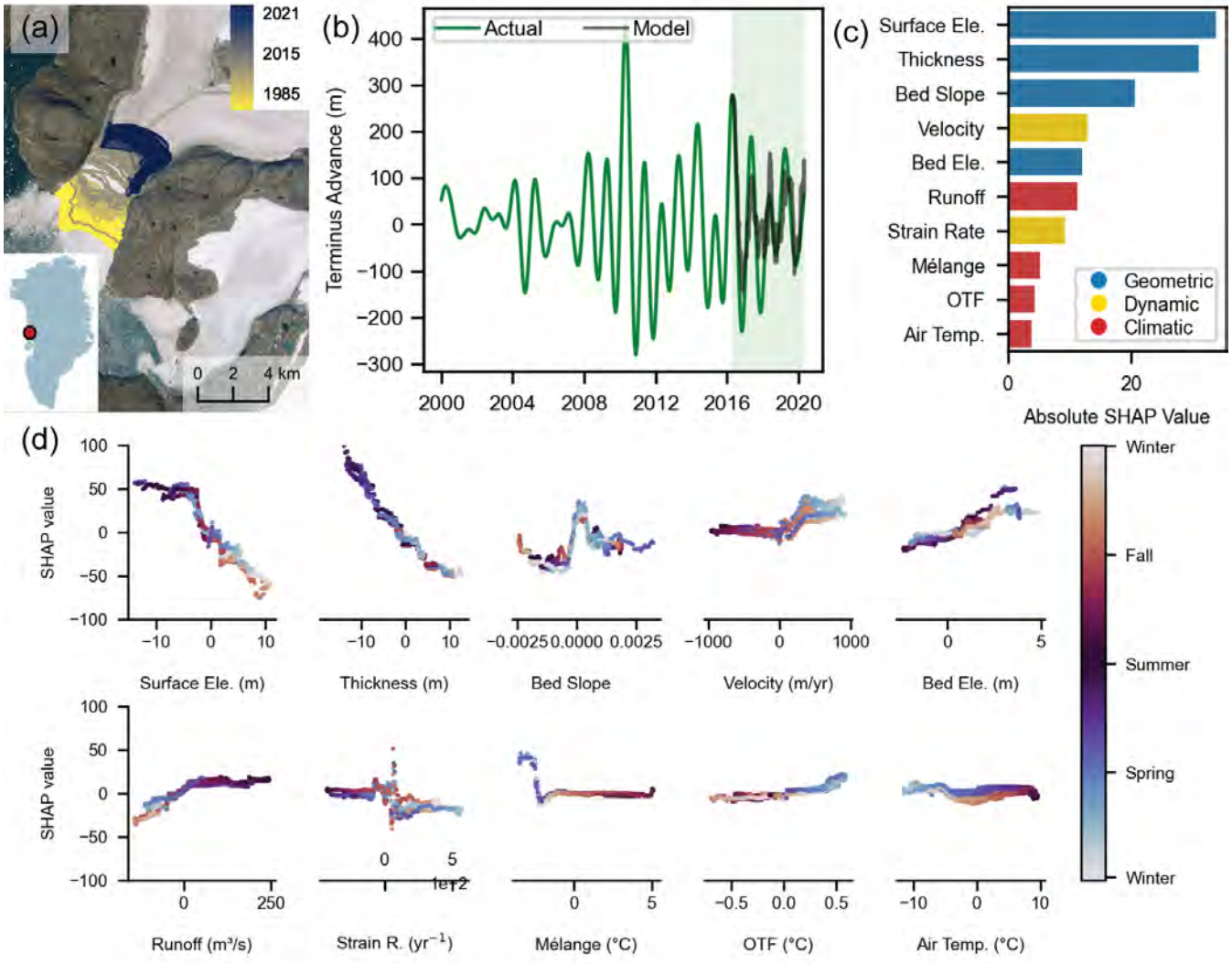

Figure S53. Same as for Fig. S10 but for Sermeq Silarleq (GID 288). Error scores for this model are NRMSE: 0.127 (RMSE: 90 m); Spearman: 0.741; R^2: 0.574; offset: 5.8 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

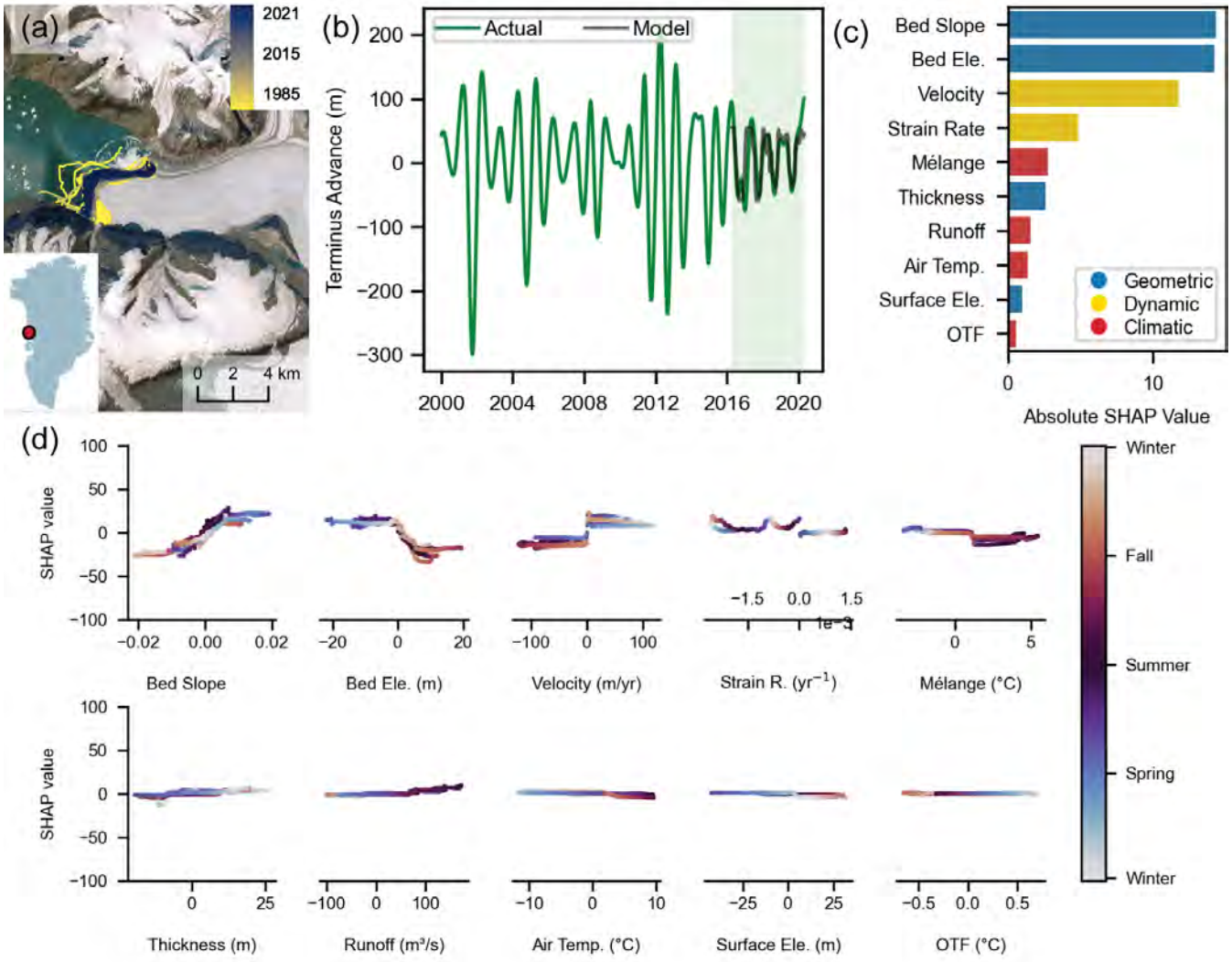

Figure S54. Same as for Fig. S10 but for Kangerlussuup Sermersua (GID 291). Error scores for this model are NRMSE: 0.120 (RMSE: 62 m); Spearman: 0.725; R^2: 0.579; offset: 15.3 weeks. Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Powered by Esri.

GID	Glacier Name	Station Name	Distance (km)
1	Rink Isbræ	Qullitsat Nuussuaq	189.0
11	Nunatakassaap Sermia	Kitsissorsuit	94.8
14	Kakivfaat Sermiat	Kitsissorsuit	65.2
15	Qeqertarsuup Sermia	Kitsissorsuit	53.2
16	Ussing Bræer	Kitsissorsuit	27.6
17	Ussing Bræer N	Kitsissorsuit	16.4
18	Cornell Gletscher	Kitsissorsuit	21.4
20	Illullip Sermia	Kitsissorsuit	40.7
24	Unnamed south Hayes N	Kitsissorsuit	92.5
27	Hayes Gletscher N'	Kitsissorsuit	116.8
30	Steenstrup Gletscher	Kitsissorsuit	145.2
32	Sverdrup Gletscher	Kitsissorsuit	178.3
34	Nansen Gletscher	Kitsissorsuit	202.5
35	Nordenskiöld Gletscher	Kitsissorsuit	214.8
39	Kong Oscar Gletscher	Kitsissorsuit	237.0
42	Issuuarsuit Sermia	Kitsissorsuit	255.3
72	Heilprin Gletscher	Kitsissut	197.0
77	Bowdoin Gletscher	Kitsissut	155.9
78	Verhoeff Gletscher	Kitsissut	152.7
110	Waltershausen Gletscher	Daneborg	144.8
114	Nordenskiöld Gletscher	Daneborg	276.9
121	Vestfjord Gletscher	Aputiteeq	309.4
125	Magga Dan Gletscher	Ittoqqortoormiit	278.2
132	Dendritgletscher	Ittoqqortoormiit	238.1
145	Kong Christian IV Gletscher	Aputiteeq	97.1
152	Kangerlussuaq Gletscher	Aputiteeq	100.6
157	Polaric Gletscher	Aputiteeq	33.7
167	Unnamed Laube S	Tasiilaq	155.3
171	K.I.V. Steenstrup Nodre Bræ	Tasiilaq	132.7
180	Fenrisgletscher	Tasiilaq	100.5
181	Helheimgletscher	Tasiilaq	112.9
186	Ikertivaq N	Ikermit	96.2
187	Ikertivaq M	Ikermit	90.5
189	Ikertivaq S	Ikermit	83.6
196	Køge Bugt C	Ikermit	80.1
197	Køge Bugt S	Ikermit	73.9
210	Graulv	Ikermit	102.5
280	Eqip Sermia	Qullitsat Nuussuaq	45.0
281	Kangilerngata Sermia	Qullitsat Nuussuaq	34.6
282	Sermeq Kujalleq	Qullitsat Nuussuaq	36.0
283	Sermeq Avannarleq	Qullitsat Nuussuaq	31.8
284	Store Gletscher	Qullitsat Nuussuaq	43.8
285	Lille Gletscher	Qullitsat Nuussuaq	57.5
286	Sermilik	Qullitsat Nuussuaq	67.5
288	Sermeq Silarleq	Qullitsat Nuussuaq	83.9
291	Kangerlussuup Sermersua	Qullitsat Nuussuaq	157.2

Table C1. Nearest Danish Meteorological Institute weather station, used for air temperature time series, for each glacier in this study.