Supporting Information for:

Combining MODIS and national land resource products to model land cover-dependent surface albedo for Norway

Ryan M. Bright & Rasmus Astrup

This Supporting Information file contains additional results, including the following:

- Table S1: Root mean squared errors of candidate models
- Table S2: White-sky model parameters for forests with *volume* as structural predictor
- Table S3: Black-sky model parameters for forests with *biomass* as structural predictor
- Table S4: White-sky model parameters for forests with *biomass* as structural predictor
- Table S5: White-sky model parameters for non-forest endmembers
- Figure S1: Number of MODIS retrievals used in model fitting and validation by month and land cover type
- Figure S2: White-sky model behavior for forests with *volume* as structural predictor
- Figure S3: Black-sky model behavior for forests with *biomass* as structural predictor
- Figure S4: White-sky model behavior for forests with *biomass* as structural predictor
- Figure S5: Weighting scheme applied when fitting models to the *effective* spatial resolution
- Figure S6: Distribution of Köppen-Geiger climate zones in Norway and the study domain

Figure S7: Fraction of total predictions having ≤ 10% normalized absolute error (SW Black-sky) by land cover type and season.**Table S1.** Root mean squared errors (RMSE) for the models presented in Table 1 of the main text.

Model	RMSE					
	SW		NIR		VIS	
	BS	WS	BS	WS	BS	WS
	Nominal resolution					
ef + *SC*	0.07	0.068	0.064	0.063	0.087	0.084
ef + *SC* + *T*	0.064	0.063	0.059	0.058	0.080	0.077
ef +*SC* +*T* + *V*	0.059	0.059	0.056	0.055	0.074	0.072
ef +*SC* +*T* + *B*	0.059	0.059	0.056	0.055	0.074	0.072
	Effective resolution					
ef + *SC*	0.069	0.067	0.063	0.062	0.086	0.083
ef + *SC* + *T*	0.063	0.062	0.058	0.057	0.079	0.076
ef +*SC* +*T* + *V*	0.058	0.058	0.055	0.054	0.073	0.071
ef +*SC* +*T* + *B*	0.058	0.058	0.055	0.054	0.073	0.071

Table S2. White-sky albedo model parameters for forests when using stand *volume* as the structural predictor. See Table 2 of the main article for nomenclature.

			β_{sc}	ρ_{sc}	λ_{sc}	β_{sf}	ρ_{sf}	λ_{sf}
Shortwave (SW)								
$\alpha_{0,sc}$	0.598	**Spruce**	0.361	1.1e-3	-0.022	0.057	-2.63e-4	-0.021
$\rho_{0,sc}$	-0.018	**Pine**	0.273	2.3e-3	-0.020	0.053	-4.80e-4	-0.025
$\alpha_{0,sf}$	0.138	**DBF**	0.228	2.6e-3	-0.007	0.037	7.46e-4	-0.004
$\rho_{0,sf}$	1.4e-3							
Near-infrared (NIR)								
$\alpha_{0,sc}$	0.432	**Spruce**	0.241	1.4e-3	-0.017	0.093	-1.24e-4	-0.021
$\rho_{0,sc}$	-0.012	**Pine**	0.159	1.9e-3	-0.016	0.077	-3.17e-4	-0.019
$\alpha_{0,sf}$	0.219	**DBF**	0.129	2.3e-3	-0.005	0.067	-2.88e-4	-0.002
$\rho_{0,sf}$	2.3e-3							
Visible (VIS)								
$\alpha_{0,sc}$	0.761	**Spruce**	0.473	2.1e-3	-0.025	0.027	-7.98e-5	-0.020
$\rho_{0,sc}$	-0.024	**Pine**	0.384	3.0e-3	-0.024	0.023	-1.5e-4	-0.026
$\alpha_{0,sf}$	0.039	**DBF**	0.317	3.1e-3	-0.010	0.004	1.11e-3	-0.007
$\rho_{0,sf}$	1.0e-3							

Table S3. Black-sky albedo model parameters for forests when fit using aboveground *biomass* as the structural predictor. See Table 2 of the main article for nomenclature.

			β_{sc}	ρ_{sc}	λ_{sc}	β_{sf}	ρ_{sf}	λ_{sf}
Shortwave (SW)								
$\alpha_{0,sc}$	0.610	**Spruce**	0.340	1.2e-3	-0.037	0.068	-2.5e-4	-0.035
$\rho_{0,sc}$	-0.020	**Pine**	0.262	2.5e-3	-0.031	0.061	-4.4e-4	-0.034
$\alpha_{0,sf}$	0.150	**DBF**	0.212	3.0e-3	-0.009	0.041	6.6e-4	-0.005
$\rho_{0,sf}$	1.0e-3							
Near-infrared (NIR)								
$\alpha_{0,sc}$	0.447	**Spruce**	0.214	1.7e-3	-0.033	0.097	-1.10e-4	-0.026
$\rho_{0,sc}$	-0.014	**Pine**	0.146	2.1e-3	-0.029	0.082	-2.6e-4	-0.028
$\alpha_{0,sf}$	0.240	**DBF**	0.132	2.7e-3	-0.005	0.073	-2.2e-4	-0.002
$\rho_{0,sf}$	1.8e-3							
Visible (VIS)								
$\alpha_{0,sc}$	0.784	**Spruce**	0.470	2.5e-3	-0.043	0.024	-7.6e-5	-0.042
$\rho_{0,sc}$	-0.027	**Pine**	0.389	3.2e-3	-0.038	0.021	-1.3e-4	-0.045
$\alpha_{0,sf}$	0.042	**DBF**	0.311	3.5e-3	-0.011	0.004	1.10e-3	-0.010

$\rho_{0,sf}$	7.0e-4

Table S4. White-sky albedo model parameters for forests when using aboveground *biomass* as the structural predictor. See Table 2 of the main article for nomenclature.

			β_{sc}	ρ_{sc}	λ_{sc}	β_{sf}	ρ_{sf}	λ_{sf}
Shortwave (SW)								
$\alpha_{0,sc}$	0.598	**Spruce**	0.361	1.1e-3	-0.033	0.058	-2.63e-4	-0.032
$\rho_{0,sc}$	-0.018	**Pine**	0.273	2.3e-3	-0.029	0.053	-4.80e-4	-0.034
$\alpha_{0,sf}$	0.139	**DBF**	0.228	2.6e-3	-0.009	0.037	7.46e-4	-0.005
$\rho_{0,sf}$	1.4e-3							
Near-infrared (NIR)								
$\alpha_{0,sc}$	0.432	**Spruce**	0.241	1.4e-3	-0.025	0.093	-1.24e-4	-0.026
$\rho_{0,sc}$	-0.012	**Pine**	0.159	1.9e-3	-0.023	0.077	-3.17e-4	-0.028
$\alpha_{0,sf}$	0.219	**DBF**	0.129	2.3e-3	-0.006	0.067	-2.88e-4	-0.002
$\rho_{0,sf}$	2.3e-3							
Visible (VIS)								
$\alpha_{0,sc}$	0.761	**Spruce**	0.473	2.1e-3	-0.038	0.027	-7.98e-5	-0.032
$\rho_{0,sc}$	-0.024	**Pine**	0.384	3.0e-3	-0.036	0.023	-1.5e-4	-0.047
$\alpha_{0,sf}$	0.039	**DBF**	0.317	3.1e-3	-0.014	0.004	1.1e-3	-0.010
$\rho_{0,sf}$	1.0e-3							

Table S5. White-sky albedo model parameters for the non-forested land covers. Values presented in boldface italics are considered insignificant at the 95% confidence level (i.e., $p > 0.05$). See Table 2 of the main article for nomenclature.

	CRO	**PAS**	**O-v**	**O-pv**	**O-sv**	**O-nv**	**PB-f**	**PB-nf**	**U&T**	**FW**
	Shortwave (SW)									
$\alpha_{0,sc}$	0.552	0.558	0.684	0.623	0.564	0.579	0.764	0.674	0.448	0.547
$\alpha_{0,sf}$	0.109	0.132	0.153	0.128	0.134	0.145	0.160	0.133	0.099	0.035
ρ_{sc}	-0.044	-0.036	-0.024	-0.034	-0.028	-0.006	-0.056	-0.039	-0.033	-0.051
ρ_{sf}	0.004	0.002	***-2.7 e-8***	***3.7 e-6***	-0.002	-0.003	7.5 e-5	0.002	0.002	0.003
	Near-infrared (NIR)									
$\alpha_{0,sc}$	0.473	0.454	0.515	0.481	0.430	0.408	0.588	0.521	0.388	0.425
$\alpha_{0,sf}$	0.153	0.223	0.205	0.166	0.175	0.167	0.180	0.189	0.131	0.067
ρ_{sc}	-0.037	-0.026	-0.018	-0.026	-0.021	-0.001	-0.046	-0.032	-0.029	-0.045
ρ_{sf}	0.008	0.003	0.004	0.003	2.2 e-4	4.3 e-5	0.007	0.005	0.005	0.004
	Visible (VIS)									
$\alpha_{0,sc}$	0.648	0.688	0.844	0.762	0.683	0.749	0.952	0.833	0.531	0.672

$\alpha_{0,sf}$	0.051	0.018	0.093	0.070	0.087	0.113	0.083	0.045	0.060	0.011
ρ_{sc}	-0.055	-0.049	-0.029	-0.046	-0.038	***-6.0 e-4***	-0.067	-0.048	-0.038	-0.060
ρ_{sf}	2.8 e-4	0.002	-0.004	-0.003	-0.004	-0.005	-0.003	-2.2 e-5	-4.7 e-4	1.2 e-4

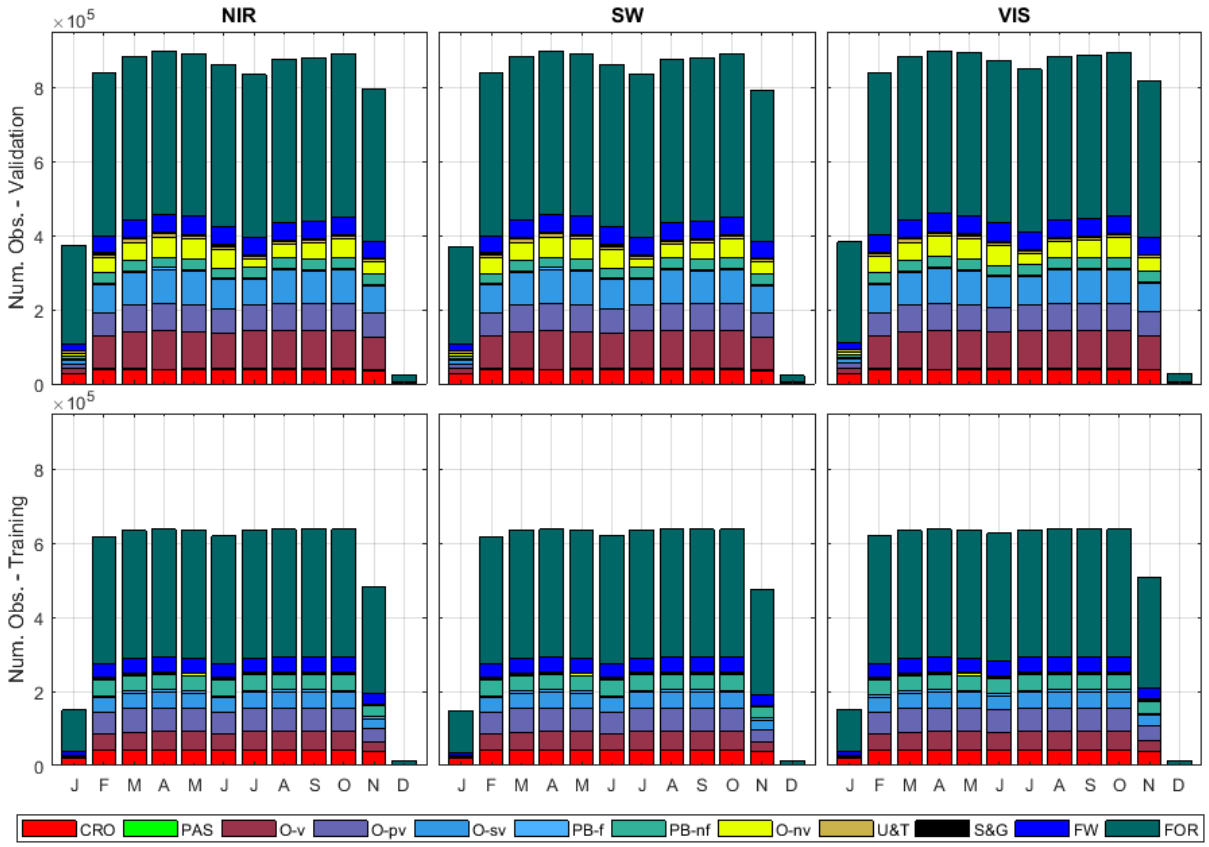

Figure S1. Distribution of the temporally synchronized and quality filtered MODIS datasets (MCD43A3 v6 BRDF/Albedo and MOD10A1 NDSI Snow Cover, 2006-2010) by month, region, and land cover (endmember) type. Note that values are multi-year (2006-2010) means. "*Num. Obs.*" = Number of pixels at the *effective* spatial resolution. Pixels are allocated to individual land cover types according to the largest relative fraction within the *effective* spatial resolution.

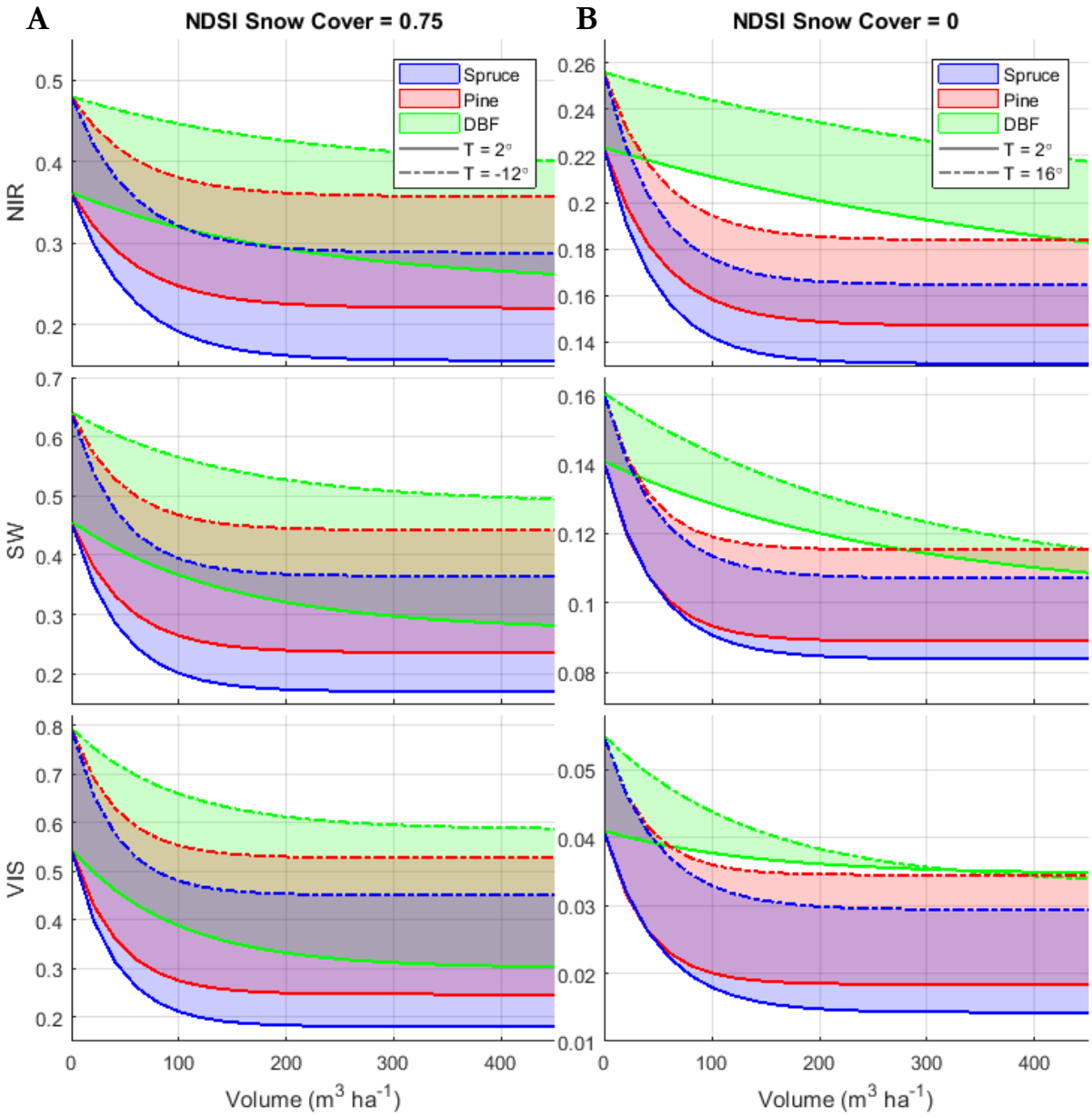

Figure S2. White-sky albedo model behavior for forest endmembers using mean stand aboveground *volume* as the structural predictor: A) with maximum snow cover, and B) with zero snow cover. Note the differences in y-axes scaling.

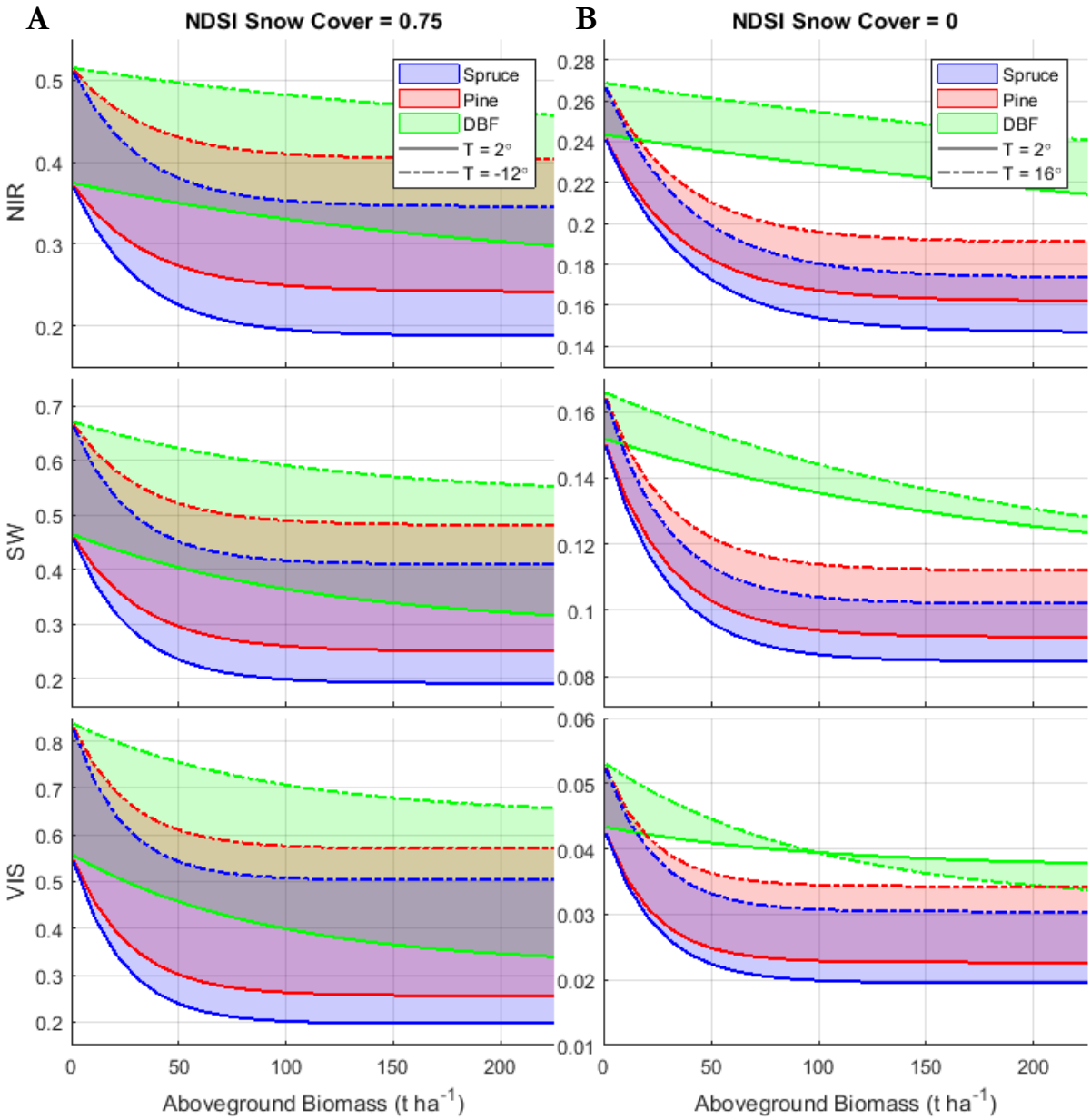

Figure S3. Black-sky albedo model behavior for forest endmembers using mean stand aboveground *biomass* as the structural predictor: A) with maximum snow cover, and B) with zero snow cover. Note the differences in y-axes scaling.

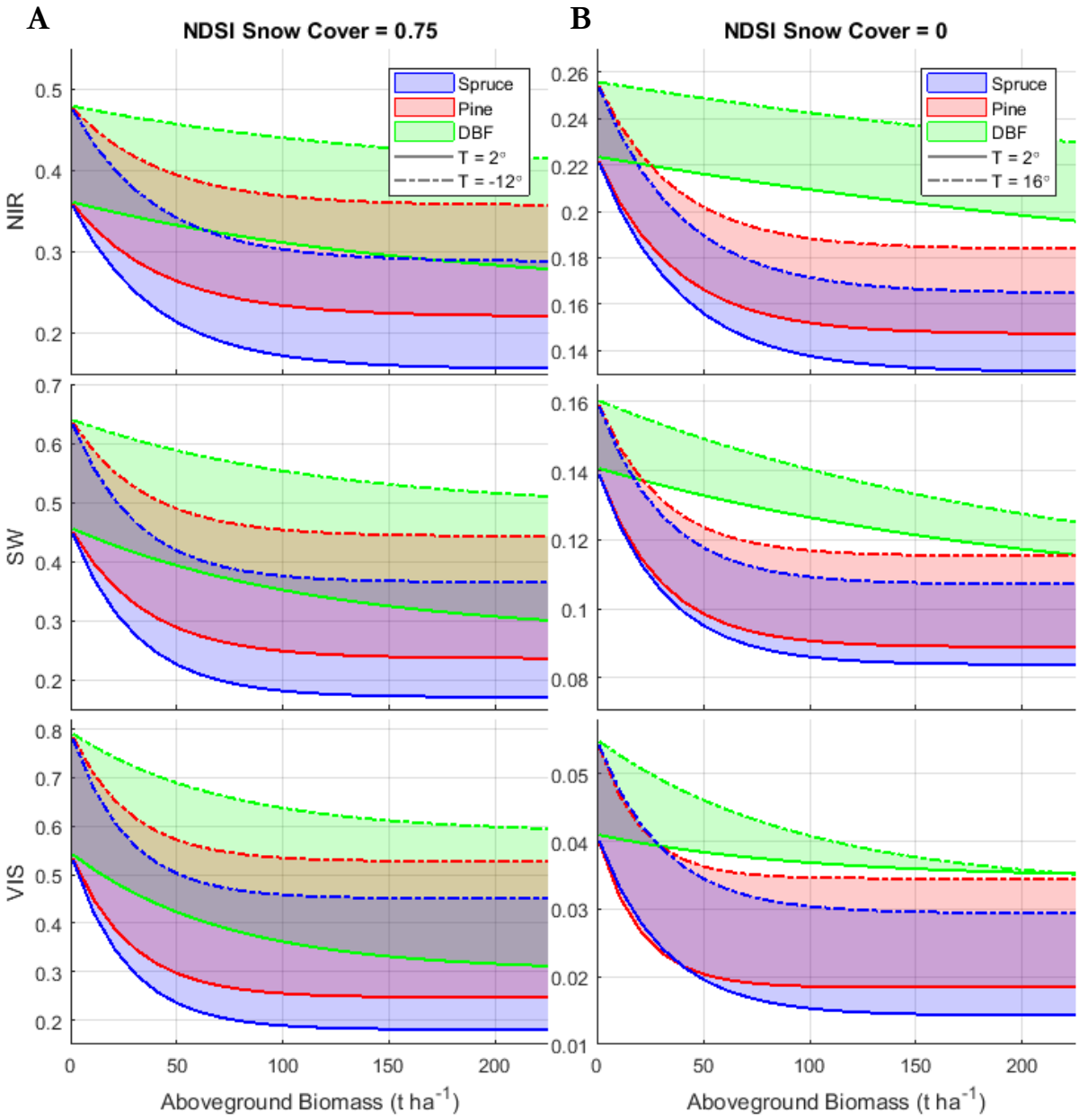

Figure S4. White-sky albedo model behavior for forest endmembers using mean stand aboveground *biomass* as the structural predictor: A) with maximum snow cover, and B) with zero snow cover. Note the differences in y-axes scaling.

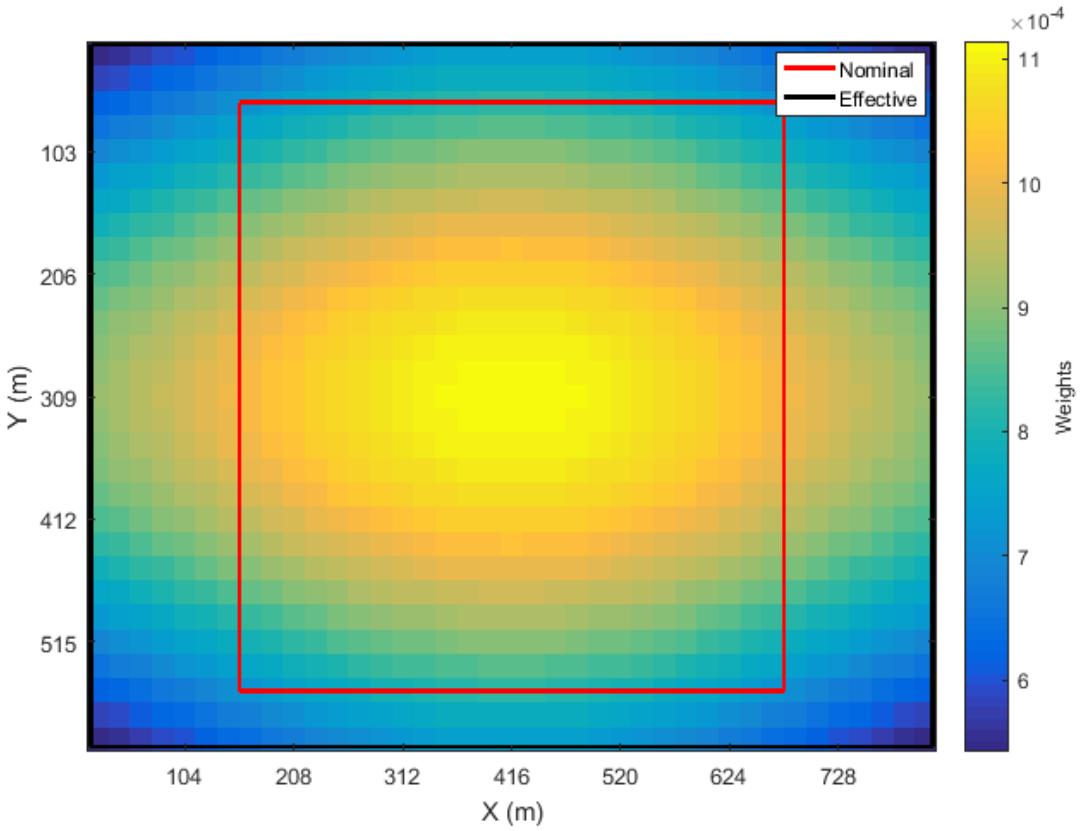

Figure S5. *Effective* vs. *nominal* spatial resolution of the MCD43A3 and MOD10A1 products shown with the *effective* resolution weights applied to the 16 m × 16 m endmember grid.

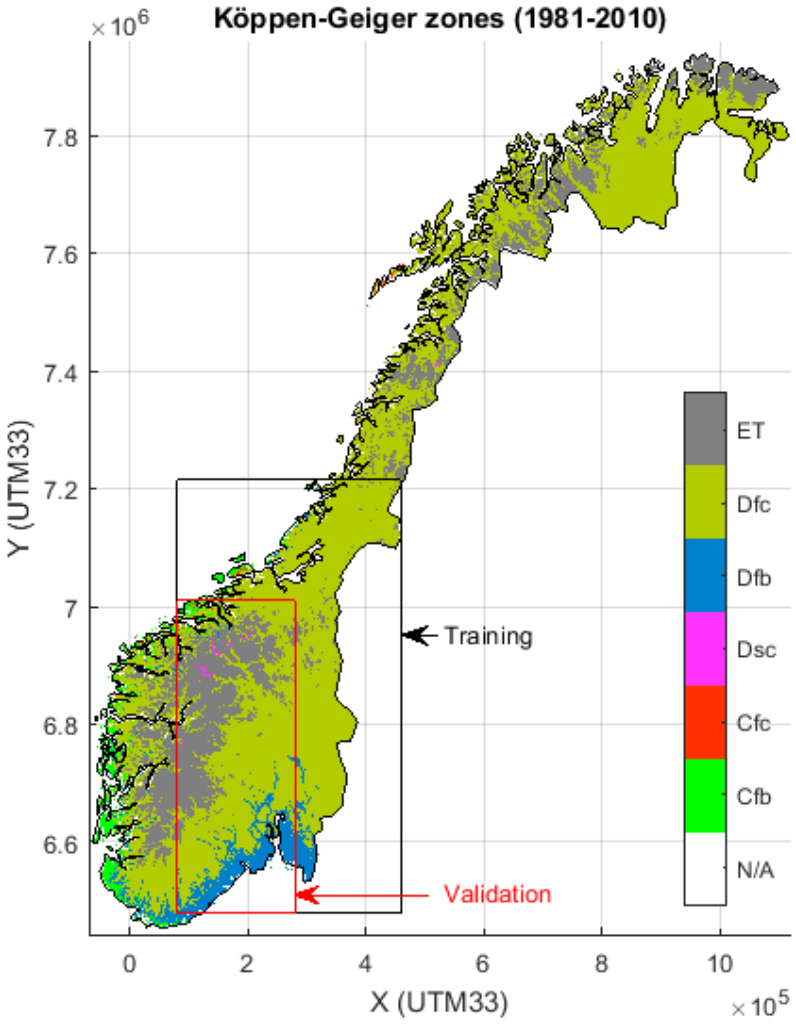

Figure S6. Distribution of Köppen-Geiger climate zones (1981-2010) amongst model training and validation regions. For zone descriptions, please refer to ref. [1].

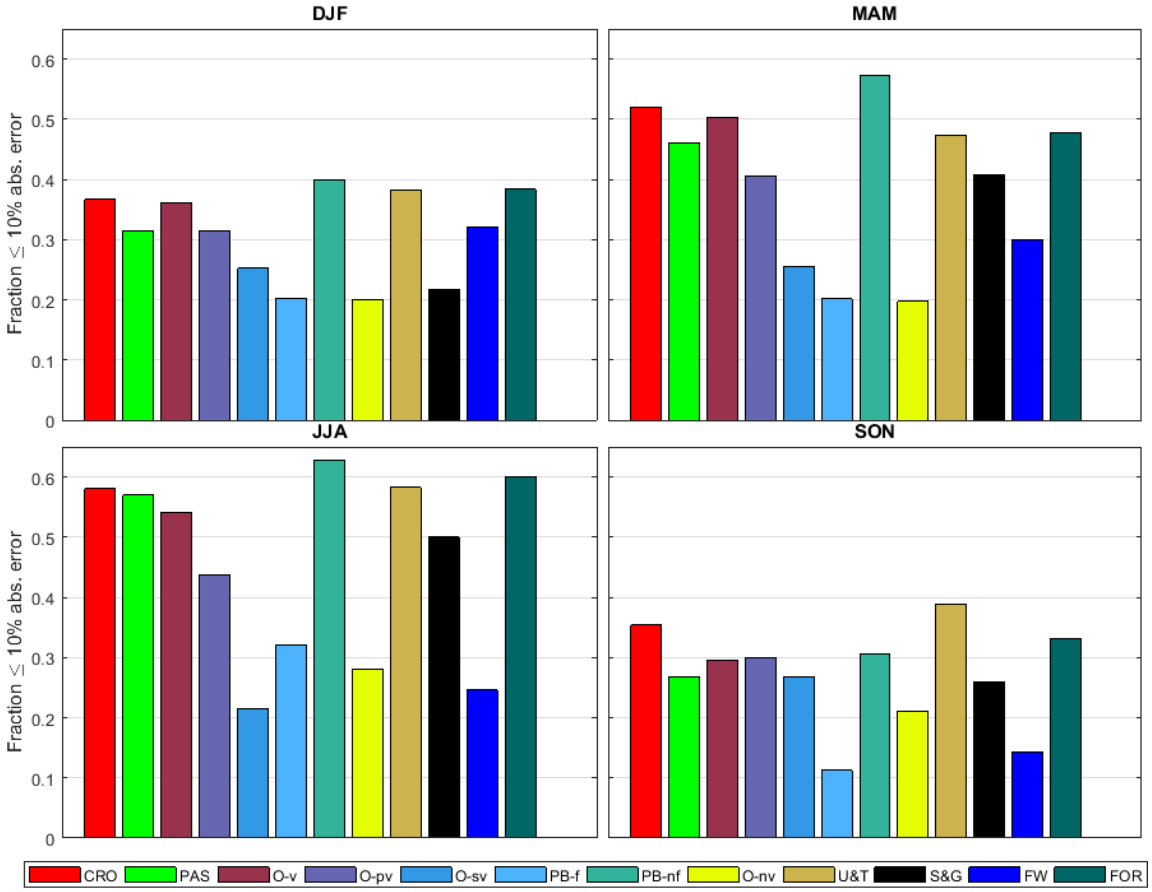

Figure S7. Fraction of total predictions having ≤ 10% normalized absolute error (SW Black-sky) by land cover (endmember) type and season. Pixels are allocated to individual land cover types according to the largest relative fraction within the MCD43A3 v6 *effective* spatial resolution.

References

1. Peel, M.C., B.L. Finlayson, and T.A. McMahon, *Updated world map of the Köppen-Geiger climate classification.* Hydrology and Earth System Sciences, 2007. **11**: p. 1633-1644.