ICAROHS
using E3SIM for the creation of realistic scenes

This talk has been motivated by requests from people wanting to know if/how E3SIM could be used in support of ECARE Cal/Val.

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2nd ESA EarthCARE Validation Workshop

25-28 May 2021 (online)

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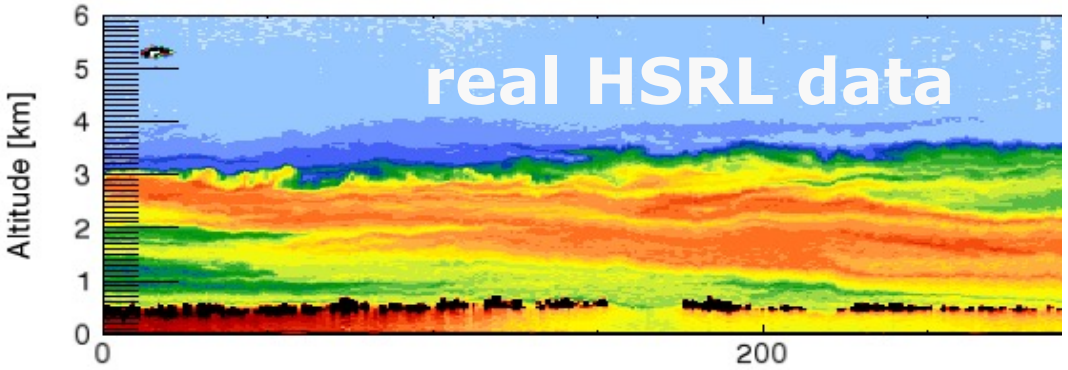
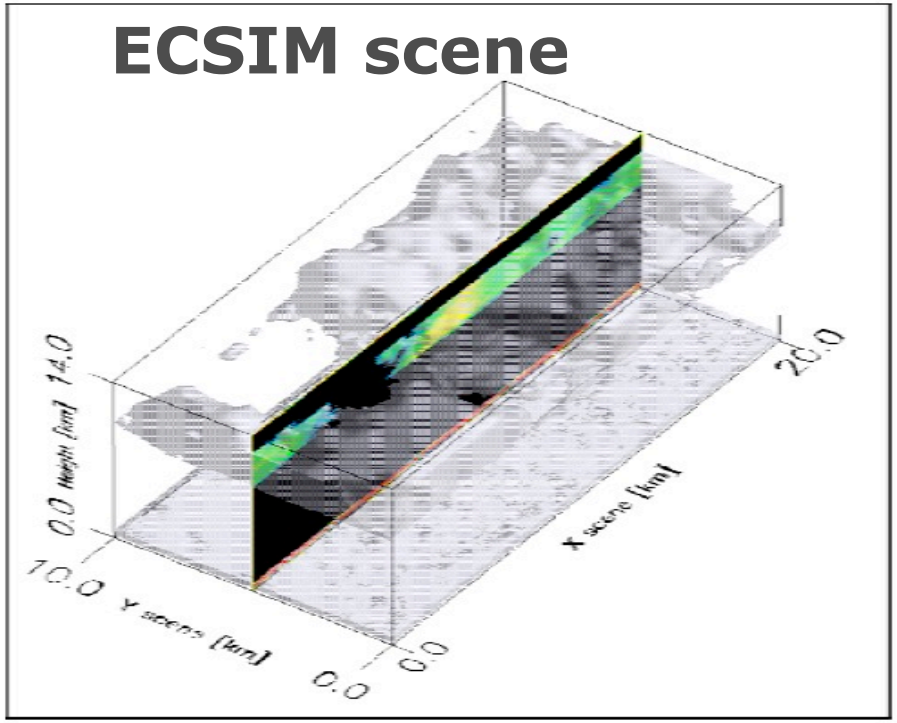
ICAROHS Project (2009-2011; Andreas Petzold)

- Provide recommendations for future single and multi-λ HSRL instruments which meet the accuracy requirements of current aerosol-climate interaction modeling.
- Within ICAROHS a prototype spaceborne multi-λ capable HSRL forward models was being developed within the EarthCARE Simulator
- For this realistic scenes were needed based on campaign data to ensure that realistic properties were forward modelled
- Realistic scenes can be used to perform:
  1. Evaluation of HSRL lidar (ATLID) L1 data
  2. Evaluation of retrieval algorithms
  3. Sensitivity studies using the forward simulations and satellite instrument (ATLID) modes
  4. Sensitivity studies determining retrieval uncertainties due to instrument parameters and atmospheric assumptions (etc.)
  5. The formulation of requirements for future airborne campaigns

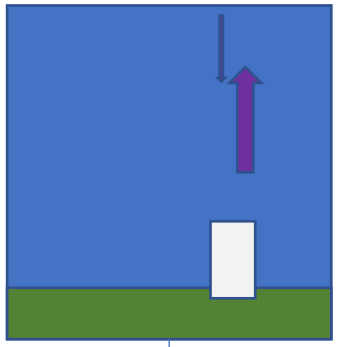
Scene Creation Approach

Define	Define field data sets (HSRL, aerosol in-situ) for instrument model validation.
Build	Build E3SIM scenes from field data; treat aircraft as low-flying satellite. One can also use a ground-based station.
Evaluate	Evaluate E3SIM output against the measured HSRL data; determine accuracy.
Assess	Assess E3SIM ATLID forward modelled signals





As a reminder:
the E3SIM route would look like..



Retrieval of beta,alpha, depol

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

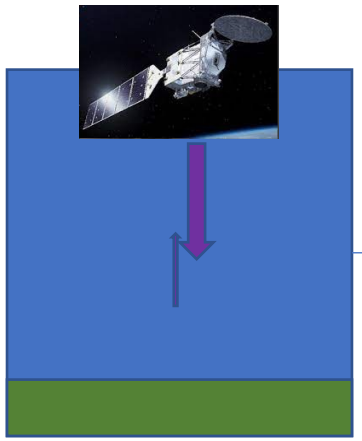
Aux data

E3SIM UFF file

Apply ECSIM RT code(s) in terrestrial mode

Apply Ground-based lidar instrument model

Check ?



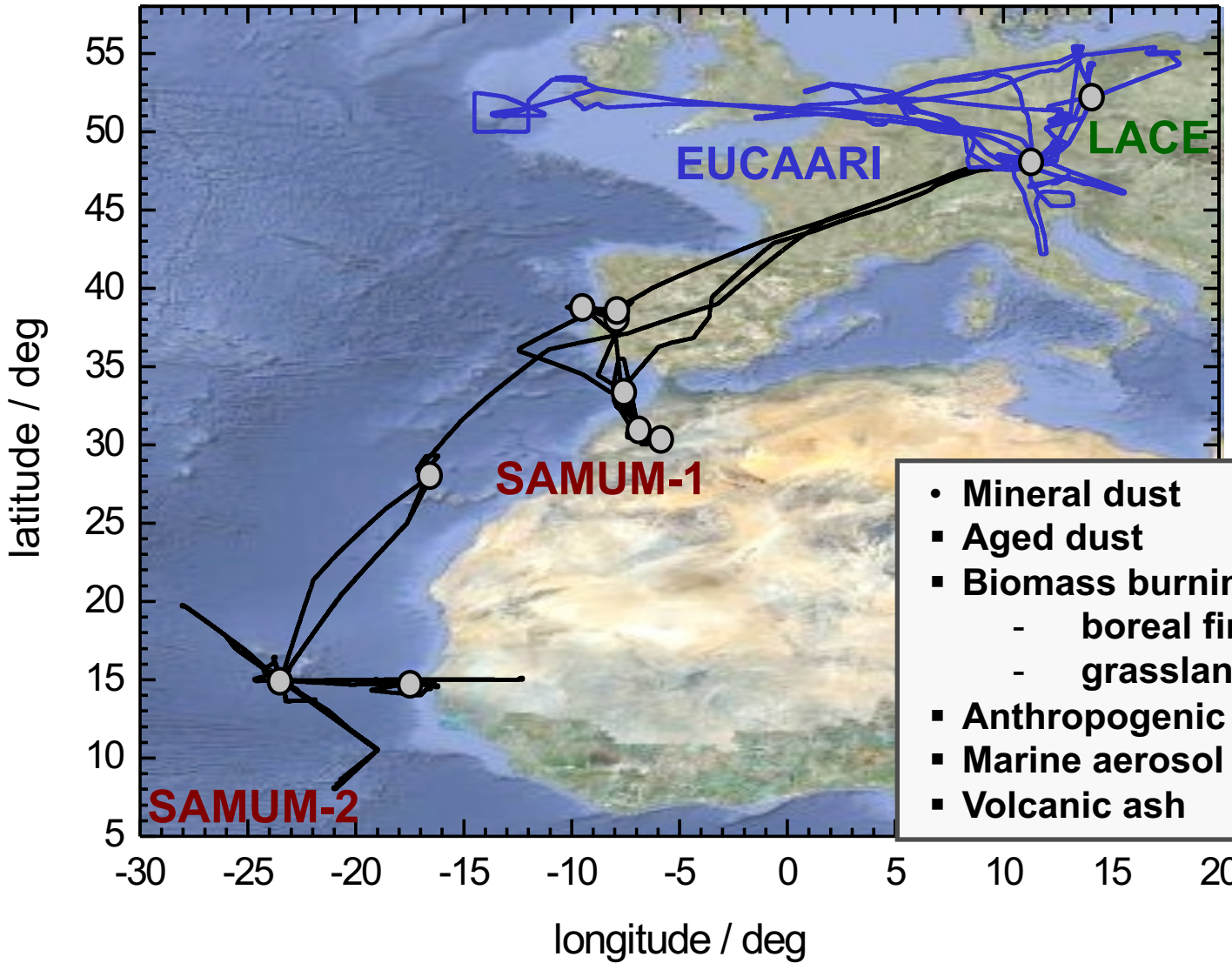
L1 Validation + Radiometric assessment

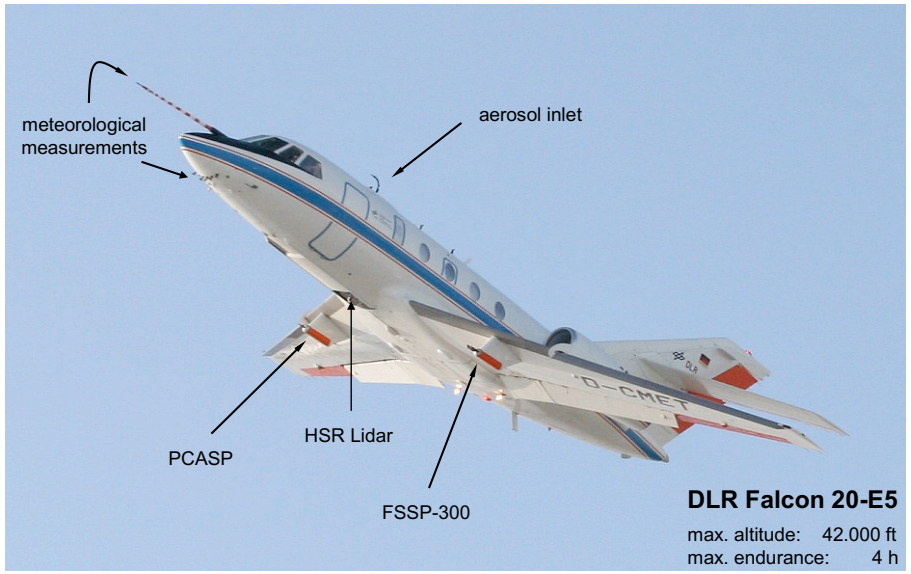
Possible iterations with different instrument model settings/adjustments

Apply ECSIM RT code(s) in satellite mode

Apply ATLID instrument model

Field data base used within ICAROHS





- **Mineral dust**
- **Aged dust**
- **Biomass burning aerosol**
  - **boreal fires**
  - **grassland fires**
- **Anthropogenic pollution**
- **Marine aerosol**
- **Volcanic ash**

Particle size spectrum
Aerosol absorption
Mixing state

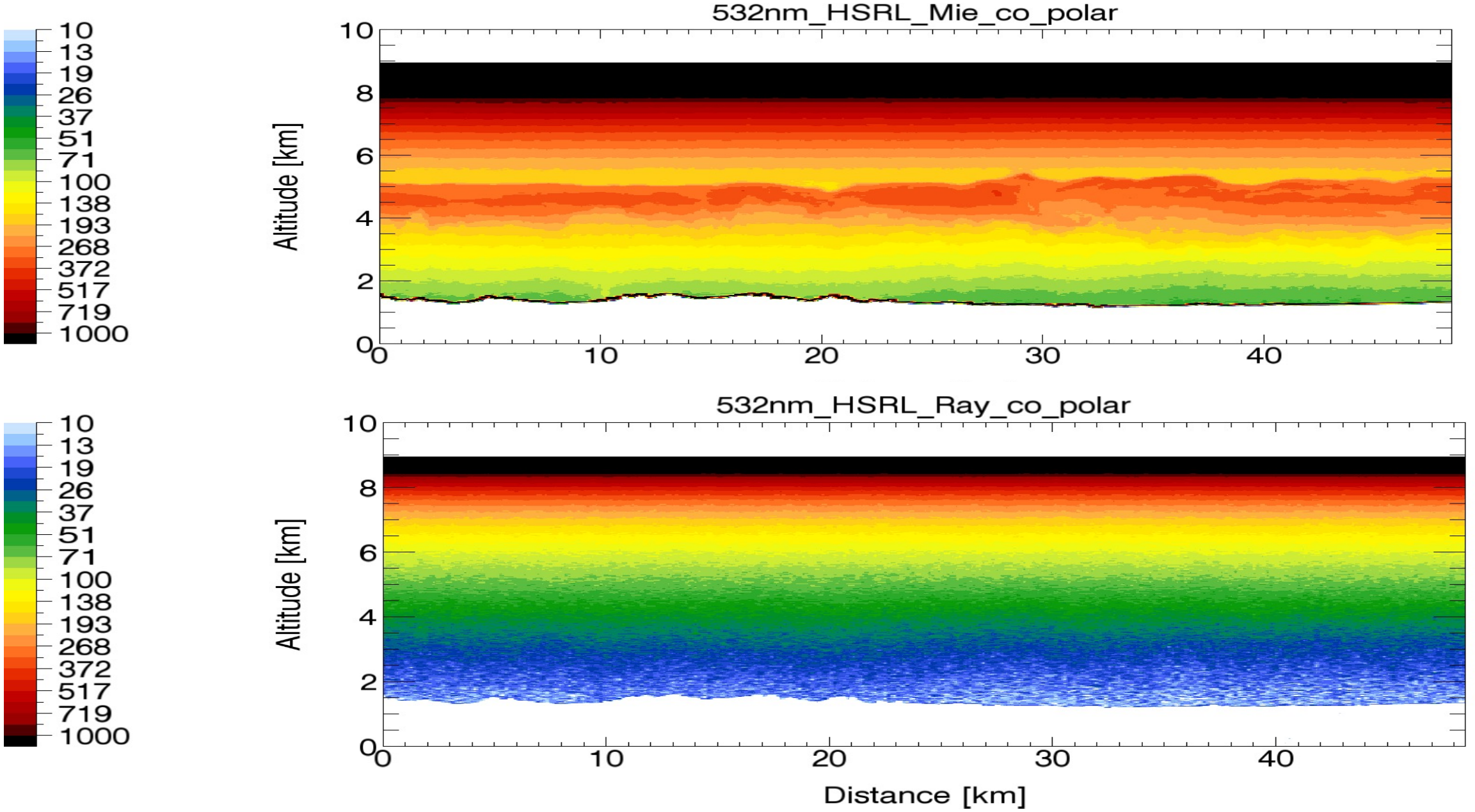
Backscatter	**@532, 1064**
Extinction, lidar ratio	**@532**
Depolarisation ratio	**@532, 1064**

E3SIM scene creation input requirements

1. **Extinction for every aerosol or cloud point**
   → **Extinction from Rayleigh channel and Backscatter Ratio**
2. **Aerosol (cloud) particle size distribution, morphology, and phase**
   → **In-situ measured PSD & mask**
3. **Cloud, aerosol, molecular mask**
   → **Mask using Depolarization and lidar Ratio**
4. **Atmospheric conditions (T, P, RH, gases):**
   → **Radiosondes/ECMWF/in-situ**
5. **Instrument lidar (freq, fov etc) & flight information (height, speed etc.)**
   → **Flight Info**

SAMUM 1
19-05-2006

HSRL measurements



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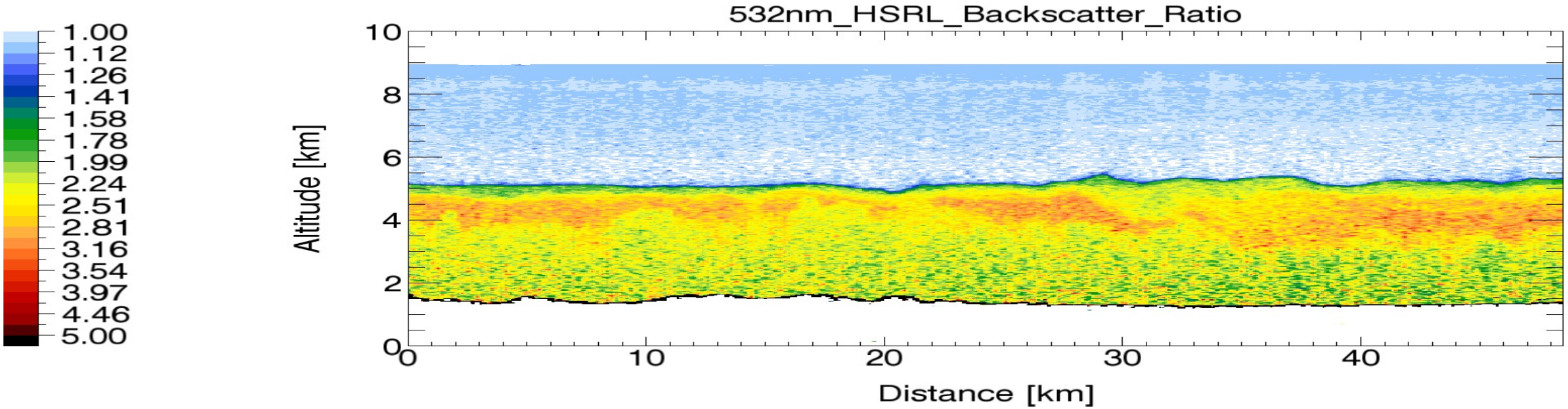
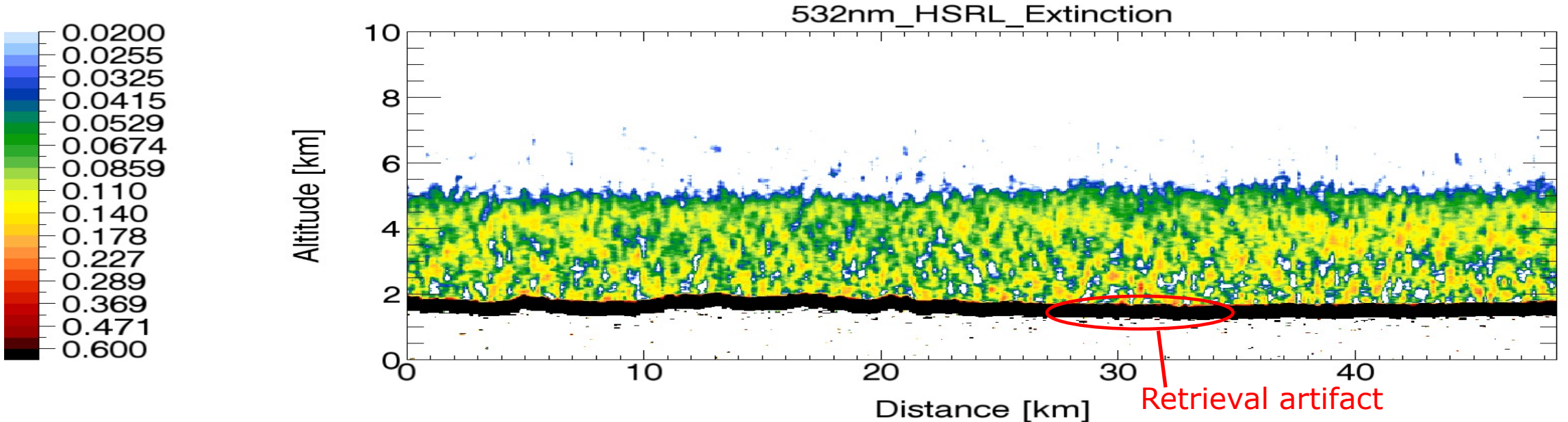
19-05-2006

HSRL measurements





For useful forward signals there is a need for higher resolution extinction and layer boundaries

→ Using backscatter ratio to update the retrieved Rayleigh based extinction

$$R = \frac{\beta_{mie} + \beta_{ray}}{\beta_{ray}} = \frac{P_{mie} + P_{ray}}{P_{ray}}$$

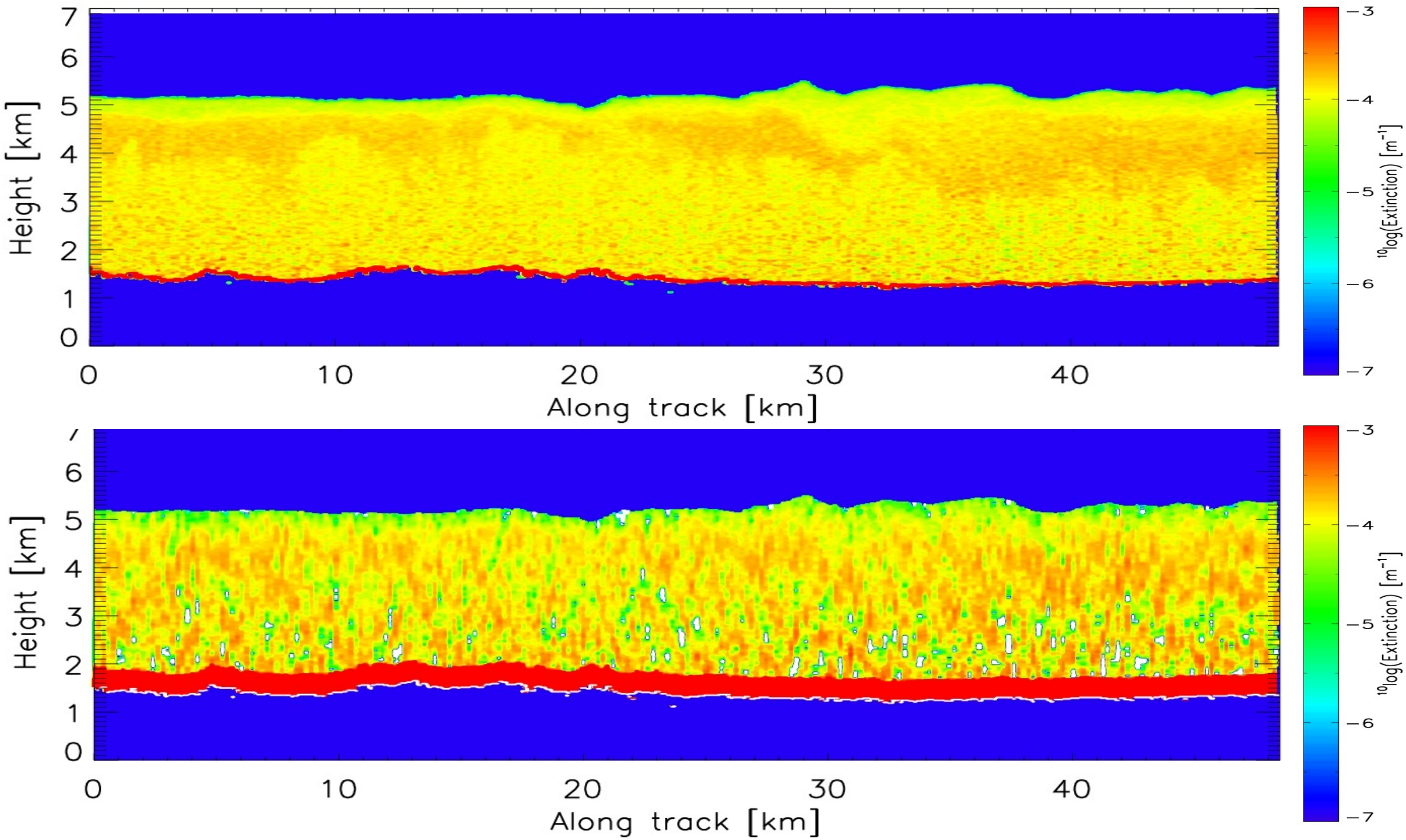
$$\alpha = \beta_{mie} \cdot S$$

$$\beta_{ray} = C_{air} \frac{P(z)}{T(z)}$$

$$\alpha = \beta_{mie} \cdot S = Cst \cdot (R-1) \cdot \frac{P(z)}{T(z)}$$

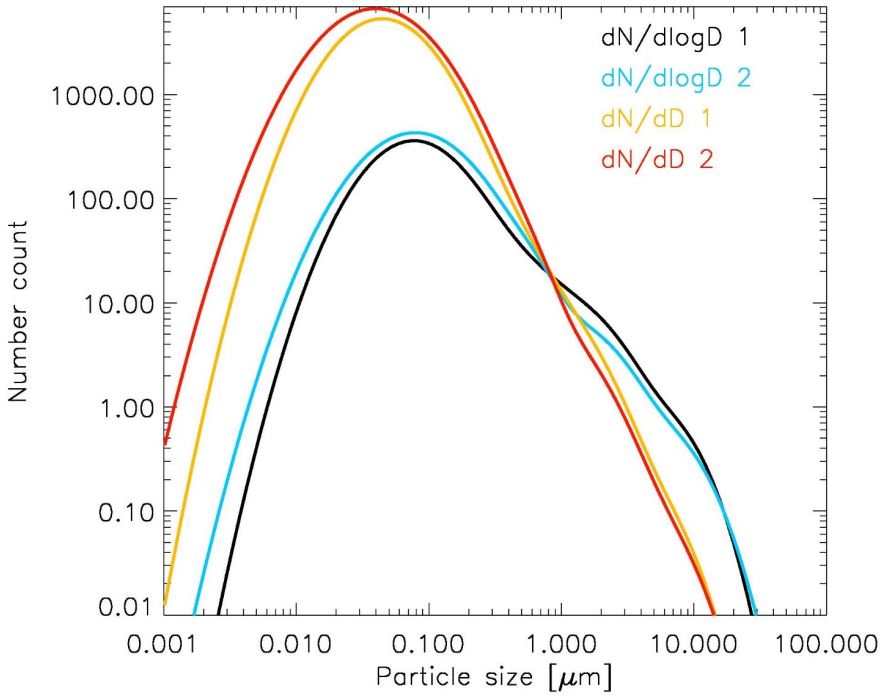
For regions which consists of the **same** aerosol type (masked using S and δ) and which have a **similar** PSD: S is roughly constant.

The mean lidar ratio for each aerosol region (S) is estimated by shifting the lidar ratio distribution to match the Rayleigh retrieved extinction peak.


Height [km]
0
1
2
3
4
5
6
7
0
10
20
30
40
Along track [km]
−3
−4
−5
−6
−7
10log(Extinction) [m-1]
Height [km]
0
1
2
3
4
5
6
7
0
10
20
30
40
Along track [km]
−3
−4
−5
−6
−7
10log(Extinction) [m-1]

Linking microphysics and extinction

- At each point the aerosol psd is scaled to match the local extinction
- Aerosol-molecular separation is masked using the β-ratio (aerosols: R>1.3)

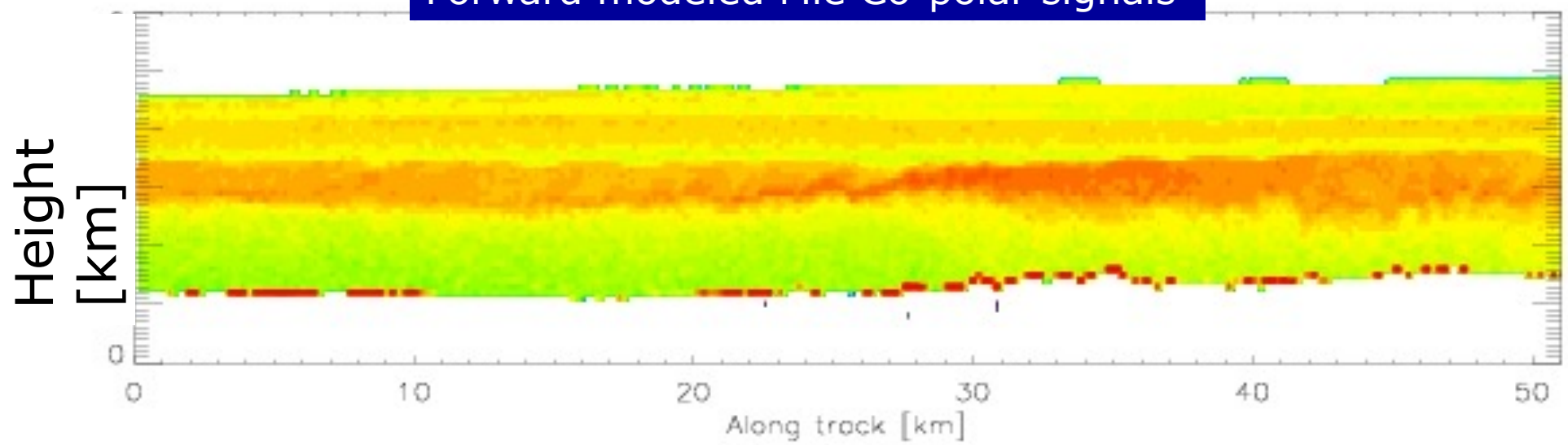


In-situ data measured by the DLR-Falcon

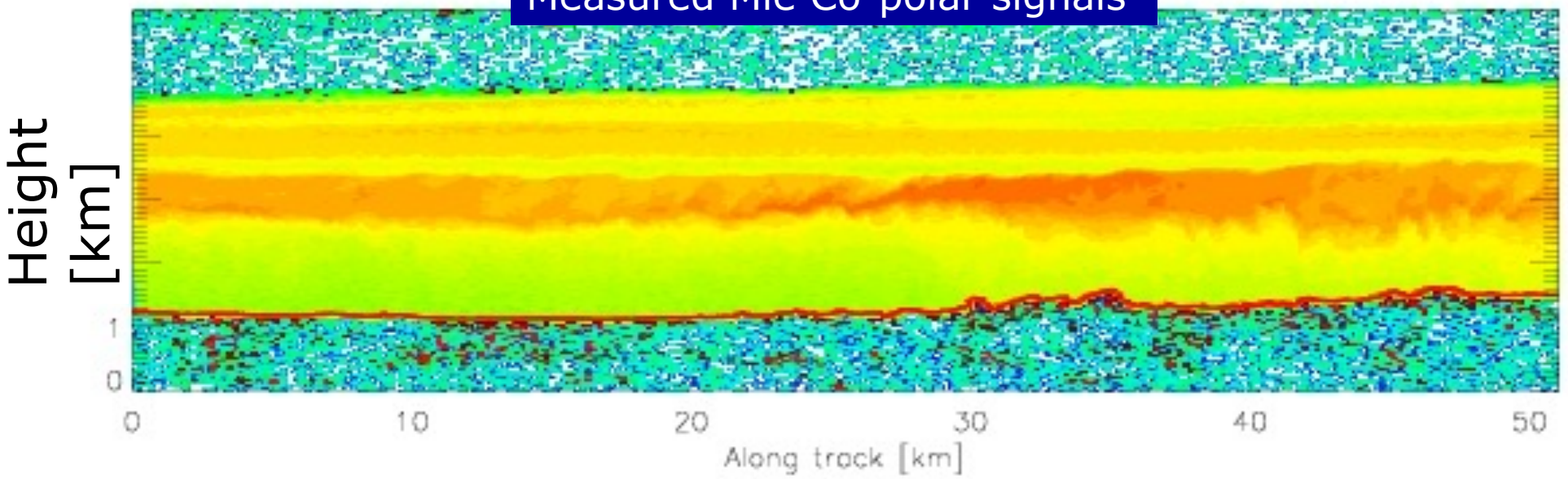
We used one PSD throughout the scene.

saharan dust layer - 4 june 2006

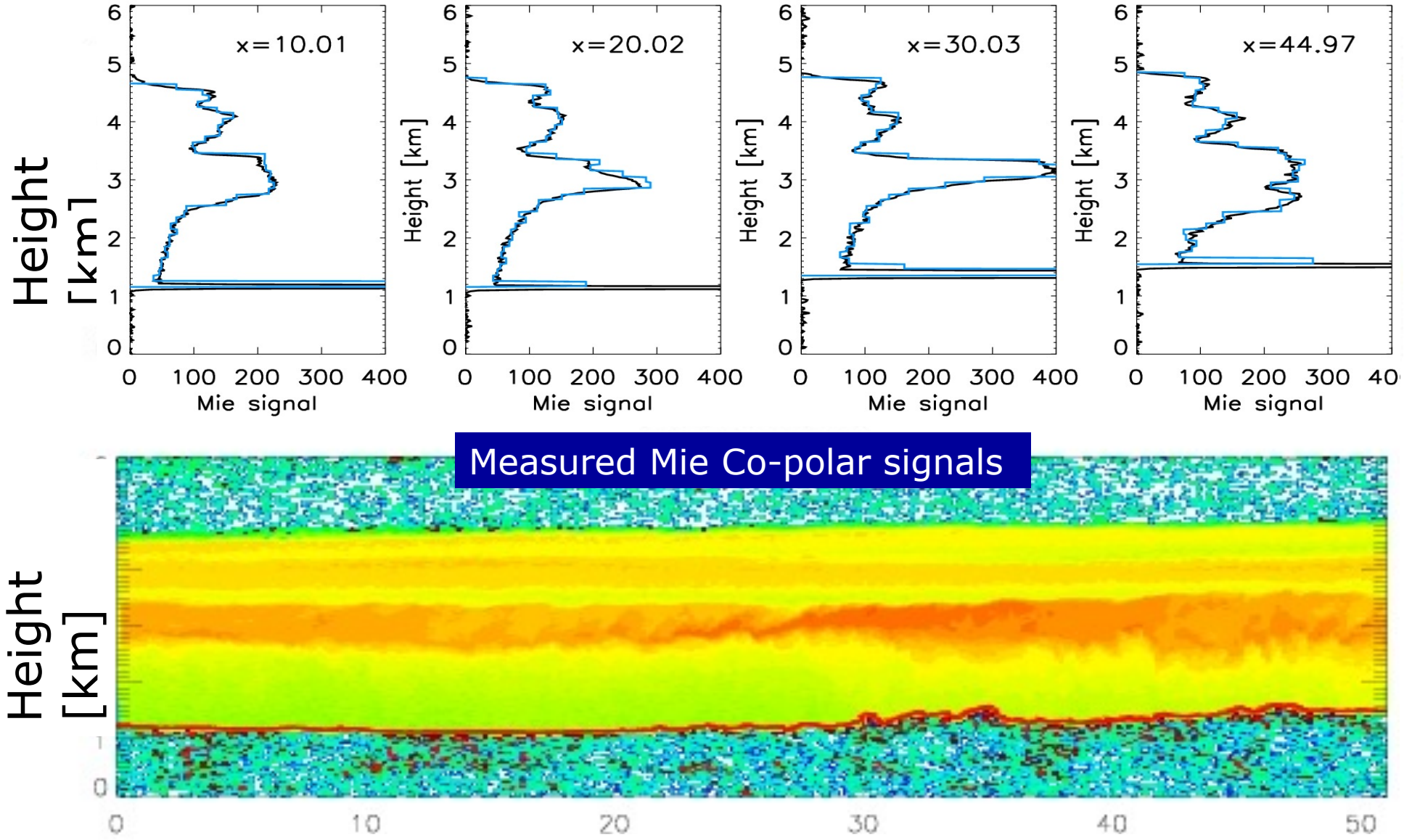
Forward modeled Mie Co-polar signals



Measured Mie Co-polar signals



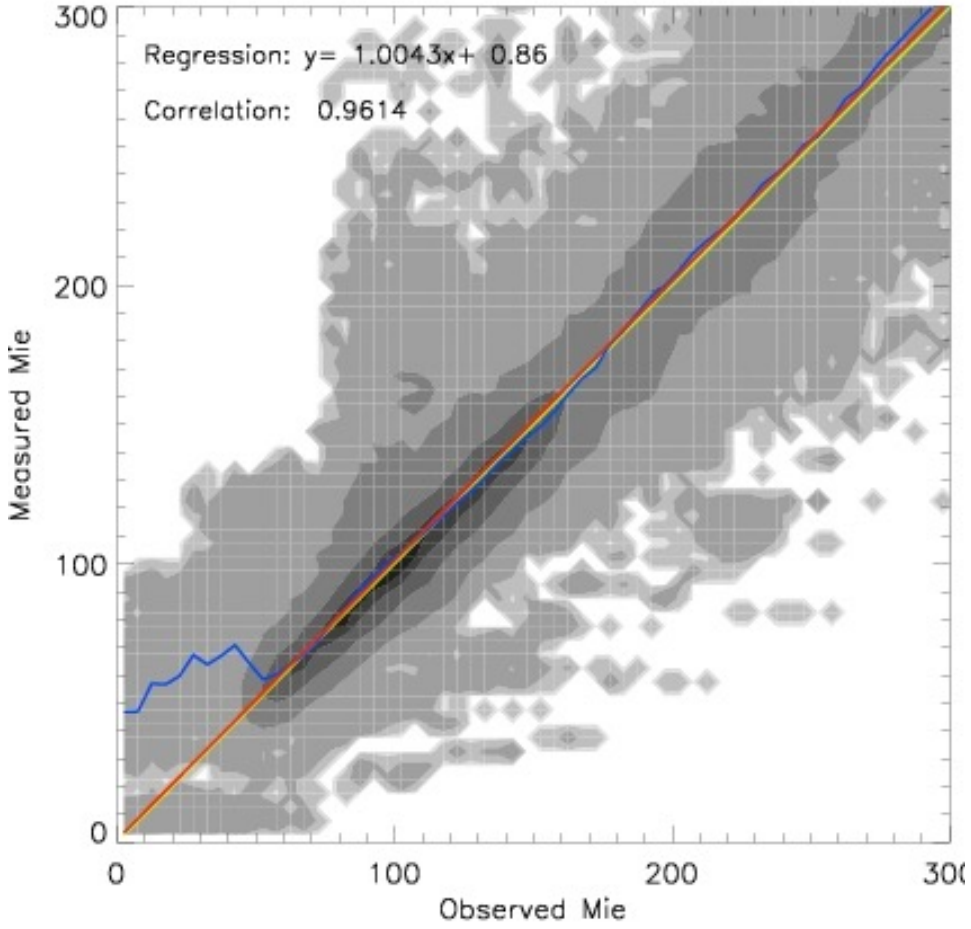
saharan dust layer - 4 june 2006



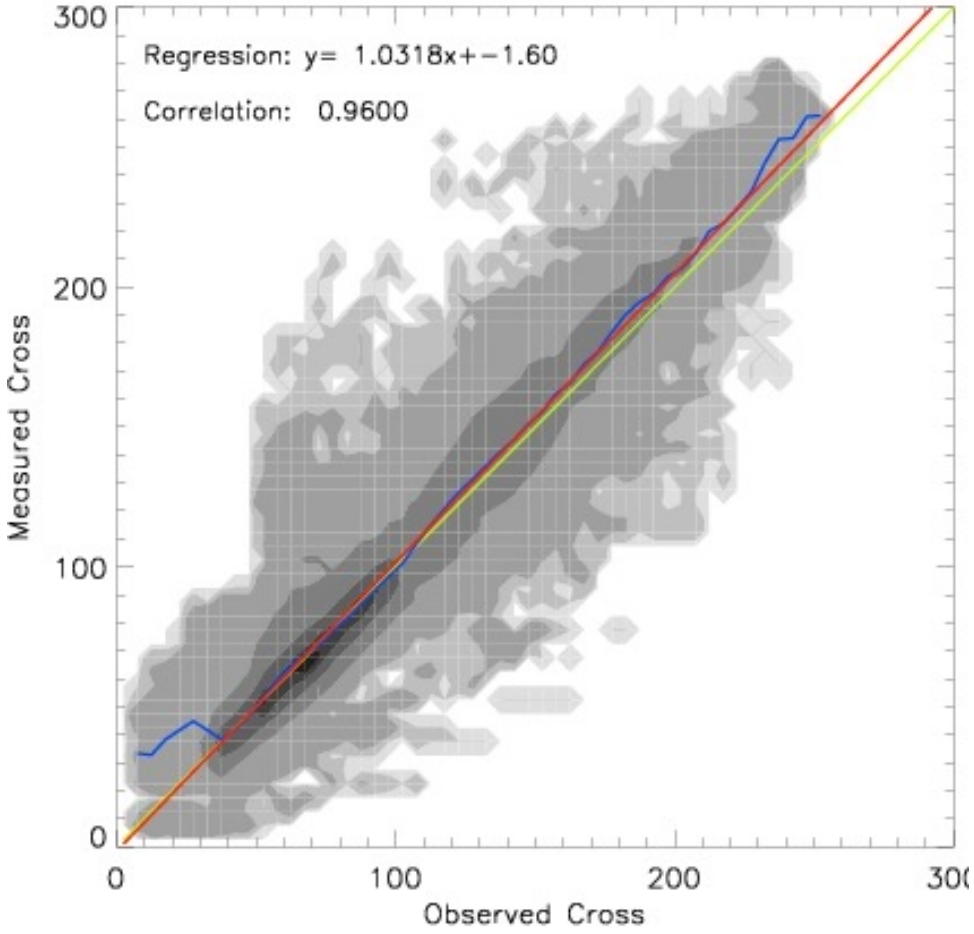
Mie co-polar signal (blue: calculated , black measured)

Statistical comparison of ECSIM forward modelled and measured signals

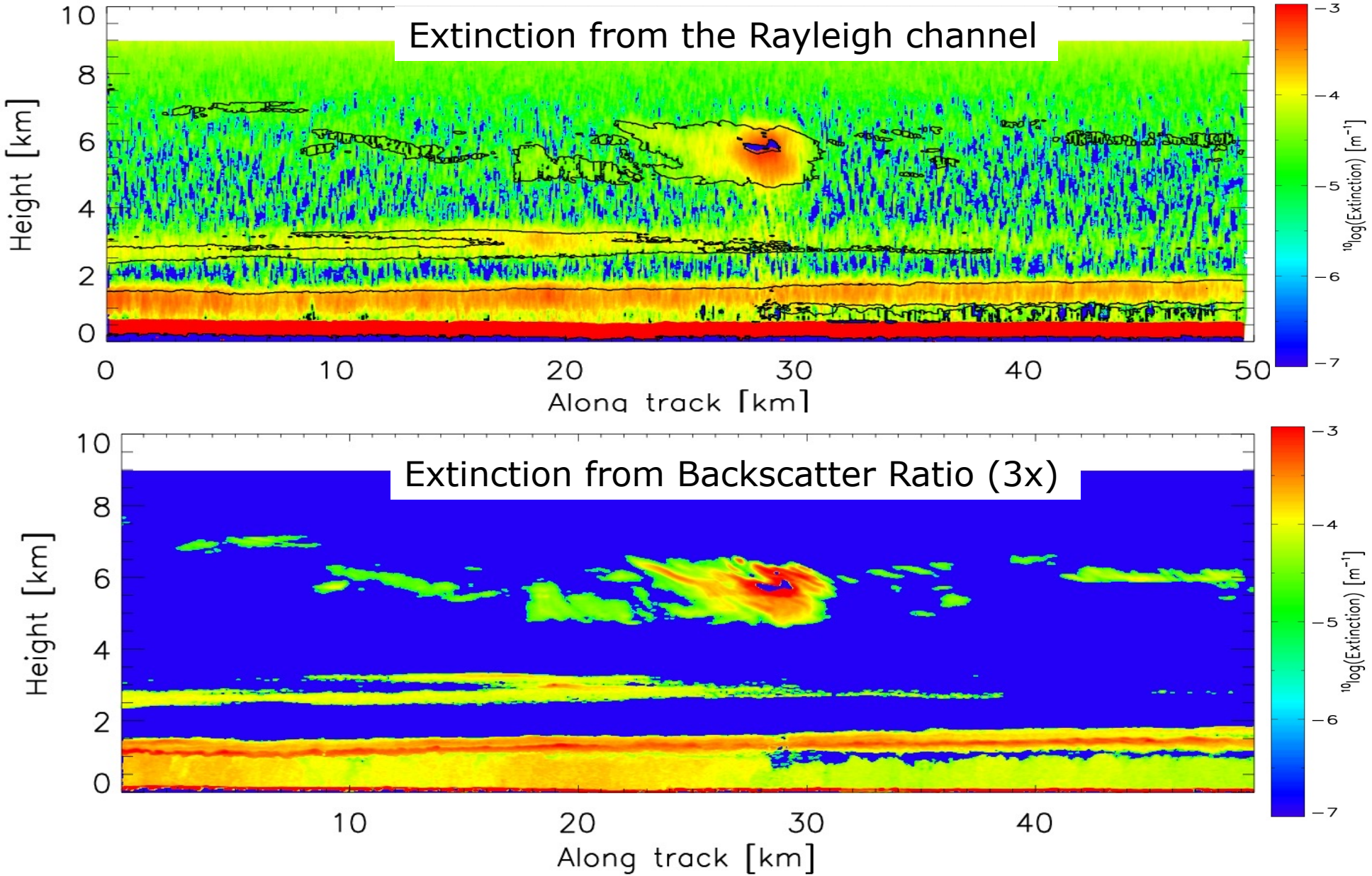
Co-polar Mie 04-06-2006



Cross-polar Mie 04-06-2006

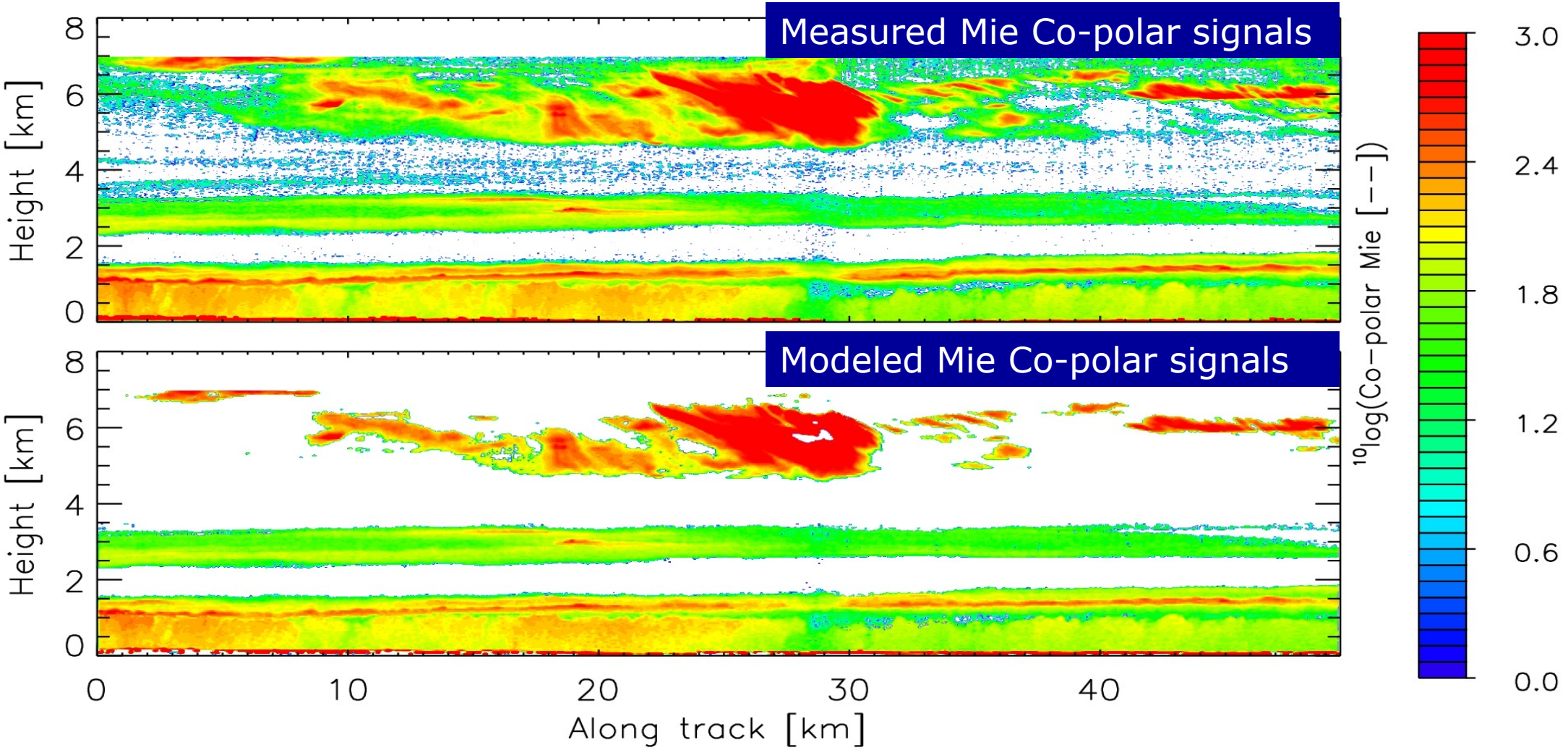


EUCAARI Example 13-05-2008



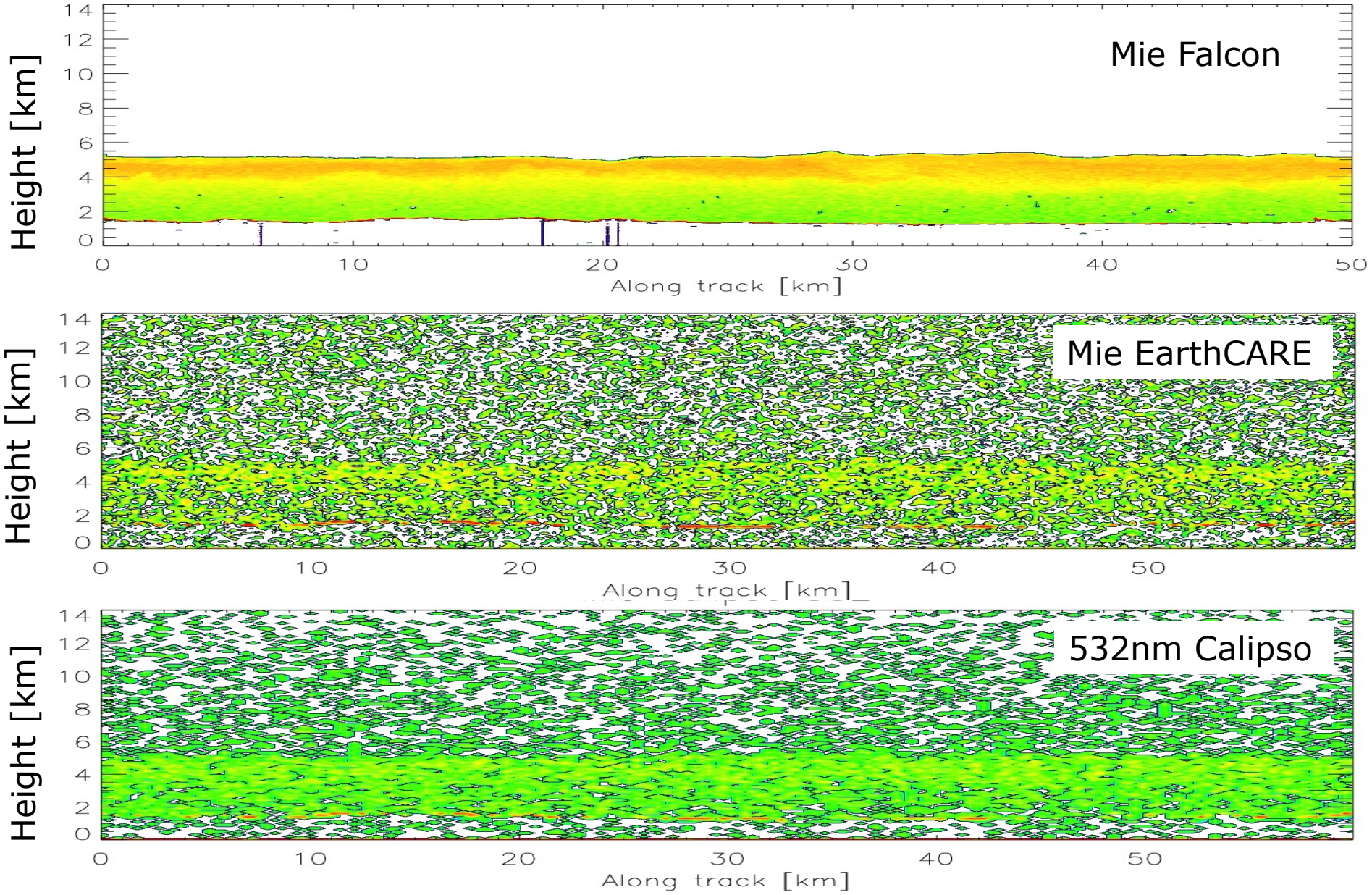
EUCAARI Validation

13-05-2008



Correlation	Aerosol Type	ECSIM scattering type
0.79 0.87 0.66	Industrial pollution Dust Ice	H2SO4-25% Spheroids Ice

Forward modeling signals for Satellite instruments



Conclusion

- Simulations (loosely defined) will play an important role in ATLID L1 validations.
- If simple approaches are not sufficient sophisticated approaches are possible.
  - The E3SIM(and like) approaches as shown is potentially powerful but very labor intensive!
  - It is not a direct validation!
  - Scenes can be defined and evaluated in detail using active instruments and in-situ observations.
  - This may enable the use of a 532nm HSRL data for evaluation of EarthCARE data
  - A single collocation (underflight) event can be extended for statistical analysis/error analysis/representativity by modeling the entire flight as if it was seen by EarthCARE.
  - 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) !