

ARTMO: an Automated Radiative Transfer Models Operator toolbox for automated retrieval of biophysical parameters through model inversion

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Content

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 - The need for a RTM toolbox

ARTMO concept

- Main module
- Design
- Leaf-level models
- Canopy-level models
- Graphics
- Inversion
- Applications
 - Case study floodplain mapping
- Conclusions



Project Description						
Project Name: BARR	AX PROJECT					
Commert SEASON 15/06/2008						
Sensor: CHRIS	MODE 1	-				
		Image Class User Classes				
Leaf Model	-Run Panel	Tools Panel				
PROSPECT 4	PROSPECT 4	SENSOR				
PROSPECT 5	PROSPECT 5	GRAPHICS				
FluorMODieaf	FluorMODIeaf	INVERSION				
Canopy Model	FLIGTH					
FLIGTH	V 4SAIL					
4SAIL	FluorSAIL	Settings				
FluorSAIL	SLC	Save Load				
Combined Model						
	RUN					



conclusions

Rationale

Radiative transfer (RT) modeling plays a key role for earth observation (EO) because it is needed to design and develop EO instruments, and to test and apply inversion algorithms.

A number of often highly specialized leaf and canopy RT models has been developed, each of which emanates from a different set of original requirements.

Currently there exists no user-friendly toolbox that brings these models together.

- RAMI only comparison excercise (ROMC)
- CRASh (Dorigo et al., 2009: PROSPECT+SAILh, class-based inversion)









Objectives

To develop a canopy radiative transfer toolbox that couples leaf-level models with canopy-level RT models for the simulation of reflectance data

- For better understanding interactions terrestrial vegetation and solar radiation in VNIR
- Simulator for the development of new Earth observators
- (class-based) model inversion for retrieval of biophysical parameters

Required features:

- plug-n-play GUI
- any sensor
- 1D and 3D models
- fast and massive forward simulations
- flexible and easy access
- graphics module
- inversion module
- Class-based inversion (e.g. surface elements, sun-target-sensor geometry)



ARTMO

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ARTMO main module

ARTMO			×	Settinigs Edit Filter	Selection of sensor or creation of
Load Project New Proje	ct DB Administration		Ľ	Sensor Information	own band settings
- Project Description-		r		CHRIS MODE 1	A number of sensors are already included:
Project Name: BARR	AX PROJECT			Sensor name CHRIS MODE 1	 CHRIS mode 1, 2, 3, 4, 5 Sentinel-2
Comment: SEAS	ON 15/06/2008			Unit wavelength Band List Details	
Sensor: CHRIS	MODE 1	<		Wanouneers Wavenumber GHz MHz MHz Max: 415	Any spectral settings can be defined by the user.
		Image Class User Classes		Index E 5 Center: 411 Unknown 7 Bwidth: 10	All data automatically resampled
Leaf Model	Run Panel	Tools Panel			to the selected sensor
PROSPECT 4	PROSPECT 4	SENSOR		Save Sensor	
PROSPECT 5	PROSPECT 5	GRAPHICS		🛃 gui_settings	
FluorMODleaf	E FluorMODleaf	INVERSION		Control Settings Path Prospect Model (ver. 4)	
				D:\artmof\PROSPECT_4_MATLAB\prospect_4.m Browser	
Canopy Model	FLIGTH			Path Prospect Model (ver. 5) D.\artmoftPROSPECT_5B_MATLAB\prospect_5B.m Browser Browser	
FLIGTH	V 4SAIL			Path Flights Model	
				Path 4SAIL Model	
4SAIL	FILOISAIL	Settings		D:\artmotPROSAIL_5B_MATLAB\PRO4SAIL5B_jp.m Browser	
FluorSAIL		Save Load		D:\artmofFluor Browser	
				Resampling Spectral CHRIS MODE 3 - LAND CHANNELS	
Combined Model				MySQL database	
SLC	RUN			Host localhost Port	
				User: root Pass: *******	
C				ОК	E /2

conclusions

Design ARTMO



The core of ARTMO is a **MySQL** DB:

- Allows efficient massive storing
- Easy data retrieval through queries
- Spectral data linked with metadata (e.g. model inputs)
- Applicable both for forward simulations and model inversion

Data hierarchy and access



Sele	ct modelatio	on										
ele	ct Proje	ct									Chan	ge DB
	ID_PROJEC	т	NAI	ME	C	ATE		SENSOR	# BAN	# CLASS	# SIM	
L		1 proj	ject_Erika_nadir		2010-1	12-07	CHRIS N	IODE 3 - LAND CHA	18	15	29090	
2		2 Erik	a plus36		2010-1	12-12	CHRIS N	IODE 3 - LAND CHA	18	11	20542	
3		3 Erik	a min 36		2010-1	12-15	CHRIS M	IODE 3 - LAND CHA	18	12	25982	
ļ		4 San	nple PROSPECT	4 + 4SAIL	2011-0)3-29	CHRIS I	IODE 3 - LAND CHA	18	2	12	
əle	ct Class	Sim	ulation									
	ID_ 1	ID_PY	DATE		MODEL	S		CLASS		# SIM		
)	31	1	2011-01-22	FLIGTH			shr	ubs nadir nadir 1		2196		
0	32	1	2011-01-22	FLIGTH			for	est nadir 1D normal	final 1	2196		
1	33	1	2011-01-22	FLIGTH			for	est nadir bg-25% 10)	1098		
2	47	1	2011-01-25	FLIGTH			for	est nadir final 3D no	rmal	1792	I	
3	51	1	2011-02-01	FLIGTH			for	est_nadir_3D_bg-25	5_wide_fco	5440		=
.4	57	1	2011-02-03	FLIGTH			for	est 3D bg-25 fcover	widened	5440		
5	65	1	2011-03-30	PROSPEC	T VER 4 + 49	SAIL	Ge	neric class		48		-
Le	af Model-						- Can	opy Model				OK
	Item	n	١	/alue				Item		Value		
1	MODELO	F	Prospect4				1	MODE r				
2	ID_MLT				6	=	2	ONED_FLAG			3	
2	ID_CLASE				1		3	SOLAR_ZENITH			46	
	N	1	.250,2.500,0.00	00			4	VIEW_ZENITH			8.6700	
4	IN											

- Data storage and access hierarchically based
- All input parameters can be consulted

applications

Leaf-level models

conclusions



PROSPECT family

🚺 PROSPECT 5		
File		Ľ
INPUT P	ROSPECT 5	
Select Class		
Generic class	3	-
– Leaf Struc	cture (N) [1:4]	P
Start:	1.25 End: 2.5 Step:	0.1
Chlorophy	/II (Cab - µg/cm²) [0-100]	
Start:	-20 End: 45 Step:	0.5
– Carotenoi	ds (µg/cm²)	
Start:	20 End: 20 Step:	0 Range
Brown Pig	jments	
Start:	20 End: 20 Step:	0 Range
Water thic	ckness (Cw - cm) [0-0.05]	
Start:	0.002 End: 0.04 Step:	.0.5 Range
Dry matte	r (Cm - g/cm²) [0-0.05]	
Start:	0.012 End: 0.012 Step:	0 Range
I		ОК

🛃 FluorMODleaf Module		x
File Atmosferic Parameters		r
FluorMODleaf	Select Class Generic class	T
Internal Structure - N [1 - 3]	Temperature °C [5 - 25]	
Min: 1.8 Max: 1.8 Step: 0	Min: 15 Max: 25 Step: 5	lange
Chlorophyll ab - Cab [5 - 100]	Fluorescence Quantum Efficiency - Fi [0 - 0.1]	
Min: 5 Max: 100 Step: 2	Min: 0.05 Max: 0.05 Step: 0	lange
– Leaf Water Content - Cw [0 - 0.05]	Stoichiometry of PS_II to PS_I - Sto [1.1 - 2]	
Min: 0.05 Max: 0.05 Step: 0	Min: 3 Max: 3 Step: 0	lange
- Dry Matter Content - Cm [0.002 - 0.02]	Species Temperature Dependence	
Min: 0.002 Max: 0.002 Step: 0	Broad Bean	(
	Bean	
	Ficus	
	Tomato	
	rea	

- Either one value can be inputted, or when the 'range' box is enabled a range of values can be inputted by providing first, last and step value
- When multiple ranges are inputted all combinations will be simulated
- When impossible values are inputted the box will turn yellow

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intro

Leaf-level models

ext me F:\INPUItxt							Browse
Option text file				1	2	3	
Tab	HeaderLines	ОК	1 31.4 2 21.5	98	0.020	0.006	
abCwCm 4980.0200.006			3 11.8	09 51	0.013	0.004	
.5740.0080.005			5 26.6	19	0.013	0.005	
0540.0150.004			0 20.4	03			
0.0000130.004 0.0100.015 0.100.0130.005 0.4660.0130.005 0.4660.0130.006 0.8910.0160.008			6 26.7 7 30.4 8 76.8	66 191	0.013	0.006	
00500 130 004 190 00 130 005 3,7890 0130 005 3,8890 0130 005 3,8810 0160 006 3,8910 0160 008			6 26.7 7 30.4 8 76.8	66	0.013	0.006	
0.050.0150.004 0.0510.0150.004 0.0130.005 0.4660.0130.005 0.4660.0130.006 0.38910.0160.008 2arameter 2m. Drv Matter Content		Column 20lumn 3	6 26.7 7 30.4 8 76.8	66 191	0.013 0.016	0.006 0.008	Ad
0.050.0150.004 0.0510.0150.004 0.0130.005 0.7880.0130.005 0.4660.0130.006 0.8810.0160.008 Parameter Cm: Dry Matter Content Param	r (Column Column 3	6 26.7 7 30.4 8 76.8	66 91 Co	0.013 0.016	0.006 0.008 0.008	Ad
Cost 0.150 004 Cost 0.0150 004 Cost 0.0150 004 Cost 0.0150 004 Cost 0.0150 005 Co	neter	Column Column 3 Column 1	0 26.7 7 30.4 8 76.8	666 191	0.013 0.016 Ca	0.006 0.008 0.008	Ad
0.050.0130.004 0.0510.0150.004 0.130.005 3.7890.0130.005 3.660.0130.006 3.8910.0160.008 Parameter Cm: Dry Matter Content 2 Cw: Leaf Water Content 2 Cw: Leaf Water Content	neter	Column Column 3 Column 1 Column 1 Column 2	0 26.7 7 30.4 8 76.8	666 191	0.013 0.016	0.006 0.008 0.008	Ad

- PROSPECT 4 x File Open ECT 4 Save Load Data Table Generic class - Leaf Structure (N) [1-4] Range 1.25 2.5 Step: 0.1 End: Start: Chlorophyll (Cab - µg/cm²) [0-100] Range 20 45 0.5 Start: End: Step: Water thickness (Cw - cm) [0-0.05] Range 0.001 0.002 0.04 End: Start: Step: Dry matter (Cm - g/cm²) [0-0.05] Range 0.012 End: 0.03 Step: 0.001 Start: OK
- Also own input data can be loaded.
- The data table window allows to open any text file, choose the right column, convert, and link with a model variable.
- The linked model variable is then disabled in the main input window.



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Canopy-level models

Ray tracing: FLIGHT

Flight		
oad Data Table		
3 🔟 💹 📟 🏶		
Input Parameters		Save Class Input
– Dimension–––––	Number of bands	– Solar Angle
● 1D ○ 3D	Bands 62	Zenith 24 Azimuth 162.8
Mode of operation	– Number of photons–	View Angle
 FORWARE REVERSE 	Photons: 10000	Zenith 21.21 Azimuth 315.20
AOT @ 550 nm	– Soil roughness in	ndex _ Leaf size
AOT: 0.08	SRI:	0 Size: 0.01
LAI		Crown Shape
Min:	1 Range	⊚ Ellipsoid ⊙ Cones ⊙ Field data
Max. dense range:	5 Step: 0.5	- Crown geo parameters
Max. sparce range	10 Step: 1	Crown radius 0.880
-FVC		Centre to top distance 4.929
Min: 0.2 Max.:	0.8 Step: 0.1 Range	Height to first branch:
		Min: 4.1
Min: 0.2 Step:	0	Max 9.9
Constant Parameter 💿 SEN 🧕	BARK Value: 0.8	Trunk DBH 0.179
LAD		
[0-10]: 0.015 [20-30]	: 0.074 [40-50]: 0.12	23 [60-70]: 0.158 [80-90]: 0.174
[10-20]: 0.045 [30-40]	: 0.100 [50-60]: 0.14	13 [70-80]: 0.168
		ОК

🛃 gui_impor3					×
Leaf Senescent S	Spectral: Class=	No Cl	ass		
Text file					
D:\artmof\samples\sen_le	af.txt				
Unit wavelength				Brow	ser
Micrometers	Option text file Delimiter character comma		Factor value	HeaderL	ines 0
MHz Index Unknown				0	к
400,0.0411,0.00026119			1	2	
401,0.041193,0.00036841 402.0.041269.0.00051235		1	400	0.0411	2
403,0.041382,0.00070602		2	401	0.0412	3.
404,0.04153,0.00096116		3	402	0.0413	5.
405,0.041687,0.0012735		4	403	0.0414	7.
407.0.042043.0.0020702		5	404	0.0415	9.
408,0.042271,0.0026083		6	405	0.0417	
409,0.042495,0.0032287		7	406	0.0419	-
410,0.042719,0.0039908			<		P.

FLIGHT can run in 1D and in 3D. When 3D is selected the cropwn architecture parameters are enabled.

Green leaf, scenescent leaf, bark and soil spectra can be loaded by means of an import window

Green leaf can either come from a leaf-level model or from imported spectra.

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Canopy-level models



SAIL family

LAI Select Max. dense range 5 Step: 0.5 Max. sparce range 10 Step: 1 Average leaf angle († 0 - 90) Min: 0 Max: 180 Step: Range Diffuse/Direct radiation (0 - 100) Min: 30 Max: 30 Step: Range Min: 0 Max: 0 Step: 0 Range Min: 0 Max: 0 Step: 0 Range Min: 0 Max: 0 Step: 0 Range	Class c class	
Min. -1 Image: Range Generic Max. dense range 5 Step. 0.5 Max. dense range 10 Step. 1 Average leaf angle (*) [0 - 90] Min: 0 Max. 180 Olffuse/Direct radiation [0 - 100] Image: Range Min: Olffuse/Direct radiation [0 - 100] Image: Range Min: Solar zenith angle (*) [0 - 90] Image: Range Obse Min: 0 Max. 0 Step. 0 Range Min: Azimuth (*) [0 - 180] Image: Image: Image: Image Range	c class	
Max. dense range 5 Step 0.5 Max. sparce range 10 Step 1 Average teaf angle (*) [0 - 90] Image Min: 0 Min: 0 Max 180 Step 0 Diffuse/Direct radiation [0 - 100] Image Min: 0 Max 30 Step 0 Range Min: Solar zenith angle (*) [0 - 90] Image Image Image Min: Obse Min: 0 Max 0 Step 0 Range Min: Azimuth (*) [0 - 180] Min: Image Min: Image		
Max. sparce range 10 Step. 1 Average leaf angle (*) (0 - 90) If Range Min. Min. 0 Max. 180 Step. If Min. Diffuse/Direct radiation (0 - 100) If Range Min. If Min. If Max. If Min. If Max. If Min. If Min.		
Average leaf angle (*) [0 - 90] Soil (*) Min. 0 Max 180 Step: 0 Min. Diffuse/Direct radiation [0 - 100] (*)		
Mm. 0 Max 180 Step 0 Range Mm. DiffuseDirect radiation [0 · 100] Mm. 30 Step 0 Range Mm. Min. 30 Max 100 Step 0 Mm. Solar zenith angle (1) [0 · 90] Mmx. 0 Step 0 Mm. Azimuth (1) [0 - 180] Max 0 Step 0 Range	oefficient 10 - 11—	
Min: 0 Max. Co Otop Min: DiffuseDirect radiation [0 · 100] Min: 30 Mare Min: Mi	0 May	0 Sten
Diffuse/Direct radiation [0 - 100] Range Min: Min: 30 Max: 30 Step: 0 Range Min: 0 Max: 0 Step: 0 Range Min: Azimuth (*) [0 - 180] 0 Step: 0 Range	U Wax.	o Step.
Min: 30 Max: 30 Step: 0 Min: Solar zenith angle () [0 - 90] Image Obse Min: Obse Min: Image Image<	oot effect (0 - 1)	
Solar zenith angle (*) [0 - 90] Obse Min: 0 Max: 0 Step: 0 Min: Azimuth (*) [0 - 180]	0 Max:	0 Step:
Min: 0 Max: 0 Step 0 Hange Min: Azimuth (*) 0 Max: 0 Step 0 Range Min: 0 Max: 0 Step 0 Range	rver zenith angle (r) [-75 -75]
Azimuth () [0 - 180] Min: 0 Max: 0 Step 0	-80 Max:	60 Step:
Min: 0 Max: 0 Step 0		
	x	
Class: Generic class (211 of 714 simulations)		

gui_sic		
Leaf optical parameters Dry soil ref	flectance	لا
Input Parameters	SLC	
Step: Image Step: Image Z4	Angular Geometry Soil	- OK
60 Step 0 File OK Soil parameters	Select Soil Reflectance	
A Sun-object-sensor geometry Sun-object-sensor geometry Hapke model parameters Scattering phase function Hot sp 0.84 c 0.68 Bo Soil moisture content [0-100] Min: 5 Max: 70 Step: Sun-object-sensor geometry	Select Soil Reflectance Text file F:lsoil_samples.txt Option text file HeaderLines Delimiter character HeaderLines OK Srowschale_calcareuos_brightlinestone_brightestdarksol OK Srowschale_calcareuos_brightlinestone_brightestdarksol OK 9479 6322 A4517 7765.9 0.4798 6236 A26 202795 55 92 0.4398 4735 4009950 0059098 0079768 0013044 0.4498 4735 4009950 0059998 077958 00344 0.4598 42735 4009950 0059998 077958 00344 0.4498 6338 77753 9430019 73898 94685 728 0.4798 5337 455 20049961 0-4521 04329 4239899 143	I 2 3 1 Sc 1 2 3 2 0.4 97.86 32.6 45.1 4 0.42 98.206 33.5 47.5 5 0.43 98.437 34.16298 48.0 6 0.44 96.4206 33.5 47.5 5 0.43 98.437 34.162986 48.0 0 0.44 96.427 35.480999 50.0 7 0.45 98.484 30.47701 53.9 9 0.47 98.536 37.82 55.8 10 0.48 98.539 33.37301 56.9 11 0.49 98.439 38.377 53.3
Solar zenith angle (*) [0 - 90] Range Min: 0 Max: Step: Observer zenith angle (*) [0 - 90] Range Min: 0 Max: Step: Azimuth (*) [0 - 180] Range Min: 0 Max: Step: OK	0 4/86 3533 2530 2536 20498 01.492/10 2620 355939 0 4486 3538 3700165 85400/11 252101 0 4489 4733 3539855 32400510 857711 50077 3456 Parameter Sc Line 1 Add Parameter Line 1 Sc 1 1	11 0.49 30.407 30.30395 50.3.4 12 0.6 1 0.6 6 1 0.6 1 0.6 0.6 1 0.6 1 0.6 0.6 2 0.7 2 0.6 0.6 3 3 1 1 0.6 2 0.7 7 0.6 0.6 1 0.6 0.6 0.6 0.6 1 1 1 0.6 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1 0.6 1 1 1 1

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Graphics

	gui_grafica2	
Select modelation	Graphic Module	
Select Project	Change DB Select Project	
ID_PROJECT NAME DATE	SENSOR # BAN # CLASS # SIM	
1 1 project_Erika_nadir 2010-12-07	CHRIS MODE 3 - LAND CHA 18 15 29090 Figure 1 Leaf Reflectance	▼
2 2 Erika plus36 2010-12-12	CHRIS MODE 3 - LAND CHA 18 11 20542	
3 3 Erika min36 2010-12-15	CHRIS MODE 3 - LAND CHA 18 12 25982 Figure 2 Empty	▼
4 4 Sample PROSPECT 4 + 4SAIL 2011-03-29	CHRIS MODE 3 - LAND CHA 18 2 12	MIN MAY # CTED Decemptor 4 (Huo)
	1 N: Internal structure	1.2500 2.5000 30 NaN Cab: Chlorophyll a+b
Select Class Simulation	2 Cab: Chlorophyll a+b	20 100 40 NaN 0.0020 0.0400 20 NaN Parameter 2 (Saturation)
ID_ ID_PY DATE MODELS	CLASS # SIM	0.0120 0.0200 20 NoN N: Internal structure
9 31 1 2011-01-22 FLIGTH	shrubs nadir nadir 1 2196 A	0.0120 0.0300 20 Nain
10 32 1 2011-01-22 FLIGTH	forest nadir 1D normal final 1 2196	
11 33 1 2011-01-22 FLIGTH	forest nadir bg-25% 1D 1098	
12 47 1 2011-01-25 FLIGTH	forest nadir final 3D normal 1792	
13 51 1 2011-02-01 FLIGTH	forest nadir 3D bo-25 wide fco 5440 - Figure 1 Canopy Reflectant	ce 🗸 🗸
14 57 1 2011-02-03 FLIGTH	forest 3D bg-25 fcover widened 5440	
15 65 1 2011-03-30 PROSPECT VER 4 + 4SAIL	Generic class 48 - Figure 2 Empty	•
	OK PARAMETER	MIN MAX # STEP Parameter 1 (Hue)
- Leaf Model	Canopy Model 1 lai: Leaf area index	1 10 20 NaN lai: Leaf area index 💌
Item Value	Item Value	0 1 20 NaN Parameter 2 (Saturation)
1 MODELO Prospect4	1 MODE r	Cab: Chlorophyll a+b
2 ID_MLT 6 =	2 ONED_FLAG 3	out. entrophyna o
3 D_CLASE 1	3 SOLAR_ZENITH 46	
4 N 1.250,2.500,0.000	4 VIEW_ZENITH 8.6700	
5 Cab 20.000,45.000,0.000		ADD
	GROUP DATA SELECT	
	Draw Descripti	ion Class #Sim #Sim Color
	Diaw Description	
gu gu	silder 1 V N: [1.25-2.5] Cab: [2	20-45j CW: Generic class 16 0 [1.0000
LA	Leaf area index 2 V: [1.25-2.5] Cab: [2	20-45] Cw: Generic class 16 0 [0.0000
	min. 3 📝 N: [1.25-2.5] Cab: [2	20-45] Cw: Generic class 16 0 [0.0431
<u> </u>	→ 0 4 V User spectral curve	Leaf Reflectance
	max.	
4	▶ 5	
	Add Singnature for file	ОК

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Graphics





Plottings of 2 variables by color and color intensity

applications

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Graphics

LEAF I	t Pro	ject METERS								
Figu	ıre 1	Empty						-		
Figu	ıre 2	Empty						•		
		PARAMETER	MIN	MAX	#	STEP	Parameter 1 (Hue)			
1	Cab:	Chlorophyll a+b	20	20	61	NaN	Cab: Chlorophyll a+b	-		
							Parameter 2 (Saturat	jan		
							Empty	Color		
CANO	PY P <i>i</i>	ARAMATERS								
Figur	e 1	Direct Top of Canop	y Reflecta	nce						
Figur	e 2	Empty								
		DADAMETER	L ATA I	A A A Y	-	CTED	Parameter 1 (Hue)			-
1	TOTA	L LAI R: Leaf are	1	9 9	#	NaN	TOTAL_LAI_R: Leaf area			
-							Parameter 2 (Saturat			-
							Empty			
								More	Colors	
								OK		Can
GROU	P DA	TA SELECT								
D	Draw	Descriptio	n		Cla	ISS	#Sim #Sim Color			
1	V (Cab: [20-20]	lear Table	eneric	class		1 81 [1.0000			



Plotting of 1 variable with an assigned color. Multiple classes can be added.



ARTMO

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Case study

A floodplain with natural vegetation in the Netherlands.

CHRIS data. (Mode 1: pixel size ~17 m, 18 bands. 400-1050 nm)

gui_ta	blaclases1			
Class	s Table			
	ID Image class	ID Image class	Class	
1	0	Unclassified	No inversion	•
2	1	Water [Blue] 385 points	No inversion	•
3	2	Bare Soil [Thistle] 93 points	No inversion	•
4	3	Forest [Green3] 88 points	Forest 1D	•
5	4	Shrubs [Green1] 84 points	Shrubs [Green1] 84 points	-
6	5	Herbaceous [Cyan1] 273 points	No inversion	-
7	6	Build up [Orange1] 123 points	Shrubs [Green1] 84 points	
8	7	Agricultural [Yellow] 79 points	Forest [Green3] 88 points	
			Forest 1D	
			herbaceous2	E
			forest_nadir_bg25	
			forest_1D-test	
			forest nadir bg-25	*
			No inversion	

Inversion

😂 #	#1 (R:Re	size (Res	ize_l	Band_8	CHRIS	ML	_050	-	
File	Overlay	Enhance	Tools	Window					
	11			1 4				0	
				6			1.3		
	120	1			10.1		a fart,	12	mar al
	<	No.	-	-	10			1	-
SHIP					- *		1	7	
	CORCE T	Party and		10			R		1
?		- 0	1	1	1		-		
		- Carlo	10				2.2	5.	10
	67	miler i	ST'	Per C			1		11
		No.	14	38	199	-	312	-	44
	-	SP-1			Pa		Re-	1	1
Sur.		-							
	12	1	1			1			der
			2		-	۰.	T All and		Same
12			NE				-		6-1
1		131	10	5	-		Ciero.		- 00-
	1	C.	and the second	1	5		4.	No.	









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applications

4SAIL





intro





SLC

RMSE









End-to-end process flow fast: < 1h

conclusions



ARTMO

Cartor Cartor Cartor Cartor Poetice File Poetice File Service File Montecta File Montecta

1D + 3D combination



Models can be combined. As such more realistic representations of patchy landscapes can be achieved

- We are working on implementing more advanced cost functions
- Compatibility of ARTMO to other platforms and resolving memory issues
- Adding more models

intro

- Coupling ARTMO with MODTRAN for simulating at-sensor radiance
- Building a scene simulation module

Conclusions

ARTMO aims to implement all the necessary models and features required for terrestrial vegetation EO applications in a GUI. ARTMO allows the user:

- i) To choose between spectral band settings of various sensors, or to define own band settings
- ii) To choose between various leaf-level and canopy-level RT models
- iii) To simulate a massive amount of spectra based on a LUT approach and storing it in a spectral database
- iv) To plot simulated spectra of multiple models and e.g. to compare it with measured spectra
- v) To run model inversion against RS imagery given land cover classes, several cost options and accuracy estimates.