Supplementary material for Shamoun-Baranes et al, 2016, **Flap or soar? How a flight generalist responds to its aerial environment**, *Phil. Trans. R. Soc. B.*
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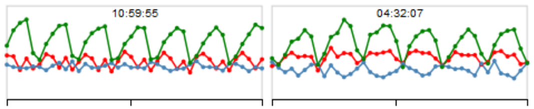
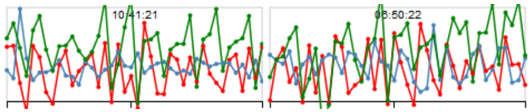
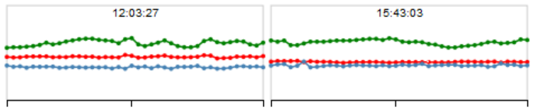
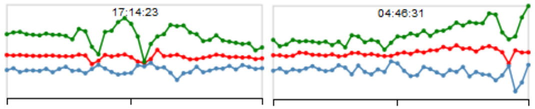
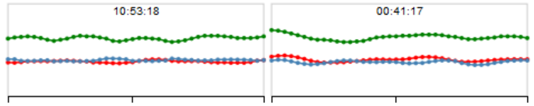
Electronic supplementary tables and figures for "Flap or soar? How a flight generalist responds to its aerial environment"

Table S1. *Definition of 10 activity classes of Lesser black-backed gulls, used to annotate tri-axial acceleration data. A 2 second segment of 20Hz tri-axial data is presented, green represents heave (z-axis), red represents surge (x-axis), blue represents sway (y-axis), the x and y axis of all figures are on the same scale and range from -1.5 – 2.5 g.*

General activity	Activity label	Activity description	1) Accelerometer characteristic and 2) additional GPS information used to distinguish behaviour	Example of typical tri-axial signal	Number of annotations
Flight	Flap	Flapping flight with regular wing beat	1) repeated and correlated oscillations, strongest in heave		634
	Exflap	Irregular and intense wing beat, during take-off or aerial interactions	1) chaotic pattern with very high amplitude in all directions		38
	Soar	Flight with no wing beat, includes climbing and gliding	1) gradually changing pattern, 2) distinguished from float by either speed, GPS-fixes over land, or lack of typical float GPS patterns [1].		501
	Mixed	Mixed flap-gliding	1) combination of flap and soar characteristics within 1 second		151
Float	Float	Floating with the currents at sea	1) smooth undulating patterns (caused by waves), 2) typical GPS patterns [1] at sea		558

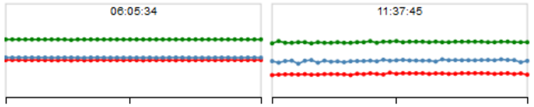
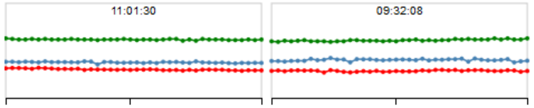
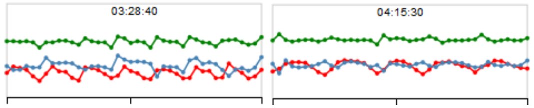
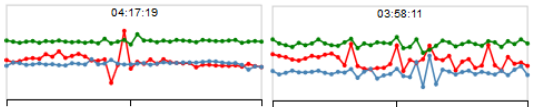
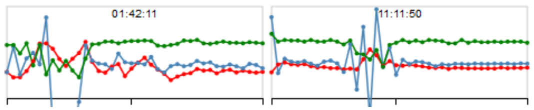
Sit-Stand	Stationary	Sitting or standing on land or static structure at sea	1) constant value for all 3 axes, 2) speed is close to zero.		894
	Boat	Sitting or standing on a boat	1) constant value for all 3 axes, 2) GPS track at sea with constant direction and constant speed (9-11 km/h)		176
Terrestrial locomotion	Walk	Walking	1) typical periodic pattern of the surge (x-axis)		318
	Peck	Walk and peck.	1) irregular active pattern 2) low speed, on land		209
Other	Other	Activity signal that doesn't fit in the above classes.			25

Table S2. Features that were used to classify gull activity. To reduce the full set of 37 features and establish a robust set of predictors three rounds of decision tree model fitting were implemented (see methods for further explanation). The table includes the abbreviated name, a definition of the feature and the level of model development in which the feature was included (1- inclusion in initial round, 2- inclusion in second round, 3-inclusion in third round). This resulted in a set of 14 features (selection –S, highlighted in grey) that were used to build a random forest classifier.

Abbreviation	Selection	Definition
mean_x	S	The mean of the x (surge) value over the accelerometer points in the segment.
mean_y	2	The mean of the y (sway) value over the accelerometer points in the segment.
mean_z	1	The mean of the z (heave) value over the accelerometer points in the segment.
std_x	S	The standard deviation of the x value over the accelerometer points in the segment.
std_y	1	The standard deviation of the y value over the accelerometer points in the segment.
std_z	S	The standard deviation of the z value over the accelerometer points in the segment.
mean_pitch	S	The mean value of the pitch over the accelerometer points in the segment. The pitch is defined as $\arctan(\frac{x}{\sqrt{y^2+z^2}})$ in degrees.
std_pitch	2	The standard deviation of the pitch over the accelerometer points in the segment.
mean_roll	1	The mean value of the roll over the accelerometer points in the segment. The roll is defined as $\arctan\left(\frac{y}{\sqrt{x^2+z^2}}\right)$ in degrees.
std_roll	1	The standard deviation of the roll over the accelerometer points in the segment.
correlation_xy	1	The Pearson's correlation between the signal of x and the signal of y.
correlation_yz	1	The Pearson's correlation between the signal of y and the signal of z.
correlation_xz	1	The Pearson's correlation between the signal of x and the signal of z.
gps_speed	S	The speed measured by the GPS device [m/s].
meanabsder_x	3	The mean of the absolute value of the derivative of x to time.
meanabsder_y	3	The mean of the absolute value of the derivative of y to time.
meanabsder_z	S	The mean of the absolute value of the derivative of z to

		time.
noise_x	S	Measure of the noise in x signal.
noise_y	S	Measure of the noise in y signal.
noise_z	3	Measure of the noise in z signal.
noise/absder_x	3	Noise in signal of x divided by the mean of the absolute derivative of x.
noise/absder_y	S	Noise in signal of y divided by the mean of the absolute derivative of y.
noise/absder_z	S	Noise in signal of z divided by the mean of the absolute derivative of z.
fundfreq_x	2	Frequency of the highest peak in the frequency domain of the Fourier transform of x.
fundfreq_y	2	Frequency of the highest peak in the frequency domain of the Fourier transform of y.
fundfreq_z	S	Frequency of the highest peak in the frequency domain of the Fourier transform of z.
odba	S	Overall dynamic body acceleration [2]
vedba	3	Vector of dynamic body acceleration [2]
fundfreqcorr_x	1	Pearson correlation of signal x with a generated sine with coefficients that show the highest correlation.
fundfreqcorr_y	1	Pearson correlation of signal y with a generated sine with coefficients that show the highest correlation.
fundfreqcorr_z	1	Pearson correlation of signal z with a generated sine with coefficients that show the highest correlation.
fundfreqmagnitude_x	S	The highest peak (spectral maximum) in the frequency domain of the Fourier transform of the x signal.
fundfreqmagnitude_y	2	The highest peak (spectral maximum) in the frequency domain of the Fourier transform of the y signal.
fundfreqmagnitude_z	S	The highest peak (spectral maximum) in the frequency domain of the Fourier transform of the z signal.
first_x	1	The first value of the x signal.
first_y	1	The first value of the y signal.
first_z	1	The first value of the z signal.

Table S3. Summary statistics of flight parameters per bird-year. n = the number of measurements of flight (flap, soar or mixed flight modes). Vg = ground speed (m s^{-1}), Va = air speed (m s^{-1}). CV = coefficient of variation.

bird	year	n	% flight	% flap	% soar	% mixed	% flight time soar	% flight land	% flight sea	% flap land	% flap sea	% soar land	% soar sea	Vg flight	Vg flap	Vg soar	Vg mixed	Va flight	Va flap	Va soar	Va mixed
533	2012	285	21.32	13.16	5.46	2.69	25.61	17.80	3.52	10.99	2.17	4.49	0.97	9.11	9.36	8.45	9.20	11.32	11.56	10.32	12.12
534	2012	927	15.48	9.32	4.77	1.39	30.85	10.00	5.48	5.19	4.12	3.59	1.19	8.04	8.61	7.35	6.61	10.52	10.99	9.60	10.51
537	2012	1483	42.86	27.23	11.24	4.39	26.23	11.24	31.62	4.74	22.49	4.54	6.71	8.77	9.17	8.21	7.65	10.74	10.79	10.27	11.61
541	2012	1443	28.45	16.90	8.34	3.21	29.31	11.75	16.70	5.66	11.24	3.94	4.40	8.36	9.14	6.69	8.56	10.88	11.36	9.48	11.99
604	2012	154	24.76	15.27	3.38	6.11	13.64	19.77	4.98	10.93	4.34	3.05	0.32	8.51	8.56	8.13	8.57	12.90	12.86	10.99	14.07
606	2012	290	35.41	19.41	11.97	4.03	33.79	6.59	28.82	2.56	16.85	2.08	9.89	6.62	7.61	5.51	5.17	10.11	10.69	9.04	10.52
608	2012	386	33.30	22.69	7.68	2.93	23.06	4.40	28.90	2.16	20.53	0.86	6.82	8.08	7.56	9.70	7.87	11.34	11.48	10.40	12.71
752	2012	215	21.96	9.70	6.84	5.41	31.16	14.81	7.15	6.23	3.47	4.49	2.35	7.82	8.88	8.86	4.61	10.43	10.96	10.51	9.38
754	2012	515	33.95	17.21	12.33	4.42	36.31	10.48	23.47	3.96	13.25	4.09	8.24	8.55	8.71	8.57	7.91	11.21	11.14	10.82	12.64
757	2012	538	50.05	33.40	12.93	3.72	25.84	1.12	48.93	0.47	32.93	0.28	12.65	8.23	8.88	6.74	7.52	10.64	11.48	8.72	9.77
781	2012	132	38.26	23.19	11.30	3.77	29.55	3.48	34.78	1.74	21.45	0.58	10.72	8.31	8.88	8.10	5.39	11.17	11.92	10.01	10.02
782	2012	270	64.13	42.99	17.81	3.33	27.78	8.79	55.34	3.80	39.19	3.09	14.73	8.76	8.81	8.49	9.49	10.57	10.90	9.40	12.67
784	2012	533	59.09	42.02	12.20	4.88	20.64	5.43	53.66	2.00	40.02	1.55	10.64	8.76	9.07	8.49	6.80	11.40	11.76	9.69	12.67
533	2013	402	15.37	8.98	3.67	2.71	23.88	8.10	7.26	3.90	5.08	2.14	1.53	7.64	7.37	8.30	7.66	10.85	10.65	10.71	11.73
534	2013	870	13.94	7.63	4.12	2.20	29.54	10.96	2.98	5.24	2.39	3.73	0.38	8.19	8.66	7.84	7.22	10.95	11.12	10.47	11.25
537	2013	1526	39.35	24.52	10.75	4.07	27.33	17.59	21.76	6.91	17.61	8.12	2.63	10.06	10.28	10.10	8.64	12.00	12.08	11.75	12.11
606	2013	766	19.06	8.88	7.56	2.61	39.69	11.40	7.66	4.03	4.85	5.30	2.26	7.52	8.75	6.13	7.36	10.07	10.75	9.02	10.81
608	2013	768	24.30	16.14	4.84	3.32	19.92	8.13	16.17	4.27	11.87	1.99	2.85	8.12	8.38	8.14	6.79	11.12	11.25	10.58	11.30
754	2013	378	20.16	9.65	7.68	2.83	38.10	18.61	1.55	8.69	0.96	7.20	0.48	9.04	8.85	9.33	8.87	12.20	12.69	11.40	12.68
757	2013	438	37.24	22.62	10.71	3.91	28.77	8.76	28.49	1.87	20.75	4.93	5.78	8.51	9.45	6.97	7.27	11.74	12.51	10.10	11.74
781	2013	221	18.87	12.47	4.10	2.31	21.72	13.49	5.38	8.28	4.18	3.07	1.02	9.66	10.48	9.38	5.70	12.18	12.59	11.88	10.49
782	2013	747	47.19	35.31	8.28	3.60	17.54	3.47	43.71	1.77	33.54	1.01	7.26	8.53	9.34	5.20	8.27	11.88	12.22	10.64	11.43
805	2013	174	57.43	27.06	15.84	14.52	27.59	37.62	19.80	14.85	12.21	10.89	4.95	10.39	10.91	8.74	11.21	14.19	14.48	12.33	15.68

806	2013	187	33.16	20.04	6.91	6.21	20.86	29.96	3.19	17.20	2.84	6.56	0.35	10.00	10.65	9.48	8.49	13.05	13.29	12.26	13.16
868	2013	135	36.10	16.31	12.57	7.22	34.81	6.15	29.95	3.21	13.10	1.07	11.50	6.04	8.08	2.95	6.80	12.65	13.96	10.90	12.75
870	2013	115	50.00	22.61	10.00	17.39	20.00	40.00	10.00	17.39	5.22	8.70	1.30	12.17	12.67	10.02	12.77	15.79	16.50	13.34	16.28
871	2013	169	53.31	28.39	16.40	8.52	30.77	10.41	42.90	1.26	27.13	5.99	10.41	8.66	8.31	8.00	11.06	13.13	13.74	12.13	13.01
606	2014	550	10.79	6.73	3.37	0.69	31.27	9.77	1.02	5.87	0.86	3.24	0.14	8.61	8.98	7.99	7.94	9.90	10.26	9.24	9.62
608	2014	138	10.35	8.78	0.53	1.05	5.07	8.78	1.58	7.35	1.43	0.45	0.08	9.80	10.00	11.99	7.06	11.32	11.45	11.29	10.29
754	2014	290	7.58	4.57	2.40	0.60	31.72	6.45	1.12	3.68	0.89	2.22	0.18	9.30	9.96	8.67	6.75	10.70	11.23	9.89	9.90
757	2014	1578	28.62	22.36	4.62	1.63	16.16	6.96	21.65	3.94	18.43	2.16	2.47	9.87	10.60	7.37	7.03	10.88	11.31	9.08	10.09
782	2014	1289	26.90	19.01	6.26	1.63	23.27	9.68	17.22	5.09	13.92	3.72	2.55	8.84	9.15	8.35	7.12	10.96	11.26	10.28	10.05
805	2014	1107	21.09	12.23	7.01	1.85	33.24	17.85	3.24	9.58	2.65	6.55	0.46	10.31	10.96	9.62	8.58	11.73	12.27	11.00	10.98
806	2014	818	10.24	5.76	3.83	0.65	37.41	9.05	1.19	4.88	0.88	3.57	0.26	8.95	9.51	8.23	8.21	10.05	10.51	9.43	9.62
871	2014	995	20.96	13.21	5.96	1.79	28.44	15.78	5.18	8.80	4.40	5.39	0.57	9.79	10.44	9.19	7.08	10.88	11.28	10.54	9.07
		mean	30.60	18.45	8.11	4.05	26.88	12.42	18.18	5.96	12.49	3.85	4.26	8.80	9.29	8.15	7.81	11.47	11.86	10.50	11.56
		SD	15.26	9.88	4.24	3.51	7.38	8.68	16.49	4.24	11.53	2.49	4.36	1.12	1.10	1.61	1.65	1.23	1.30	1.08	1.68
		CV	0.50	0.54	0.52	0.87	0.27	0.70	0.91	0.71	0.92	0.65	1.02	0.13	0.12	0.20	0.21	0.11	0.11	0.10	0.15

Table S4. Best models during calibration (measurements in 2012 and 2013), based on AUC. Only models within the 25 percentile of the AUC are shown. Models meeting the AUC selection criterion and including only significant predictors are highlighted in grey. Also the AUC values for the validation data (measurements in 2014) are shown. All models include individual birds as a random effect for the intercept. The number of non-significant predictors is provided in n-sig, if all predictors are significant n-sig = 0.

Model	Function	AUC-calib.	AUC-valid.	n-sig
16	classR ~ hourR+blh+V_w	0.6773	0.6834	0
26	classR ~ hourR+blh+V_w+ ΔV_w	0.6771	0.6833	1
27	classR ~ hourR+blh+V_w+$w*$	0.6769	0.6837	1
31	classR ~ hourR+blh+V_w+d ΔV_w + $w*$	0.6768	0.6836	2
6	classR ~ hourR+blh	0.6766	0.6838	0
18	classR ~ hourR+blh+$w*$	0.6764	0.6837	1
17	classR ~ hourR+blh+ΔV_w	0.6764	0.6837	1
28	classR ~ hourR+blh+ΔV_w+$w*$	0.6762	0.6838	2

Figure S1: *Percentage of time spent flapping (red) or soaring(blue) in relation to (A) boundary layer height (m) and (B) time of day (UTC).*

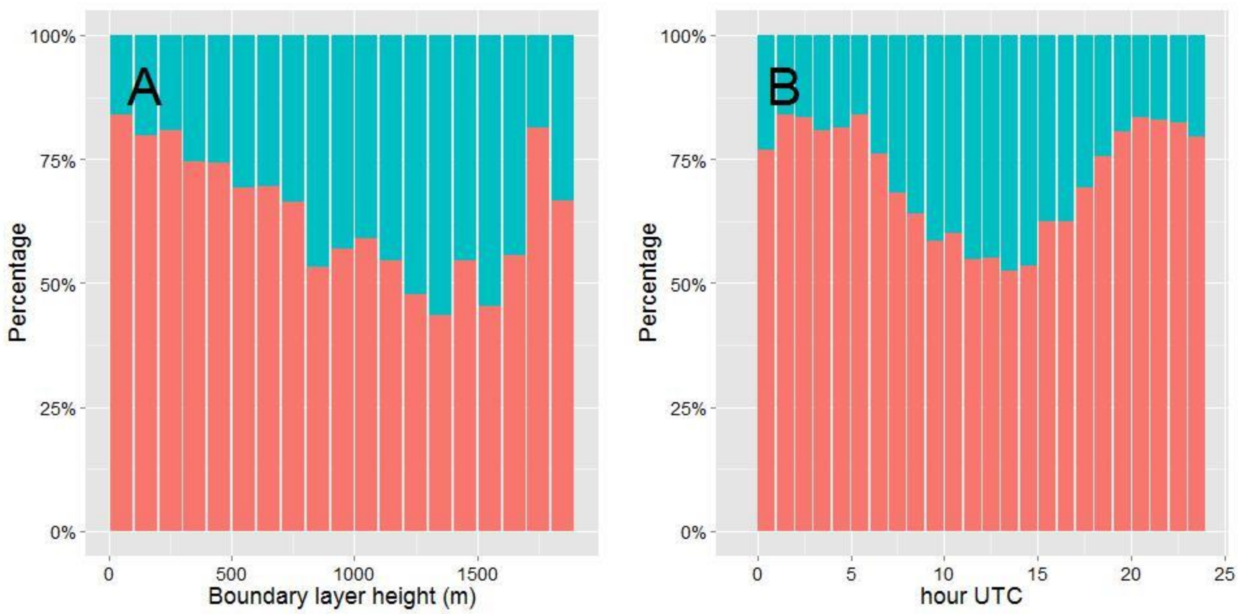


Figure S2. Distribution of instantaneous ground speeds (A) and air speeds (B) across all bird-years and shown separately for flapping (red), soaring (blue) and mixed (green) flight modes. Ground speeds and air speeds are provided in ms^{-1}.

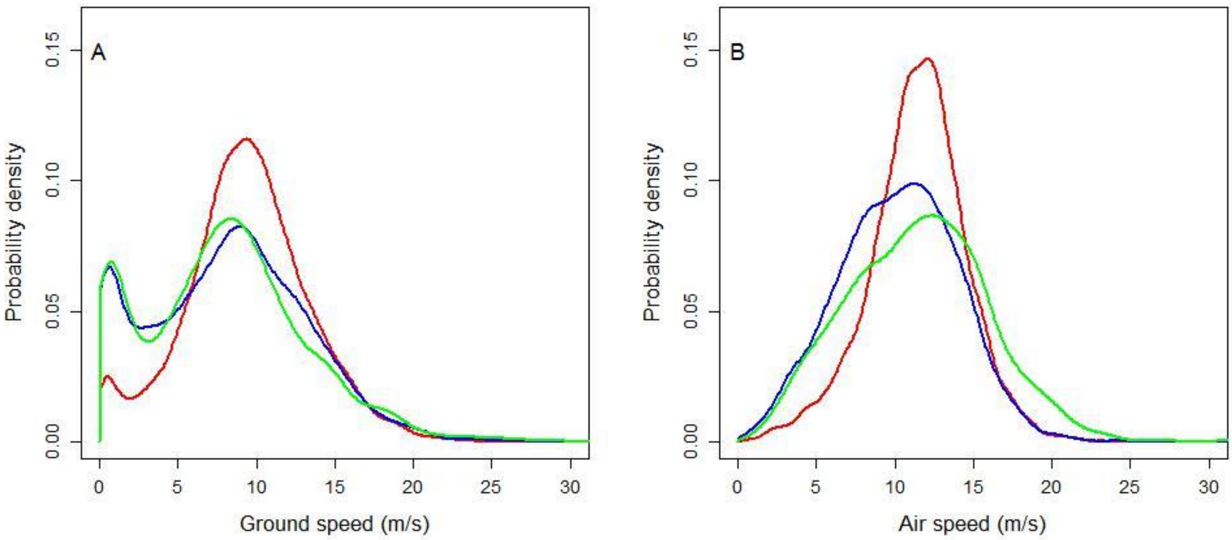
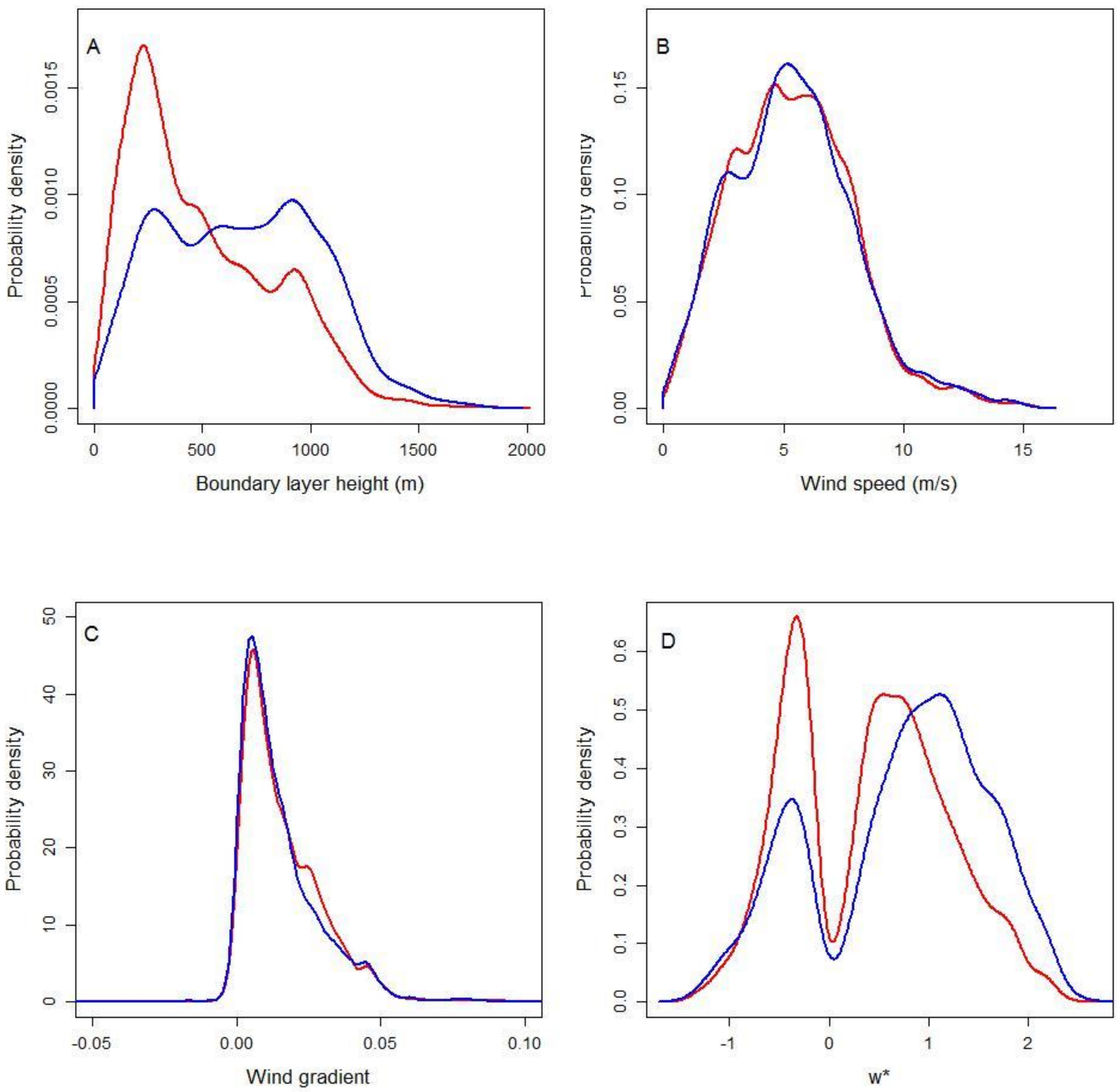


Figure S3. Distribution of weather variables for flapping (red) and soaring (blue) flight for all bird-years combined. (A) boundary layer height (m), (B) wind speed at 10 m (ms^{-1}), (C) wind gradient (ms^{-1} m^{-1}), (D) *w**.



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