

Figure S1. Diagram of custom CNN architectures utilized to assess lodging severity, 2D-CNN (a) and 3D-CNN (b).

Table S1. Description of the 60 CNN models implemented according to combinations of UAV-based image features, CNN architectures, and target traits.

Model name	Image features	Trait	Statistical method	Model architecture	Time length	Flights DAPs included
RGB_TP_75 (1)	RGB	Lodging detection	Classification	2D-CNN	1	75
RGB_TP_75 (1)	RGB	Lodging severity	Regression	2D-CNN	1	75
MS_TP_75 (1)	RGB, Re, NIR	Lodging detection	Classification	2D-CNN	1	75
MS_TP_75 (1)	RGB, Re, NIR	Lodging severity	Regression	2D-CNN	1	75
CSM_MS_TP_75 (1)	RGB, Re, NIR, CSM	Lodging detection	Classification	2D-CNN	1	75
CSM_MS_TP_75 (1)	RGB, Re, NIR, CSM	Lodging severity	Regression	2D-CNN	1	75
RGB_TP_83 (1)	RGB	Lodging detection	Classification	2D-CNN	1	83
RGB_TP_83 (1)	RGB	Lodging severity	Regression	2D-CNN	1	83
MS_TP_83 (1)	RGB, Re, NIR	Lodging detection	Classification	2D-CNN	1	83
MS_TP_83 (1)	RGB, Re, NIR	Lodging severity	Regression	2D-CNN	1	83
CSM_MS_TP_83 (1)	RGB, Re, NIR, CSM	Lodging detection	Classification	2D-CNN	1	83
CSM_MS_TP_83 (1)	RGB, Re, NIR, CSM	Lodging severity	Regression	2D-CNN	1	83
RGB_TP_88 (1)	RGB	Lodging detection	Classification	2D-CNN	1	88
RGB_TP_88 (1)	RGB	Lodging severity	Regression	2D-CNN	1	88
MS_TP_88 (1)	RGB, Re, NIR	Lodging detection	Classification	2D-CNN	1	88
MS_TP_88 (1)	RGB, Re, NIR	Lodging severity	Regression	2D-CNN	1	88
CSM_MS_TP_88 (1)	RGB, Re, NIR, CSM	Lodging detection	Classification	2D-CNN	1	88
CSM_MS_TP_88 (1)	RGB, Re, NIR, CSM	Lodging severity	Regression	2D-CNN	1	88
RGB_TP_97 (1)	RGB	Lodging detection	Classification	2D-CNN	1	97
RGB_TP_97 (1)	RGB	Lodging severity	Regression	2D-CNN	1	97
MS_TP_97 (1)	RGB, Re, NIR	Lodging detection	Classification	2D-CNN	1	97
MS_TP_97 (1)	RGB, Re, NIR	Lodging severity	Regression	2D-CNN	1	97
CSM_MS_TP_97 (1)	RGB, Re, NIR, CSM	Lodging detection	Classification	2D-CNN	1	97
CSM_MS_TP_97 (1)	RGB, Re, NIR, CSM	Lodging severity	Regression	2D-CNN	1	97
RGB_TR_69_83 (2)	RGB	Lodging detection	Classification	3D-CNN	2	69,83
RGB_TR_69_83 (2)	RGB	Lodging severity	Regression	3D-CNN	2	69,83
MS_TR_69_83 (2)	RGB, Re, NIR	Lodging detection	Classification	3D-CNN	2	69,83
MS_TR_69_83 (2)	RGB, Re, NIR	Lodging severity	Regression	3D-CNN	2	69,83
CSM_MS_TR_69_83 (2)	RGB, Re, NIR, CSM	Lodging detection	Classification	3D-CNN	2	69,83
CSM_MS_TP_69_83 (2)	RGB, Re, NIR, CSM	Lodging severity	Regression	3D-CNN	2	69,83
RGB_TR_75_83 (2)	RGB	Lodging detection	Classification	3D-CNN	2	75,83

RGB_TR_75_83 (2)	RGB	Lodging severity	Regression	3D-CNN	2	75,83
MS_TR_75_83 (2)	RGB, Re, NIR	Lodging detection	Classification	3D-CNN	2	75,83
MS_TR_75_83 (2)	RGB, Re, NIR	Lodging severity	Regression	3D-CNN	2	75,83
CSM_MS_TR_75_83 (2)	RGB, Re, NIR, CSM	Lodging detection	Classification	3D-CNN	2	75,83
CSM_MS_TP_75_83 (2)	RGB, Re, NIR, CSM	Lodging severity	Regression	3D-CNN	2	75,83
RGB_TR_69_75_83 (3)	RGB	Lodging detection	Classification	3D-CNN	3	69,75,83
RGB_TR_69_75_83 (3)	RGB	Lodging severity	Regression	3D-CNN	3	69,75,83
MS_TR_69_75_83 (3)	RGB, Re, NIR	Lodging detection	Classification	3D-CNN	3	69,75,83
MS_TR_69_75_83 (3)	RGB, Re, NIR	Lodging severity	Regression	3D-CNN	3	69,75,83
CSM_MS_TR_69_75_83 (3)	RGB, Re, NIR, CSM	Lodging detection	Classification	3D-CNN	3	69,75,83
CSM_MS_TP_69_75_83 (3)	RGB, Re, NIR, CSM	Lodging severity	Regression	3D-CNN	3	69,75,83
RGB_TR_69_75_83 (3)	RGB	Lodging detection	Classification	3D-CNN	3	69,75,83
RGB_TR_83_88_97 (3)	RGB	Lodging severity	Regression	3D-CNN	3	83,88,97
MS_TR_83_88_97 (3)	RGB, Re, NIR	Lodging detection	Classification	3D-CNN	3	83,88,97
MS_TR_83_88_97 (3)	RGB, Re, NIR	Lodging severity	Regression	3D-CNN	3	83,88,97
CSM_MS_TR_83_88_97 (3)	RGB, Re, NIR, CSM	Lodging detection	Classification	3D-CNN	3	83,88,97
CSM_MS_TP_83_88_97 (3)	RGB, Re, NIR, CSM	Lodging severity	Regression	3D-CNN	3	83,88,97
RGB_TR_62_69_75_83 (4)	RGB	Lodging detection	Classification	3D-CNN	4	62,69,75,83
RGB_TR_62_69_75_83 (4)	RGB	Lodging severity	Regression	3D-CNN	4	62,69,75,83
MS_TR_62_69_75_83 (4)	RGB, Re, NIR	Lodging detection	Classification	3D-CNN	4	62,69,75,83
MS_TR_62_69_75_83 (4)	RGB, Re, NIR	Lodging severity	Regression	3D-CNN	4	62,69,75,83
CSM_MS_TR_62_69_75_83 (4)	RGB, Re, NIR, CSM	Lodging detection	Classification	3D-CNN	4	62,69,75,83
CSM_MS_TP_62_69_75_83 (4)	RGB, Re, NIR, CSM	Lodging severity	Regression	3D-CNN	4	62,69,75,83
RGB_TR_31:83 (9)	RGB	Lodging detection	Classification	3D-CNN	9	31,38,42,49,55,62,69,75,83
RGB_TR_31:83 (9)	RGB	Lodging severity	Regression	3D-CNN	9	31,38,42,49,55,62,69,75,83
MS_TR_31:83 (9)	RGB, Re, NIR	Lodging detection	Classification	3D-CNN	9	31,38,42,49,55,62,69,75,83
MS_TR_31:83 (9)	RGB, Re, NIR	Lodging severity	Regression	3D-CNN	9	31,38,42,49,55,62,69,75,83
CSM_MS_TR_31:83 (9)	RGB, Re, NIR, CSM	Lodging detection	Classification	3D-CNN	9	31,38,42,49,55,62,69,75,83
CSM_MS_TP_31:83 (9)	RGB, Re, NIR, CSM	Lodging severity	Regression	3D-CNN	9	31,38,42,49,55,62,69,75,83

R=red, G=green, B=blue spectral bands

Re=red edge, NIR=near-infrared spectral bands

CSM=Crop surface model or 3D-photogrammetry reconstruction of the canopy

RGB=model includes R,G,B spectral channels features

MS=model includes R,G,B,Re,NIR spectral channels features

CSM\_MS=model includes R,G,B,Re,NIR, spectral channels and CSM features

\_TP\_=time-point model

\_TR\_=time-range model

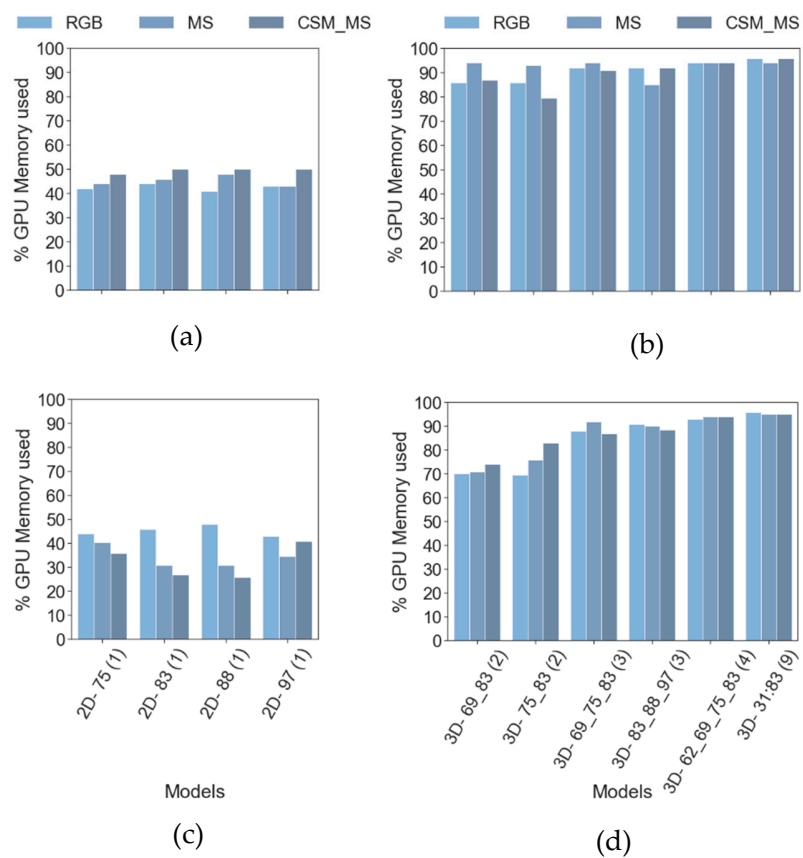


Figure S2. Utilization of GPU memory during models training, validation, and testing steps for lodging detection prediction via 2D-models (a) and 3D-models (b), and lodging severity prediction via 2D-models (c) and 3D-models (d), respectively.