BroadBand Radiometer and MultiSpectral Imager L2a test data 3D radiative transfer simulations status update

Najda Villefranque et al., MTR, WP-0240, 24^{th} August 2022

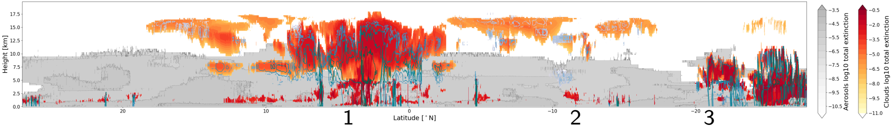
L2 algorithms are currently tested using 1D BBR and MSI test data
Columns are radiatively independent / isolated from each other
$\Rightarrow$ clouds are homogeneous and horizontally infinite in each column

Assumptions in current test data and L2 algorithms are consistent
Retrieval algorithms also assume independent pixels
$\Rightarrow$ 1D radiances are interpreted as such and inverted accordingly

In reality, photons also travel horizontally (i.e., in 3D)
Complex cloud geometry leads to shadowing and brightening effects
$\Rightarrow$ light received by one sensor has been “polluted” by neighbouring clouds

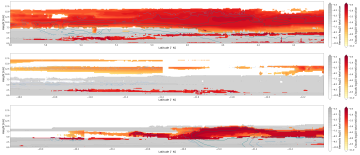
What errors can be expected from 1DRT-based retrieval algorithms when acting upon 3D RT data ?
e.g. over- (under-) estimate cloud optical depth of illuminated (shadowed) cloud sides ? Compared to current errors ? Impact on the closure assessment ? Mitigation ?

Ongoing 3D RT simulations...



3 scenes from the Hawaii frame, each 200 km x 30 km @ 250 m horizontal res.

Scene	Latitude (° N)	SZA (°)	SAA (°)
1	4.03 – 5.80	34	113
2	-12.32 – -10.55	44	130
3	-21.59 – -19.83	51	136



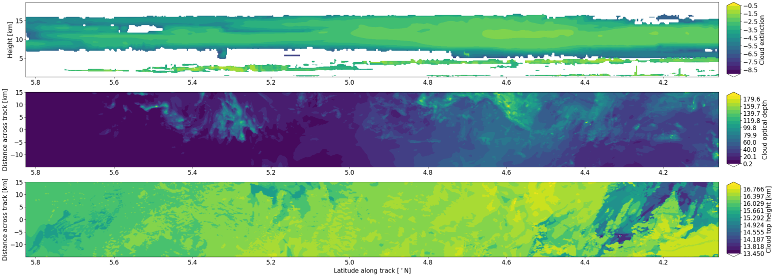
First set of "idealized" Monte Carlo simulations (with the `htrdr` code)

- 3D cloud fields from the GEM simulations (liquid and ice water contents and radii)
- 1D atmospheric profiles (T, P, q, O3 horizontally averaged over the scene)
- Gas optics = same correlated-k model as other test data (thanks Dave!)
- No precips, no aerosols, Lambertian surface with albedo 0.05, HG phase function

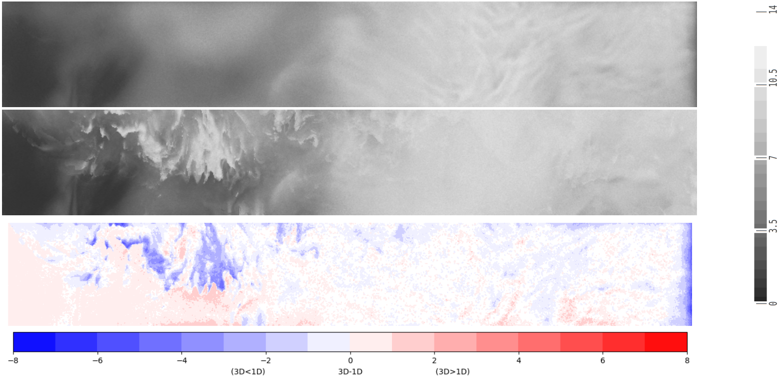
For each scene, 22 maps of 800 x 121 pixels, 4096 photons per pixel

- MSI : 3 channels (0.680/0.865/10.85) × (3D + 1D)
- BBR : (SW + LW) × 3 views (fore/nadir/aft) × (3D + 1D)
- Fluxes at reference height : (SW + LW) × (3D + 1D)

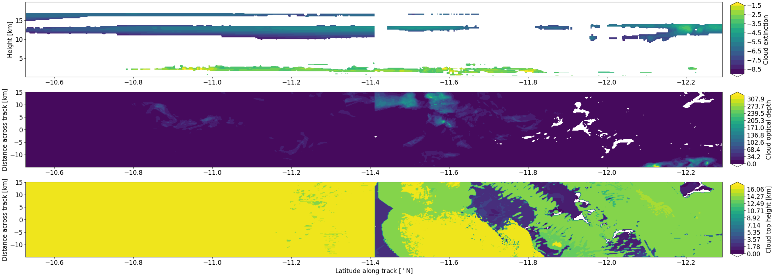
3D vs 1D RT on MSI simulations, scene 1, SZA 34°, SAA 67°, sat track →



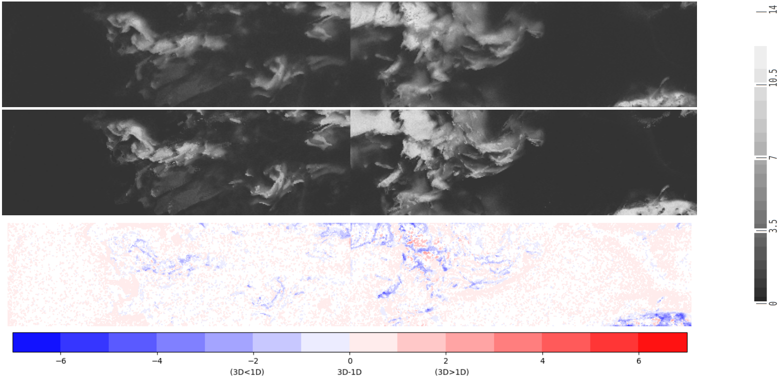
Channel 680, 3D, 1D and 3D-1D nadir radiances



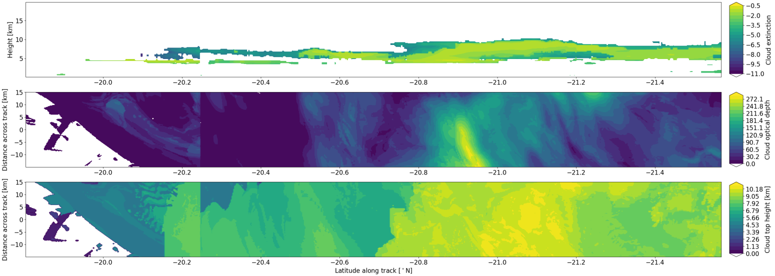
3D vs 1D RT on MSI simulations, scene 2, SZA 44°, SAA 50°, sat track →



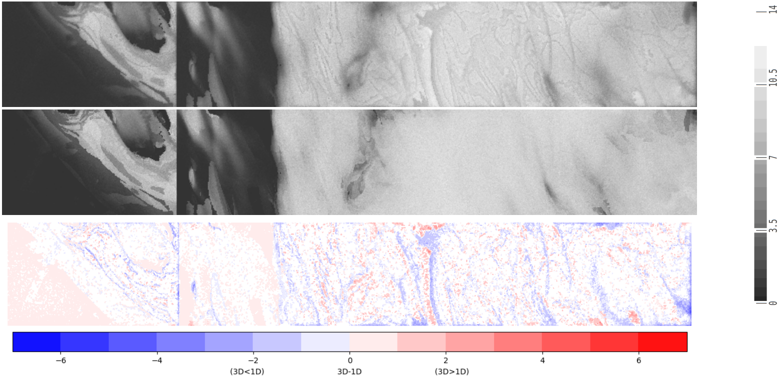
Channel 680, 3D, 1D and 3D-1D nadir radiances



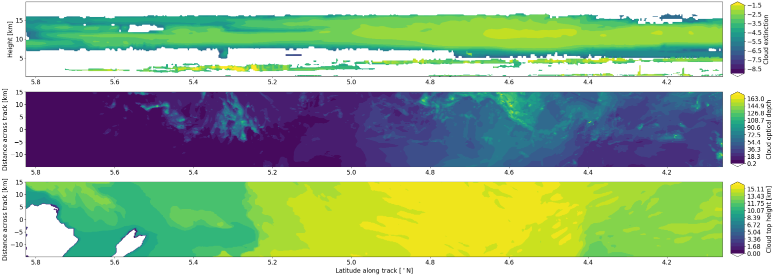
3D vs 1D RT on MSI simulations, scene 3, SZA 51°, SAA 44°, sat track →



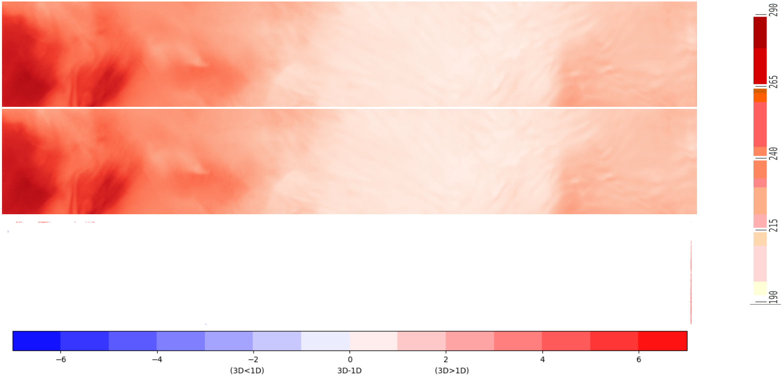
Channel 680, 3D, 1D and 3D-1D nadir radiances



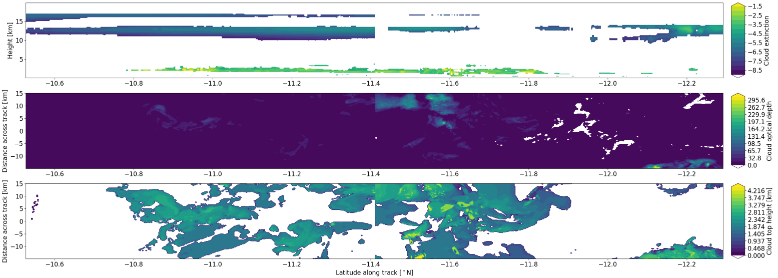
3D vs 1D RT on MSI simulations, scene 1, sat track →



Channel 10.85, 3D, 1D and 3D-1D brightness temperatures



3D vs 1D RT on MSI simulations, scene 2, sat track →



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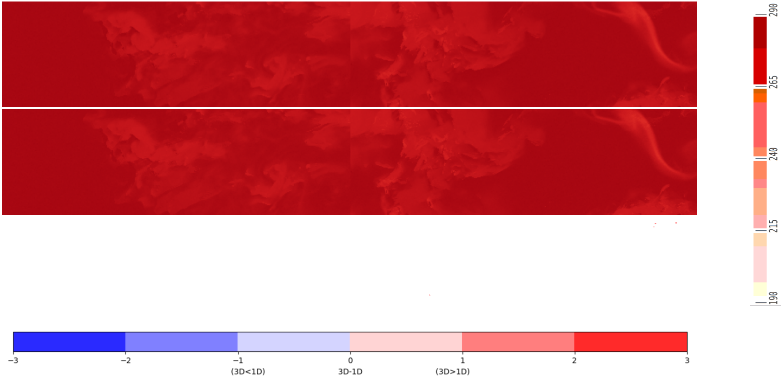
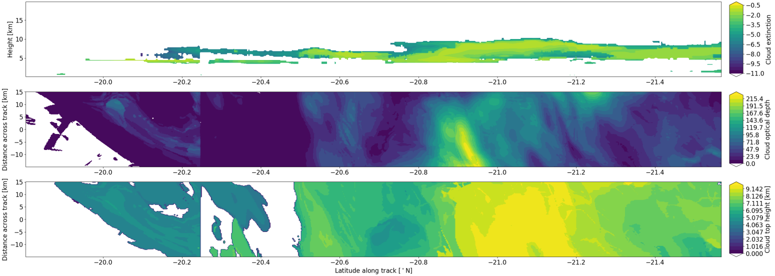


3D vs 1D RT on MSI simulations, scene 3, sat track →



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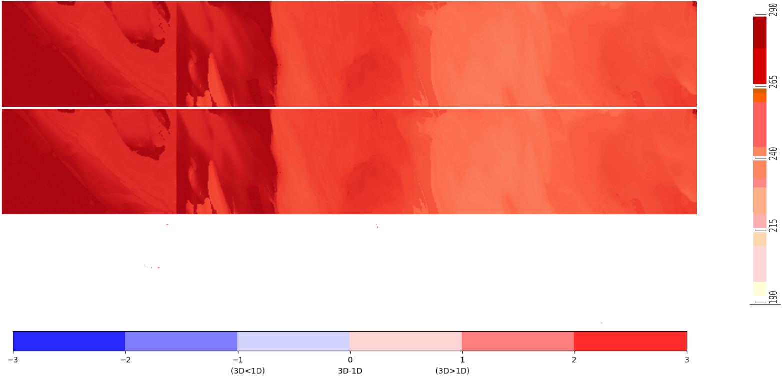
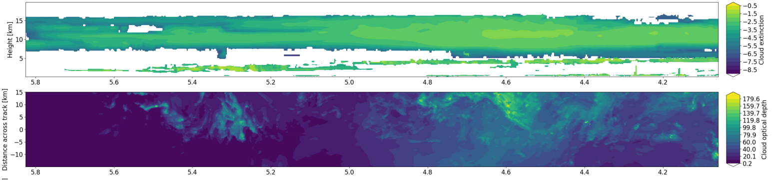
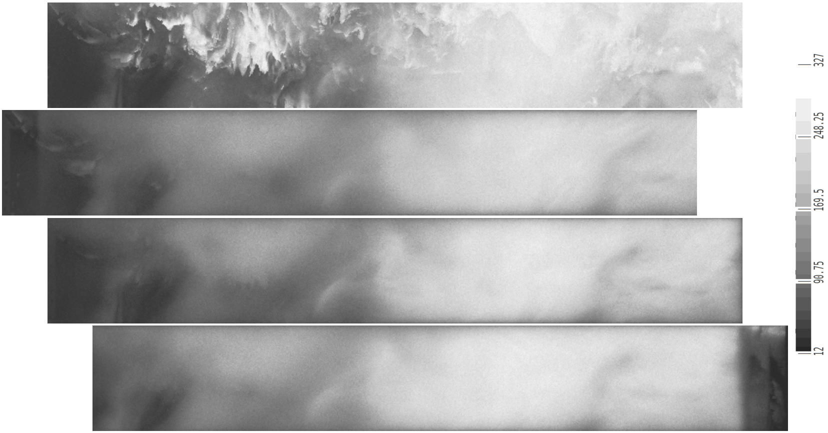


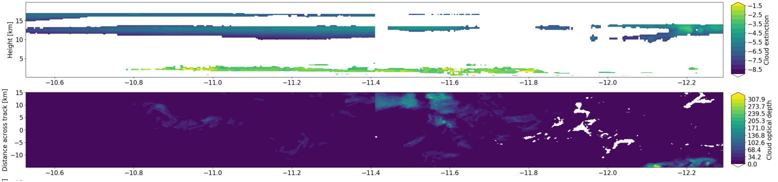
3D vs 1D RT on BBR SW simulations, scene 1, SZA 34°, SAA 67°, sat track →



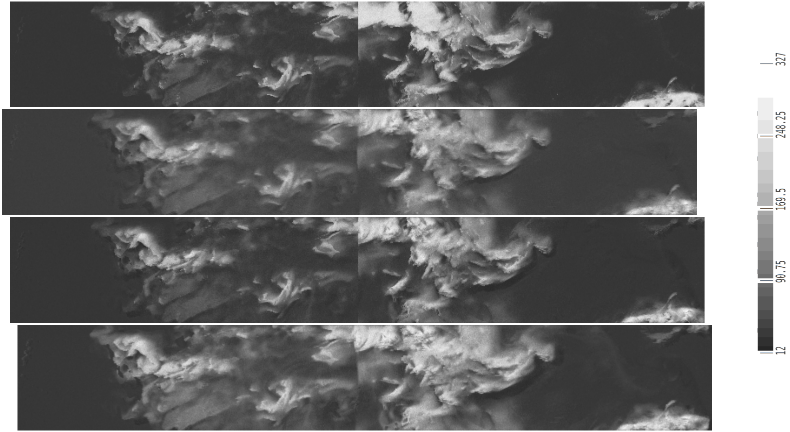
1D nadir, 3D fore, 3D nadir, 3D aft, BB SW radiances



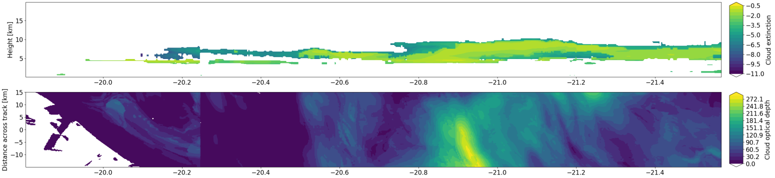
3D vs 1D RT on BBR SW simulations, scene 2, SZA 44°, SAA 50°, sat track →



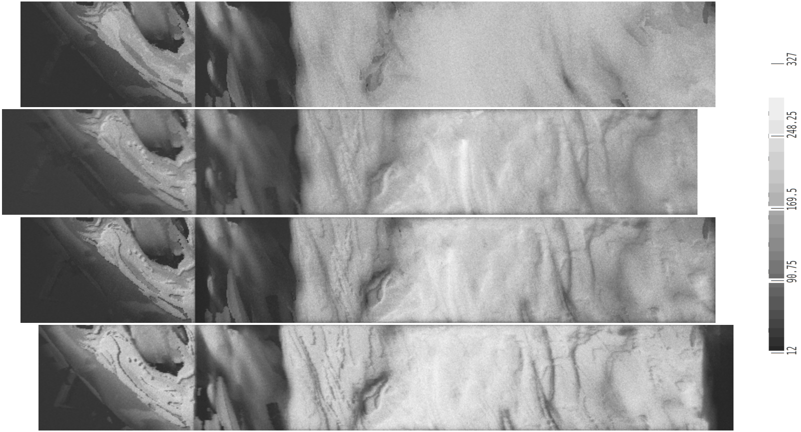
1D nadir, 3D fore, 3D nadir, 3D aft, BB SW radiances



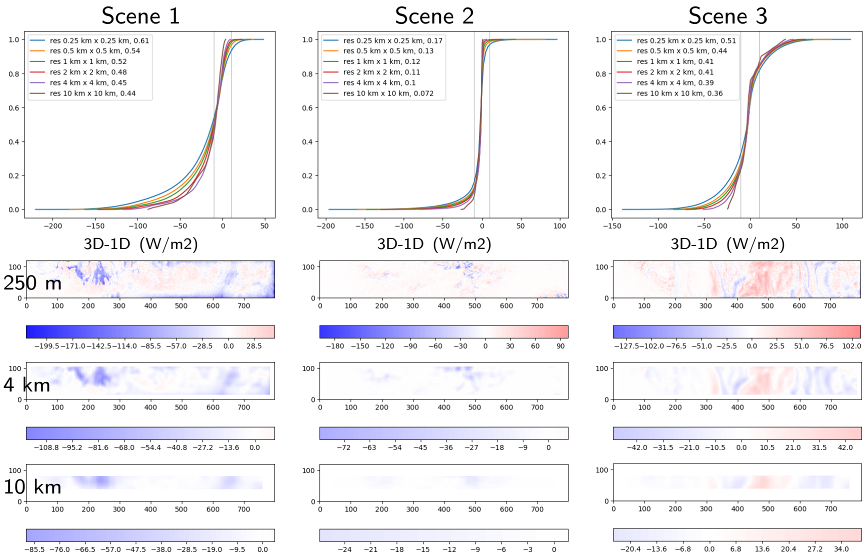
3D vs 1D RT on BBR SW simulations, scene 3, SZA 51°, SAA 44°, sat track →



1D nadir, 3D fore, 3D nadir, 3D aft, BB SW radiances



3D vs 1D RT on BBR SW simulations, cumulated distributions of 3D-1D differences



A large dataset to investigate 3D effects! As a function of scene type, cloud geometry, solar angles, cloud optical and geometrical depth...

To be continued...

- LW BB radiances and upward fluxes at reference heights for the 3 scenes (ongoing)
  $\rightarrow$ these will be used to test the colocating part of BMA-FLX (WP0240)

- Add aerosols and precips (MSI code ready, BBR code in dev.),
  and a more realistic surface (eg for ocean need to input wind, code not ready)
  $\rightarrow$ to be consistent with the other test data (rad/lid)
  $\rightarrow$ will be used for other MSI-related processors (?)

- Go to full frame ? Expensive but feasible. Would it be useful ?

I will be leaving the project at the end of September...
(for a permanent position @ Météo-France)
but will finish these simulations anyway!

Thanks!