E3SIM potential role in Cal/Val activities

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- 25-28 May 2021 (online)

Outline

- The general problem with direct comparisons of ATBs.
  - E.G. The viewing direction does matter (even in the simplest conditions).
- A solution!
  - Terrestrial L1➔L2=➔”Simulation” ➔Space-based L1
- Simulation strategies
  - Simple direct approaches (advantages and limitations)
  - Heavy (e.g. ECSIM) approaches (advantages and disadvantages)
- Conclusions

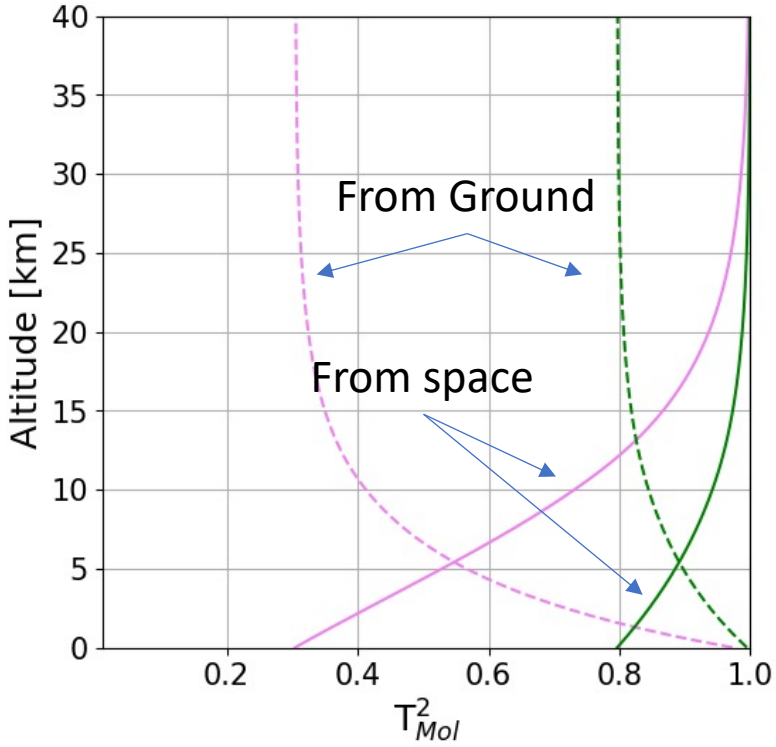
Why direct comparison of ATBs is not enough for quantitative validation*.

(Even in the case of where space/time co-location is perfect, and/or the atmospheric is horizontally homogeneous.)

Geometry is important !

(because with lidars, attenuation is important)

$$ATB(r) = \left(\beta(r)_M + \beta(r)_R\right)\exp[-2T(0,r)]$$



*Note: using R and Depol info from ground-based could be somewhat directly compared…but these are ratios so e.g. absolute calibration factors, radiometric assessment can not be checked/validated.

Another issue: Depol ratio as measured by ATLID (after cross-talk correction !)

Ratio directly derived by dividing the ATLID (total=Mie+Ray) cross-polar and co-polar Mie attenuated backscatters

$$\delta_{Ec} \equiv \frac{b_{T,\perp}}{b_{M,\parallel}}$$

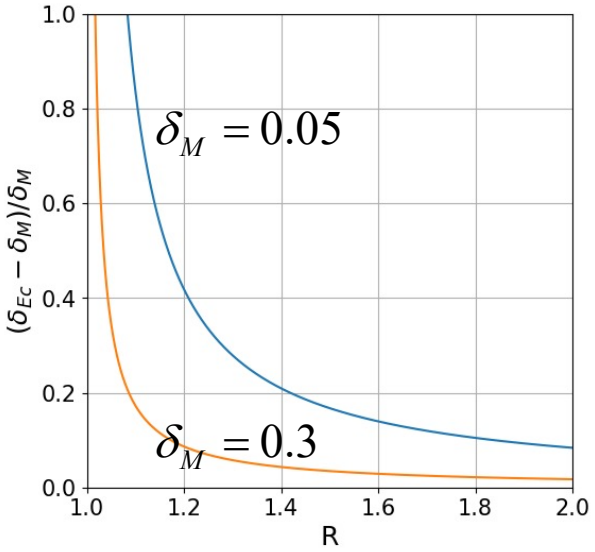
Neither the volume depol nor the particle depol ratio !

$$\delta_M = \frac{\delta_{Ec} - \frac{\delta_R}{(1+\delta_R)(R-1)}}{1 + \frac{\delta_R}{(1+\delta_R)(R-1)}}$$

$$\delta_M \equiv \frac{b_{M,\perp}}{b_{M,\parallel}} = \left(\delta_{Ec} - \frac{b_{R,\parallel}\delta_R}{b_{M,\parallel}} \right)$$

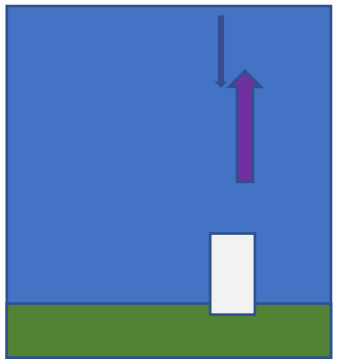
Usual definition of Aerosol Linear Depolarization ratio

Relative difference can be significant for small values of R !



There is a need to validate the value of the effective Rayleigh Depolarization ratio for ATLID !

The role of simulation in general



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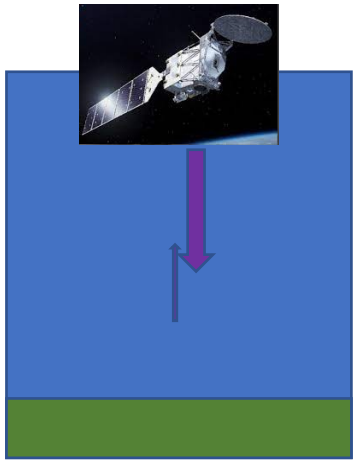
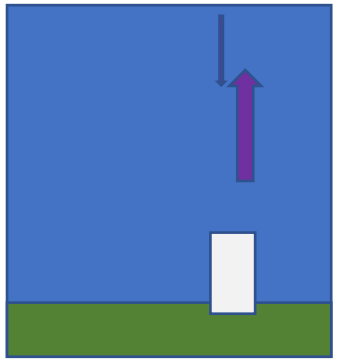


ATBs from ground-bases systems can NOT be directly compared to space-based ATBs, even in the best of circumstances.

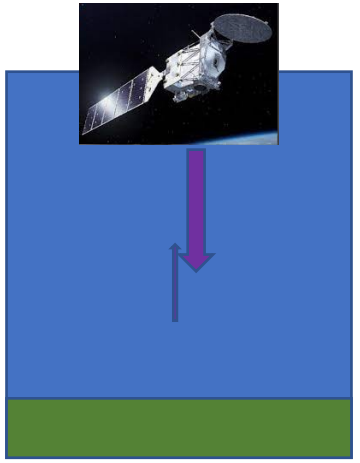
So, something (at least somewhat) more involved is needed !



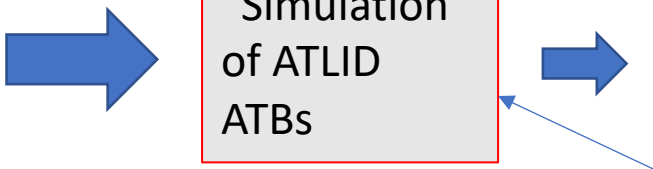
Retrieval of beta,alpha, depol

"Simulation" of ATLID ATBs

Compare



Validation + Radiometric assessment



This step, in particular, can be done at various levels of detail and sophistication..

Simple: e.g. Use single-scattering lidar equations for each ATLID channel.

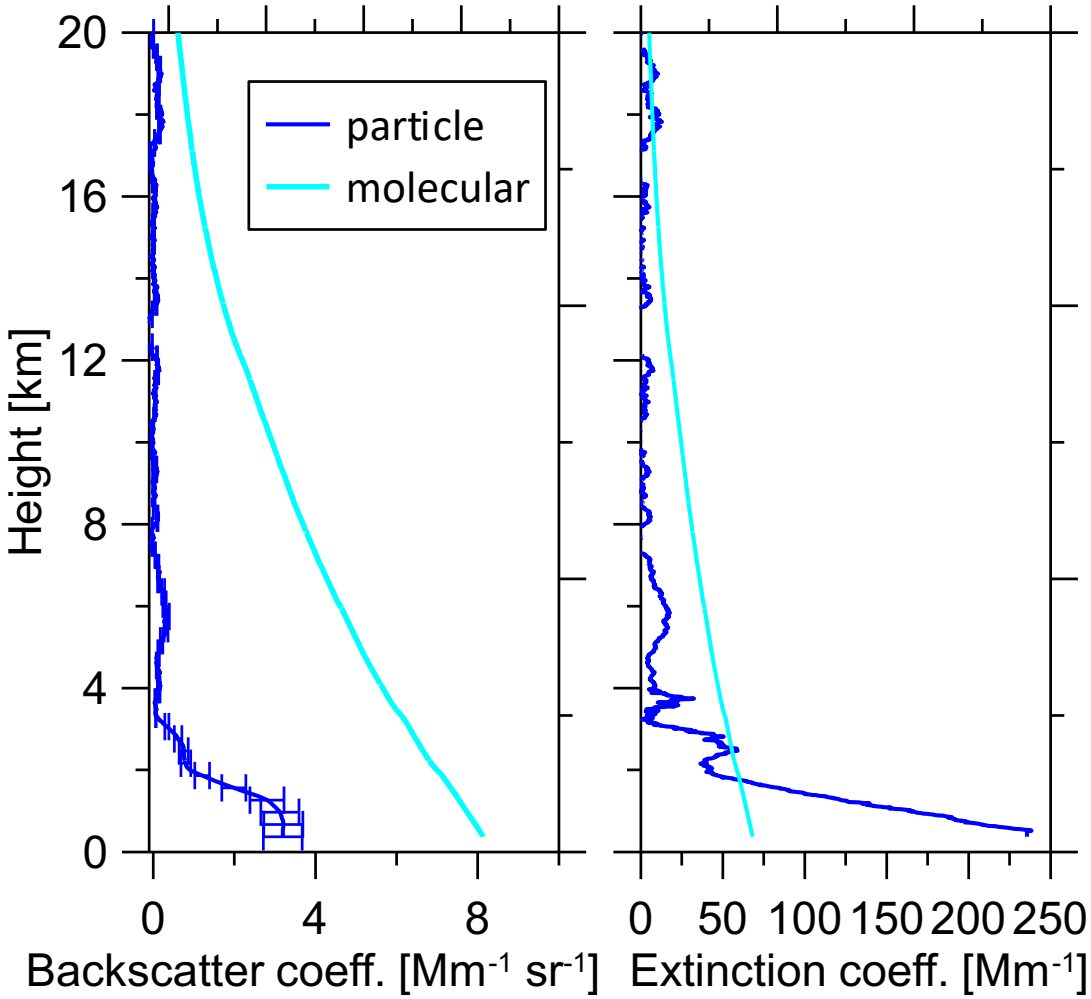
- **Big advantage…simplicity !!**
- **Limitations:** Limited ability to traceback potential problems to ATLID in case of problems.

Complex: e.g. Use a more detailed approach using a lidar RT model that calculates spectral/polarization characteristics (and included multiple scattering effects) coupled with a detailed ATLID instrument model.

- **Ability to investigate issues in depth (e.g. track down specific cross-talk correction issues by adjusting virtual FP parameters).**
- **Ability to pull in other sources of information (e.g. in-situ data) .**
- **Ability to use data not at 355nm in a manner more accurate than simple approaches.**
- **Disadvantage: NOT SIMPLE!!**

Example at 355 nm (using a “simple” approach).

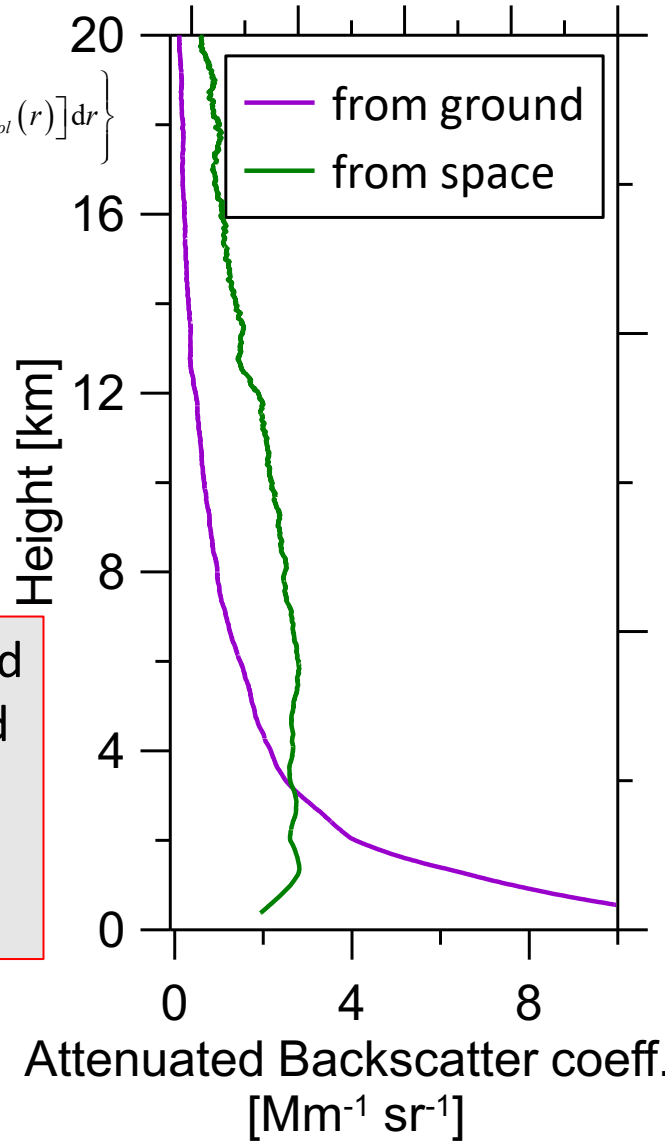
PollyXT_TROPOS; Leipzig, Germany,
27 March 2020. 1830-1930 UTC



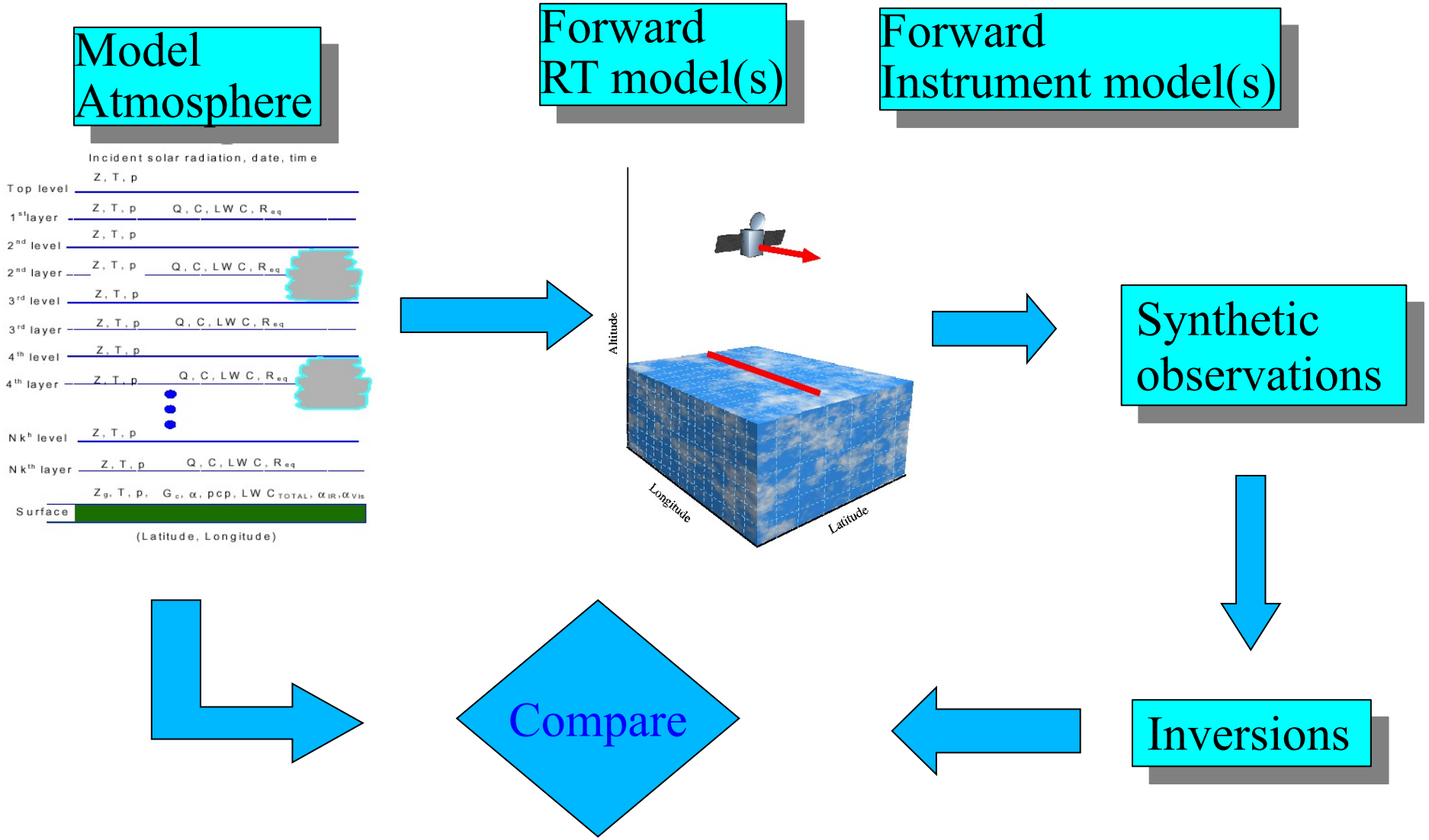
$$P^{\lambda}(z) = \frac{C_{sys}^{\lambda} O^{\lambda}(z)}{z^2}\left[\beta_{par}^{\lambda}(z) + \beta_{mol}^{\lambda}(z)\right]\exp\left\{-2\int_{z_1}^{z_2}\left[\alpha_{par}^{\lambda}(r) + \alpha_{mol}^{\lambda}(r)\right]dr\right\}$$

from ground: z1=0 km
from space: z1= 20 km

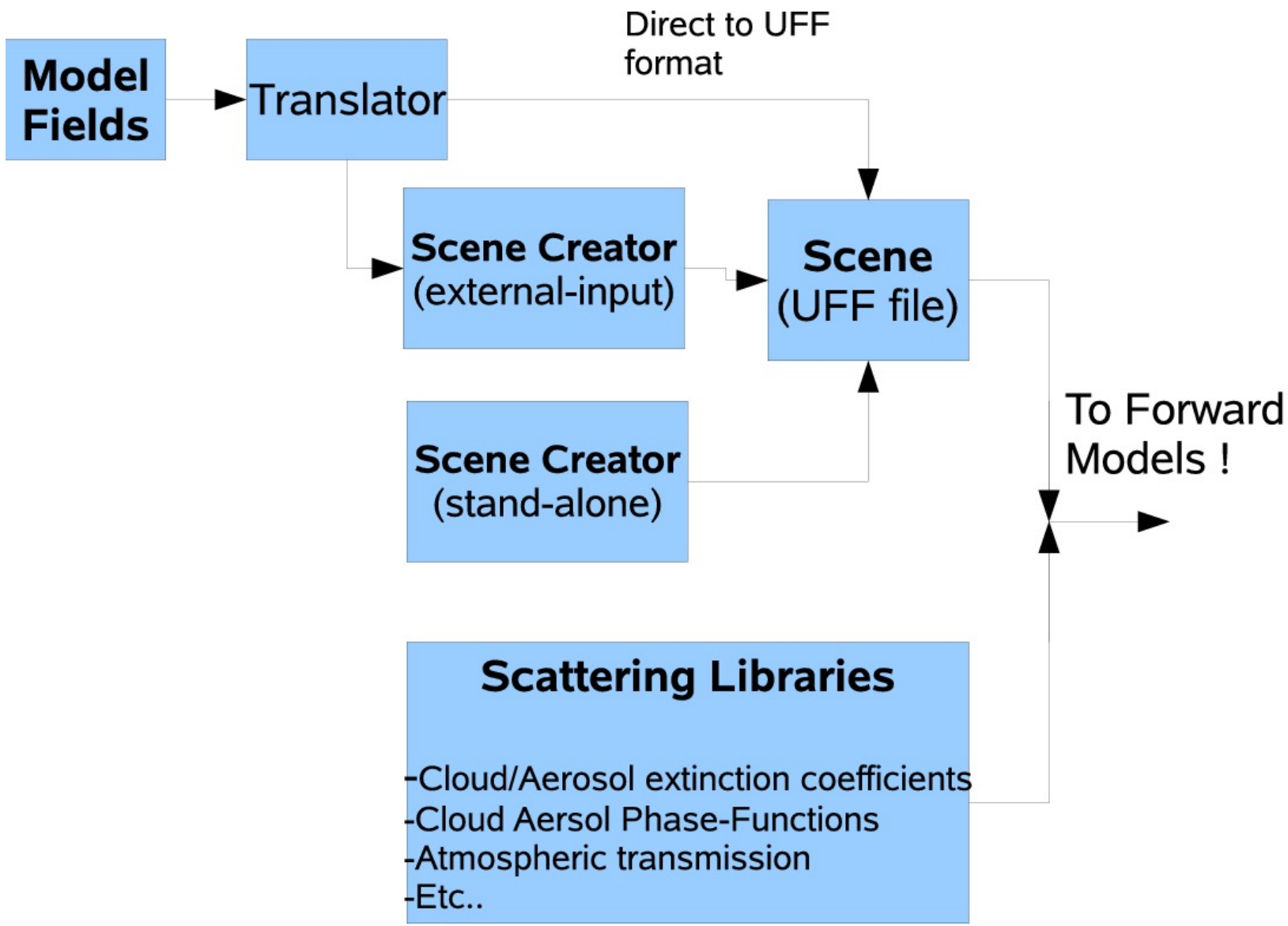
With measured backscatter and extinction profiles from ground one can calculate the attenuated backscatter from space!



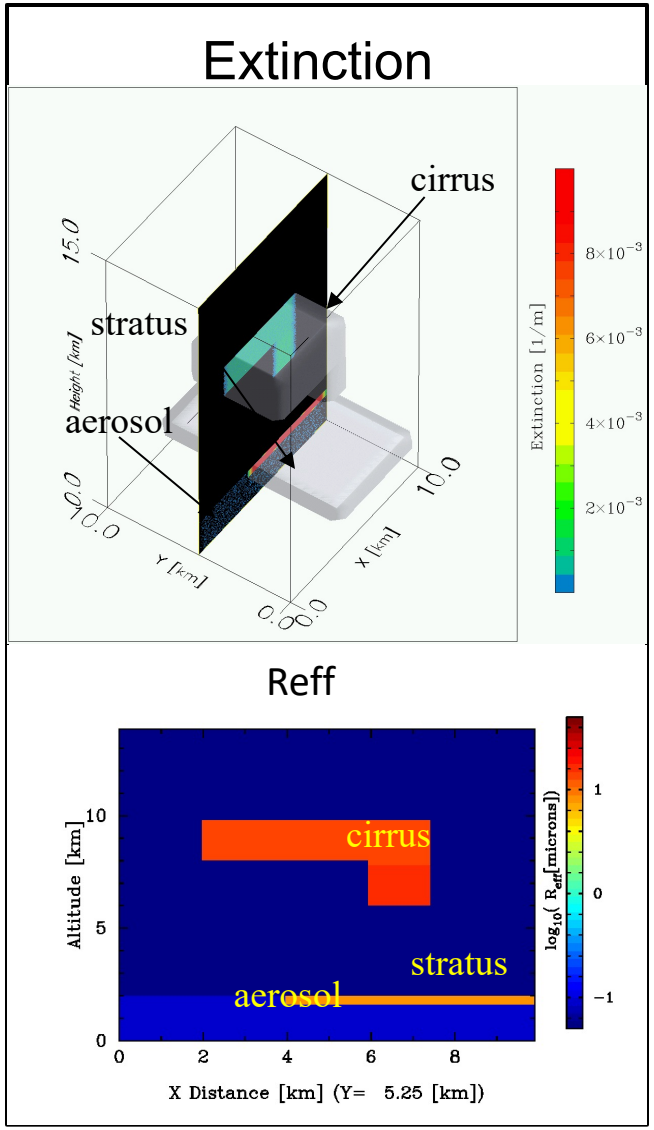
An example of a non-simple approach is the use of E3SIM



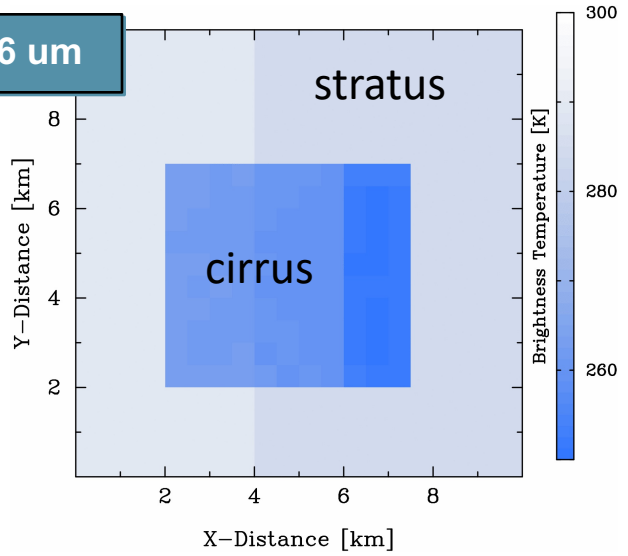
The simulator can ingest varied data steams in a consistent manner



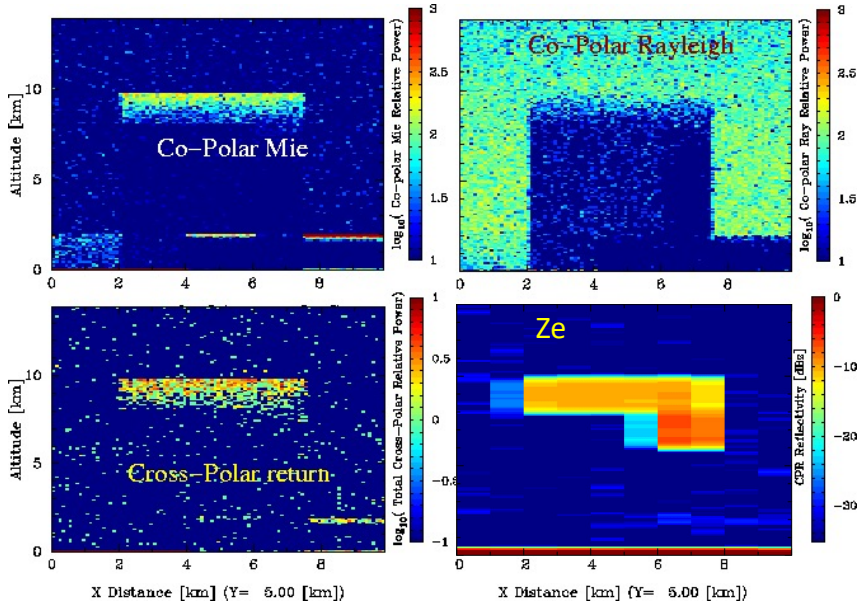
Mission Performance
EarthCARE Simulator - Example atmospheric scene



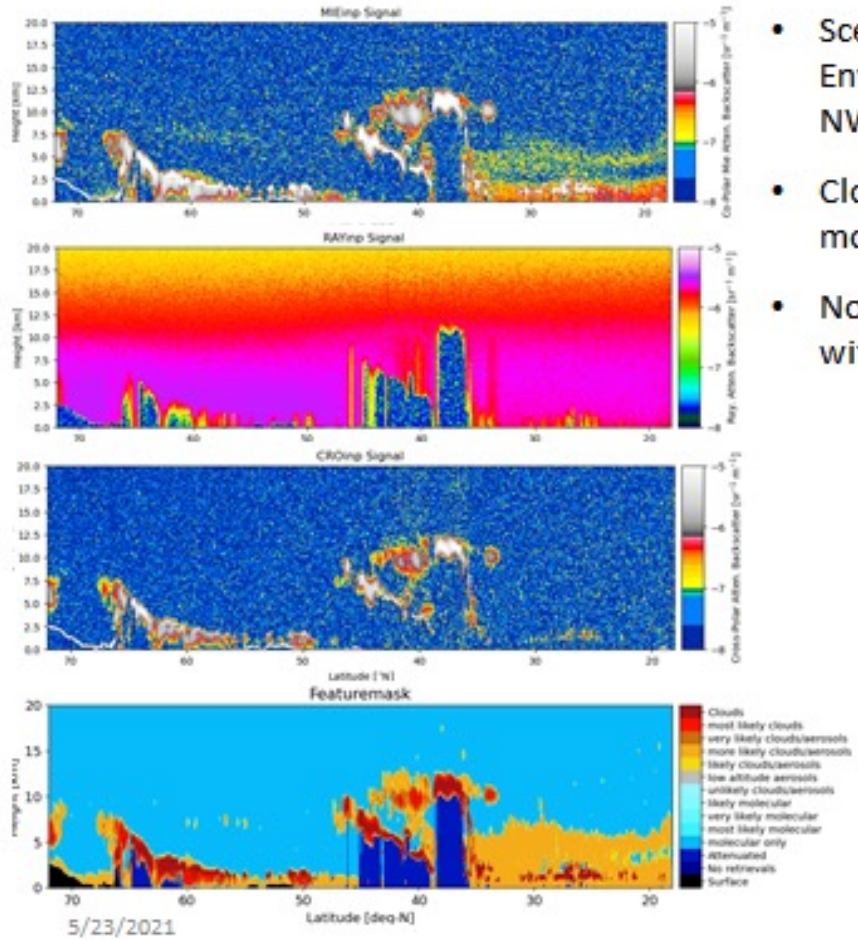
MSI 8.6 um



Lidar + Radar

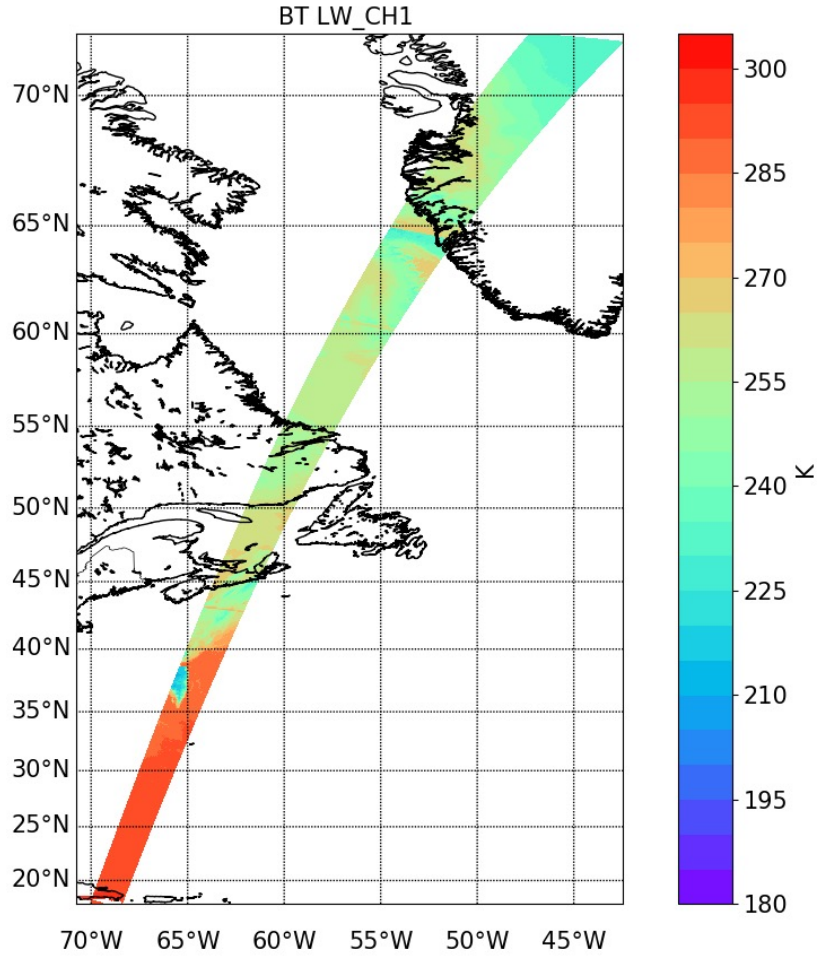


Some Examples based on simulated scenes



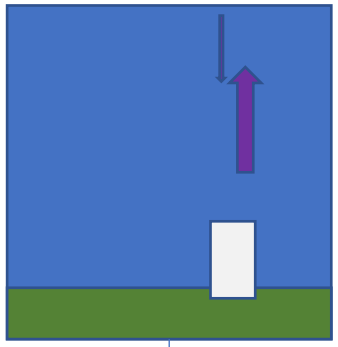
- Scenes have been built using ECSIM using Environment Canada's high-res global NWP model run at 0.25 km hor. res.
- Clouds/precip. are handled by a two-mode bulk scheme (Milbrandt-Yau)
- No Aerosols in provided fields ➔ Merge with ECMWF CAMS fields.

Figure 2: the swath of the high resolution simulation with 0.25 km grid-spacing and the seven section of the separated simulation.



So the E3SIM route would look like..

(A concrete example will be given in G-J's talk)



Retrieval of beta,alpha, depol

Aux data

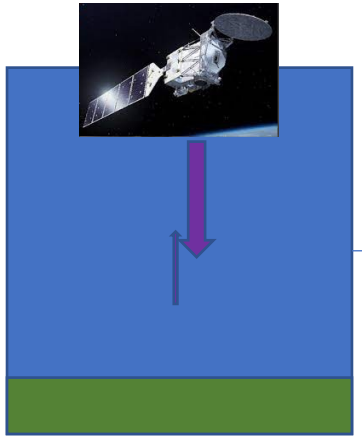
(3D) field of Scattering-type and Size Distribution parameters !

E3SIM UFF file

Check ?

Apply ECSIM RT code(s) in terrestrial mode

Apply Ground-based lidar instrument model



L1 Validation + Radiometric assessment

Possible iterations with different instrument model settings/adjustments

Apply ECSIM RT code(s) in satellite mode

Apply ATLID instrument model

How Could this work in practice ?

- Simple simulation approach:
  - Each group could do its own thing (and maybe this is well enough !).
- E3SIM(-like) approach.
  - KNMI (maybe in cooperation with established partners) will most-likely use ECSIM in a few selected cases but we would not be able to offer a ``general service'' to the community.
  - Maybe resources can be found to assembling an e.g. virtual machine with an example that people could then follow ?
    - Making things ``plug and play'' would be **very difficult !**
    - There would have to be enough demand to go this route…and...(arguably under-resourced) **earlier efforts by ESA to do similar things with ECSIM met with little success.**

Conclusions

- Simulation (loosely defined) will play an important role in ATLID L1 validations !
- Hopefully, simple approaches will be sufficient !
- If not, more sophisticated approaches are possible..
  - The E3SIM(and like) approaches are potentially powerful !
  - At the same time E3SIM is far from a Plug-and-Play tool (and likely, practically speaking, could never be made into one without significant resources and commitment) !