

Supplementary information for “Hierarchical Classification of Soybean in the Brazilian Savanna Based on Harmonized Landsat Sentinel Data” by Taya C. Parreiras (t234520@dac.unicamp.br) and co-authors.

Table S1. Confusion matrices for Level 1 classifications with the three Landsat 8 OLI (L8) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VI (MS+VIs). AG = agricultural areas; NV = native vegetation; UA = users’ accuracy; PA = producers’ accuracy.

L8 MS					L8 VIs					L8 MS + VIs				
Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)
AG	46	6	52	88.46	AG	43	2	45	95.55	AG	46	4	50	92.00
NV	0	45	45	100.00	NV	3	49	52	94.23	NV	0	47	47	100.00
Total	46	51	97		Total	46	51	97		Total	46	51	97	
PA (%)	100.00	88.23			PA (%)	93.48	96.08			PA (%)	100.00	90.19		

Table S2. Confusion matrices for Level 1 classifications with the three Harmonized Landsat Sentinel-2 (HLS) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). AG = agricultural areas; NV = native vegetation; UA = users’ accuracy; PA = producers’ accuracy.

HLS MS					HLS VIs					HLS MS + VIs				
Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)
AG	44	6	50	88.00	AG	42	2	44	95.45	AG	44	2	46	95.65
NV	2	45	47	95.74	NV	4	49	53	92.45	NV	2	49	51	96.08
Total	46	51	97		Total	44	51	99		Total	46	51	98	
PA (%)	95.65	88.23			PA (%)	91.3	96.08			PA (%)	95.65	96.07		

Table S3. Confusion matrices for Level 2 classifications with the three Landsat 8 OLI (L8) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). AC = annual crops; PC = perennial crops; PT = pasturelands; UA = users’ accuracy; PA = producers’ accuracy.

L8 MS						L8 VIs						L8 MS + VIs					
Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)
AC	14	0	3	17	82.35	AC	15	0	1	16	93.75	AC	15	0	2	17	88.23
PC	1	8	0	9	88.89	PC	1	8	0	9	88.89	PC	0	8	0	8	100.00
PT	1	0	4	5	80.00	PT	0	0	6	6	100.00	PT	1	0	5	6	83.33
Total	16	8	7	31		Total	16	8	7	31		Total	16	8	7	31	
PA (%)	87.50	100.00	57.14			PA (%)	93.75	100.00	85.71			PA (%)	93.75	100.00	71.43		

Table S4. Confusion matrices for Level 2 classifications with the three Harmonized Landsat Sentinel-2 (HLS) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and a combination of MS and VIs (MS+VIs). AC = annual crops; PC = perennial crops; PT = pasturelands; UA = users' accuracy; PA = producers' accuracy.

HLS MS						HLS VIs						HLS MS + VIs					
Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)
AC	15	1	3	19	78.95	AC	16	1	1	18	88.88	AC	16	1	1	18	88.88
PC	0	7	0	7	100.00	PC	0	7	0	7	100.00	PC	0	7	0	7	100.00
PT	1	0	4	5	80.00	PT	0	0	6	6	100.00	PT	0	0	6	6	100.00
Total	16	8	7	31		Total	16	8	7	31		Total	16	8	7	31	
PA (%)	93.75	87.5	57.14			PA (%)	100.00	87.50	85.71			PA (%)	100.00	87.50	85.70		

Table S5. Confusion matrices for Level 3 classifications with the three Landsat 8 OLI (L8) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). SB = soybean; OAC = other annual crops; UA = users' accuracy; PA = producers' accuracy.

L8 MS					L8 VIs					L8 MS + VIs				
Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)
SB	11	1	12	91.66	SB	11	3	14	78.57	SB	11	1	12	91.66
OAC	4	7	11	63.64	OAC	4	5	9	55.55	OAC	4	7	11	63.63
Total	15	8	23		Total	15	8	23		Total	15	8	23	
PA (%)	73.33	87.50			PA (%)	73.33	62.5			PA (%)	73.33	87.50		

Table S6. Confusion matrices for Level 3 classifications with the three Harmonized Landsat Sentinel-2 (HLS) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and a combination of MS and VIs (MS+VIs). SB = soybean; OAC = other annual crops; UA = users' accuracy; PA = producers' accuracy.

HLS MS					HLS VIs					HLS MS + VIs				
Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)
SB	13	1	14	92.85	SB	14	2	16	87.50	SB	14	1	15	93.33
OAC	2	7	9	77.78	OAC	1	6	7	85.71	OAC	1	7	8	87.50
Total	15	8	23		Total	15	8	23		Total	15	8	23	
PA (%)	86.66	86.95			PA (%)	93.33	75			PA (%)	93.33	87.50		

Table S7. Confusion matrix for Level 1 classifications with the three Sentinel-2 Multi-spectral Instrument Surface Reflectance (HLSS30) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). AG = agricultural areas; NV = native vegetation; UA = users' accuracy; PA = producers' accuracy.

HLSS30 MS					HLSS30 VIs					HLSS30 MS + VIs				
Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)
AG	42	3	45	93.33	AG	44	3	47	93.62	AG	45	3	48	93.75
NV	4	48	52	92.31	NV	2	48	50	96.00	NV	1	48	49	97.96

Total	46	51	97	Total	46	51	97	Total	46	51	97
PA (%)	91.30	94.12		PA (%)	95.65	94.12		PA (%)	97.83	94.11	

Table S8. Confusion matrix for Level 2 classifications with the three Sentinel-2 Multi-spectral Instrument Surface Reflectance (HLSS30) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). AC = annual crops; PC = perennial crops; PT = pasturelands; UA = users' accuracy; PA = producers' accuracy.

HLSS30 MS						HLSS30 VIs						HLSS30 MS + VIs					
Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)
AC	15	0	2	17	88.23	AC	13	0	1	14	92.86	AC	13	0	0	13	100.00
PC	0	7	0	7	100.00	PC	0	7	0	7	100.00	PC	0	7	0	7	100.00
PT	1	1	5	7	71.43	PT	3	1	6	10	60.00	PT	3	1	7	11	63.64
Total	16	8	7	31		Total	16	8	7	31		Total	16	8	7	31	
PA (%)						PA (%)	81.25	87.50	85.71			PA (%)	81.25	87.50	100.00		

Table S9. Confusion matrix for Level 3 classifications with the three Sentinel-2 Multi-spectral Instrument Surface Reflectance (HLSS30) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and a combination of MS and VIs (MS+VIs). SB = soybean; OAC = other annual crops; UA = users' accuracy; PA = producers' accuracy.

HLSS30 MS					HLSS30 VIs					HLSS30 + MS + VIs				
Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)
SB	13	1	14	92.85	SB	14	4	18	77.78	SB	14	2	16	87.50
OAC	2	7	9	77.77	OAC	1	4	5	80.00	OAC	1	6	7	85.71
Total	15	8	23		Total	15	8	23		Total	15	8	23	
PA (%)	86.67	87.50			PA (%)	93.33	50.00			PA (%)	93.33	75.00		

Table S10. Confusion matrix for Level 1 classifications with the three Landsat Operational Land Imager Surface Reflectance and TOA Brightness (HLSL30) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). AG = agricultural areas; NV = native vegetation; UA = users' accuracy; PA = producers' accuracy.

HLSL30 MS					HLSL30 VIs					HLSL30 MS + VIs				
Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)	Class	AG	NV	Total	UA (%)
AG	43	7	50	86.00	AG	37	6	43	86.04	AG	35	3	38	92.10
NV	3	44	47	93.62	NV	9	45	54	83.33	NV	11	48	59	81.35
Total	46	51	97		Total	46	51	97		Total	46	51	97	
PA (%)	93.48	86.27			PA (%)	80.43	88.23			PA (%)	76.09	94.12		

Table S11 Confusion matrix for Level 2 classifications with the three Landsat Operational Land Imager Surface Reflectance and TOA Brightness (HLSL30) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). AC = annual crops; PC = perennial crops; PT = pasturelands; UA = users' accuracy; PA = producers' accuracy.

HLSL30 MS						HLSL30 VIs						HLSL30 MS + VIs					
Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)	Class	AC	PC	PT	Total	UA (%)
AC	13	1	4	18	72.22	AC	14	0	4	18	77.78	AC	14	0	4	18	77.78
PC	1	7	0	8	87.50	PC	1	7	0	8	87.50	PC	1	7	0	8	87.50
PT	2	0	3	5	60.00	PT	1	1	3	5	60.00	PT	1	1	3	5	60.00
Total	16	8	7	31		Total	16	8	7	31		Total	16	8	7	31	
PA (%)	81.25	87.50	42.86			PA (%)	87.50	87.50	42.86			PA (%)	87.50	87.50	42.86		

Table S12. Confusion matrix for Level 3 classifications with the three Landsat Operational Land Imager Surface Reflectance and TOA Brightness (HLSL30) datasets: multispectral bands (MS), spectral vegetation indices (VIs), and combination of MS and VIs (MS+VIs). SB = soybean; OAC = other annual crops; UA = users' accuracy; PT = producers' accuracy.

HLSL30 MS					HLSL30 VIs					HLSL30 + MS + VIs				
Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)	Class	SB	OAC	Total	UA (%)
SB	9	1	10	90.00	SB	12	3	15	80.00	SB	10	1	11	90.91
OAC	6	7	13	53.85	OAC	3	5	8	62.50	OAC	5	7	12	58.33
Total	15	8	23		Total	15	8	23		Total	15	8	23	
PA (%)	60.00	87.50			PA (%)	80.00	62.50			PA (%)	66.67	87.50		

Table S13. Results of the Students' *t*-test showing the level of significance of HLS datasets performances *versus* the HLS30, HL30, and L8 datasets in a 95% confidence interval.

Level	Dataset	Overall Accuracy		Kappa	
		<i>t</i> -Value	<i>p</i> -Value	<i>t</i> -Value	<i>p</i> -Value
Level 1	HLSS30	-62.402	1	-29.753	1
	HL30	-43.445	0.000001667 *	-18.237	0.0000493 *
	L8	-69.954	1	-33.887	1
Level 2	HLSS30	-24.044	0.99	-13.478	0.99
	HL30	-20.518	0.0002118 *	-7.4076	0.003981 *
	L8	-26.607	0.99	-11.294	0.99
Level 3	HLSS30	-25.849	0.00005546 *	-7.398	0.003887 *
	HL30	-34.509	0.00000219 *	-11.296	0.0003345 *
	L8	-23.077	0.00008019 *	-6.3461	0.004798 *

* significant at $p < 0.05$.

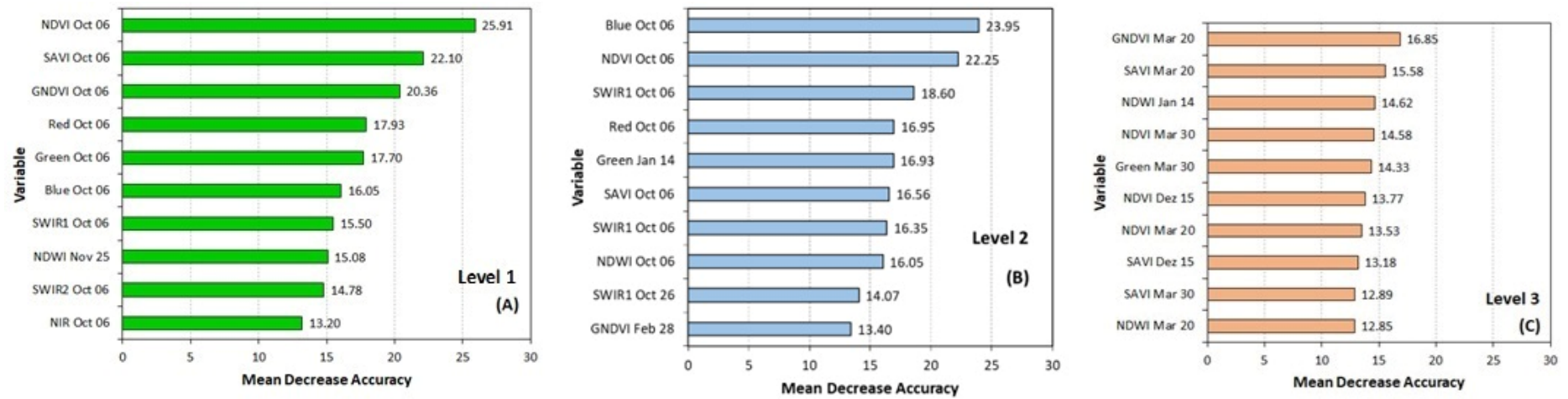


Figure S1. Measures of the importance of the Random Forest top 10 predictor variables for Level 1 (A), Level 2 (B), and Level 3 (C) hierarchical classifications based on the Sentinel-2 Multi-spectral Instrument Surface Reflectance (HLSS30) datasets. The months' names are abbreviated as Oct (October), Nov (November), Feb (February), Mar (March), and Jan (January).

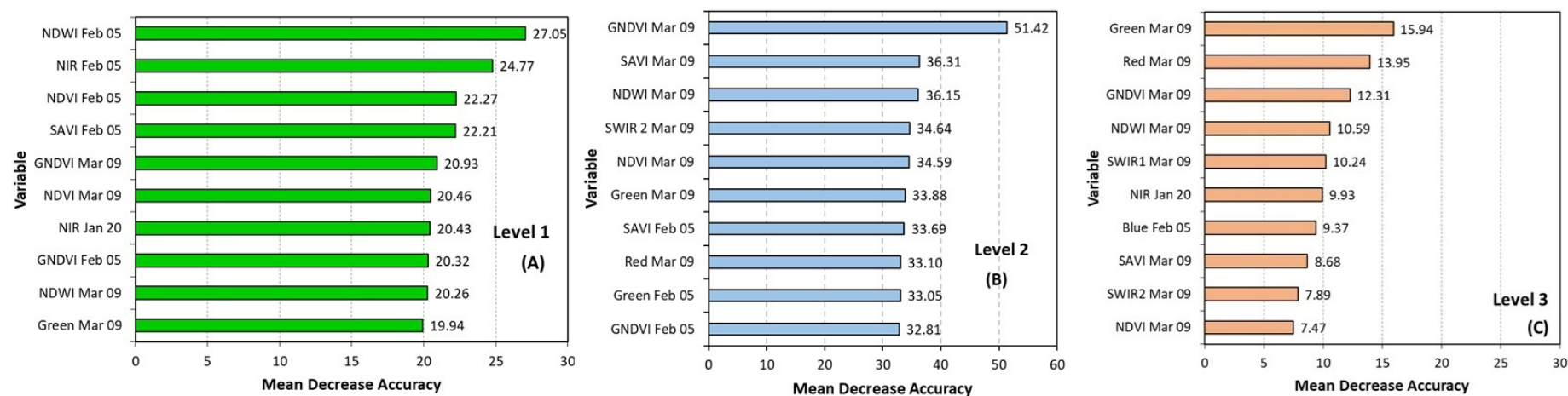


Figure S2. Measures of the importance of the Random Forest top 10 predictor variables for Level 1 (A), Level 2 (B), and Level 3 (C) hierarchical classifications based on the Landsat Operational Land Imager Surface Reflectance and TOA Brightness (HLSL30) datasets. The months' names are abbreviated as Oct (October), Nov (November), Feb (February), Mar (March), and Jan (January).

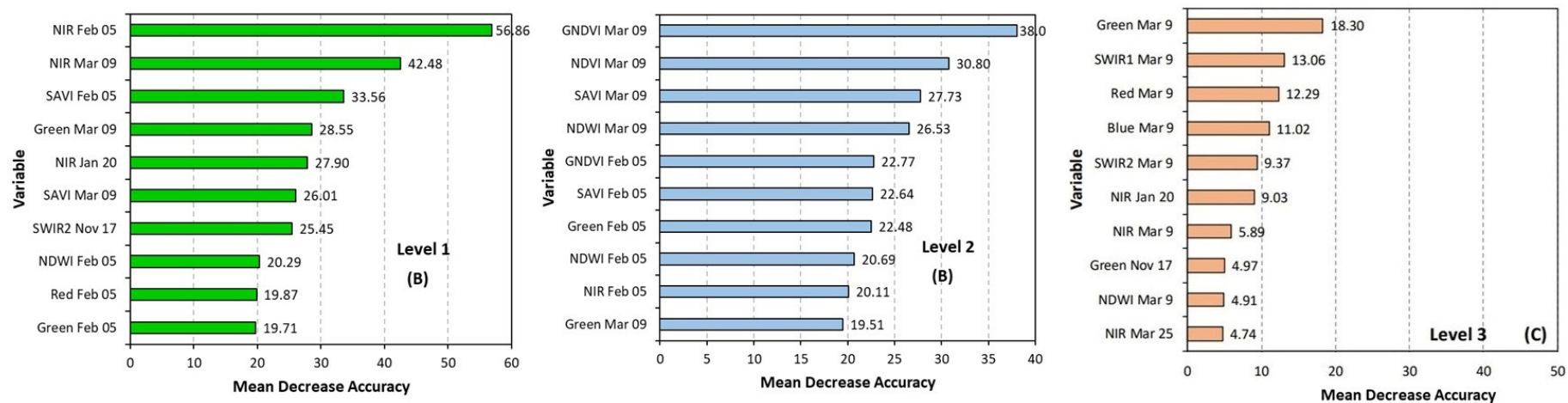


Figure S3. Measures of the importance of the Random Forest top 10 predictor variables for Level 1 (A), Level 2 (B), and Level 3 (C) hierarchical classifications based on the Landsat 8 Operational Land Imager (L8) datasets. The months' names are abbreviated as Oct (October), Nov (November), Feb (February), Mar (March), and Jan (January).