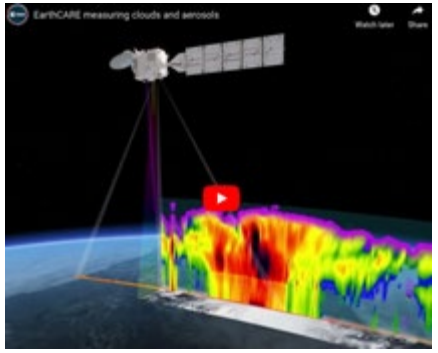
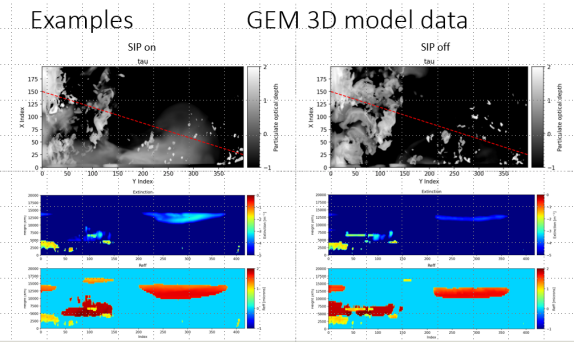
Lidar Simulation Tool

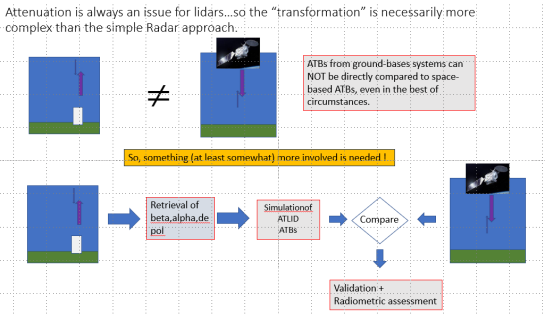
D.P. Donovan, Jos de Kloes, G-J van Zadelhoff



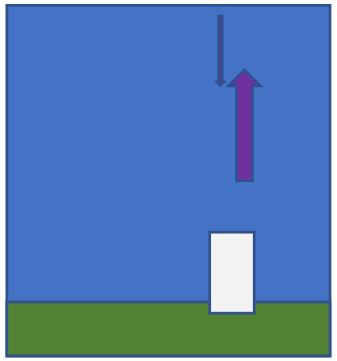
Examples GEM 3D model data



- Realistic space-based lidar simulations based on:
  - Model fields
  - Aircraft and ground-based data.
- Easy to use
- Flexible with respect to input data sources
- `Lightweight'..unlike ECSIM.
- Output in ATLID L1 format.



Attenuation is always an issue for lidars…so the “transformation” is necessarily more complex than the simple Radar approach.



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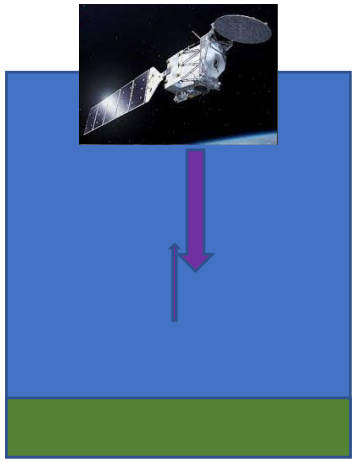
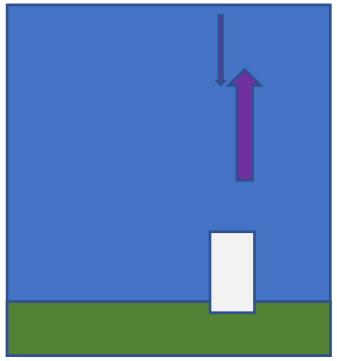


ATBs from ground-bases systems can NOT be directly compared to space-based ATBs, even in the best of circumstances.

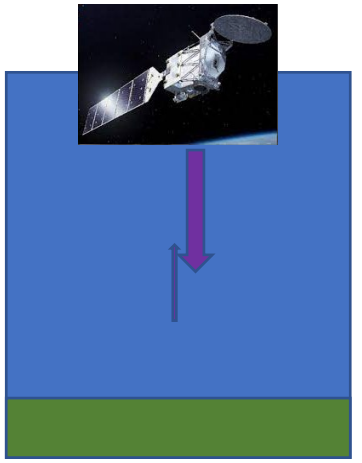
So, something (at least somewhat) more involved is needed !



Retrieval of beta,alpha,de pol

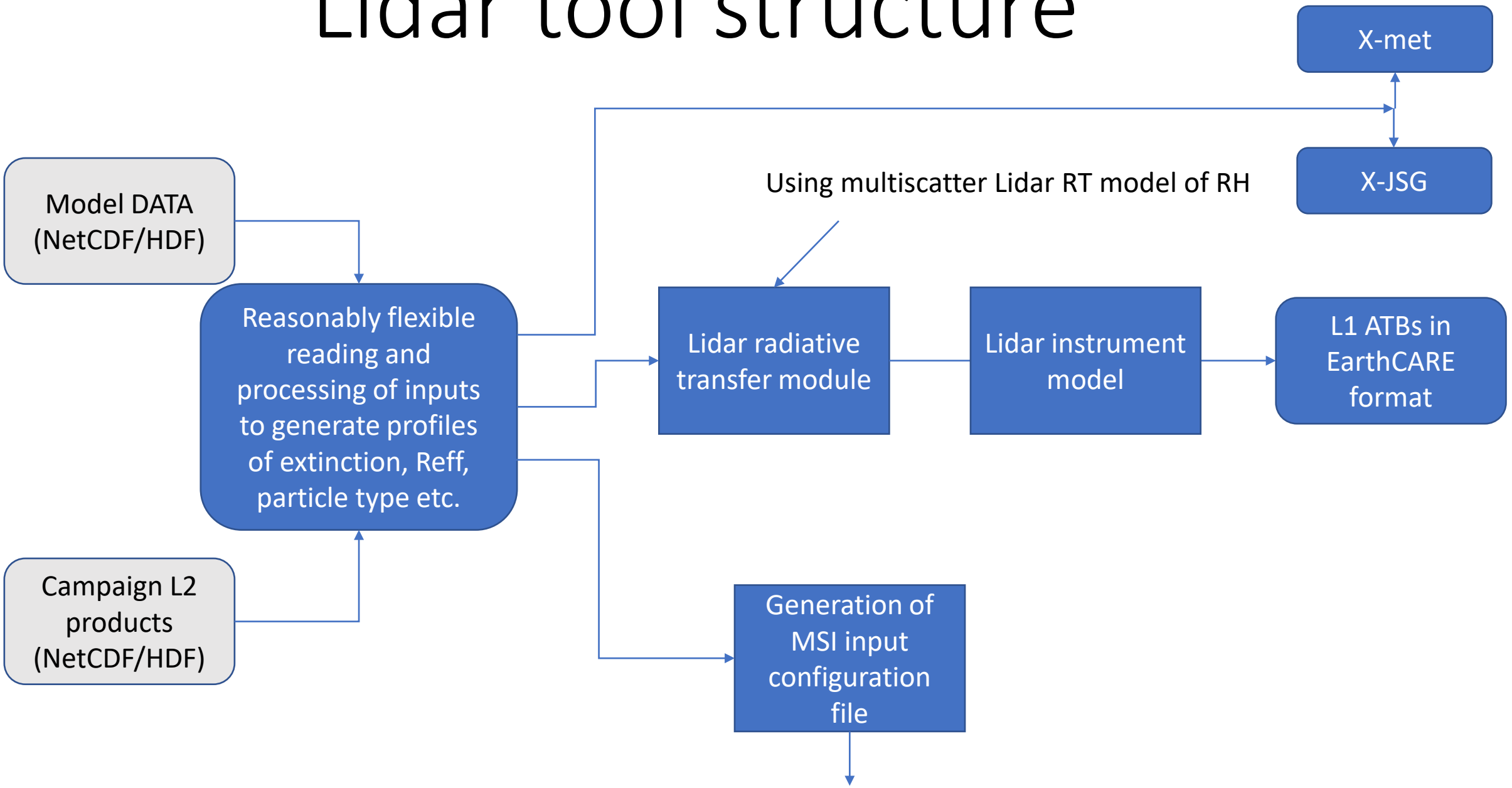
Simulationof ATLID ATBs

Compare



Validation + Radiometric assessment

Lidar tool structure



Reasonably flexible input processing (RFIP)

Test_input_spread_sheet_GEM_data.xlsx - LibreOffice Calc

File Edit View Insert Format Styles Sheet Data Tools Window Help

Cambria 11 pt

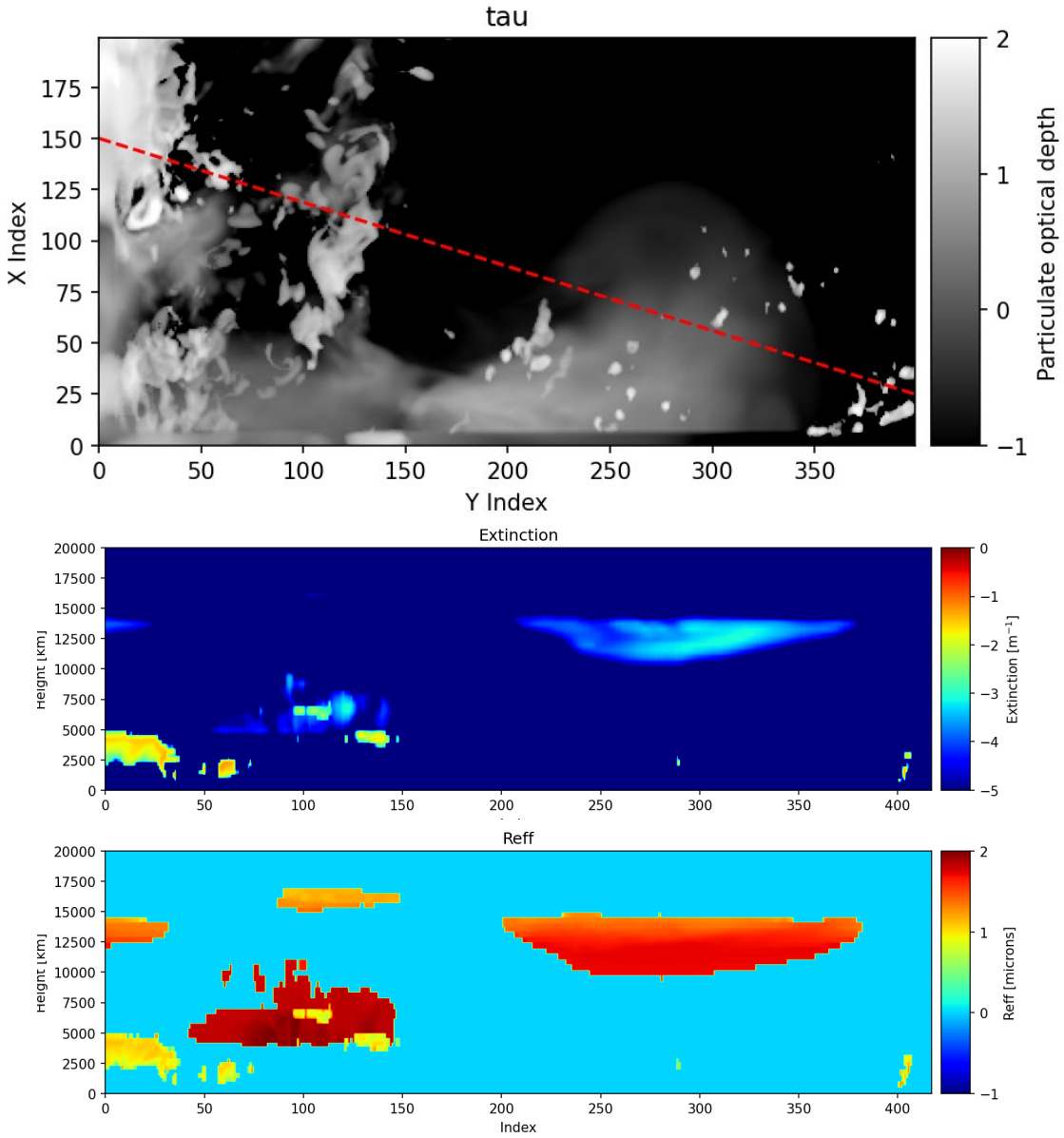
A1 config format version

	A	B	C	D	E	F	G	H	I	J
1	config format version	0.4								
2				**File List**						
3	Table Upper Left Corner	Cell Index		Variable	Value					
4	Domain Table	A22		Data Dir	./data/GEM_DATA					
5	Lidar Table	A11		Number of input files						2
6	File Table	D3		FILE#1	Cape_Verde_F12_GEM_2021091812_300min_SIPon_trimmed.nc					
7	Meteo SimVar Table	D12		FILE#2	Coordinates_flight12_2021091812_300m.nc					
8	Water and Ice SimVar Table	D20								
9	Aerosol SimVar Table	D62					0: vertical			
10							1: latitude or time			
11	Lidar parameters	Values		**Meteorological inputs**			2:longitude			
12	Sat_alt[km]	400		Simulation Variable	Input File	File variable	Dimension order	Scale Factor	Shift	Fixed value
13	z1[m]	40000		Met_height[km]	FILE#1	height_thermodynamic	0,1,2	0.001		
14	z2[m]	20000		Met_temperature[K]	FILE#1	temperature	0,1,2		273.15	
15	dz1[m]	500		Met_pressure[mb]	FILE#1	pressure_thermodynamic	0,1,2	0.01		
16	z3[m]	-500		Met_latitude	FILE#2	lat	0,1,2			
17	dz2[m]	100		Met_longitude	FILE#2	lon	0,1,2			
18	fov_telescope[mrads]	0.01		Met_time						
19	div_laser[mrads]	0.005		**Water and Ice inputs**						
20	laser_wavelength[nm]	355		Simulation Variable	Input File	File variable	Dimension order	Scale Factor	Shift	Fixed value
21				Height[km]	FILE#1	height_thermodynamic	0,1,2	0.001		
22	Domain to convert	Value		Latitude	FILE#2	lat	0,1,2			
23	ix1	1		Longitude	FILE#2	lon	0,1,2			
24	ix2	100		Time[Sec]						
25	iy1	1		Species_ID						
26	iy2	50		Water_id						

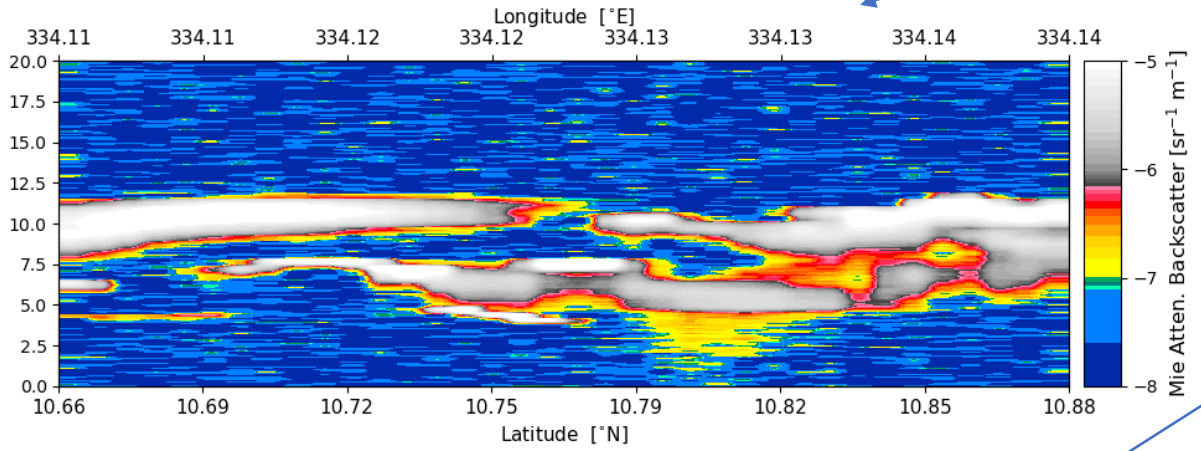
Sheet1

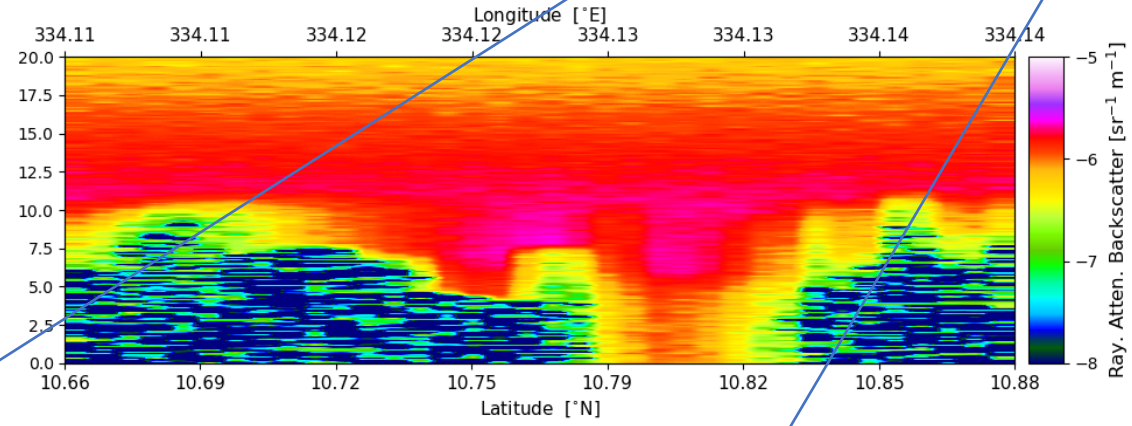
Sheet 1 of 1 | PageStyle_Sheet1 | English (USA) | Average: ; Sum: 0 | 110%

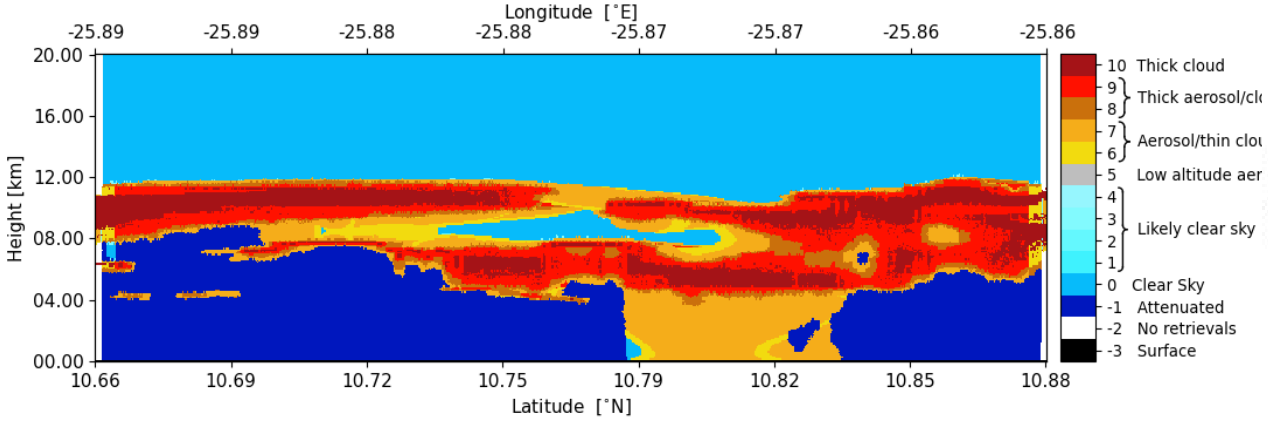
GEM 3D model data

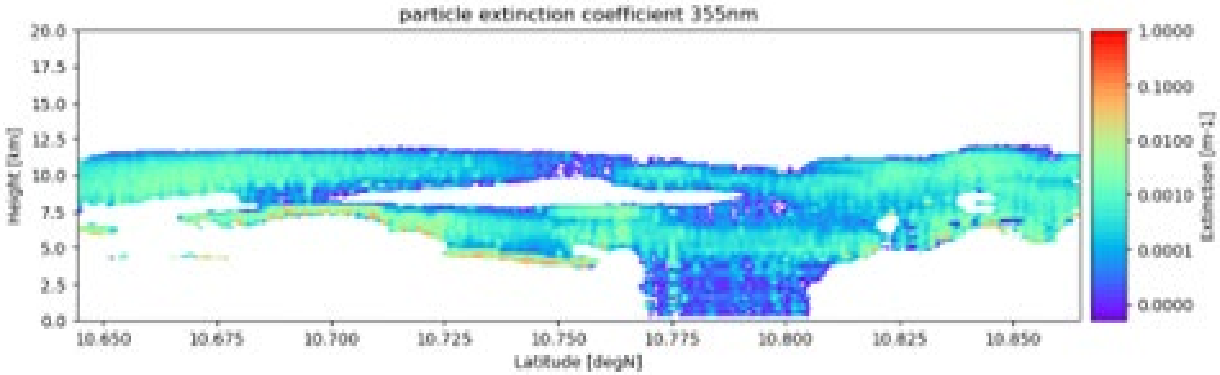


Lidar RT data → Instrument model → ATLID-like data → Operation A-FM code → A-FM output → A-PRO output





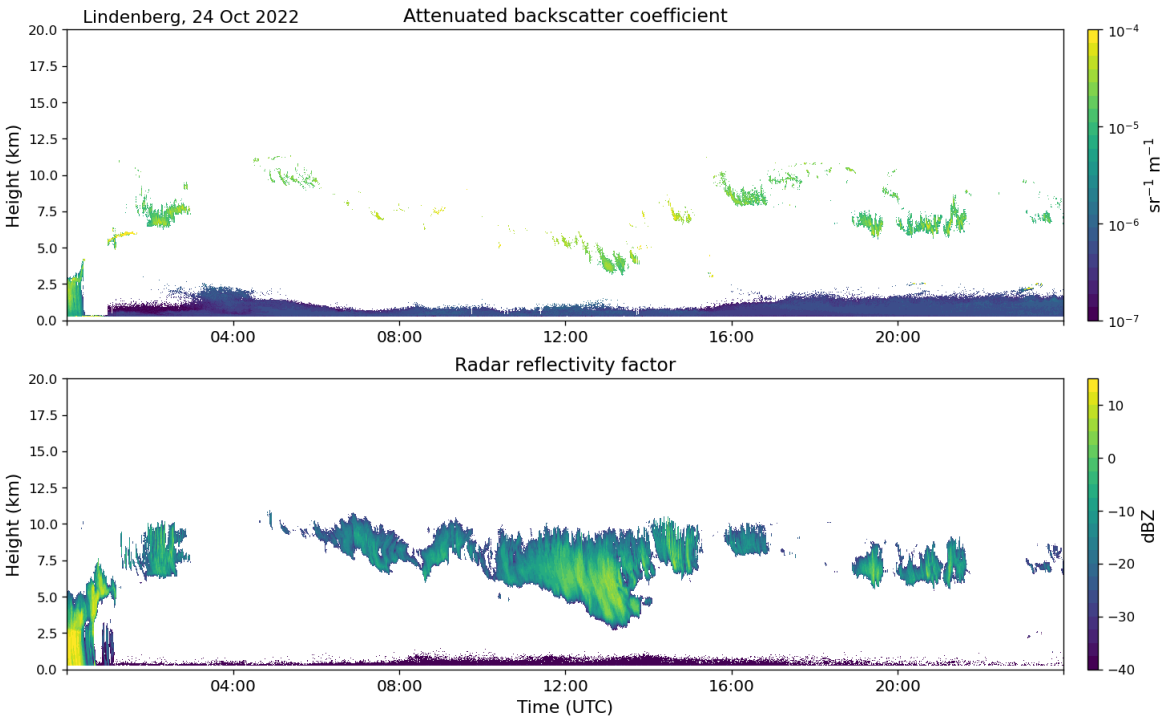


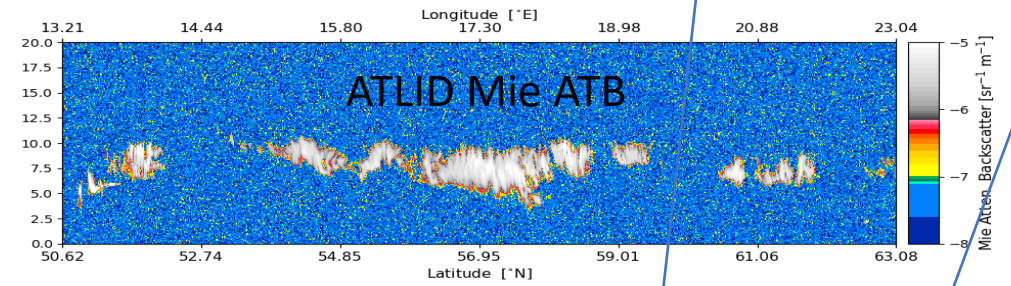


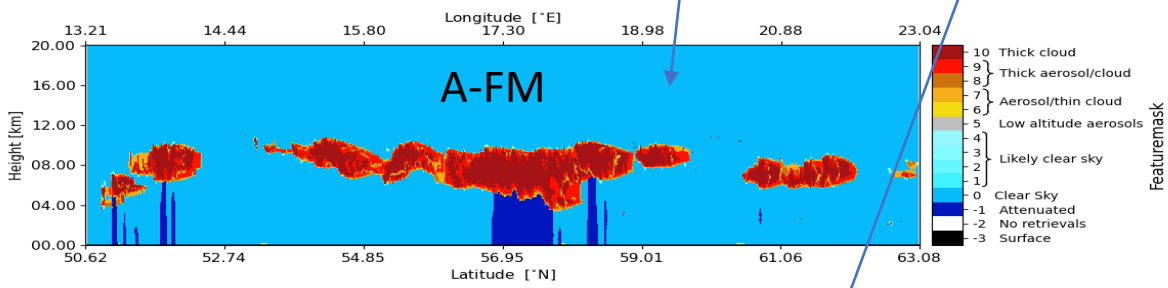
Lidar RT data → Instrument model → ATLID-like data → Operation A-FM code → A-FM output → A-PRO output

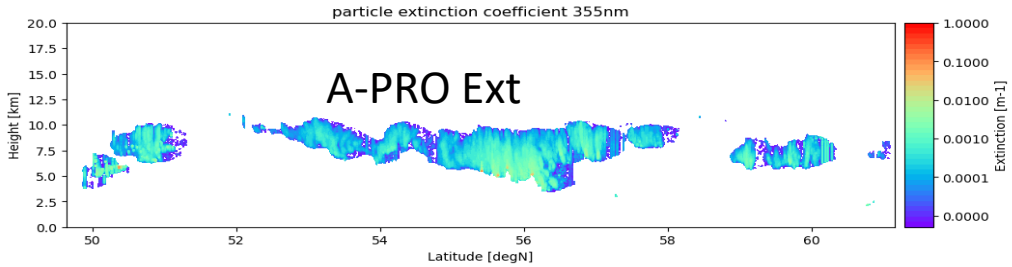
Cloud Net Input Example

(LWC and IWC are actually ingested)



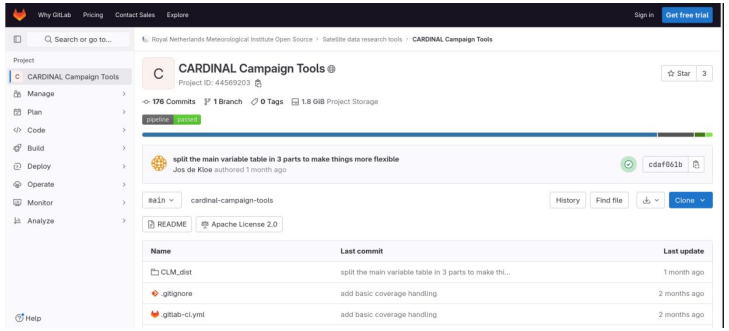






Status

- Instrument model is still largely a place holder.
- Demonstrated ability to ingest various diverse data streams !
- Demonstrated ability to generate data that can be ingested by the ATLID operational processors.
- Beta testing is underway (in collaboration with NOA).
- Creation of input spread-sheet templates via a python application has been achieved (**facilitates automated processing** !).
- Gitlab project created at this address: **https://gitlab.com/KNMI-OSS/satellite-data-research-tools/cardinal-campaign-tools**
- Next release in January



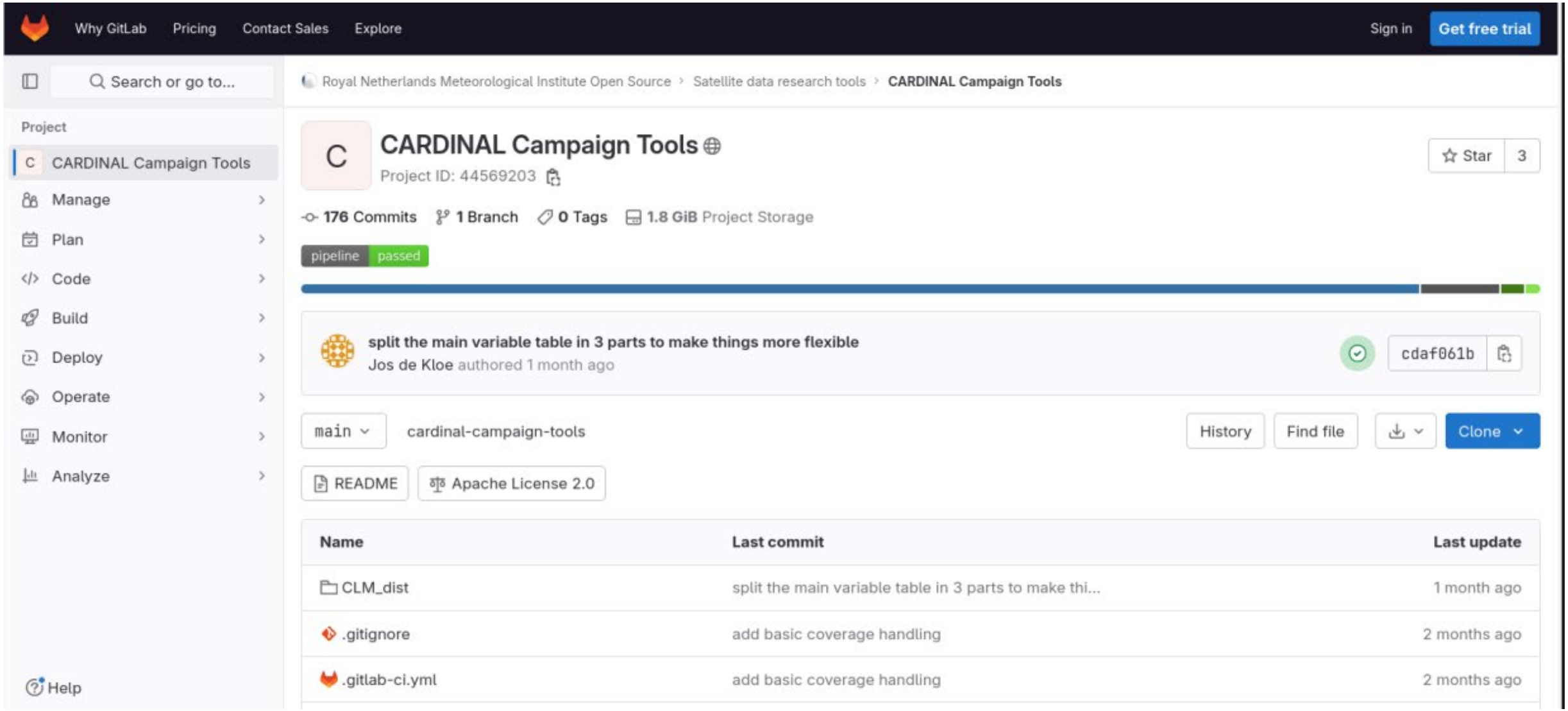
BACKUP SLIDES

RT model

- QSA code of RH is used (fast multiple-scattering model)
  - Well understood.
  - MS induced Depol in water clouds included using a parameterization.

Instrument model

- Modelling of instrument noise
- Modelling of Polarization-spectral Cross-talk effects
  - Including ability to model the effect of inaccurate calibrations and cross-talk corrections.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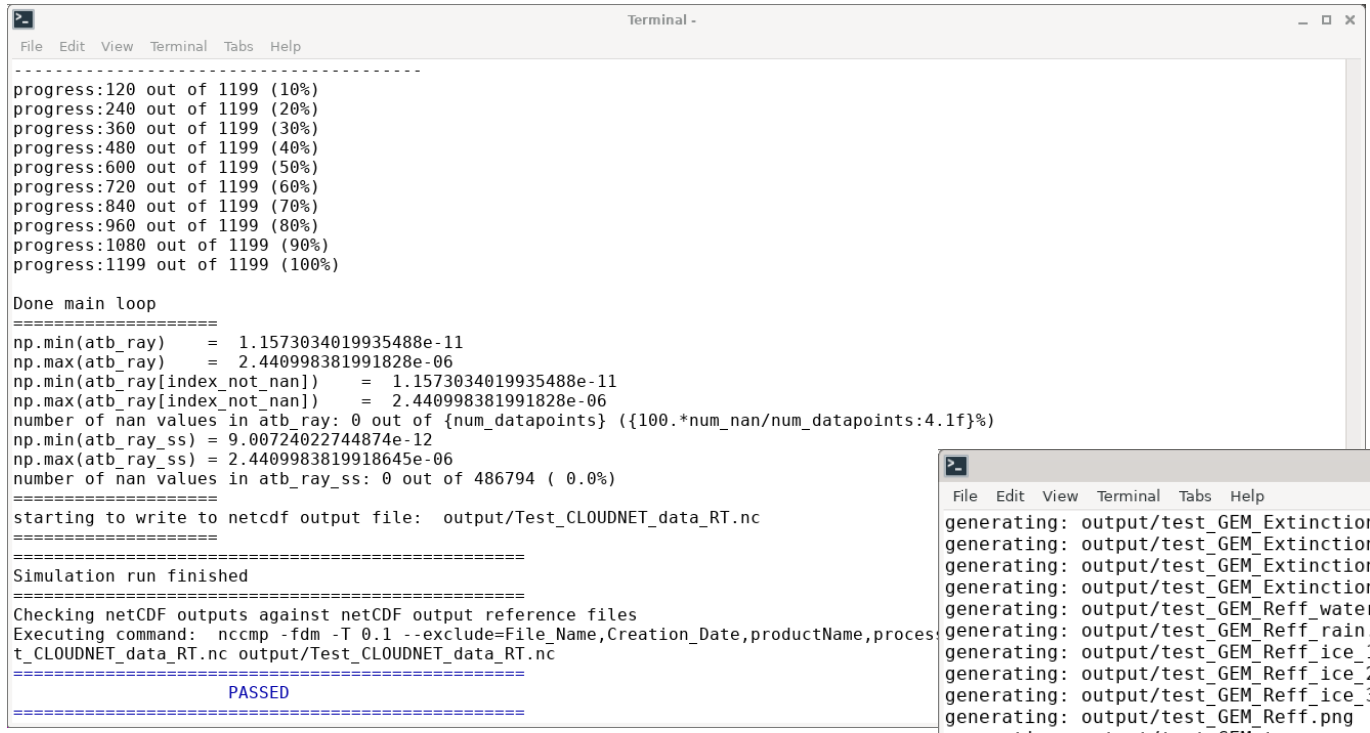
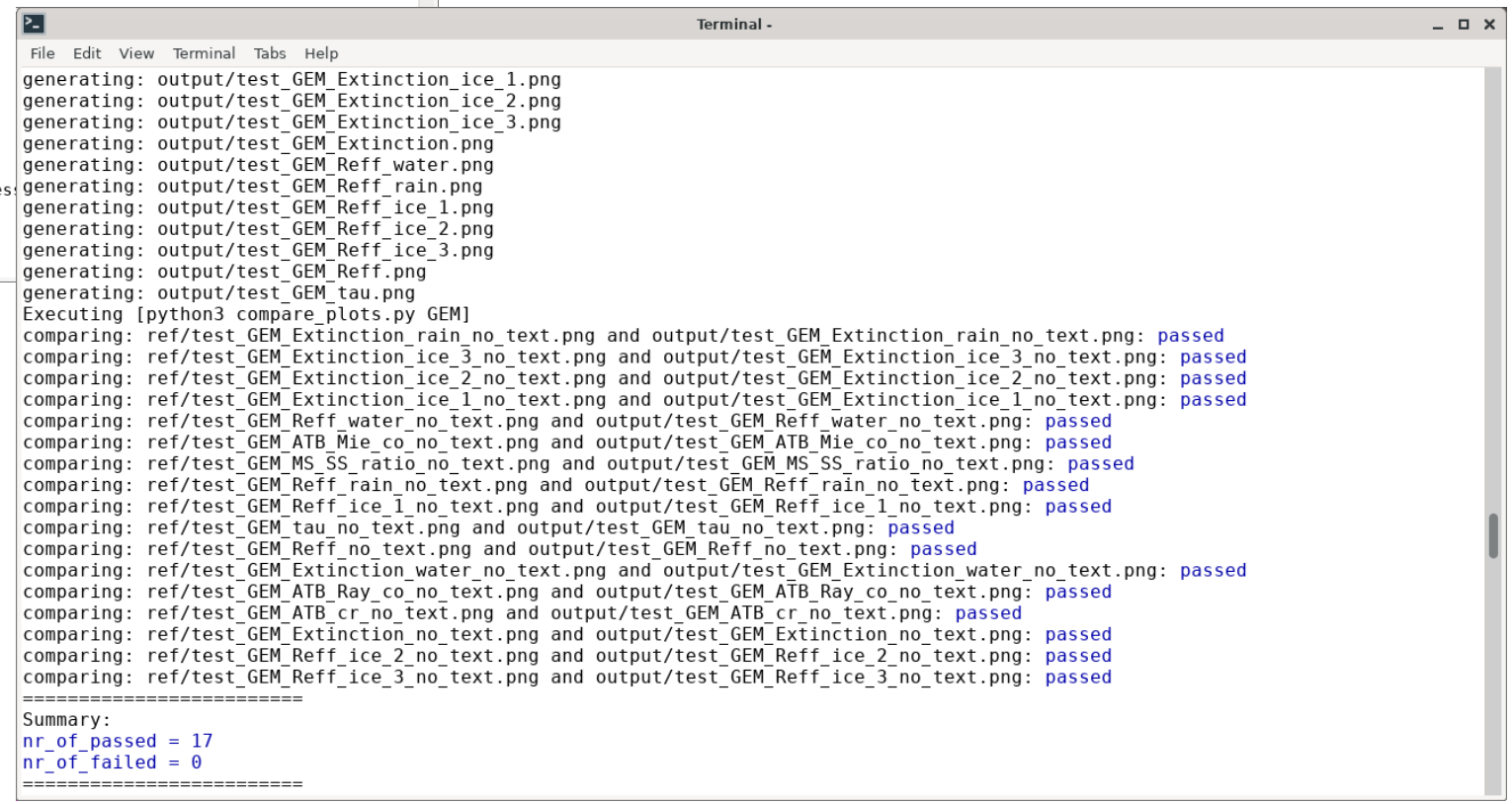
Satellite data research tools
CARDINAL Campaign Tools
Project
CARDINAL Campaign Tools
Manage
Plan
Code
Build
Deploy
Operate
Monitor
Analyze
Help
C
CARDINAL Campaign Tools
Project ID: 44569203
Star
3
176 Commits
1 Branch
0 Tags
1.8 GiB Project Storage
pipeline
passed
split the main variable table in 3 parts to make things more flexible
Jos de Kloe authored 1 month ago
cdaf061b
main
cardinal-campaign-tools
History
Find file
Clone
README
Apache License 2.0
Name
Last commit
Last update
CLM_dist
split the main variable table in 3 parts to make thi...
1 month ago
.gitignore
add basic coverage handling
2 months ago
.gitlab-ci.yml
add basic coverage handling
2 months ago


Terminal -
File Edit View Terminal Tabs Help
----
progress:120 out of 1199 (10%)
progress:240 out of 1199 (20%)
progress:360 out of 1199 (30%)
progress:480 out of 1199 (40%)
progress:600 out of 1199 (50%)
progress:720 out of 1199 (60%)
progress:840 out of 1199 (70%)
progress:960 out of 1199 (80%)
progress:1080 out of 1199 (90%)
progress:1199 out of 1199 (100%)
Done main loop
==========
np.min(atb_ray) = 1.1573034019935488e-11
np.max(atb_ray) = 2.440998381991828e-06
np.min(atb_ray[index_not_nan]) = 1.1573034019935488e-11
np.max(atb_ray[index_not_nan]) = 2.440998381991828e-06
number of nan values in atb_ray: 0 out of {num_datapoints} ({100.*num_nan/num_datapoints:4.1f}%)
np.min(atb_ray_ss) = 9.00724022744874e-12
np.max(atb_ray_ss) = 2.4409983819918645e-06
number of nan values in atb_ray_ss: 0 out of 486794 (0.0%)
==========
starting to write to netcdf output file: output/Test_CLOUDNET_data_RT.nc
==========
==========
Simulation run finished
==========
Checking netCDF outputs against netCDF output reference files
Executing command: nccmp -fdm -T 0.1 --exclude=File_Name,Creation_Date,productName,proces
t_CLOUDNET_data_RT.nc output/Test_CLOUDNET_data_RT.nc
==========
PASSED
==========


Terminal -
File Edit View Terminal Tabs Help
generating: output/test_GEM_Extinction_ice_1.png
generating: output/test_GEM_Extinction_ice_2.png
generating: output/test_GEM_Extinction_ice_3.png
generating: output/test_GEM_Extinction.png
generating: output/test_GEM_Reff_water.png
generating: output/test_GEM_Reff_rain.png
generating: output/test_GEM_Reff_ice_1.png
generating: output/test_GEM_Reff_ice_2.png
generating: output/test_GEM_Reff_ice_3.png
generating: output/test_GEM_Reff.png
generating: output/test_GEM_tau.png
Executing [python3 compare_plots.py GEM]
comparing: ref/test_GEM_Extinction_rain_no_text.png and output/test_GEM_Extinction_rain_no_text.png: passed
comparing: ref/test_GEM_Extinction_ice_3_no_text.png and output/test_GEM_Extinction_ice_3_no_text.png: passed
comparing: ref/test_GEM_Extinction_ice_2_no_text.png and output/test_GEM_Extinction_ice_2_no_text.png: passed
comparing: ref/test_GEM_Extinction_ice_1_no_text.png and output/test_GEM_Extinction_ice_1_no_text.png: passed
comparing: ref/test_GEM_Reff_water_no_text.png and output/test_GEM_Reff_water_no_text.png: passed
comparing: ref/test_GEM_ATB_Mie_co_no_text.png and output/test_GEM_ATB_Mie_co_no_text.png: passed
comparing: ref/test_GEM_MS_SS_ratio_no_text.png and output/test_GEM_MS_SS_ratio_no_text.png: passed
comparing: ref/test_GEM_Reff_rain_no_text.png and output/test_GEM_Reff_rain_no_text.png: passed
comparing: ref/test_GEM_Reff_ice_1_no_text.png and output/test_GEM_Reff_ice_1_no_text.png: passed
comparing: ref/test_GEM_tau_no_text.png and output/test_GEM_tau_no_text.png: passed
comparing: ref/test_GEM_Reff_no_text.png and output/test_GEM_Reff_no_text.png: passed
comparing: ref/test_GEM_Extinction_water_no_text.png and output/test_GEM_Extinction_water_no_text.png: passed
comparing: ref/test_GEM_ATB_Ray_co_no_text.png and output/test_GEM_ATB_Ray_co_no_text.png: passed
comparing: ref/test_GEM_ATB_cr_no_text.png and output/test_GEM_ATB_cr_no_text.png: passed
comparing: ref/test_GEM_Extinction_no_text.png and output/test_GEM_Extinction_no_text.png: passed
comparing: ref/test_GEM_Reff_ice_2_no_text.png and output/test_GEM_Reff_ice_2_no_text.png: passed
comparing: ref/test_GEM_Reff_ice_3_no_text.png and output/test_GEM_Reff_ice_3_no_text.png: passed
==========
Summary:
nr_of_passed = 17
nr_of_failed = 0
==========

Test_input_spread_sheet_CLOUDNET_data.xlsx - LibreOffice Calc

File Edit View Insert Format Styles Sheet Data Tools Window Help

Cambria 11 pt

A1 config format version

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	config format version	0.4														
2				**File List**												
3	Table Upper Left Corner	Cell Index		Variable	Value											
4	Domain Table	A22		Data Dir	./data/CLOUDNET_DATA											
5	Lidar Table	A11		Number of input files						3						
6	File Table	D3		FILE#1	20221024_lindenberg_categorize.nc											
7	Meteo SimVar Table	D13		FILE#2	20221024_lindenberg_lwc-scaled-adiabatic.nc											
8	Water and Ice SimVar Table	D21		FILE#3	20221024_lindenberg_iwc-Z-T-method.nc											
9	Aerosol SimVar Table	D63														
10							0: vertical									
11	Lidar parameters	Values					1: latitude or time									
12	Sat_alt[km]	400		**Meteorological inputs**			2:longitude									
13	z1[m]	40000		Simulation Variable	Input File	File variable	Dimension order	Scale Factor	Shift	Fixed value						
14	z2[m]	20000		Met_height[km]	FILE#1	model_height	0	0.001								
15	dz1[m]	500		Met_temperature[K]	FILE#1	temperature	1,0		273.15							
16	z3[m]	-500		Met_pressure[mb]	FILE#1	pressure	1,0	0.01								
17	dz2[m]	100		Met_latitude	FILE#1	latitude	constant									
18	fov_telescope[mrads]	0.01		Met_longitude	FILE#1	longitude	constant									
19	div_laser[mrads]	0.005		Met_time	FILE#1	model_time	0									
20	laser_wavelength[nm]	355		**Water and Ice inputs**												
21				Simulation Variable	Input File	File variable	Dimension order	Scale Factor	Shift	Fixed value						
22	Domain to convert	Value		Height[km]	FILE#1	height	0	0.001								
23	ix1	1		Latitude	FILE#1	latitude	constant									
24	ix2	1200		Longitude	FILE#1	longitude	constant									
25	iy1	-1		Time[Sec]	FILE#1	time	1									
26	iy2	-1		Species_ID												

Sheet1

Sheet 1 of 1 | PageStyle_Sheet1 | English (USA) | Average: ; Sum: 0 | 110%

Auto generation of spread-sheets !
(can be used for automation, template creation etc..)

config_CLOUDNET.toml

File Edit Options Buffers Tools Help

New File Open Open Directory Close Save Undo Cut Copy Paste

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[Table_Position_Definitions]
domain_table = "A22"
lidar_table = "A11"
file_table = "D3"
meteo_simvar_table = "D13"
water_and_ice_simvar_table = "D21"
aerosol_simvar_table = "D63"

[File_List]
data_dir = "./data/CLOUDNET_DATA"
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input_file.01.refname = 'FILE#1'
input_file.01.filename = "20221024_lindenberg_categorize.nc"
input_file.02.refname = 'FILE#2'
input_file.02.filename = "20221024_lindenberg_lwc-scaled-adiabatic.nc"
input_file.03.refname = 'FILE#3'
input_file.03.filename = "20221024_lindenberg_iwc-Z-T-method.nc"

[Domain_to_convert]
ix1=1
ix2=1200
iy1=-1
iy2=-1

[Lidar_paras]
Sat_alt = 400 # [km]
z1 = 40000 # [m]
z2 = 20000 # [m]
dz1 = 500 # [m]
z3 = -500 # [m]
dz2 = 100 # [m]
fov_telescope = 0.01 # [mrads]
div_laser = 0.005 # [mrads]
laser_wavelength = 355 # [nm]
```

-:--- config_CLOUDNET.toml Top (29,0) (Fundamental)

Test_input_spread_sheet_CLOUDNET_data.xlsx - LibreOffice Calc

File Edit View Insert Format Styles Sheet Data Tools Window Help

Cambria 11 pt

A1 config format version

	A	B	C	D	E	F	G	H	I	J
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2				**File List**						
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4	Domain Table	A22		Data Dir	./data/CLOUDNET_DATA					
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6	File Table	D3		FILE#1	20221024_lindenberg_categorize.nc					
7	Meteo SimVar Table	D13		FILE#2	20221024_lindenberg_lwc-scaled-adiabatic.nc					
8	Water and Ice SimVar Table	D21		FILE#3	20221024_lindenberg_iwc-Z-T-method.nc					
9	Aerosol SimVar Table	D63								
10							0: vertical			
11	Lidar parameters	Values					1: latitude or time			
12	Sat_alt[km]	400		**Meteorological inputs**			2:longitude			
13	z1[m]	40000		Simulation Variable	Input File	File variable	Dimension order	Scale Factor	Shift	Fixed value
14	z2[m]	20000		Met_height[km]	FILE#1	model_height	0	0.001		
15	dz1[m]	500		Met_temperature[K]	FILE#1	temperature	1,0		273.15	
16	z3[m]	-500		Met_pressure[mb]	FILE#1	pressure	1,0	0.01		
17	dz2[m]	100		Met_latitude	FILE#1	latitude	constant			
18	fov_telescope[mrads]	0.01		Met_longitude	FILE#1	longitude	constant			
19	div_laser[mrads]	0.005		Met_time	FILE#1	model_time	0			
20	laser_wavelength[nm]	355		**Water and Ice inputs**						
21				Simulation Variable	Input File	File variable	Dimension order	Scale Factor	Shift	Fixed value
22	Domain to convert	Value		Height[km]	FILE#1	height	0	0.001		
23	ix1	1		Latitude	FILE#1	latitude	constant			
24	ix2	1200		Longitude	FILE#1	longitude	constant			
25	iy1	-1		Time[Sec]	FILE#1	time	1			
26	iy2	-1		Species_ID						

Sheet1

Sheet 1 of 1 PageStyle_Sheet1 English (USA) Average: ; Sum: 0 110%