

Validation of EarthCARE L2a products using ground-based lidar measurements at Cabo Verde, Tajikistan and Germany in the framework of the German Initiative for the Validation of EarthCARE (GIVE)

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2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop

17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

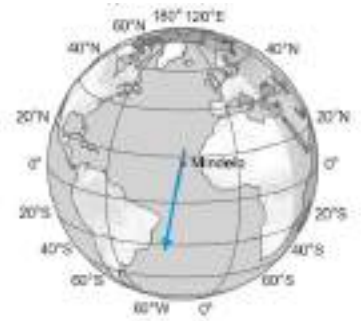
Outline

1. Overview of the ground-site at Mindelo

2. ATLID L2a Cal/Val results – Case studies for A-EBD
    1. based on L1 input baseline AC
    2. based on L1 input baseline AD

3. Summary & Outlook

1. Overview of the ground-site at Mindelo



Tropics, frames A (3:30 UTC) & E (16 UTC)



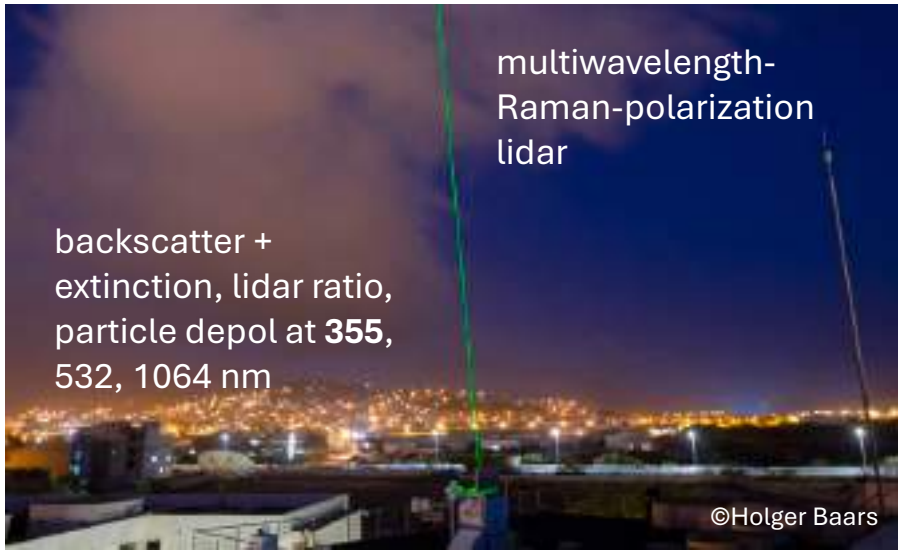


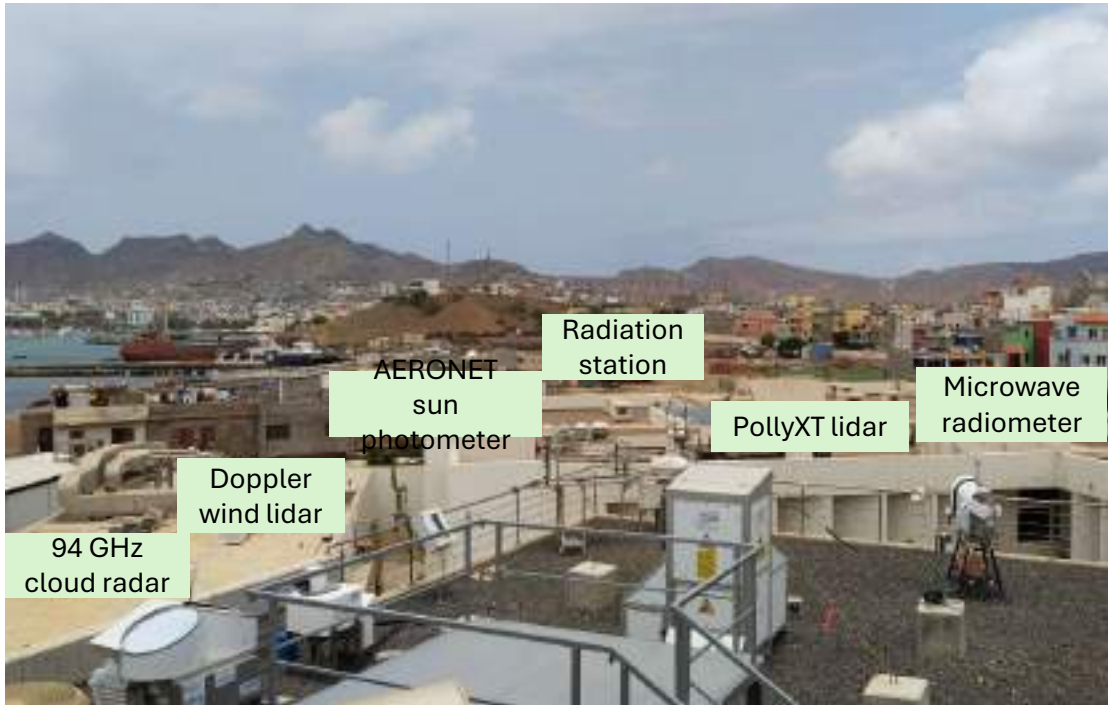
ACTRIS station at Ocean Science Center Mindelo (OSCM) since June 2021



CLARINET ORCESTRA

August – September 2024





Outline

1. Overview of the ground-site at Mindelo

2. ATLID L2a Cal/Val results – Case studies for A-EBD

   1. based on L1 input baseline AC

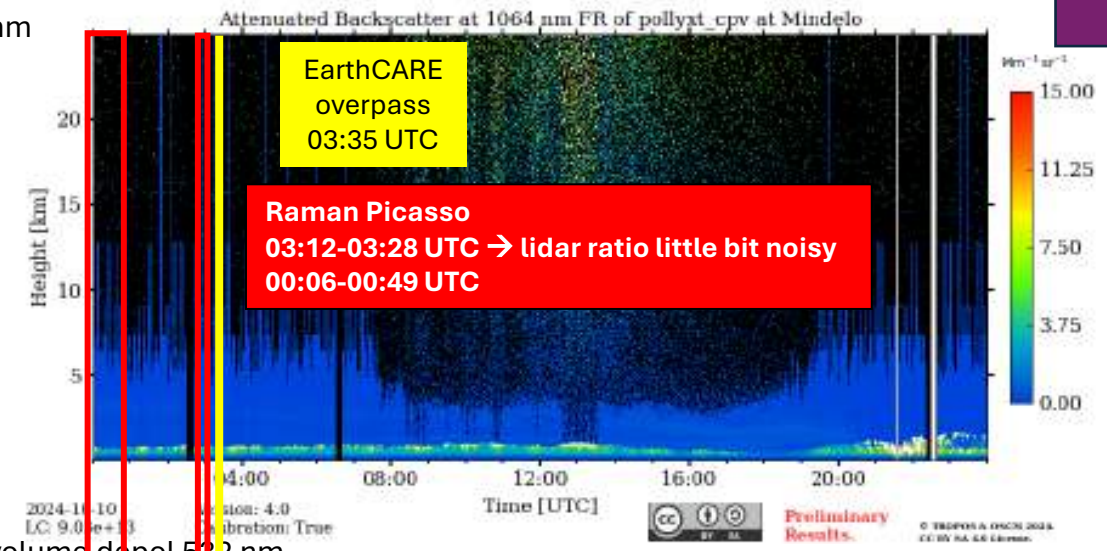
   2. based on L1 input baseline AD

3. Summary & Outlook

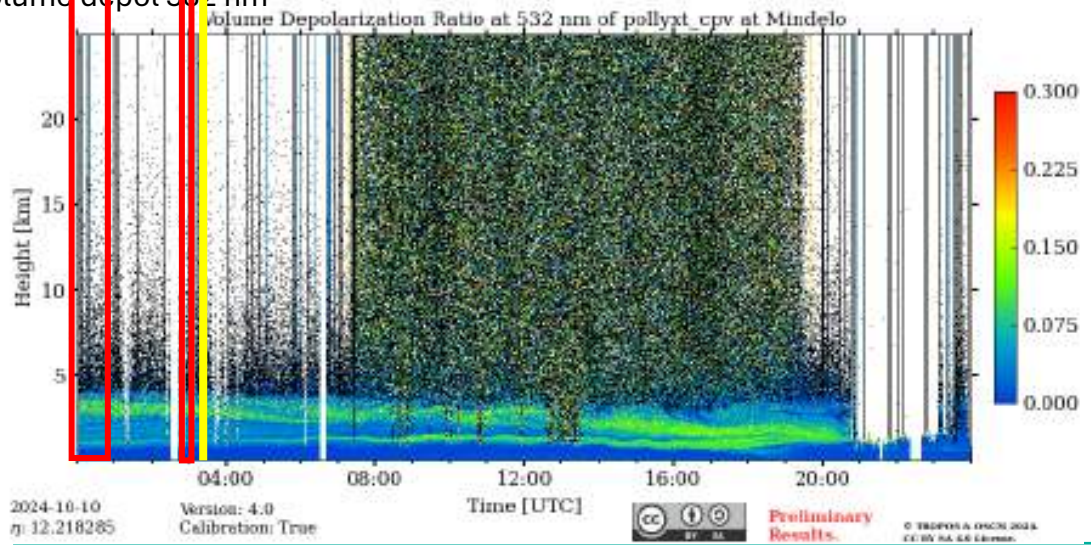
2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AC)

10 Oct 2024

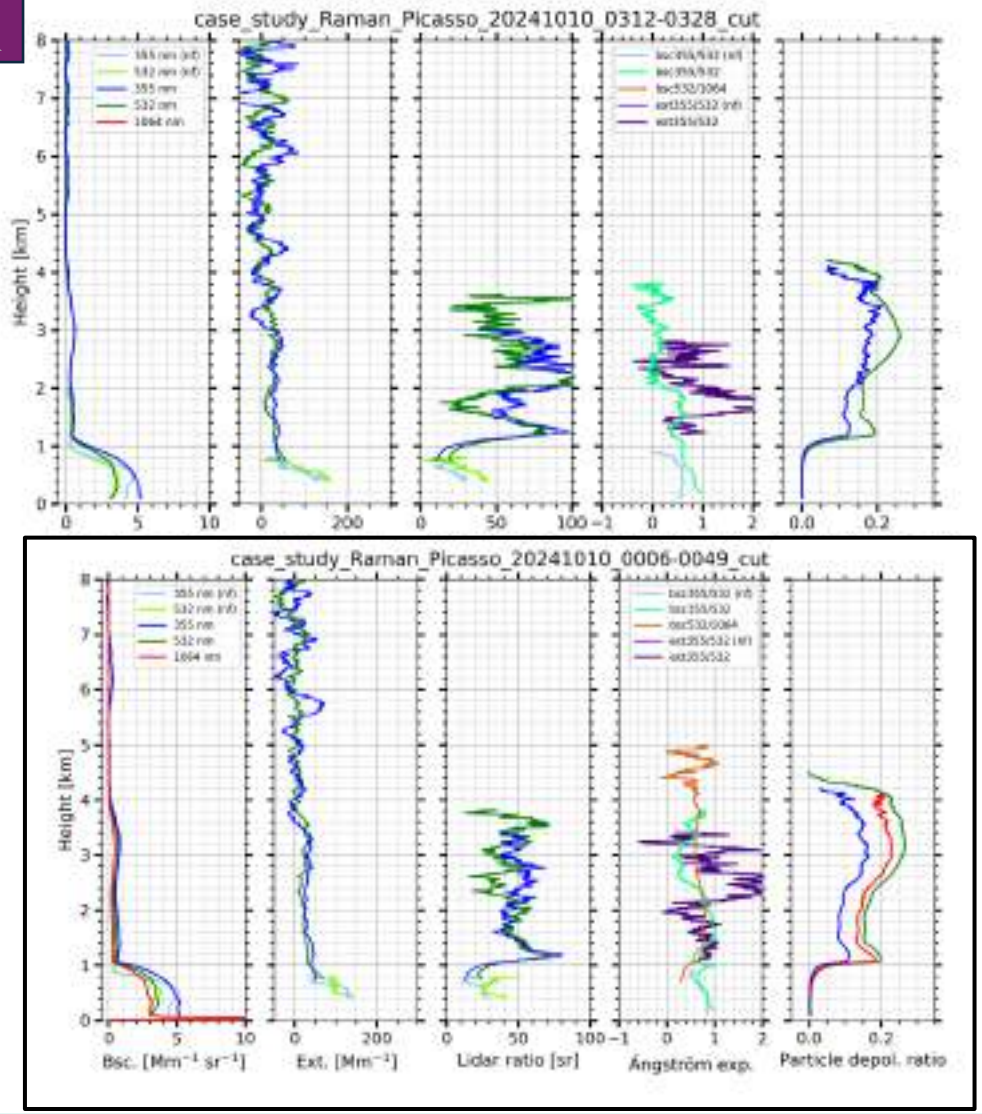
backscatter 1064 nm



volume depol 532 nm



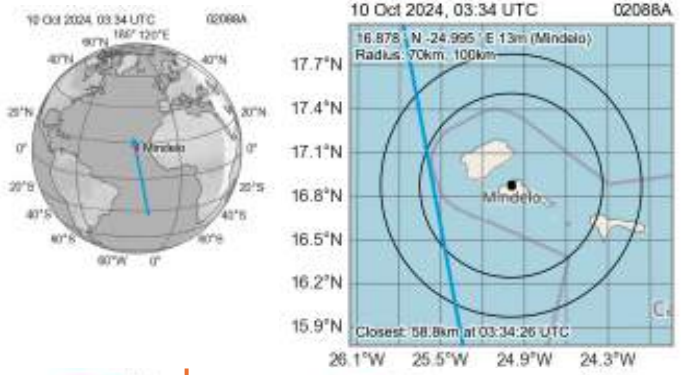
Polly^{XT}



2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AC)

10 Oct 2024

- For dust layer nice agreement layer boundaries, backscatter, extinctio



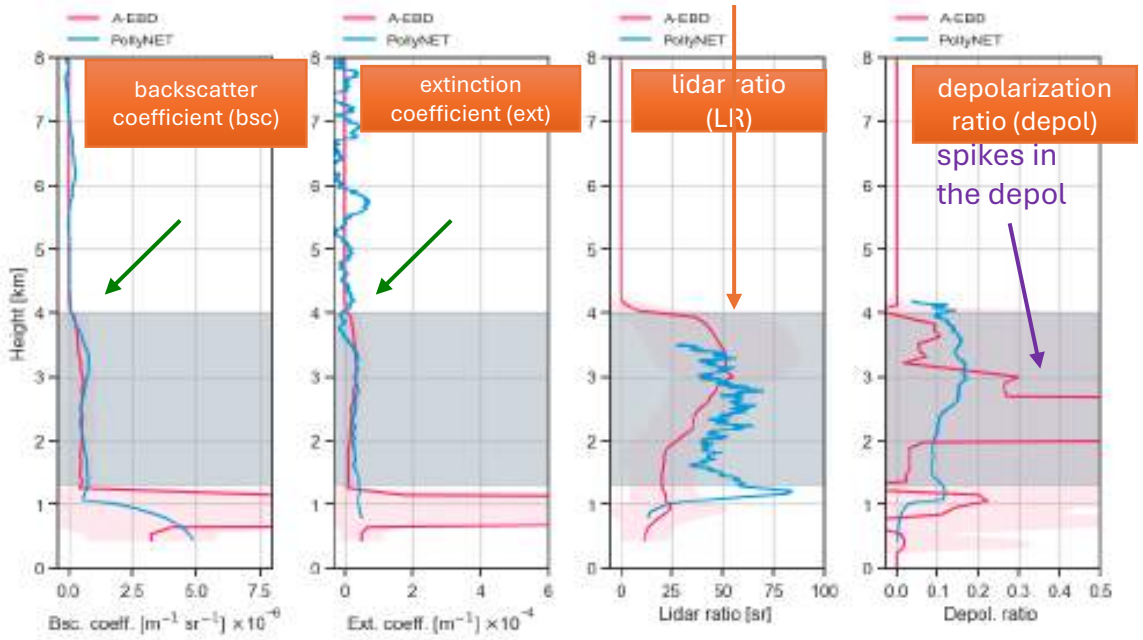
ATLID A-EBD

Baseline AC

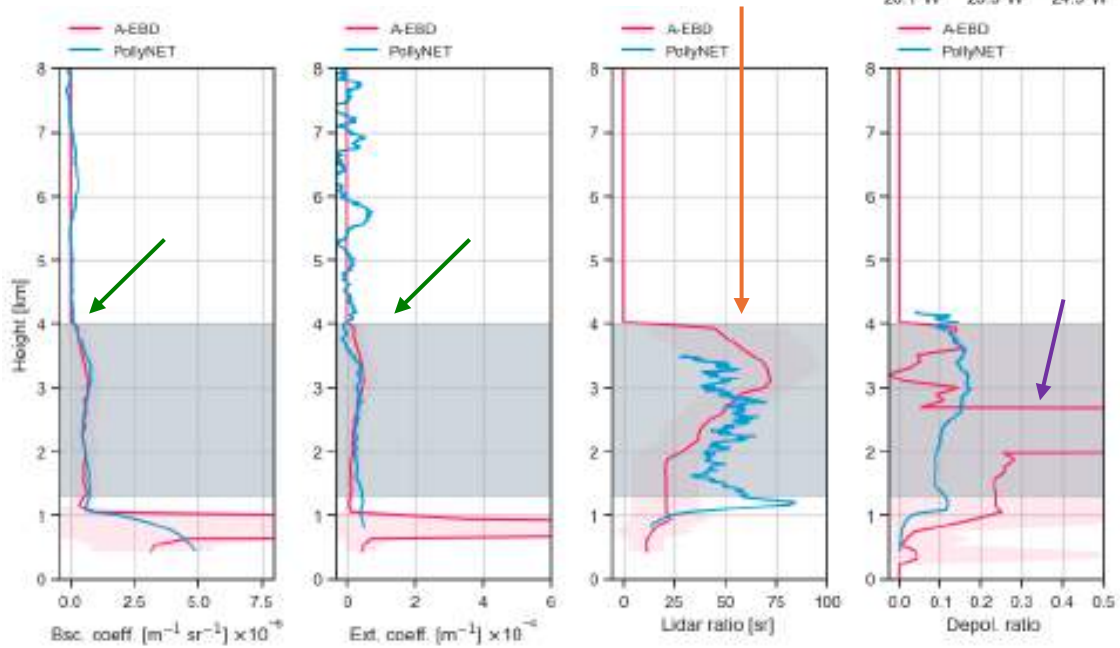
Frame 02088A

59 km distance

step in lidar ratio within dust layer: 25sr → 50-75sr



100 km along-track distance: 160 km



70 km along-track distance: 75 km

ATLID highest resolution averaged over radius around ground-site

2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AC)

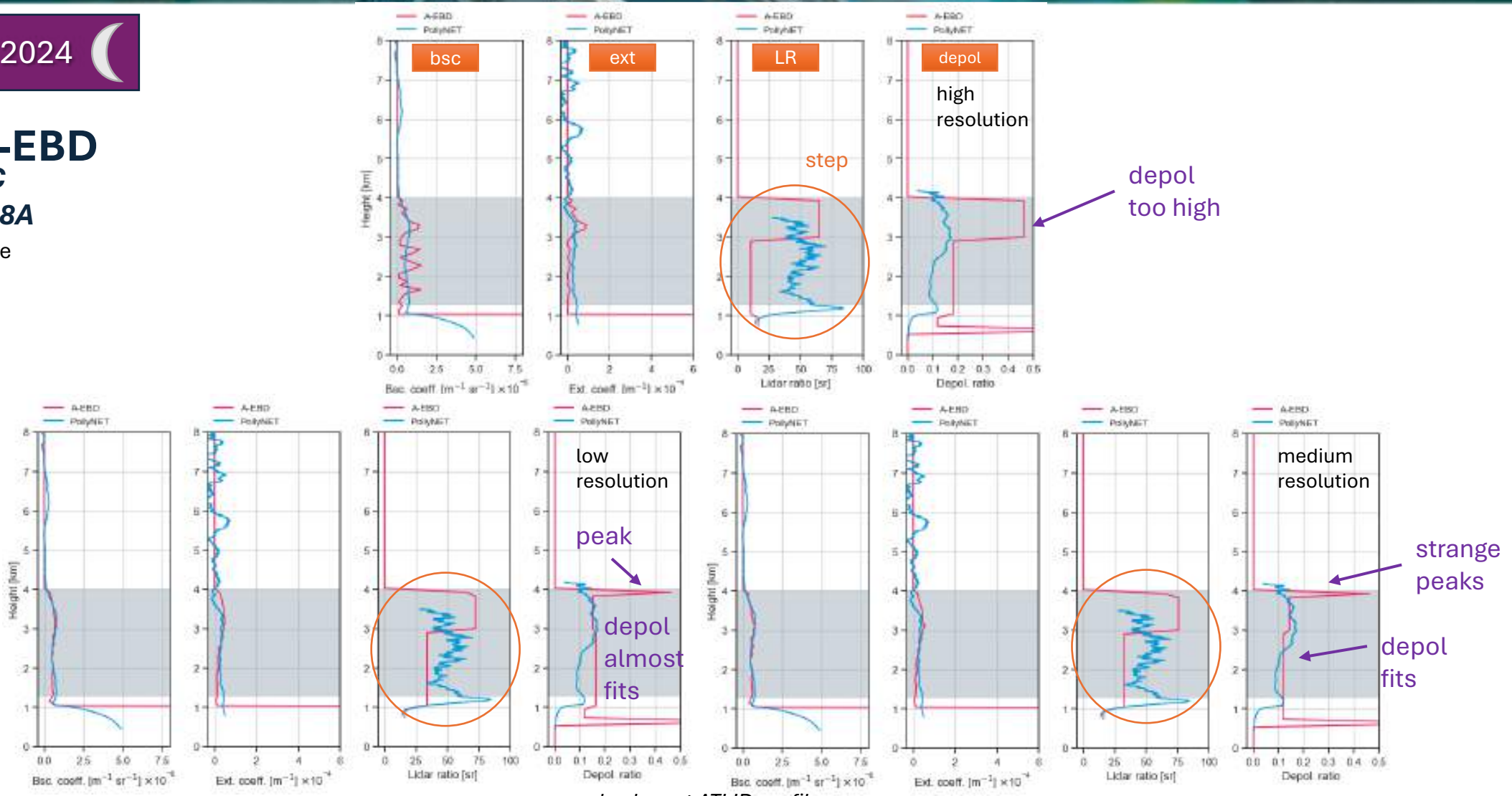
10 Oct 2024

ATLID A-EBD

Baseline AC

Frame 02088A

59 km distance

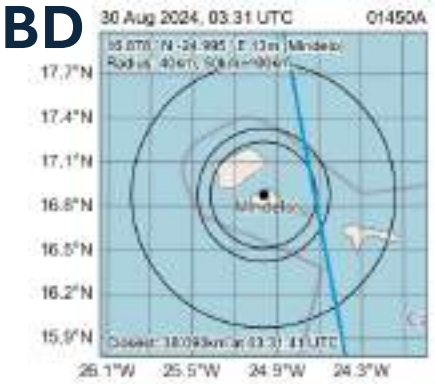


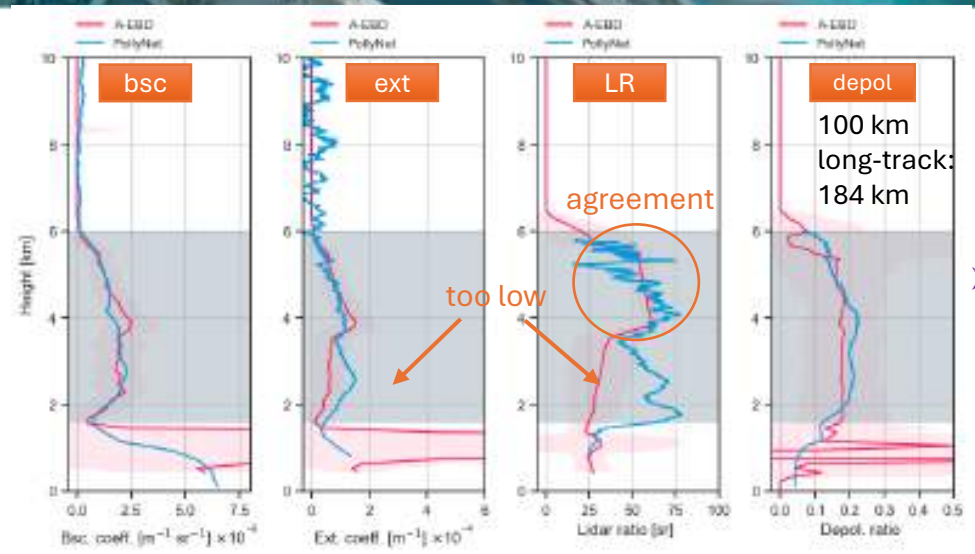
only closest ATLID profile

2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AC)

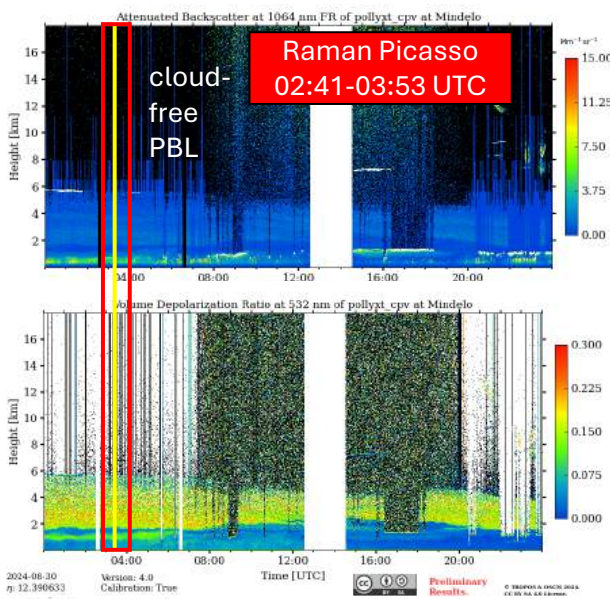
30 Aug 2024

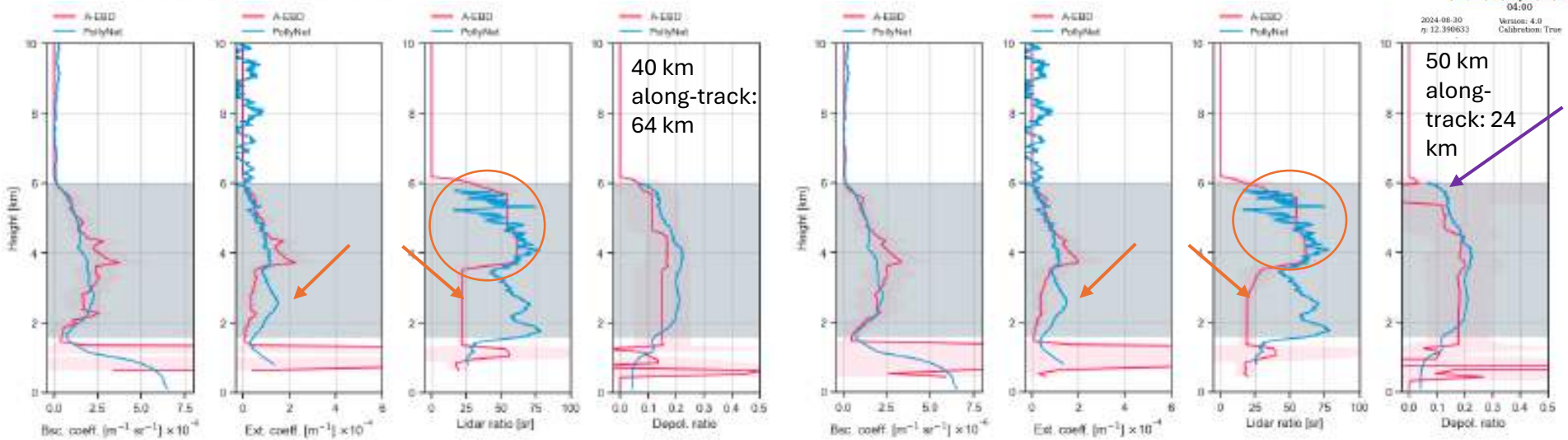
ATLID A-EBD
Baseline AC
Frame 01450A
38 km distance





- depol mainly fits, but little bit too low





- negative spike
- extinction & lidar ratio too low in lower part of the dust layer, but agreement in the upper part

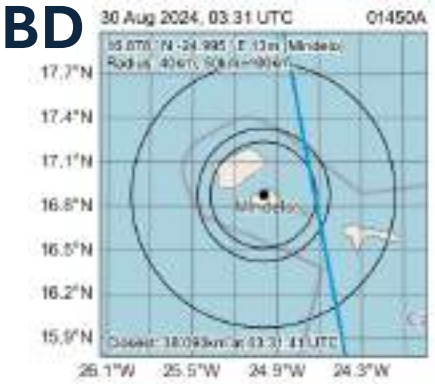
ATLID highest resolution averaged over radius around ground-site

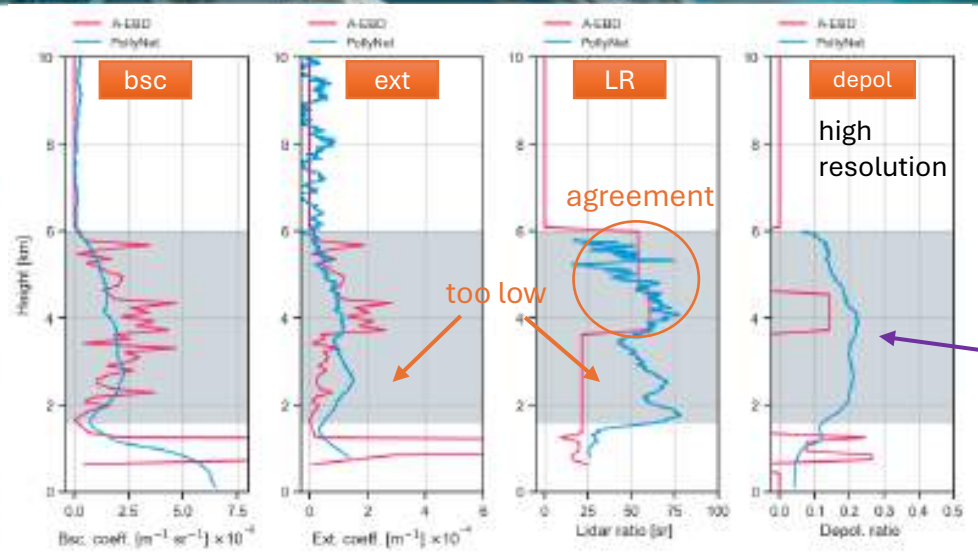
PBL … planetary boundary layer

2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AC)

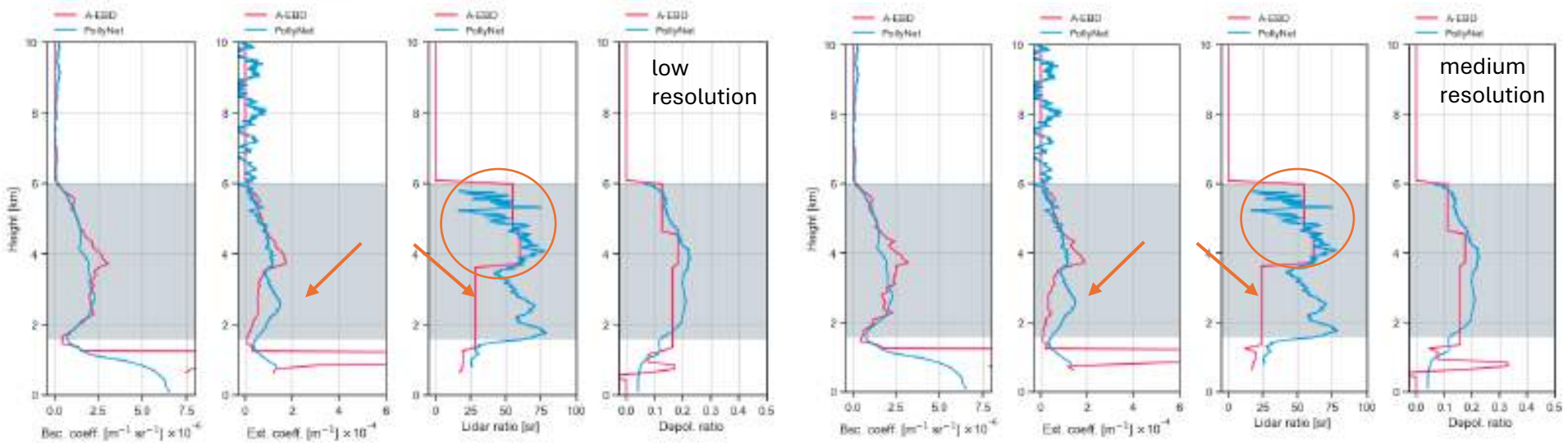
30 Aug 2024

ATLID A-EBD
Baseline AC
Frame 01450A
38 km distance





strange behaviour depol → but averaged over radius nevertheless reasonable results



only closest ATLID profile

- extinction & lidar ratio too low in lower part of the dust layer, but agreement in the upper part
- depol mainly fits, but little bit too low

Outline

1. Overview of the ground-site at Mindelo

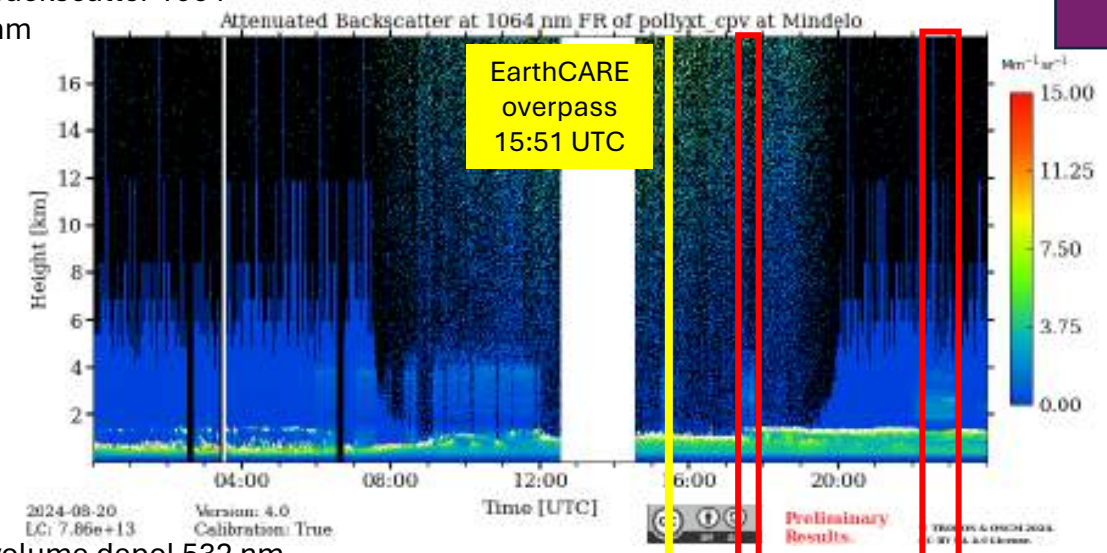
2. ATLID L2a Cal/Val results – Case studies for A-EBD

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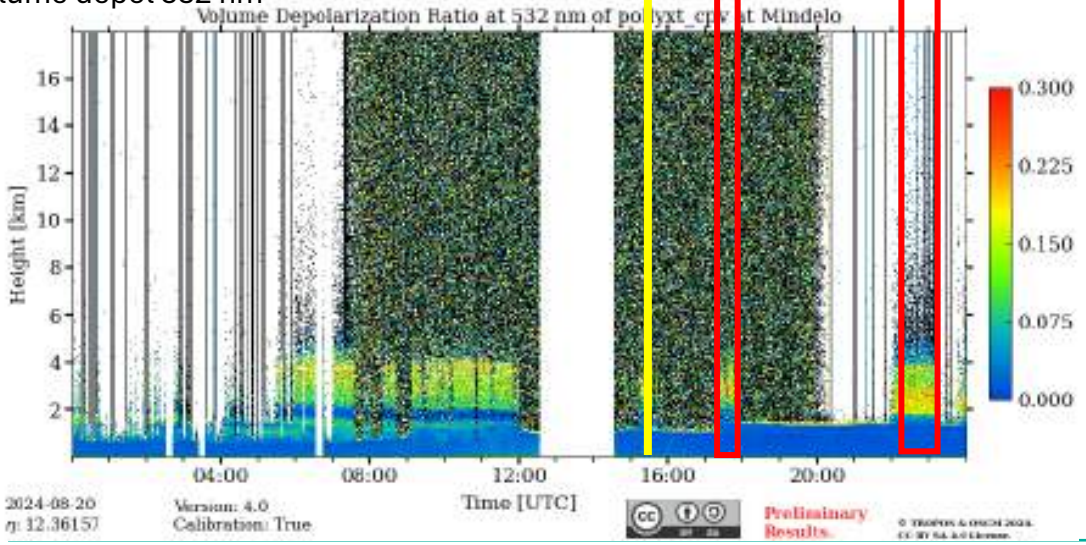
3. Summary & Outlook

2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AD)

backscatter 1064 nm



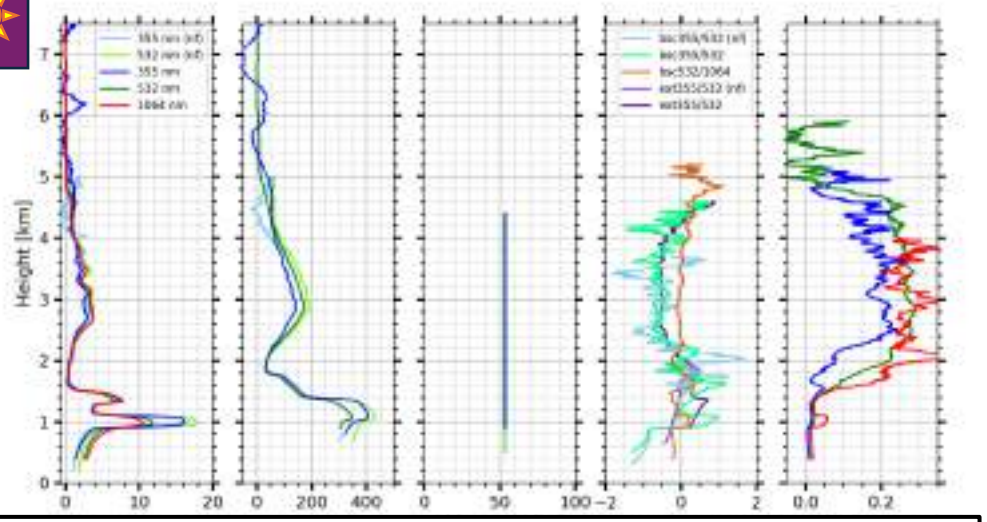
volume depol 532 nm



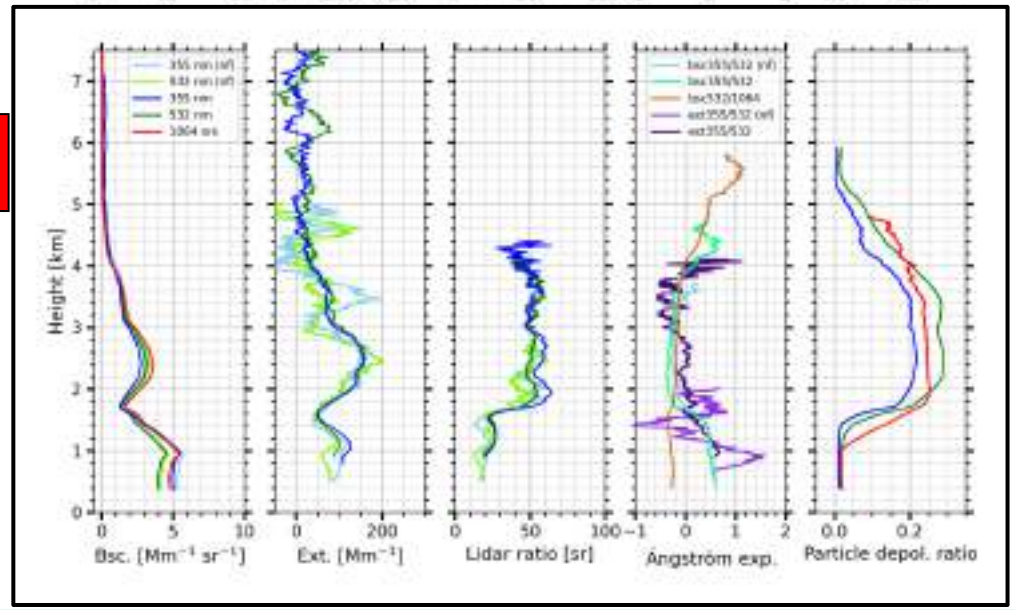
20 Aug 2024

Polly^{XT}

Klett manual 17:31-17:41 UTC

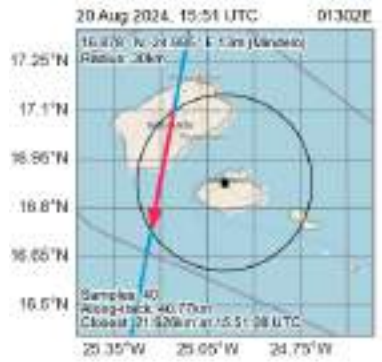


Raman manual 22:10-23:05 UTC



2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AD)

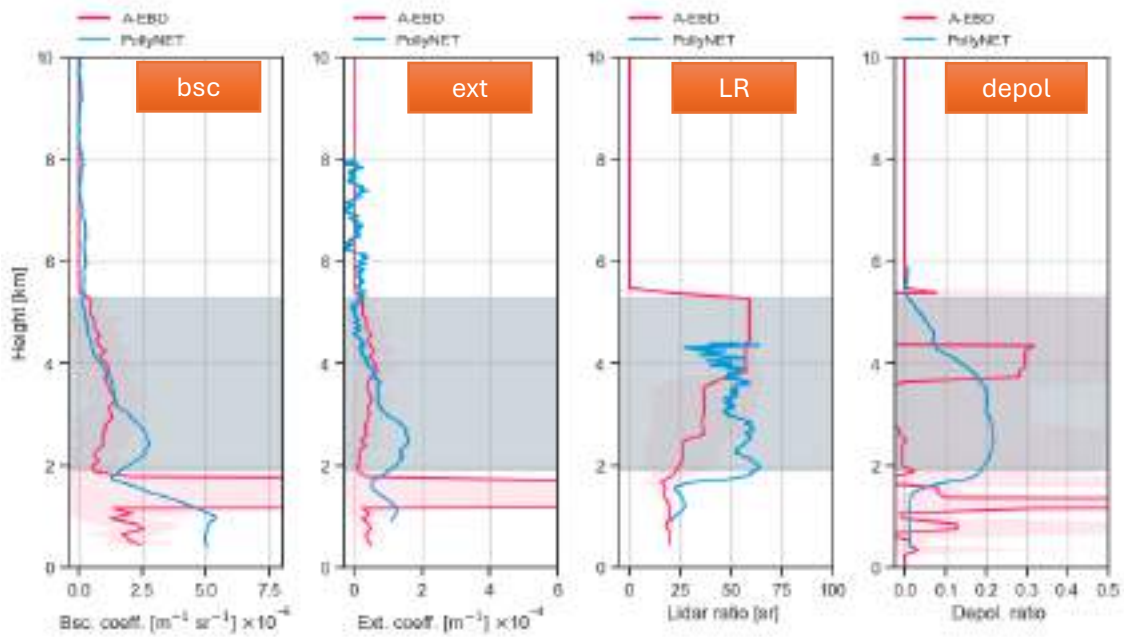
20 Aug 2024



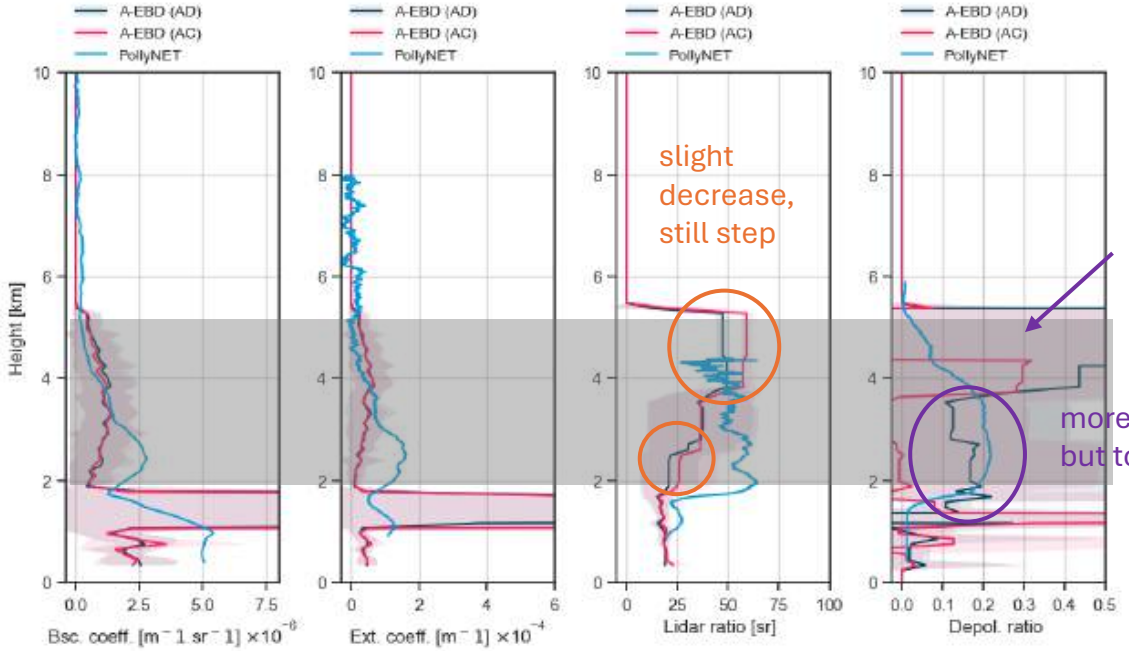
30 km radius
along-track distance:
41 km

ATLID A-EBD
Baseline AC + AD
Frame 01302E

22 km distance



Baseline AC



Baseline AD

ATLID highest resolution averaged over radius around ground-site

2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AD)

backscatter 1064 nm

Raman Picasso 20:48-21:13 UTC

17 Jan 2025

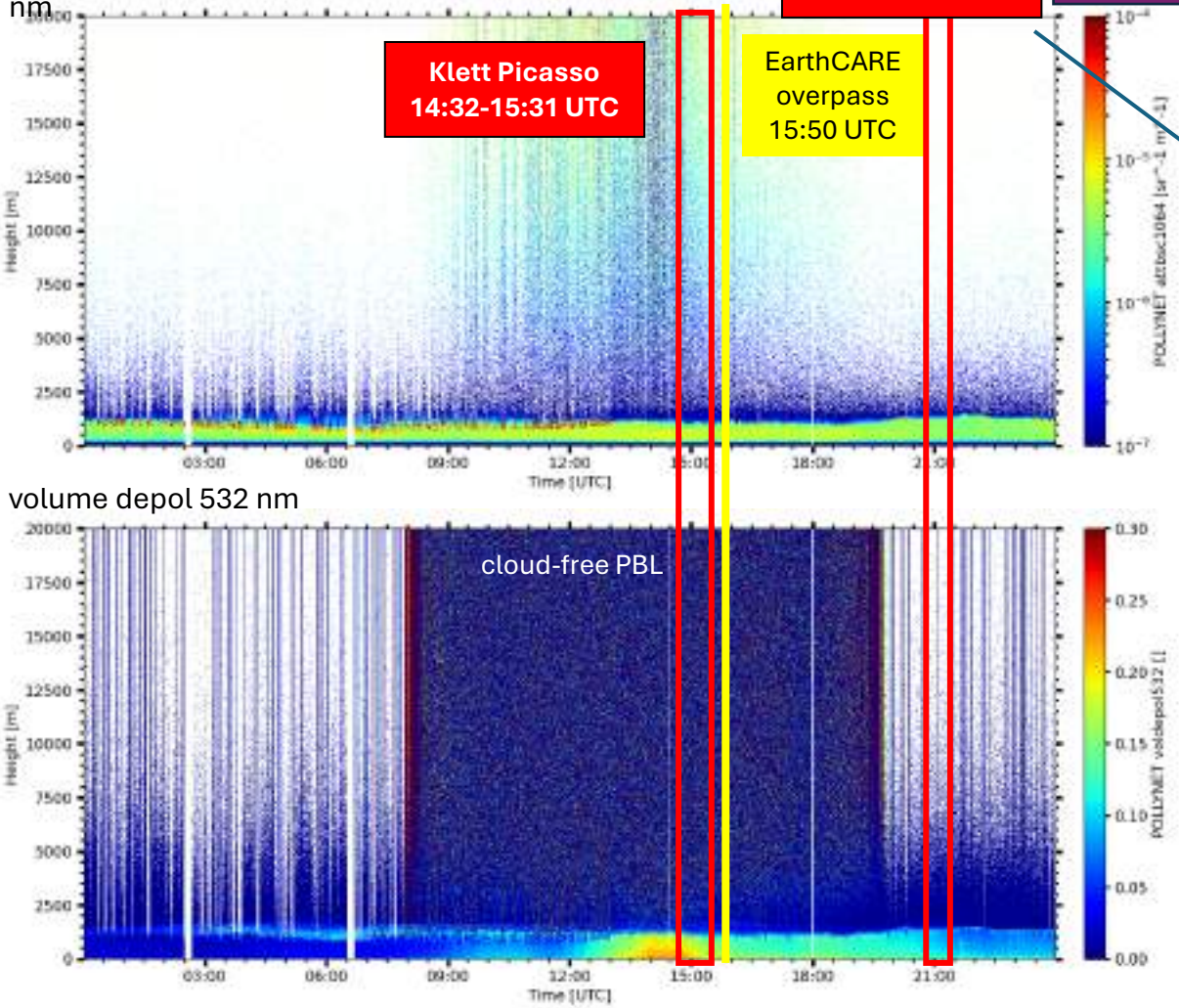
Klett Picasso 14:32-15:31 UTC

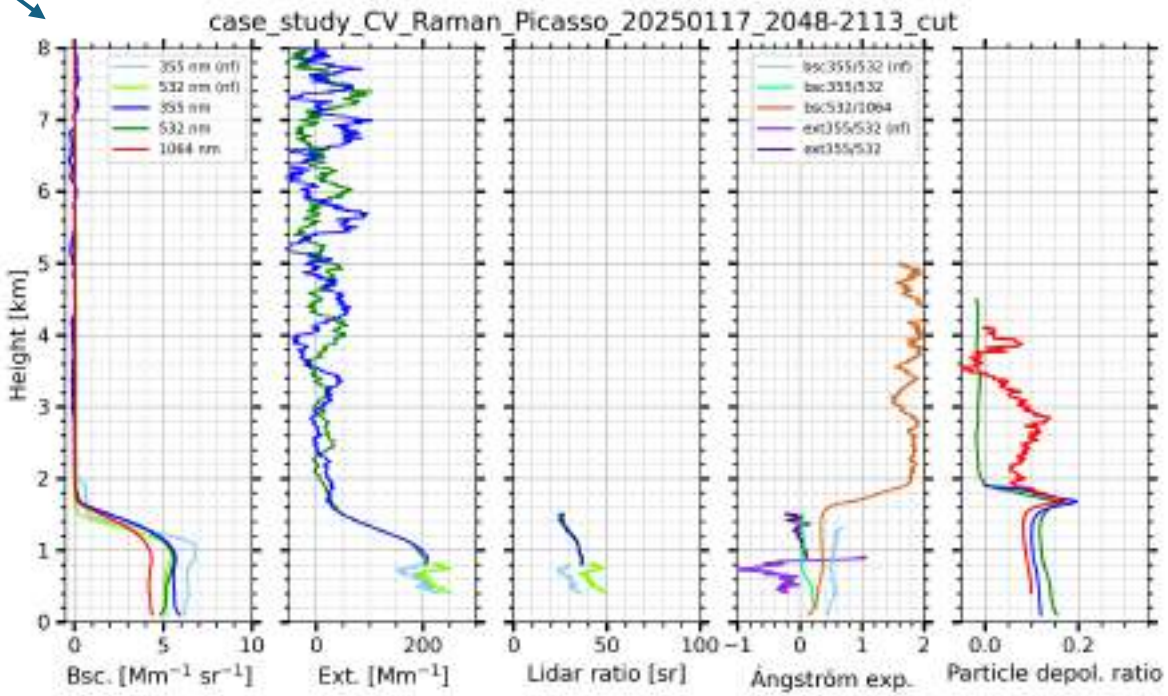
EarthCARE overpass 15:50 UTC

Polly^{XT}

volume depol 532 nm

cloud-free PBL





2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AD)

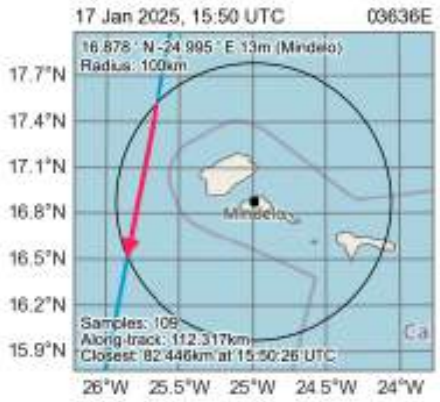
17 Jan 2025

ATLID A-EBD

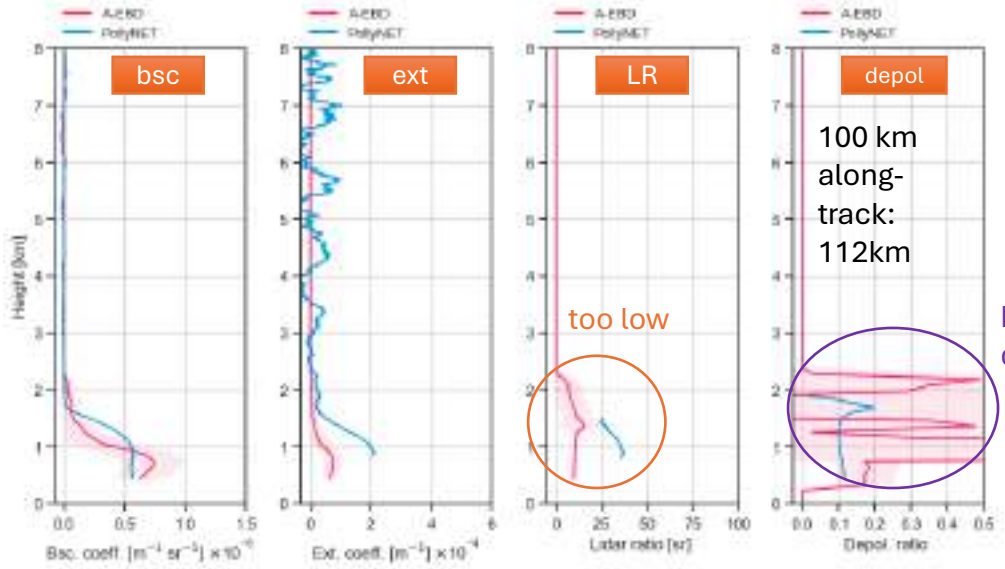
Baseline AC

Frame 03636E

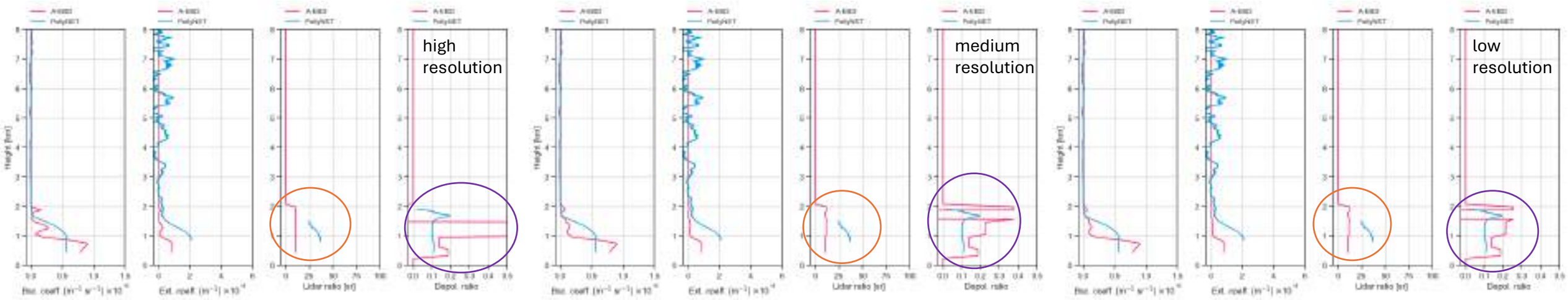
82 km distance



not much improvement with L1 baseline AD



average of high resolution



only closest ATLID profile

3. Summary & Outlook

Highlights

- layer boundaries + backscatter + extinction of dust layers agree well

Problems

- issues with the **lidar ratio**:
  - step within the dust layer
  - too low lower part, sometimes fitting upper part
  - vertical gradient more pronounced the higher the resolution

- issues with the **depol**:
  - often strange behaviuor/noisy
  - sometimes negative at top of the dust layer

General findings:

- lower resolution (single profiles medium/low resolution or averaged over 100 km radius) slightly better agreement with Polly than higher resolution

- if averaged within radius → still important to check quality of the single ATLID profiles used for averaging, because they may look strange!

- not much improvement with new L1 baseline

Outlook:

- Where do the issues come from? → optimal estimation?, from the input data (L1, A-AER)?
- Validate A-AER product!
- Check regional differences: step in LR seems to be Mindelo-specific issue

Appendix

Appendix

20 Aug 24:

- AC:
  - processed 11 Dec 24
  - creator_version 1103
  - **ANOM AC** from 18 Oct 24
  - *AFM AC* from 11 Dec 24
  - **AUX-JSG AB** from 15 Nov 24
  - AUX MET AA from 20 Aug 24
  - EXAA_CFG_APRO

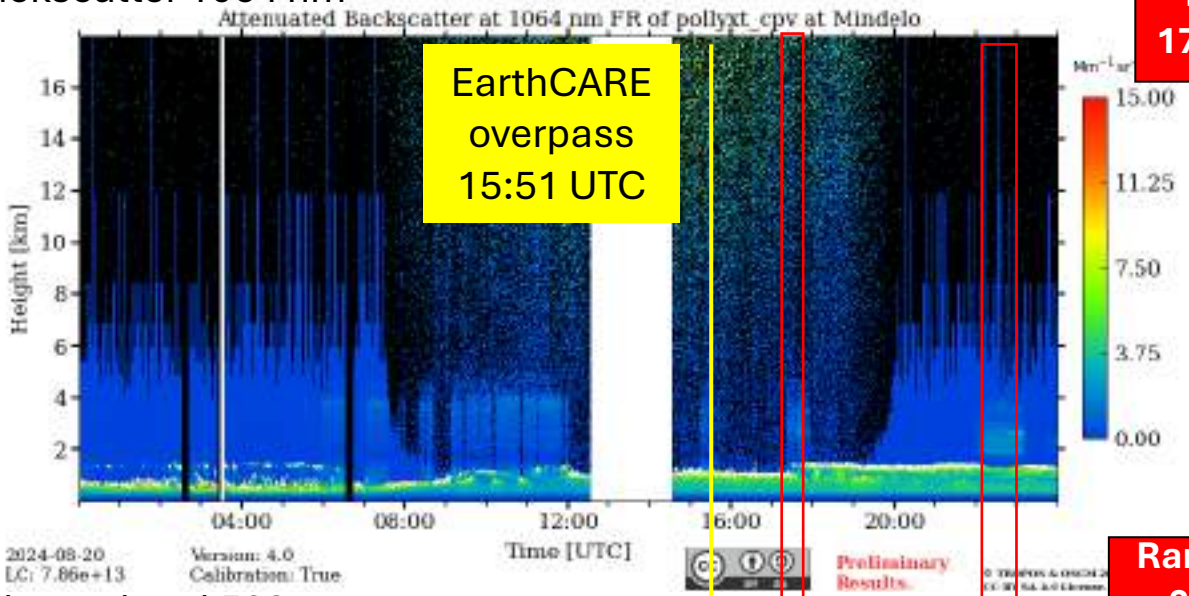
- AD:
  - processed 18 Feb 25
  - creator_version 1103
  - **ANOM AD** from 18 Feb 25
  - *AFM AC* from 18 Feb 24
  - **AUX-JSG AC** from 18 Feb
  - AUX-MET AA from 20 Aug 24
  - EXAA_CFG_APRO

17 Jan 25:

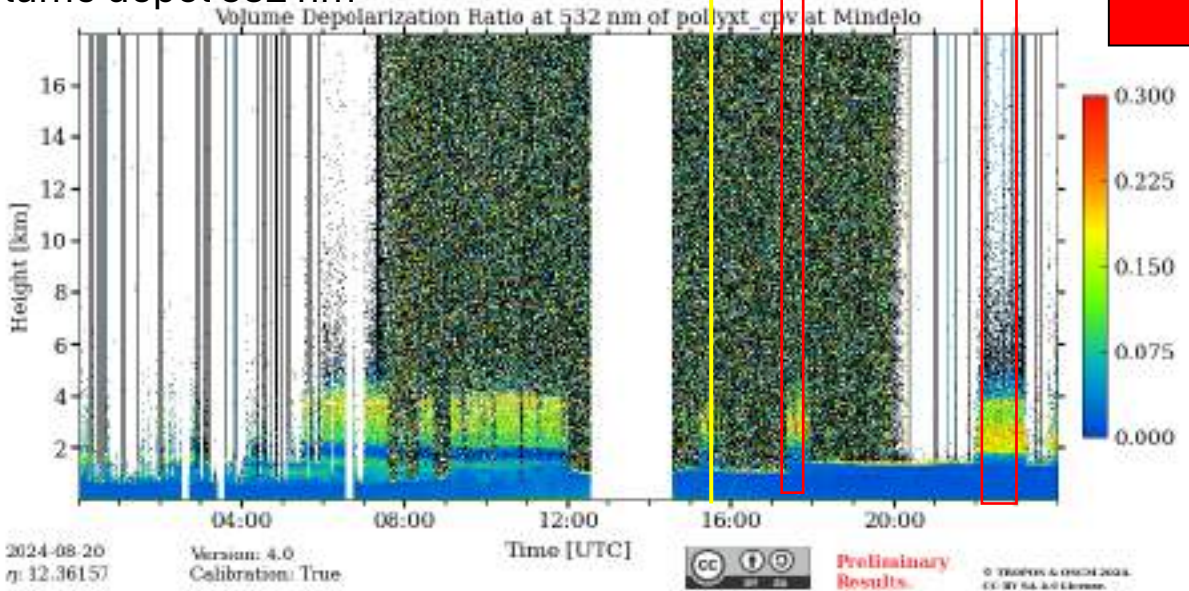
- AC:
  - Processed 17 Jan 25
  - Creator_version 1103
  - **ANOM AD** from 17 Jan 25
  - *AFM AC* from 17 Jan 25
  - AUX-JSG AB from 17 Jan 25
  - AUX-MET AA from 17 Jan 25
  - EXAA_CFG_APRO

3. ATLID validation results with ground-based measurements

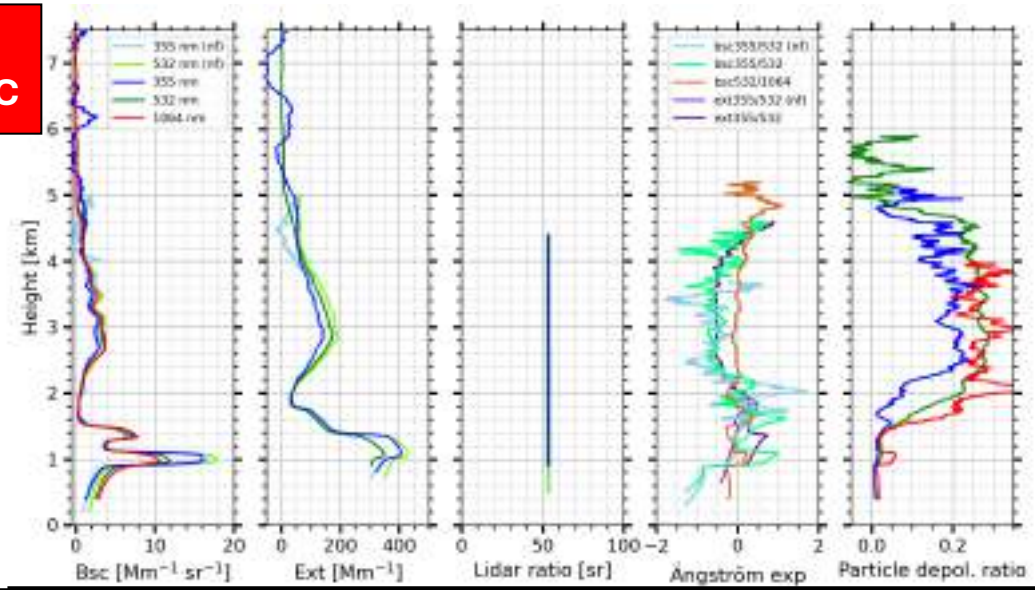
backscatter 1064 nm



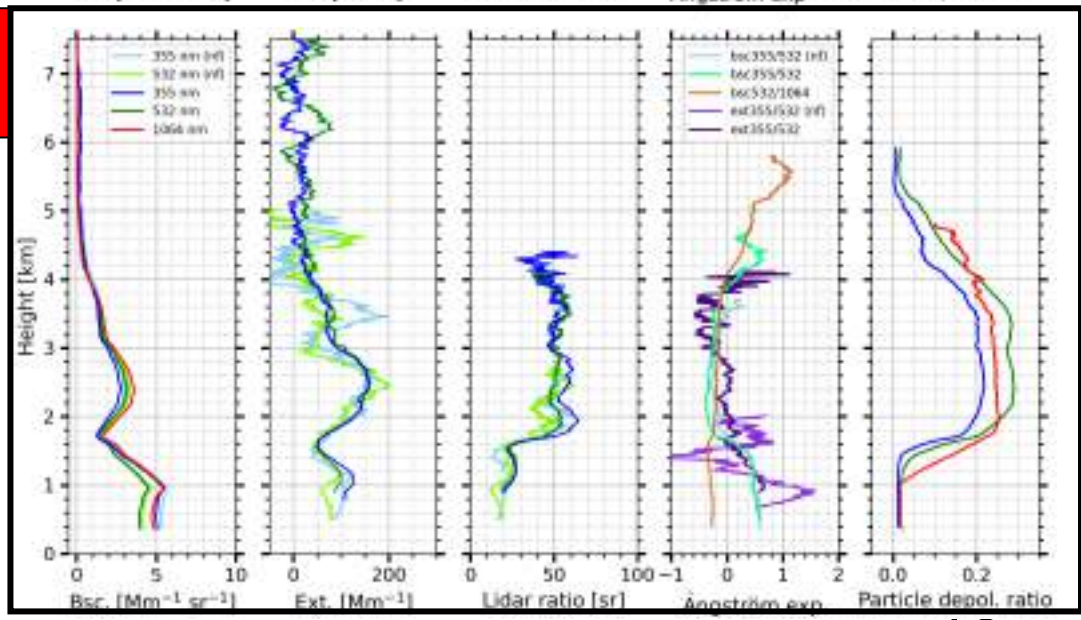
volume depol 532 nm



Klett manual 17:31-17:41 UTC



Raman manual 22:10-23:05 UTC



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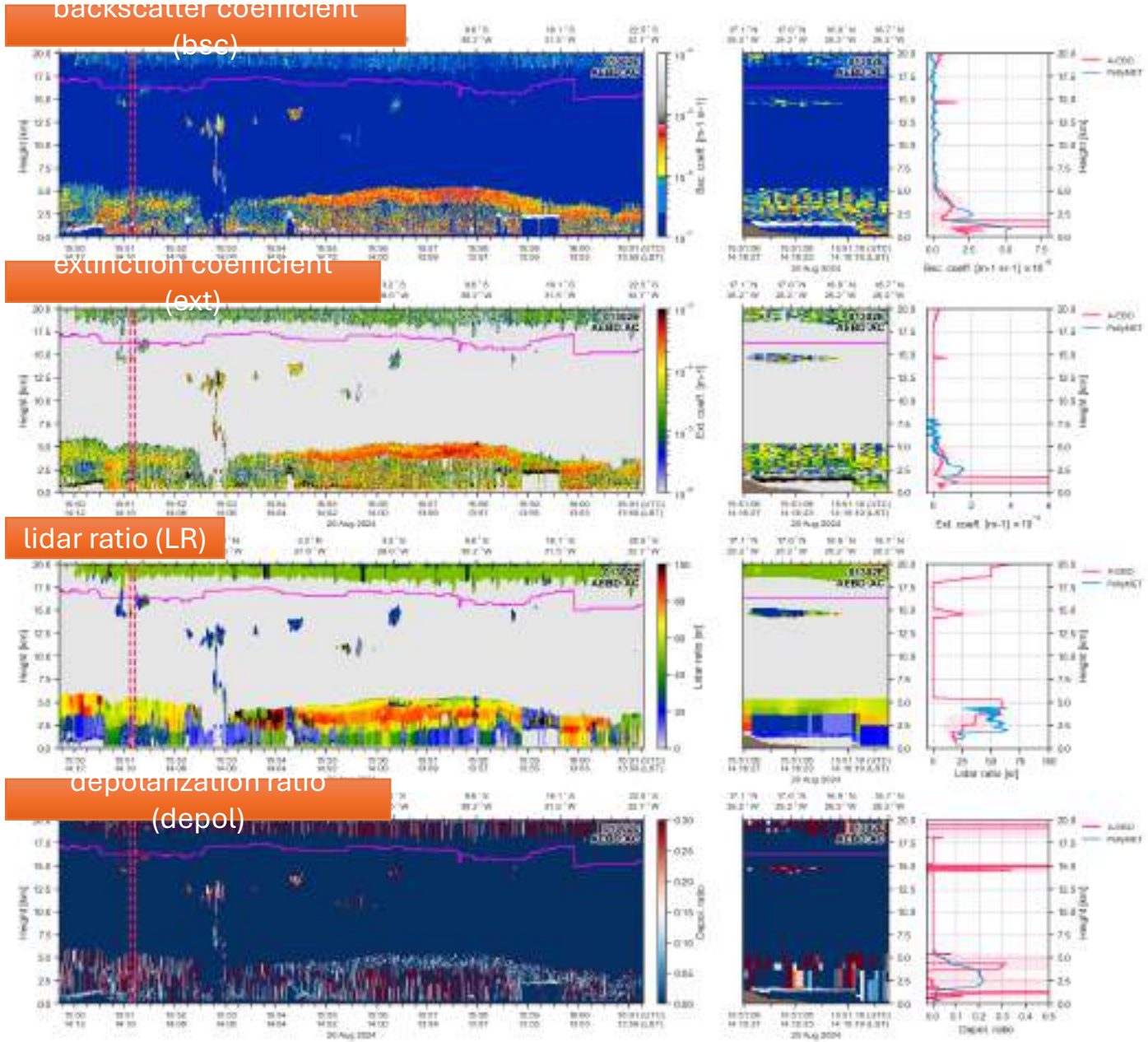
01302E
A-EBD AC

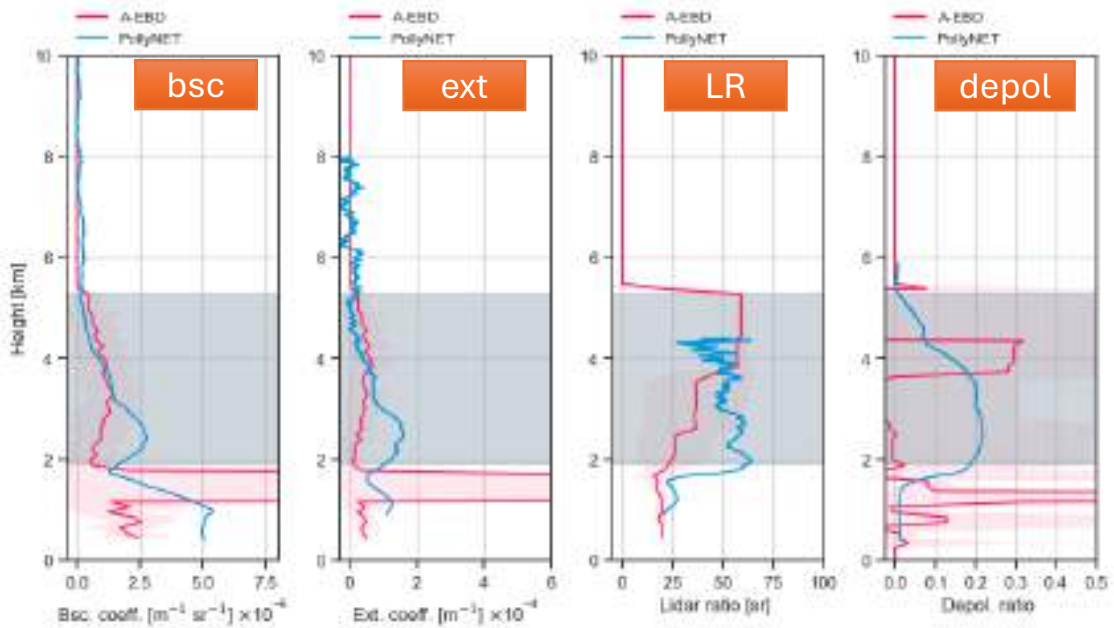
backscatter coefficient (bsc)

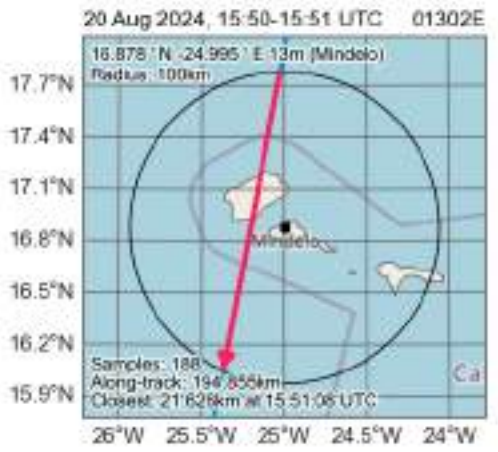
extinction coefficient (ext)

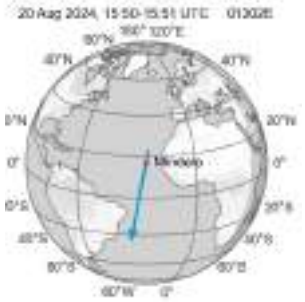
lidar ratio (LR)

depolarization ratio (depol)









30 km radius

22 km distance

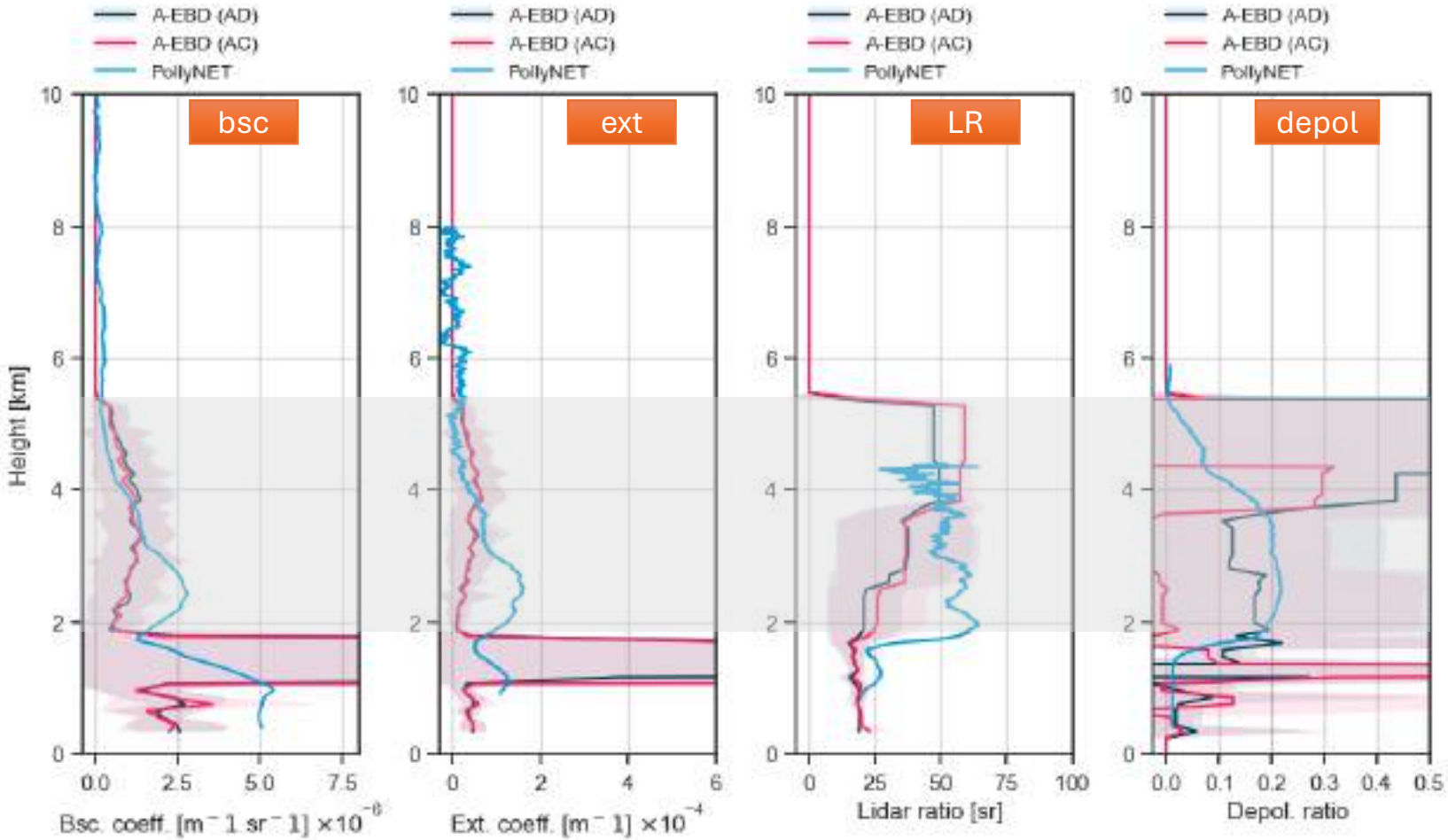
TROPOS

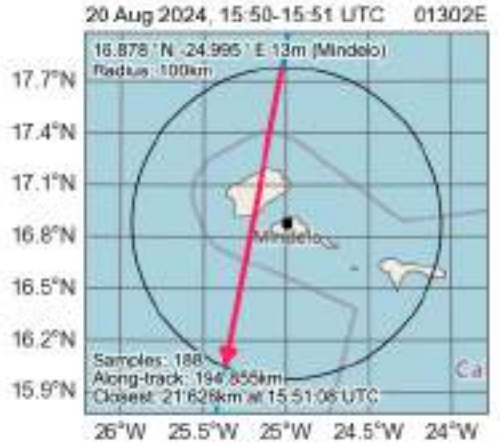
20 Aug

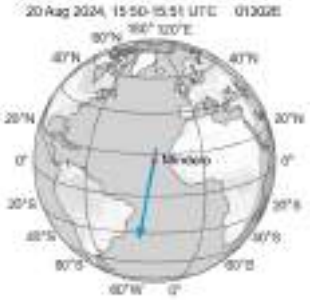
3. ATLID validation results with ground-based measurements

01302E

A-EBD AC vs. AD







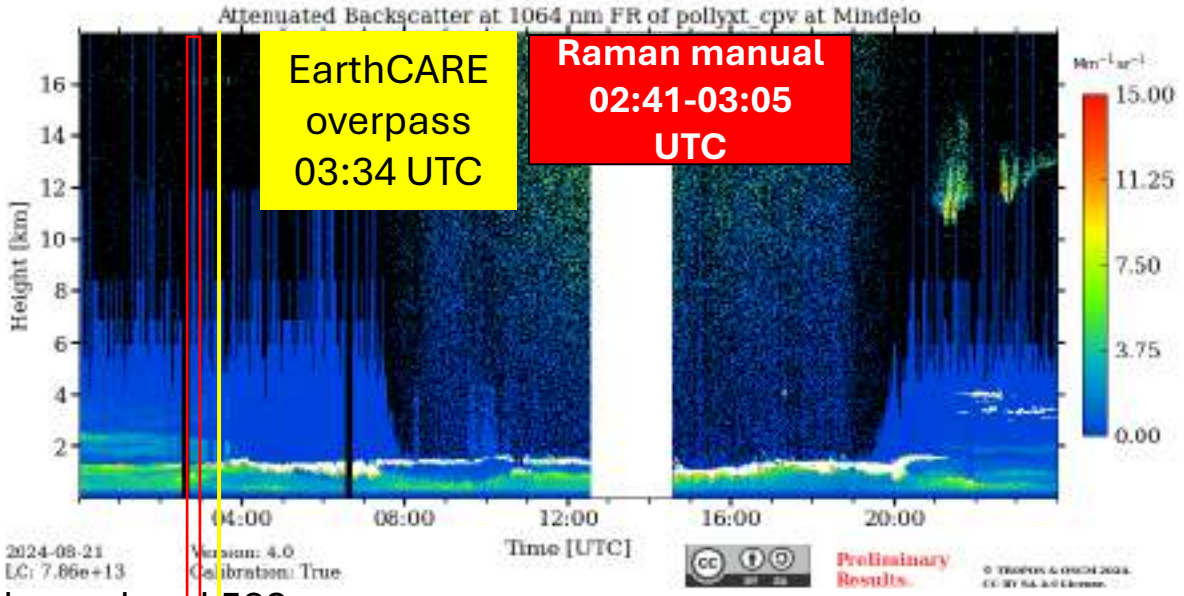
30 km radius

22 km distance

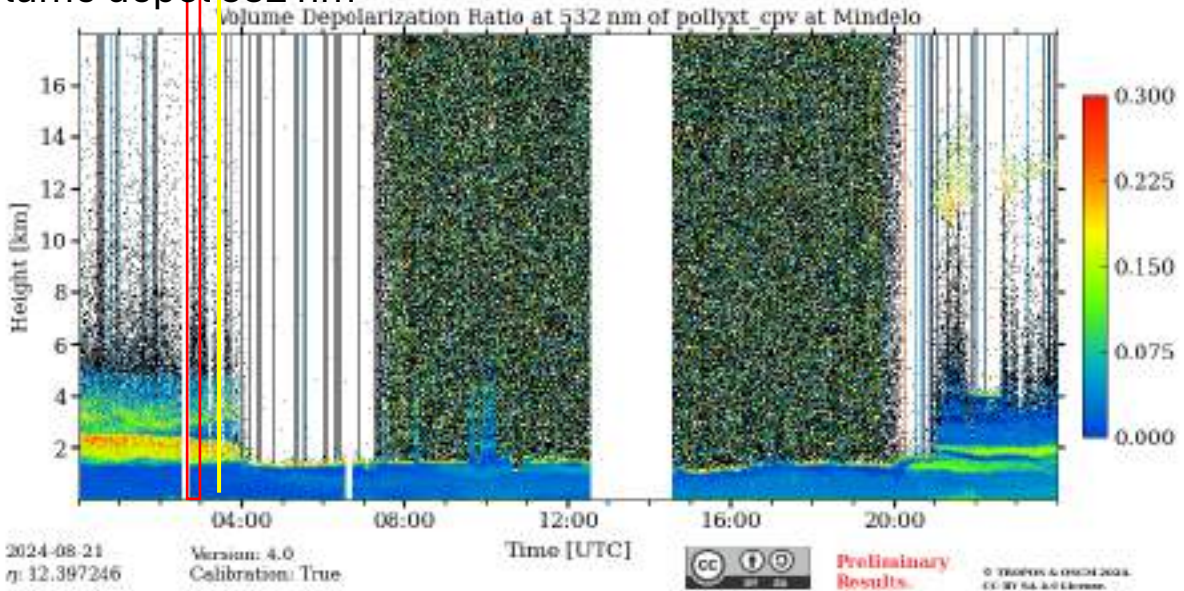
TROPOS

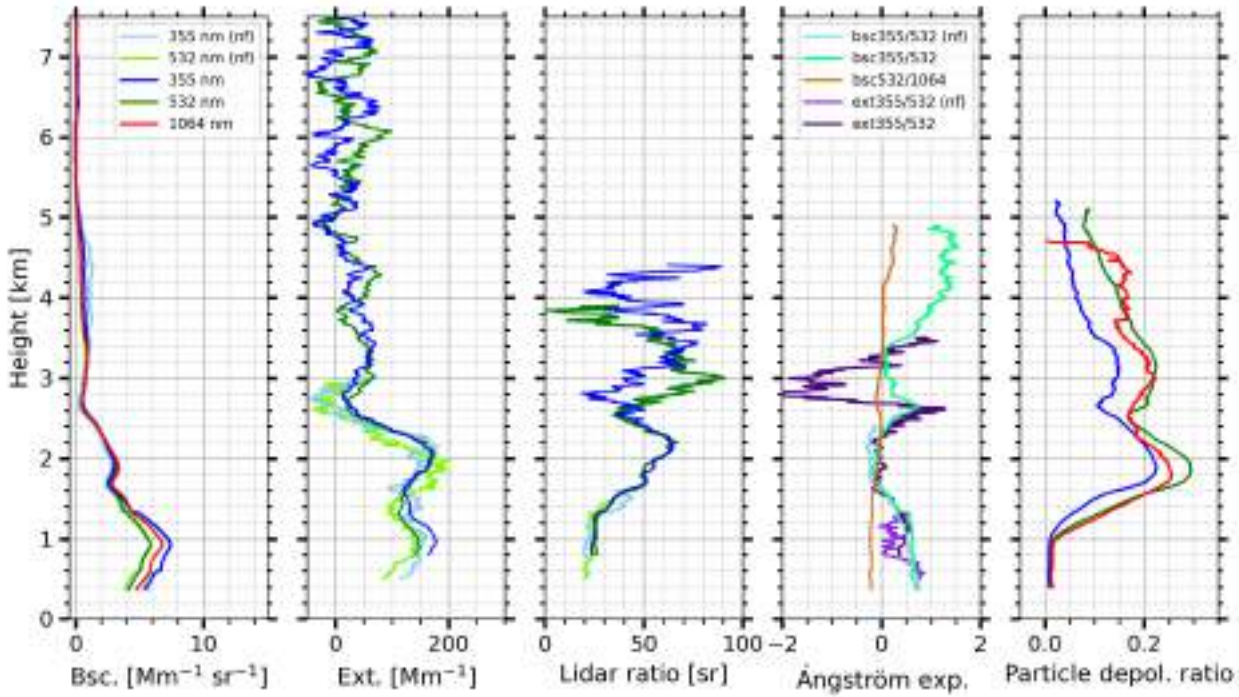
3. ATLID validation results with ground-based measurements

backscatter 1064 nm



volume depol 532 nm





TROPOS

3. ATLID validation results with ground-based measurements

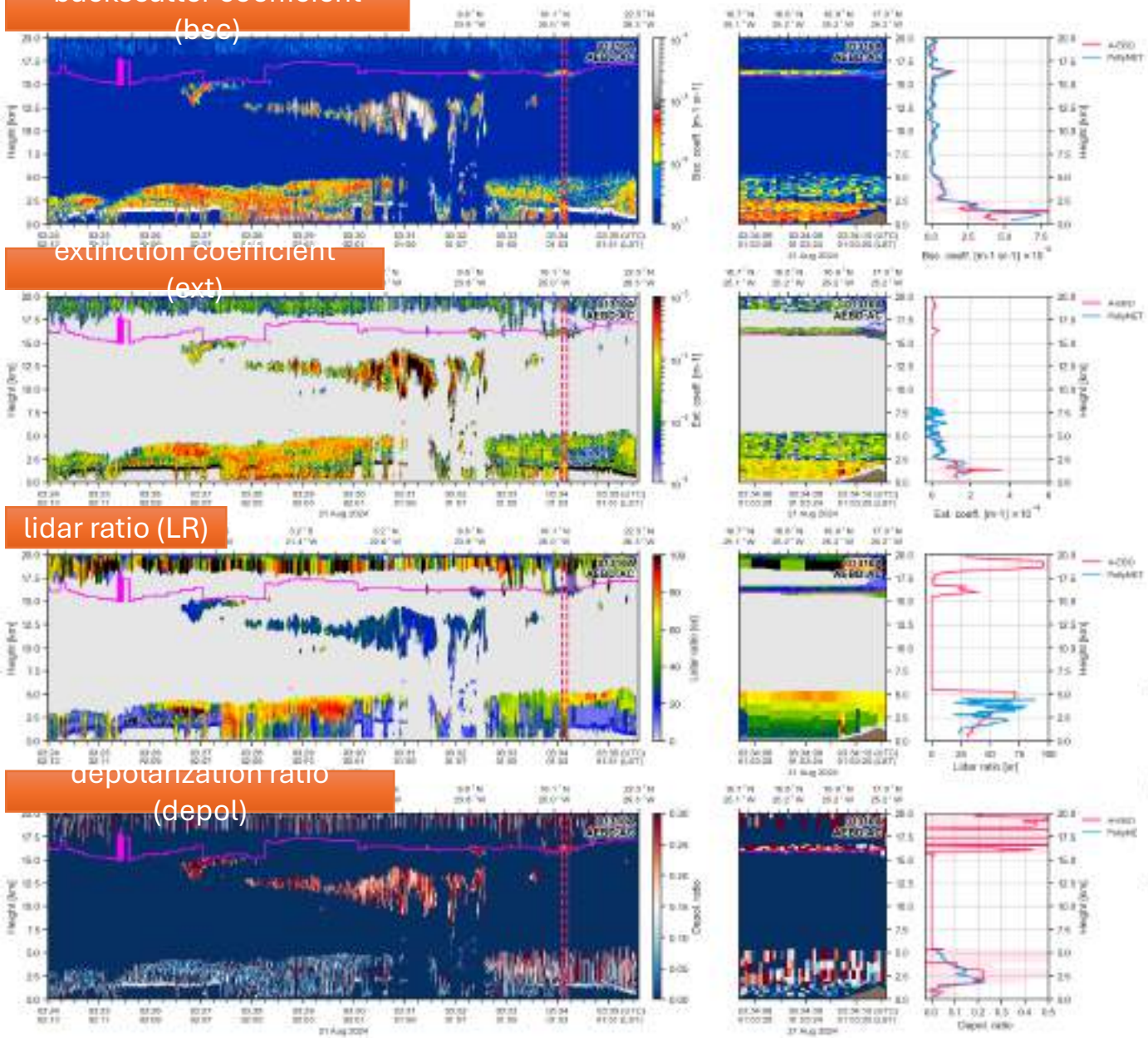
01310A
A-EBD AC

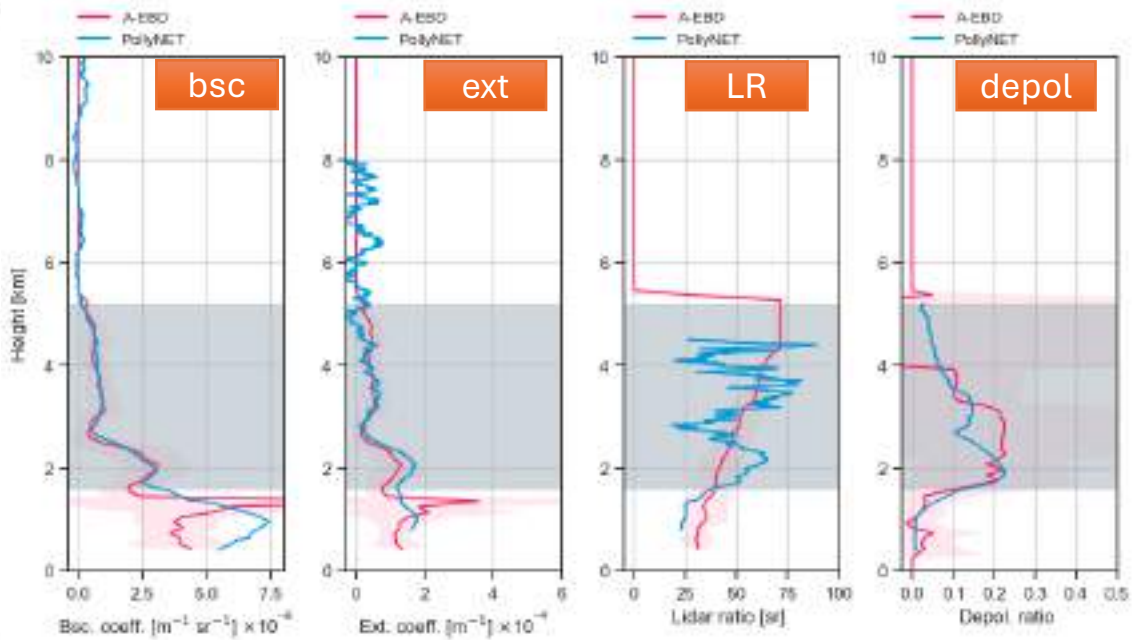
backscatter coefficient (bsc)

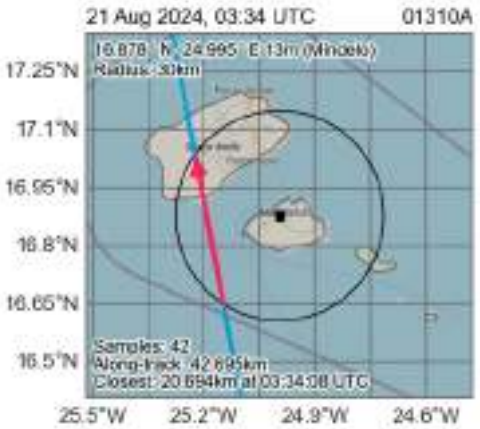
extinction coefficient (ext)

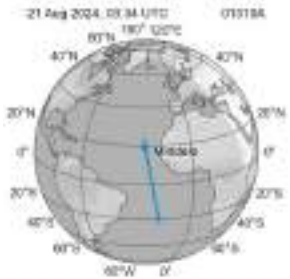
lidar ratio (LR)

depolarization ratio (depol)









30 km radius

21 km distance

TROPOS

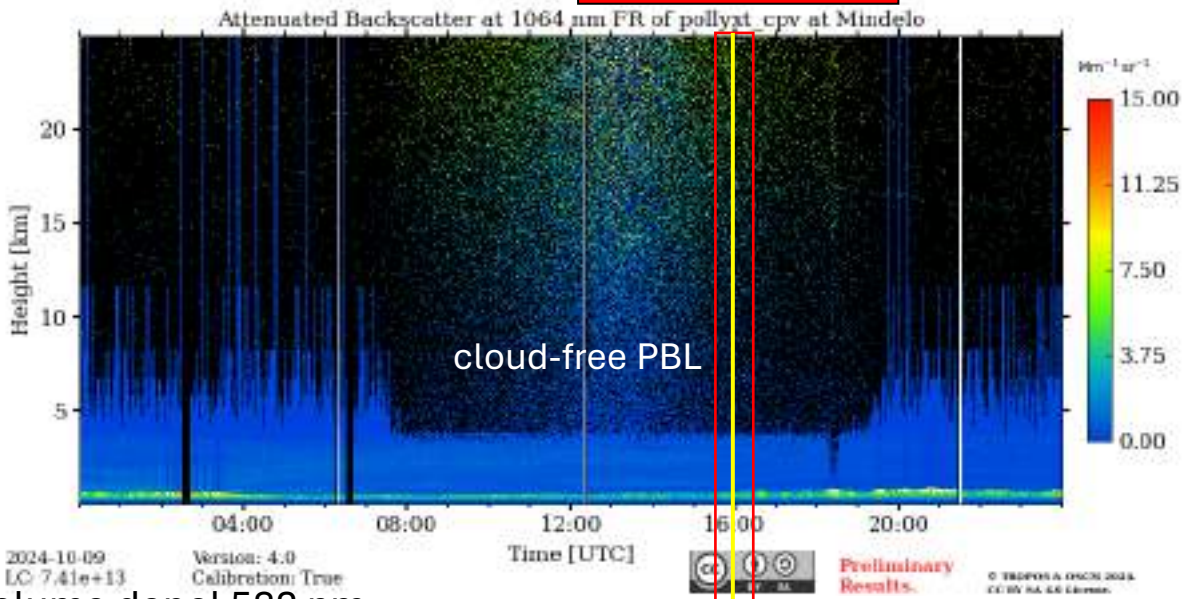
9 Oct 2024

EarthCARE overpass 15:52 UTC

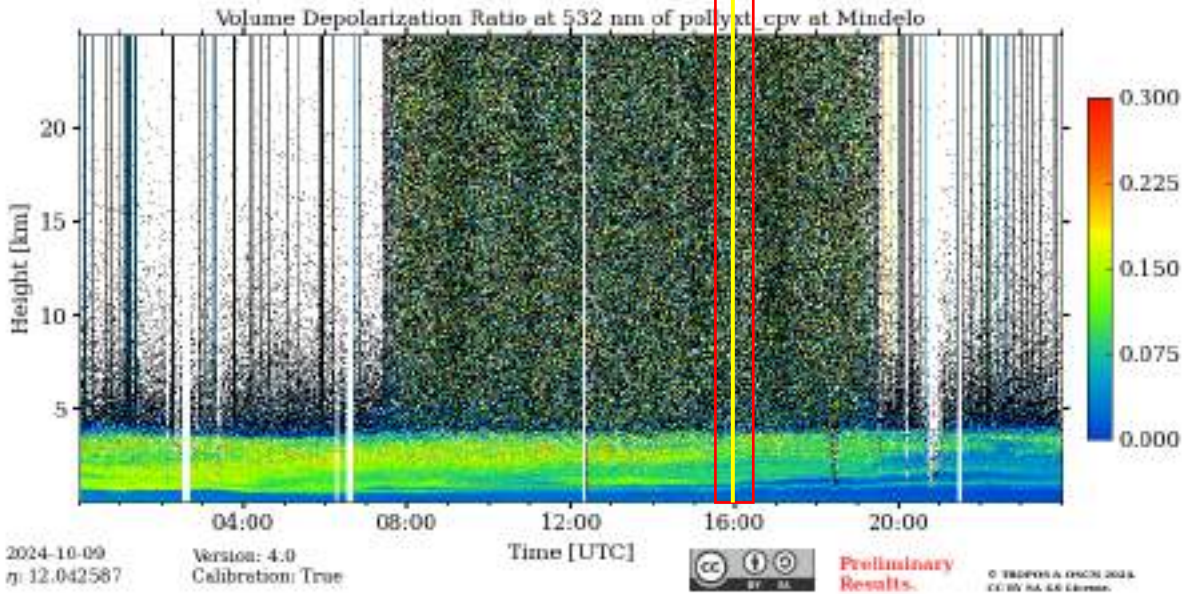
Klett Picasso 15:20-16:32 UTC

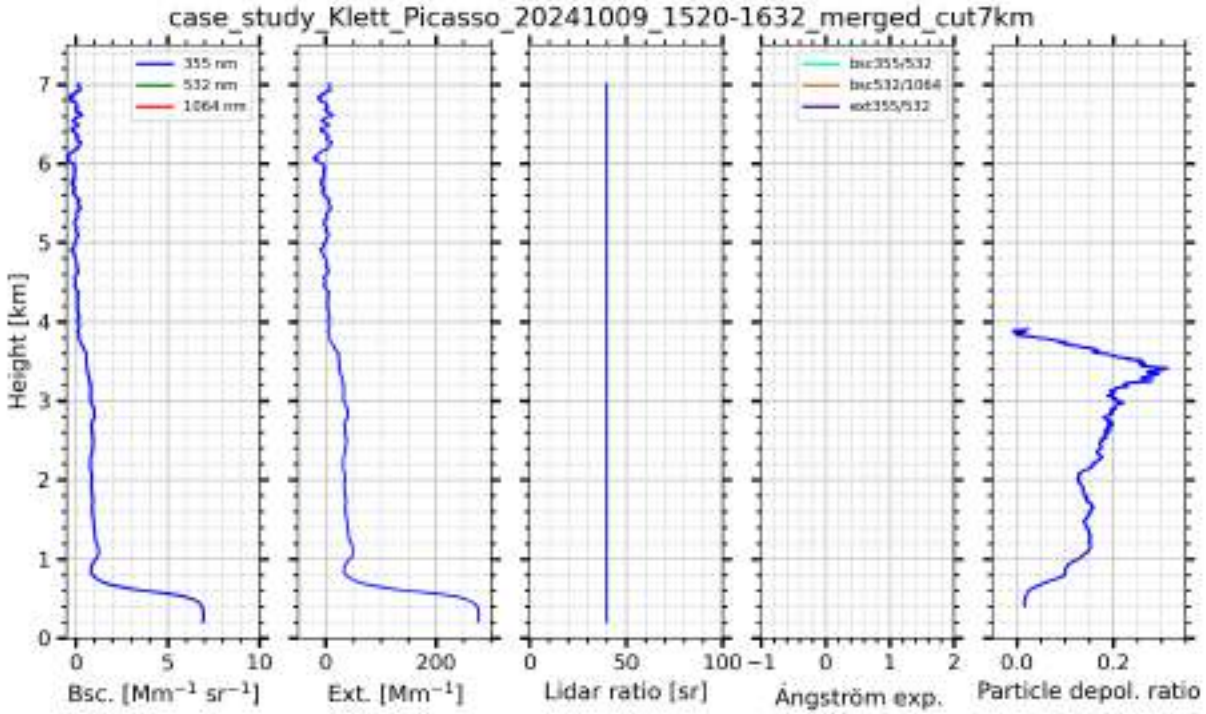
Polly^{XT}

backscatter 1064 nm



volume depol 532 nm





PBL … planetary boundary layer

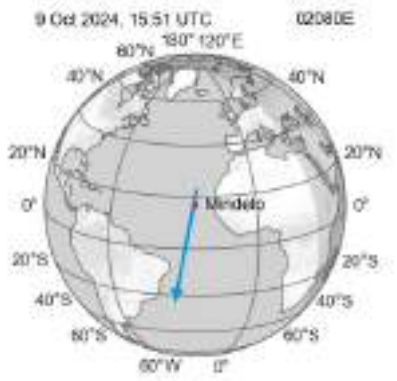
9 Oct 2024

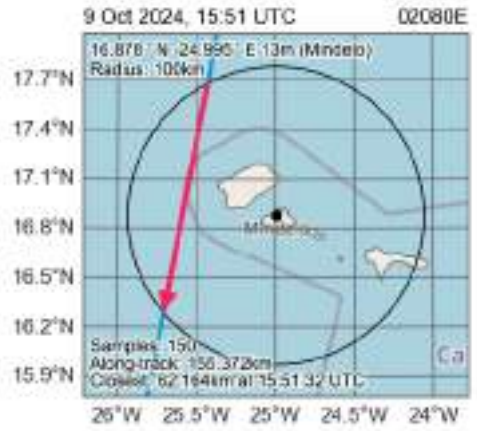
ATLID A-EBD

Baseline AC

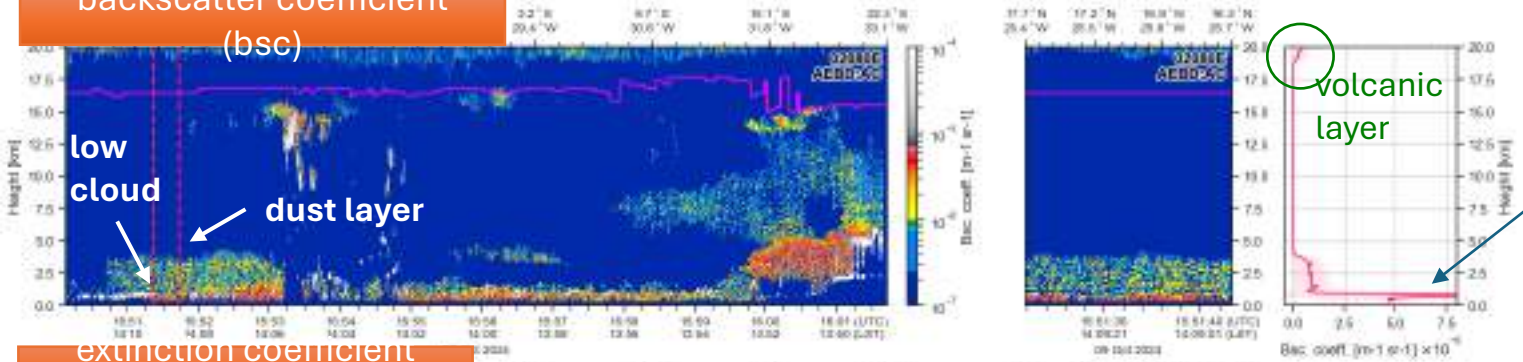
Frame 02080E

100 km radius
62 km distance

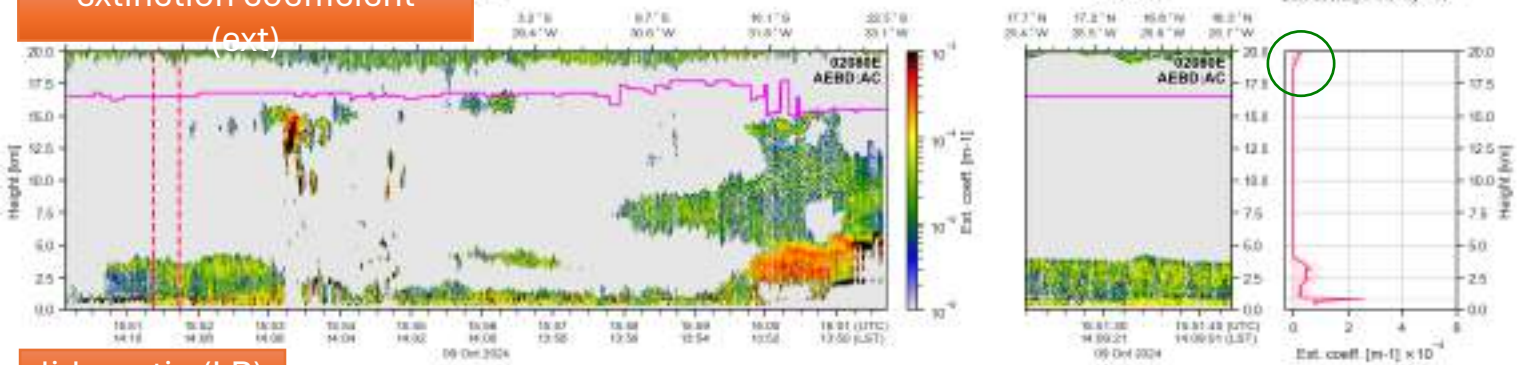




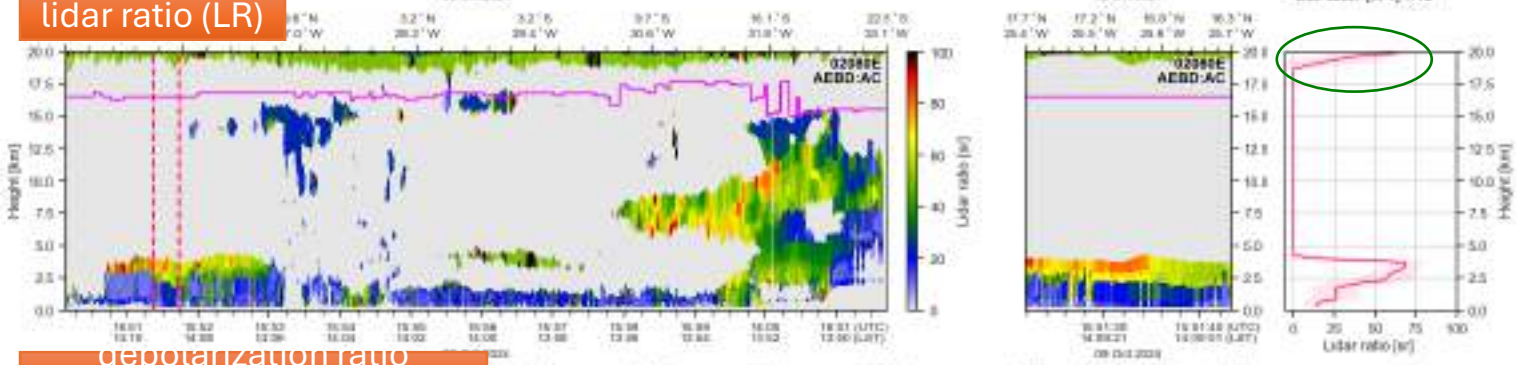
backscatter coefficient (bsc)



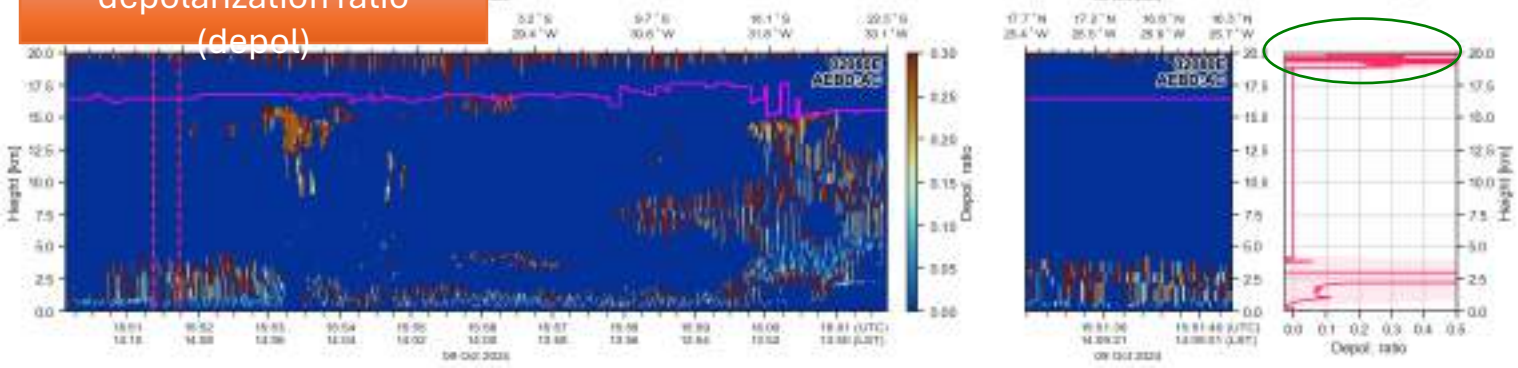
extinction coefficient (ext)



lidar ratio (LR)



depolarization ratio (depol)



TROPOS

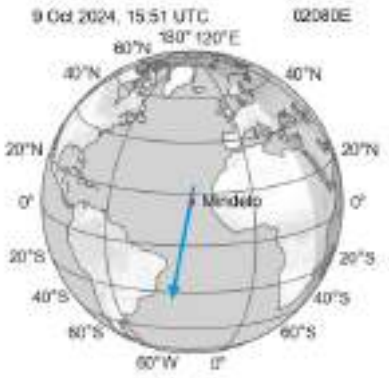
9 Oct 2024

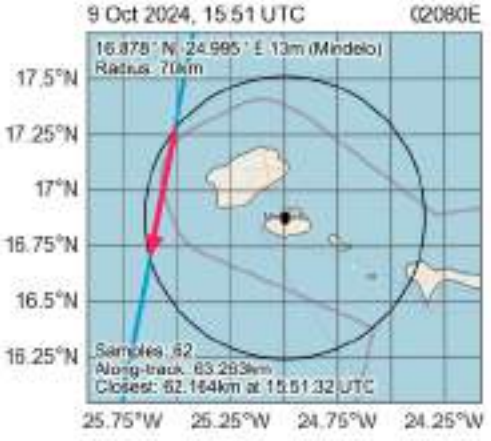
ATLID A-EBD

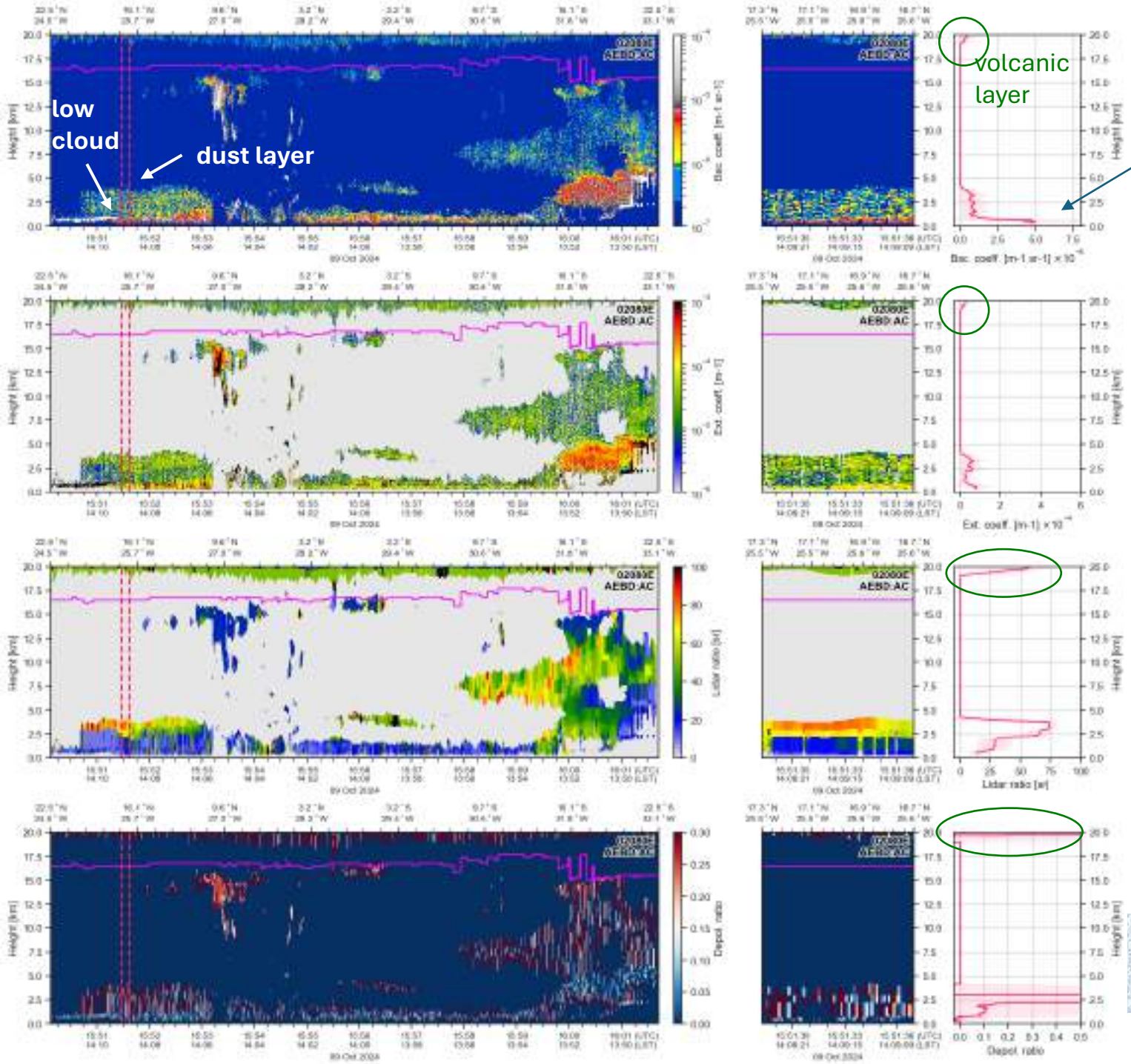
Baseline AC

Frame 02080E

70 km radius
62 km distance







TROPOS

9 Oct 2024

ATLID A-EBD

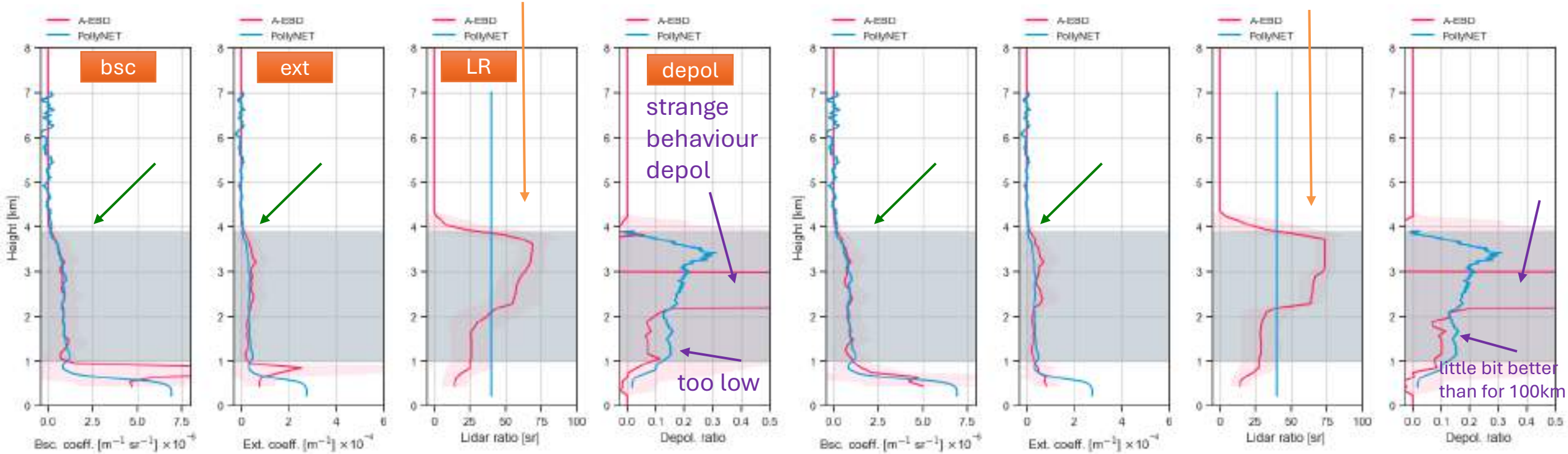
Baseline AC

Frame 02080E

62 km distance

- For dust layer nice agreement layer boundaries, backscatter, extinction!

step in lidar ratio within dust layer: 25sr → 70sr



100 km

70 km

ATLID highest resolution averaged over radius around ground-site

TROPOS

9 Oct 2024

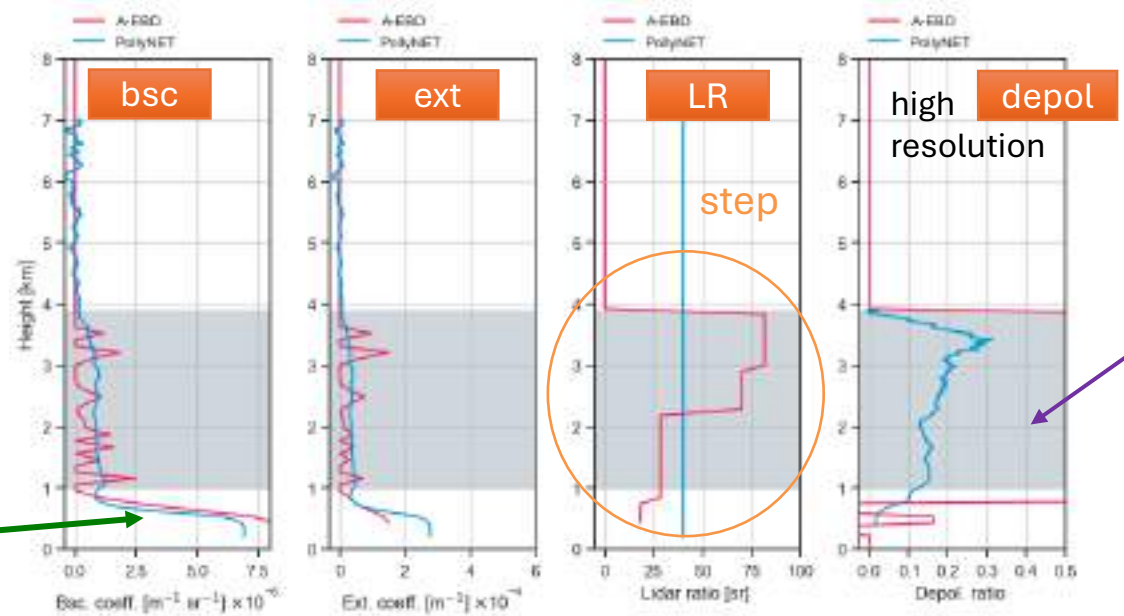
ATLID A-EBD

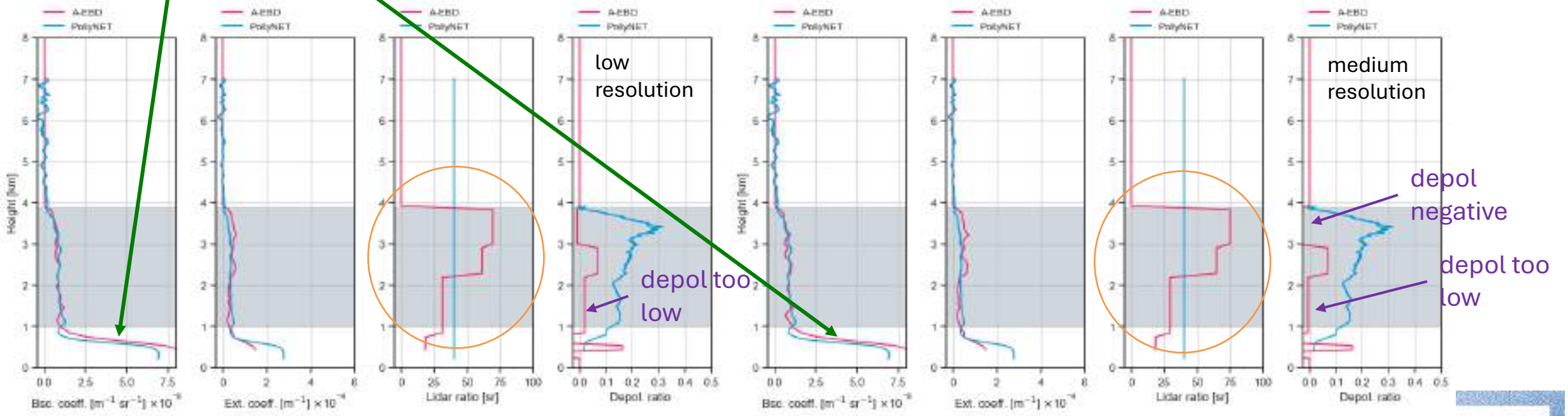
Baseline AC

Frame 02080E

62 km distance

agreement also for PBL



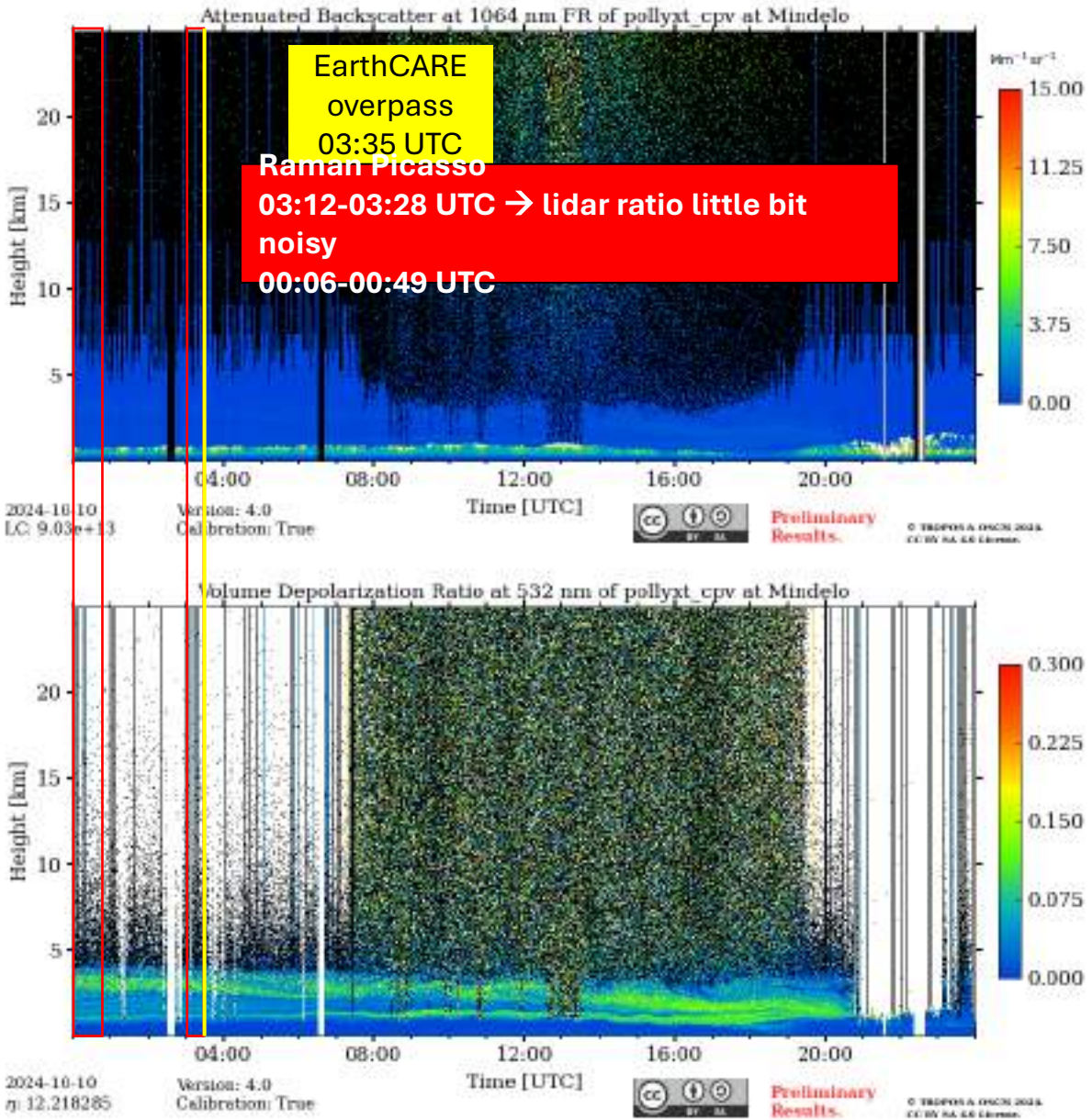


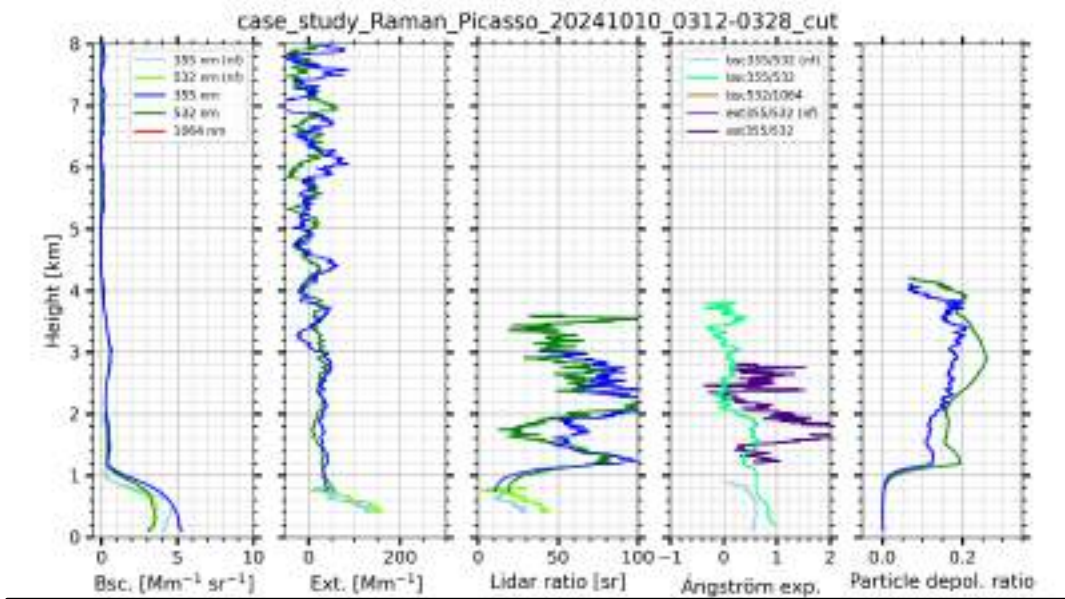
only closest ATLID profile

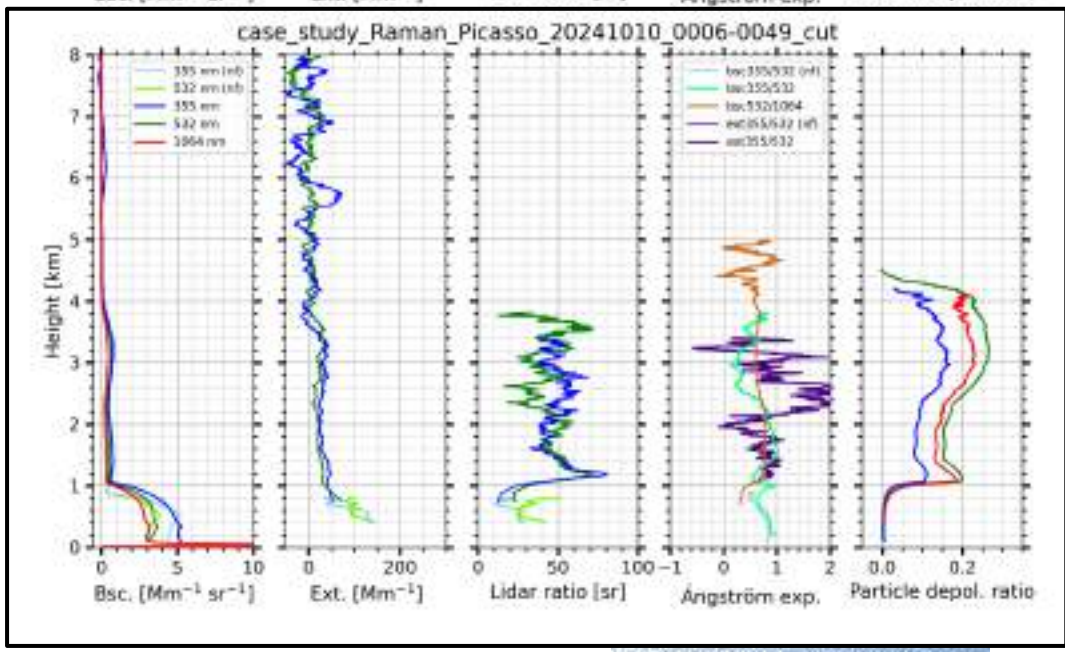
TROPOS

10 Oct 2024

Polly^{XT}





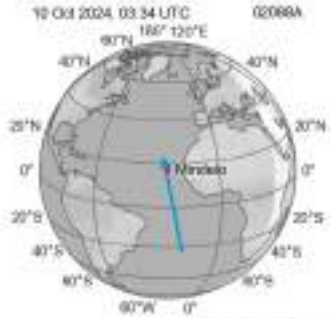


TROPOS

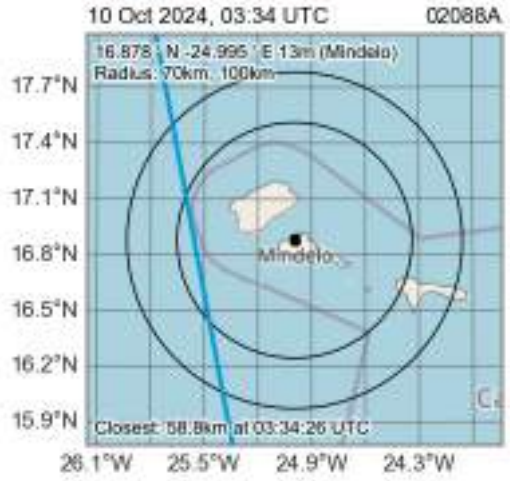
2. ATLID L2a Cal/Val results – case studies for A-EBD (L1 baseline AC)

10 Oct 2024

ATLID A-EBD
Baseline AC
Frame 02088A



100 + 70 km radius
59 km distance

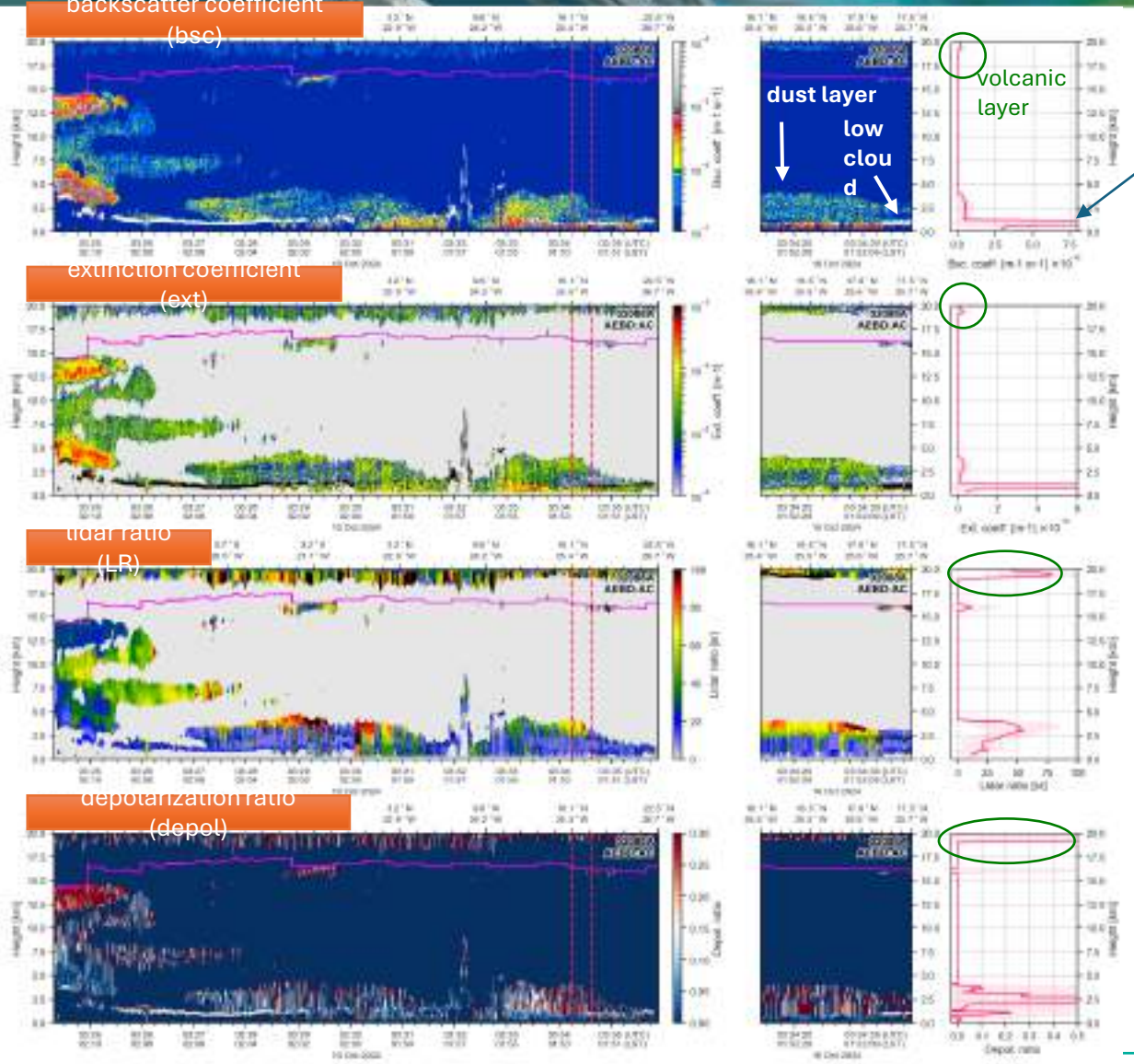


backscatter coefficient (bsc)

extinction coefficient (ext)

lidar ratio (LR)

depolarization ratio (depol)



10 Oct 2024

ATLID A-EBD

Baseline AC

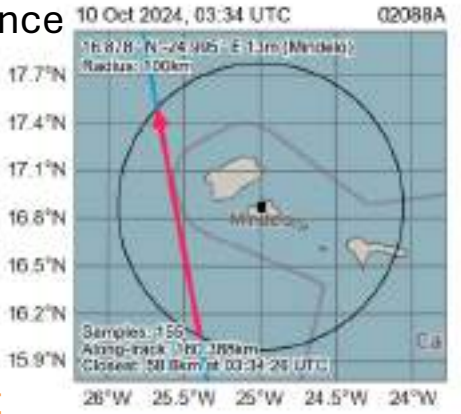
Frame 02088A

Similar issues:

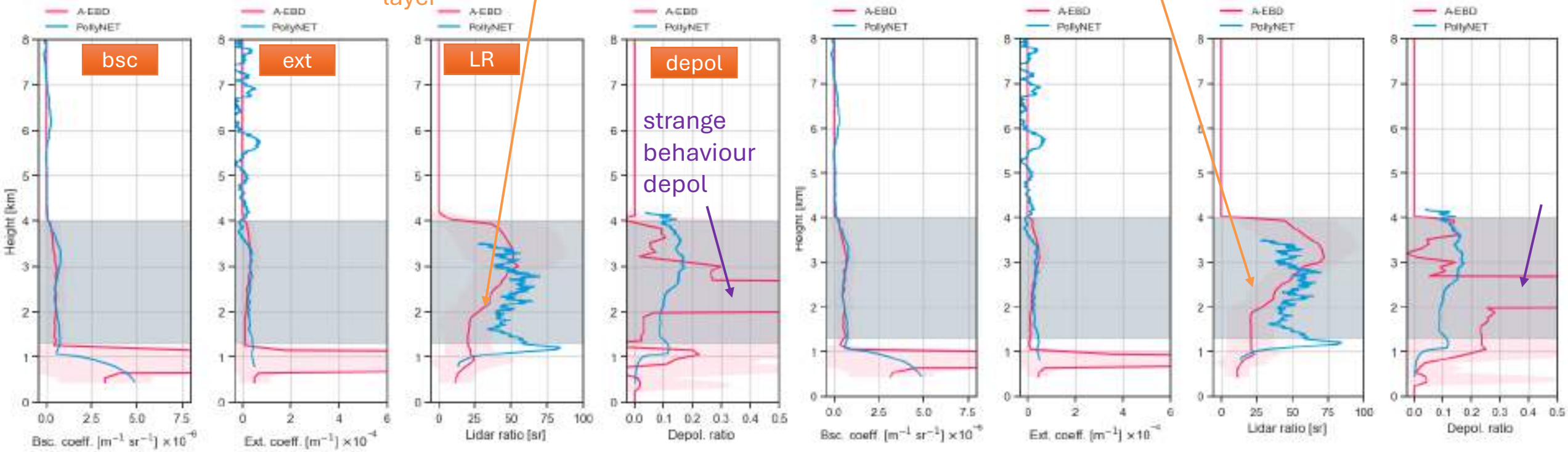
- good agreement dust layer backscatter + extinction
- strange behaviour depol
- step in lidar ratio within dust layer → the more pronounced the higher the resolution

→ obviously no pure daytime-nighttime-issues

59 km distance



Advantage: measurement of lidar ratio → ATLID too low in lower part of the dust layer



100 km

70 km

ATLID highest resolution averaged over radius around ground-site

TROPOS

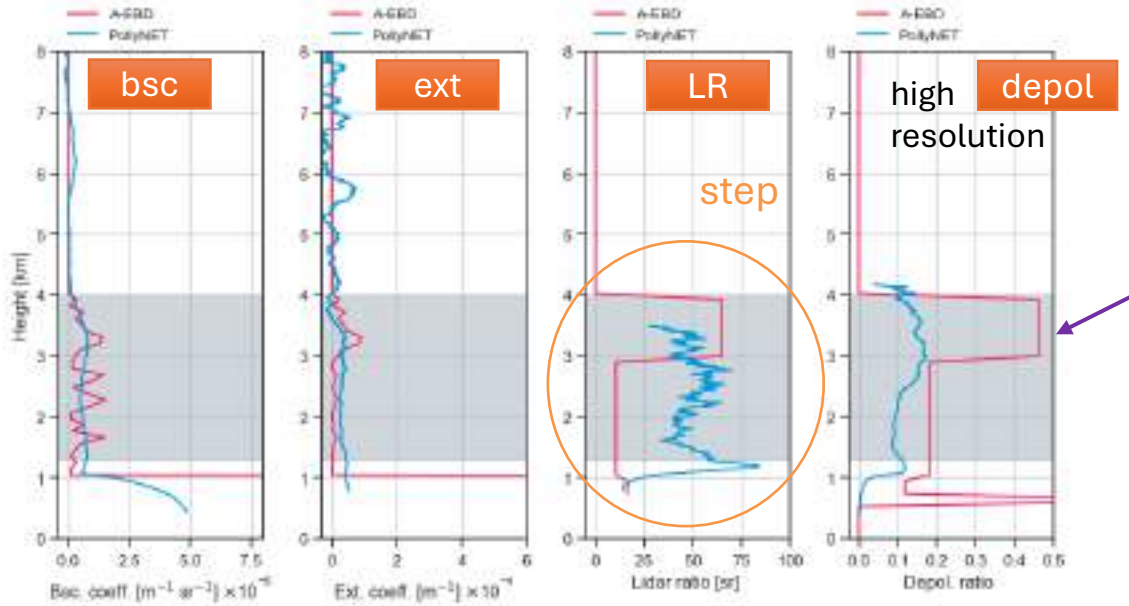
10 Oct 2024

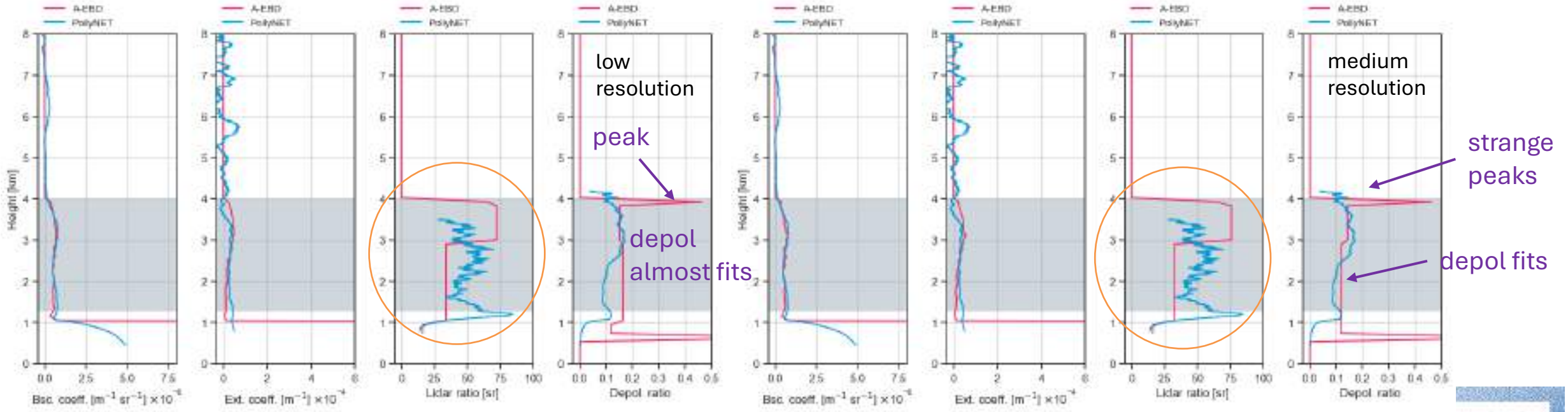
ATLID A-EBD

Baseline AC

Frame 02088A

59 km distance





only closest ATLID profile

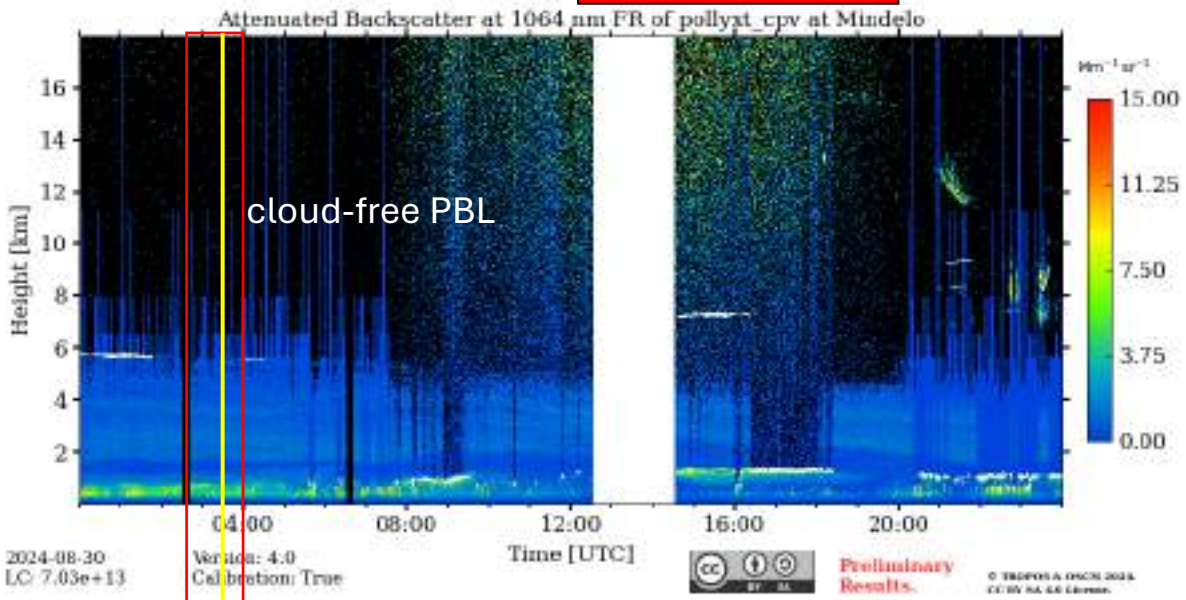
TROPOS

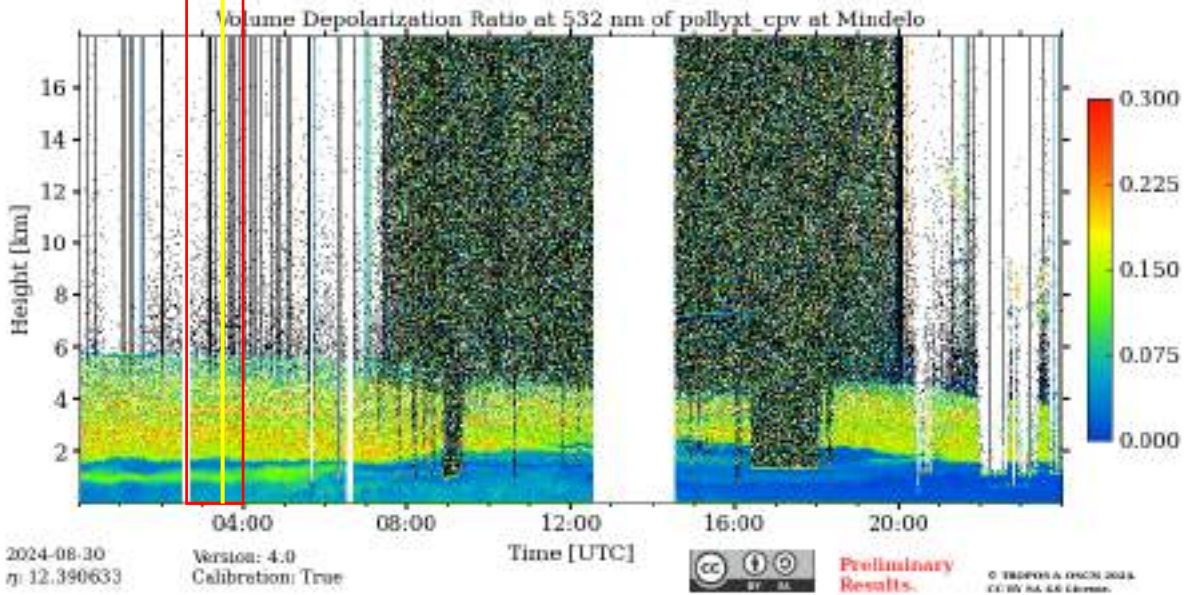
30 Aug 2024

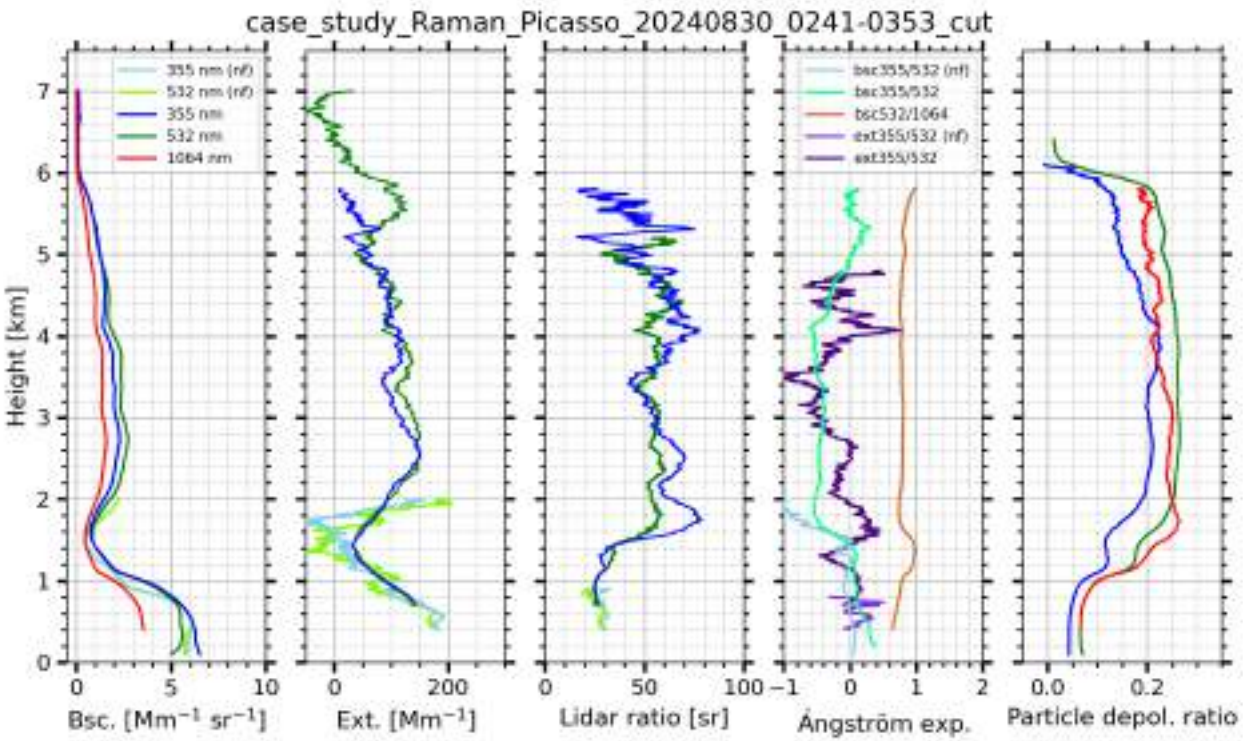
EarthCARE overpass 03:30 UTC

Raman Picasso 02:41-03:53 UTC

Polly^{XT}







TROPOS

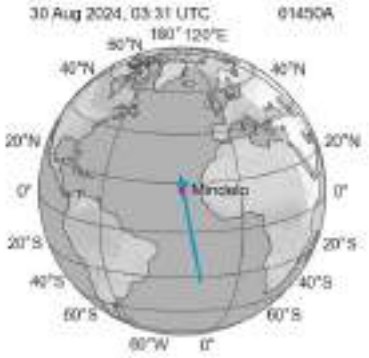
30 Aug 2024

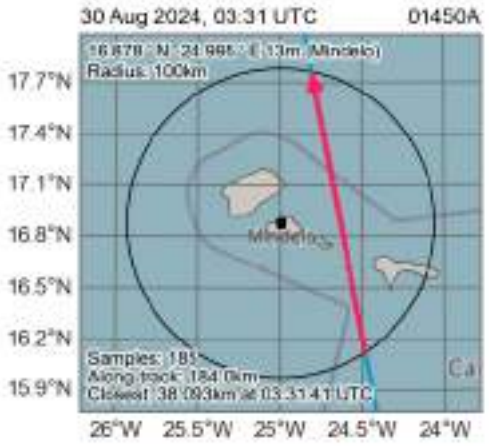
ATLID A-EBD

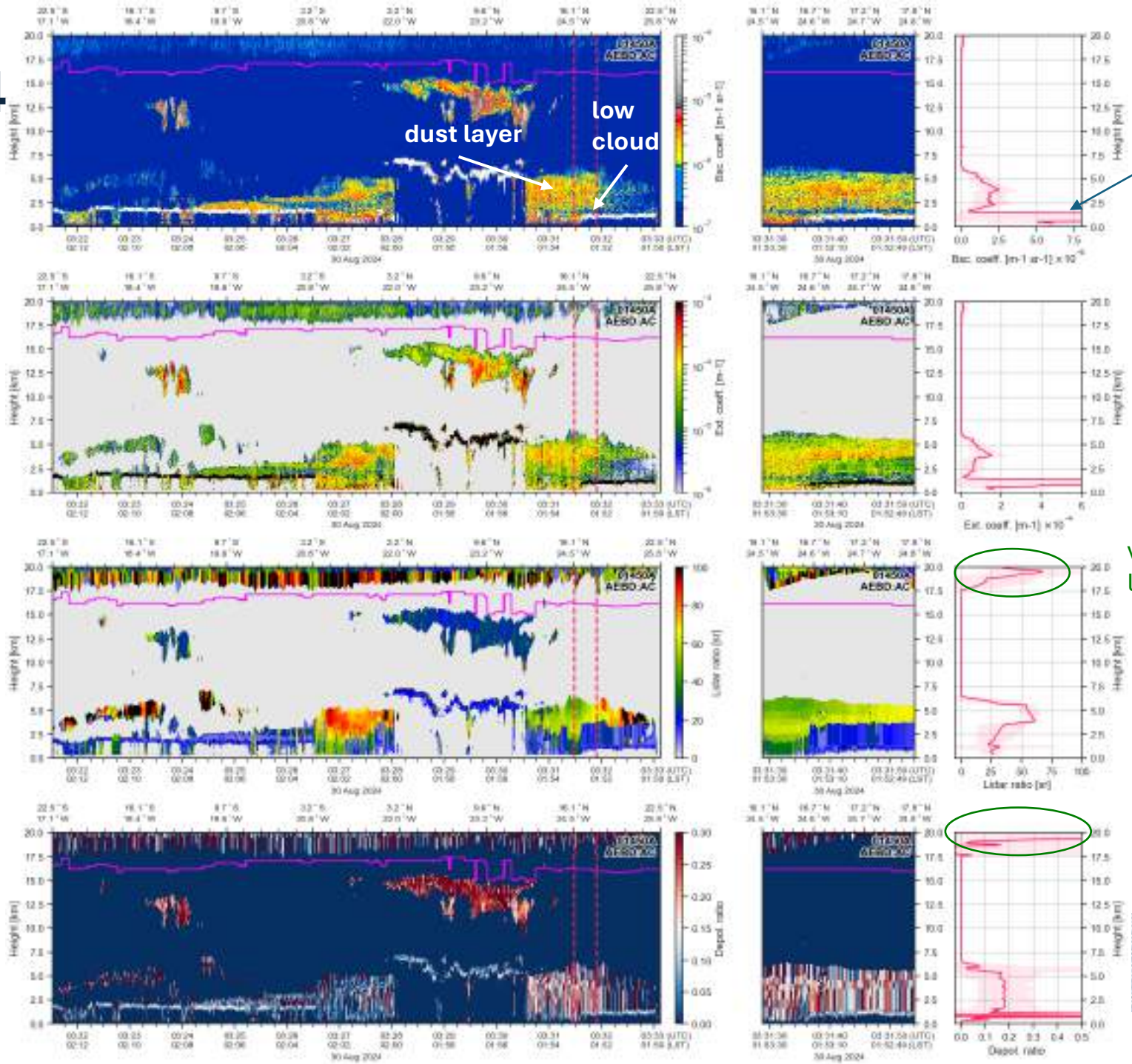
Baseline AC

Frame 01450A

100 km radius
38 km distance







edge of low cloud,
(also for smaller radii + closest profiles due to distance between EarthCARE + Mindelo)

volcanic layer?

TROPOS

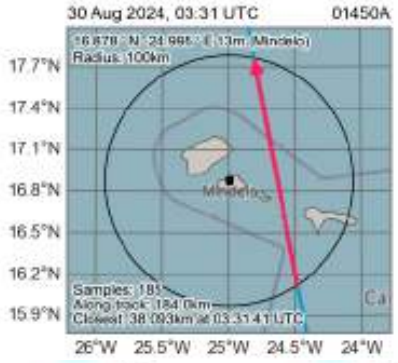
30 Aug 2024

ATLID A-EBD

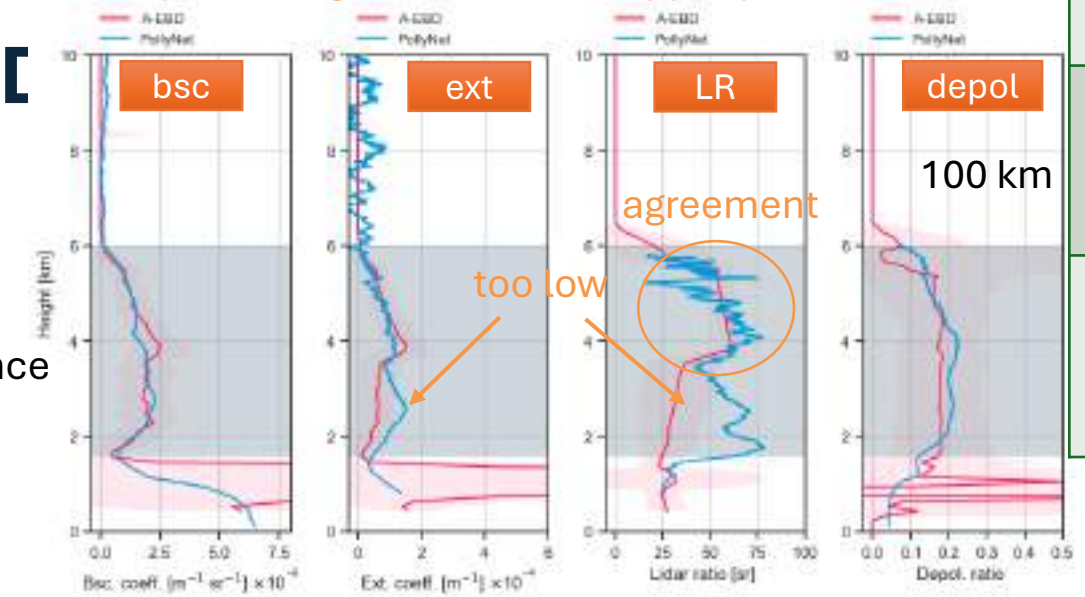
Baseline AC

Frame 01450A

- depol mainly fits, but a little bit too low
- extinction & lidar ratio too low in lower part of the dust layer, but agreement in the upper part



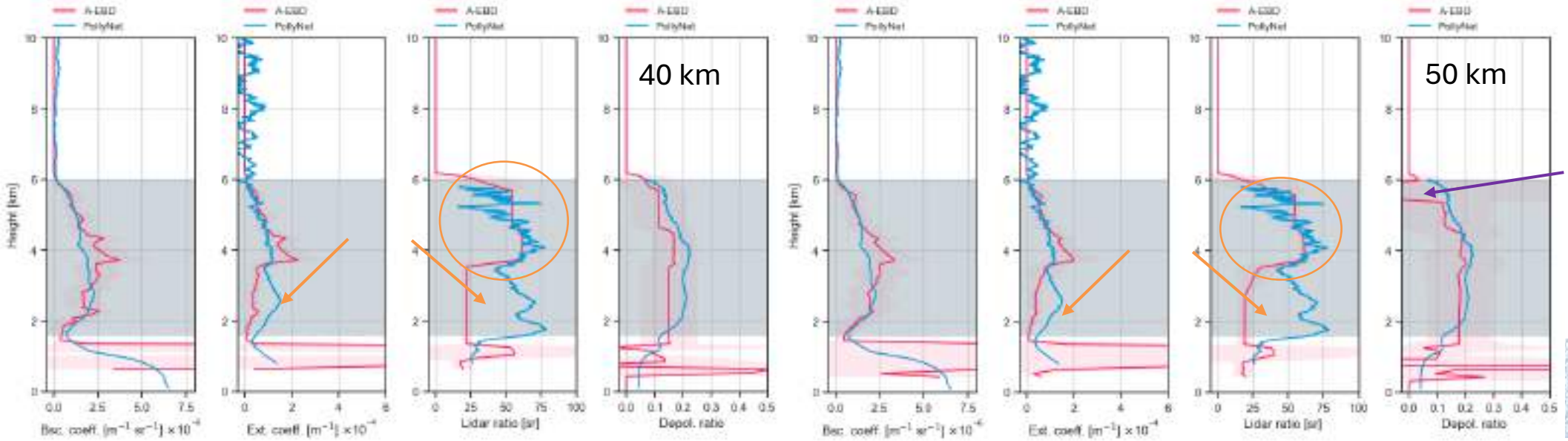
38 km distance



root mean square error & mean difference for the dust layer (Polly minus ATLID)

1.6 – 6 km		40 km	50 km	100 km
RMSE	Bsc Ext LR depol	0.58 $Mm^{-1}sr^{-1}$ 58 Mm^{-1} 29 sr 0.044	0.51 $Mm^{-1}sr^{-1}$ 56 Mm^{-1} 29 sr 0.084	0.3 $Mm^{-1}sr^{-1}$ 41 Mm^{-1} 24 sr 0.037
Mean diff	Bsc Ext LR depol	-0.2 $Mm^{-1}sr^{-1}$ 15 Mm^{-1} 15 sr 0.041	-0.21 $Mm^{-1}sr^{-1}$ 14 Mm^{-1} 16 sr 0.046	-0.05 $Mm^{-1}sr^{-1}$ 15 Mm^{-1} 13 sr 0.021

- ATLID underestimates extinction & depol
- slightly overestimates backscatter
- better agreement for 100 km than for smaller radi



ATLID highest resolution averaged over radius around ground-site

30 Aug 2024

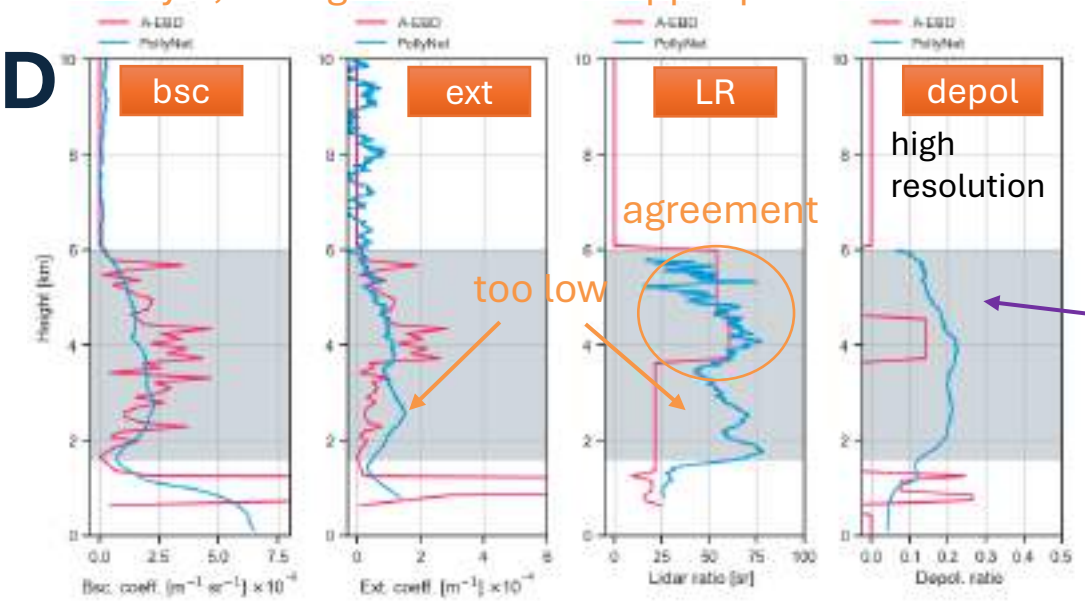
ATLID A-EBD

Baseline AC

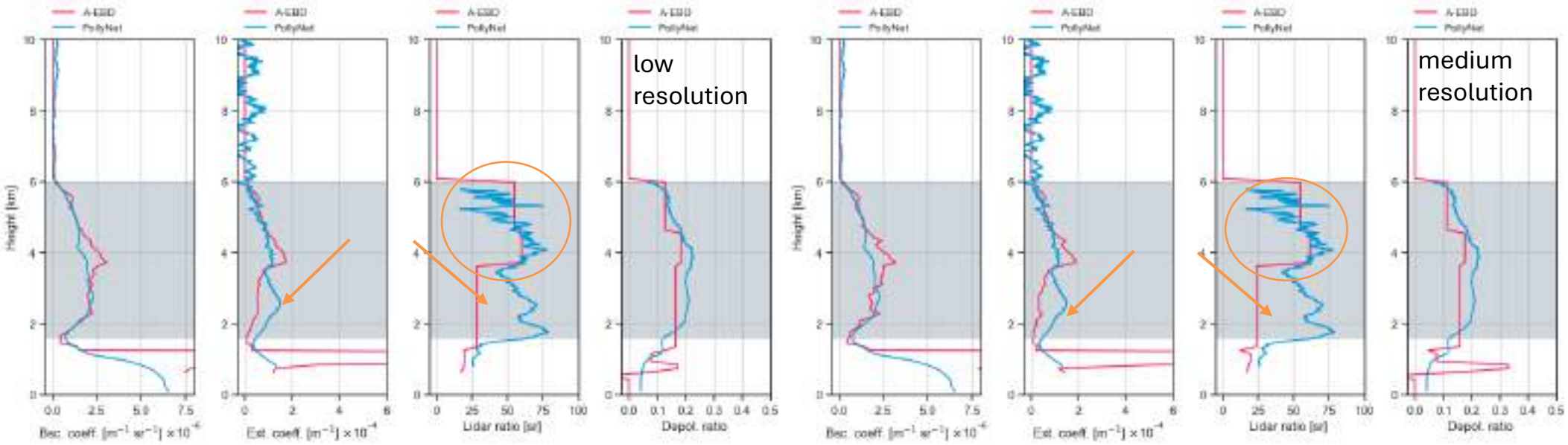
Frame 01450A

38 km distance

- depol mainly fits, but a little bit too low
- extinction & lidar ratio too low in lower part of the dust layer, but agreement in the upper part



strange behaviour depol → but averaged over radius nevertheless reasonable results



only closest ATLID profile

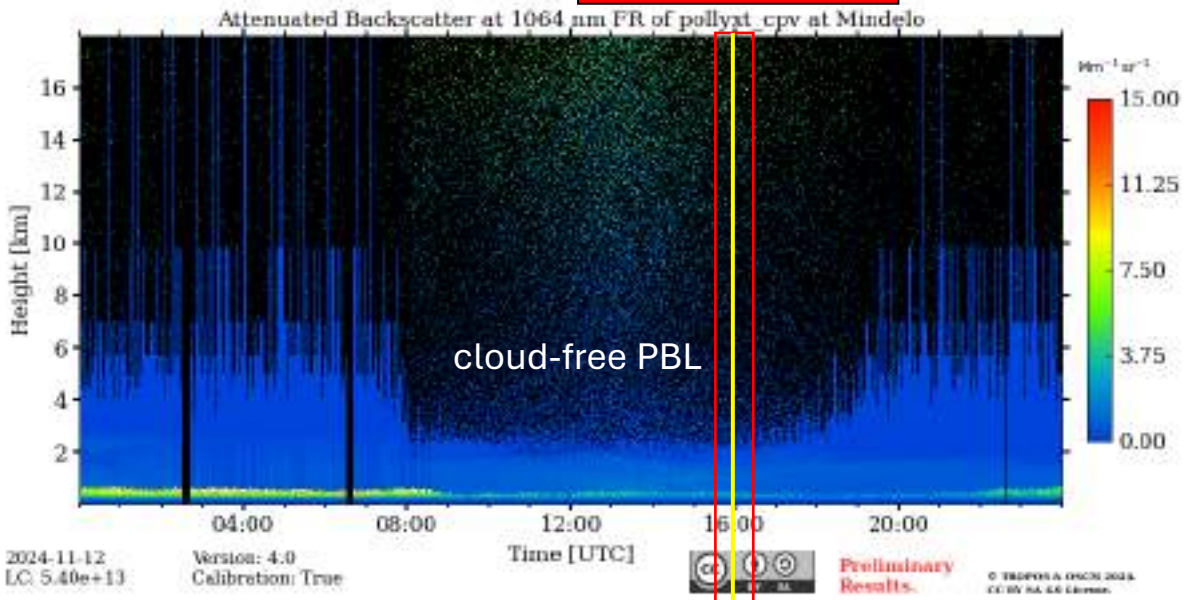
TROPOS

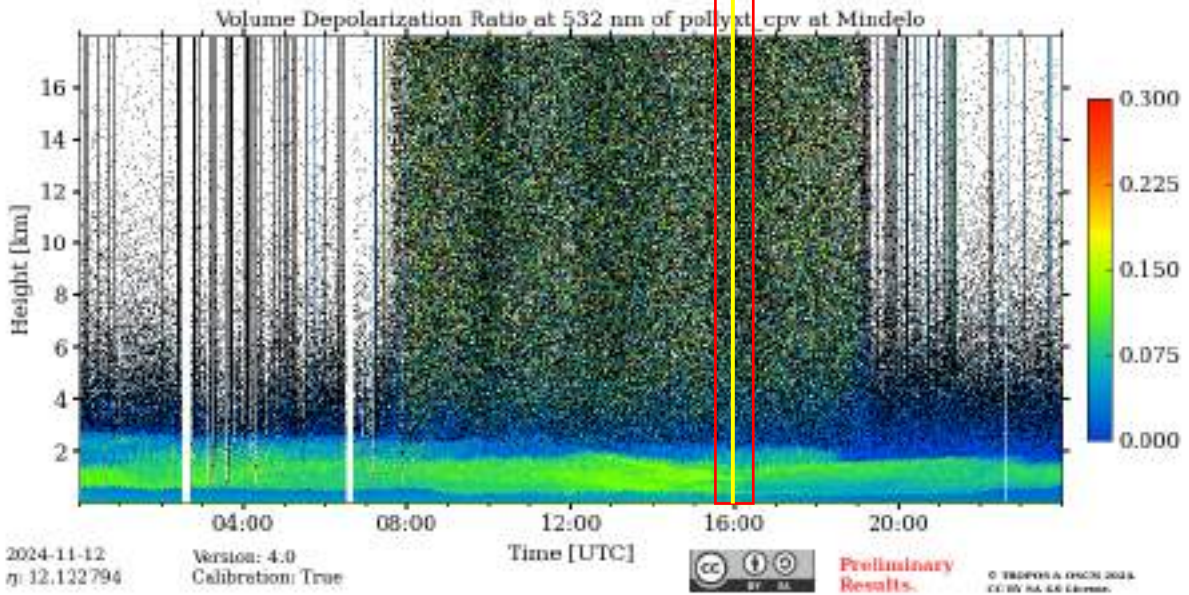
12 Nov 2024

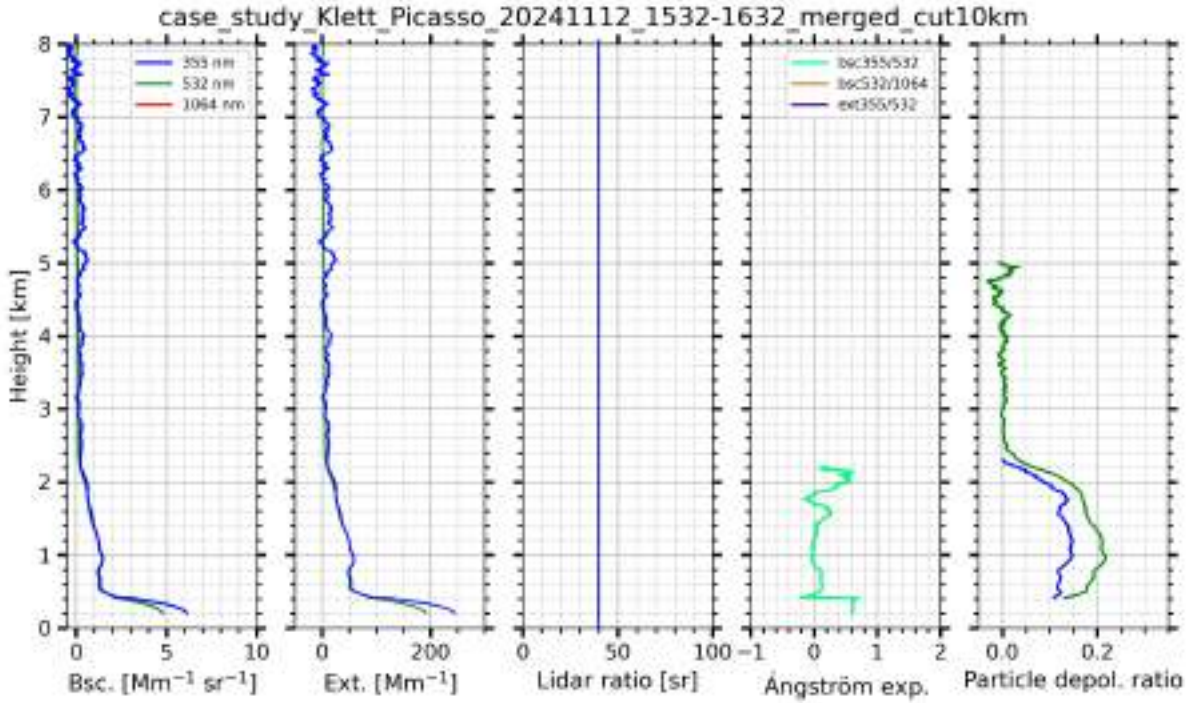
EarthCARE overpass 15:48 UTC

Klett Picasso 15:32-16:32 UTC

Polly^{XT}







TROPOS

PBL … planetary boundary layer

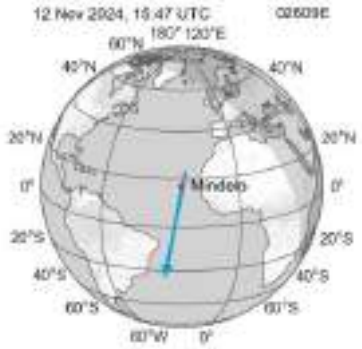
12 Nov 2024

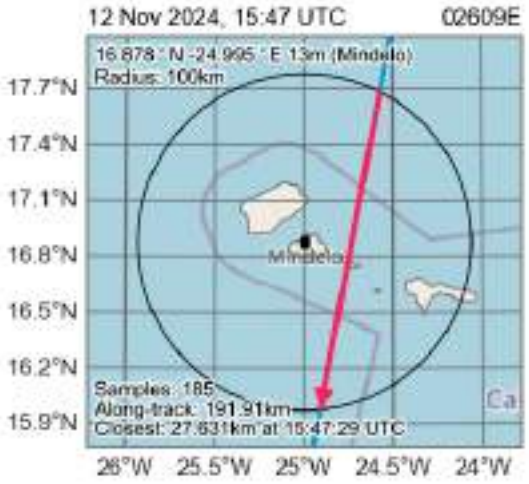
ATLID A-EBD

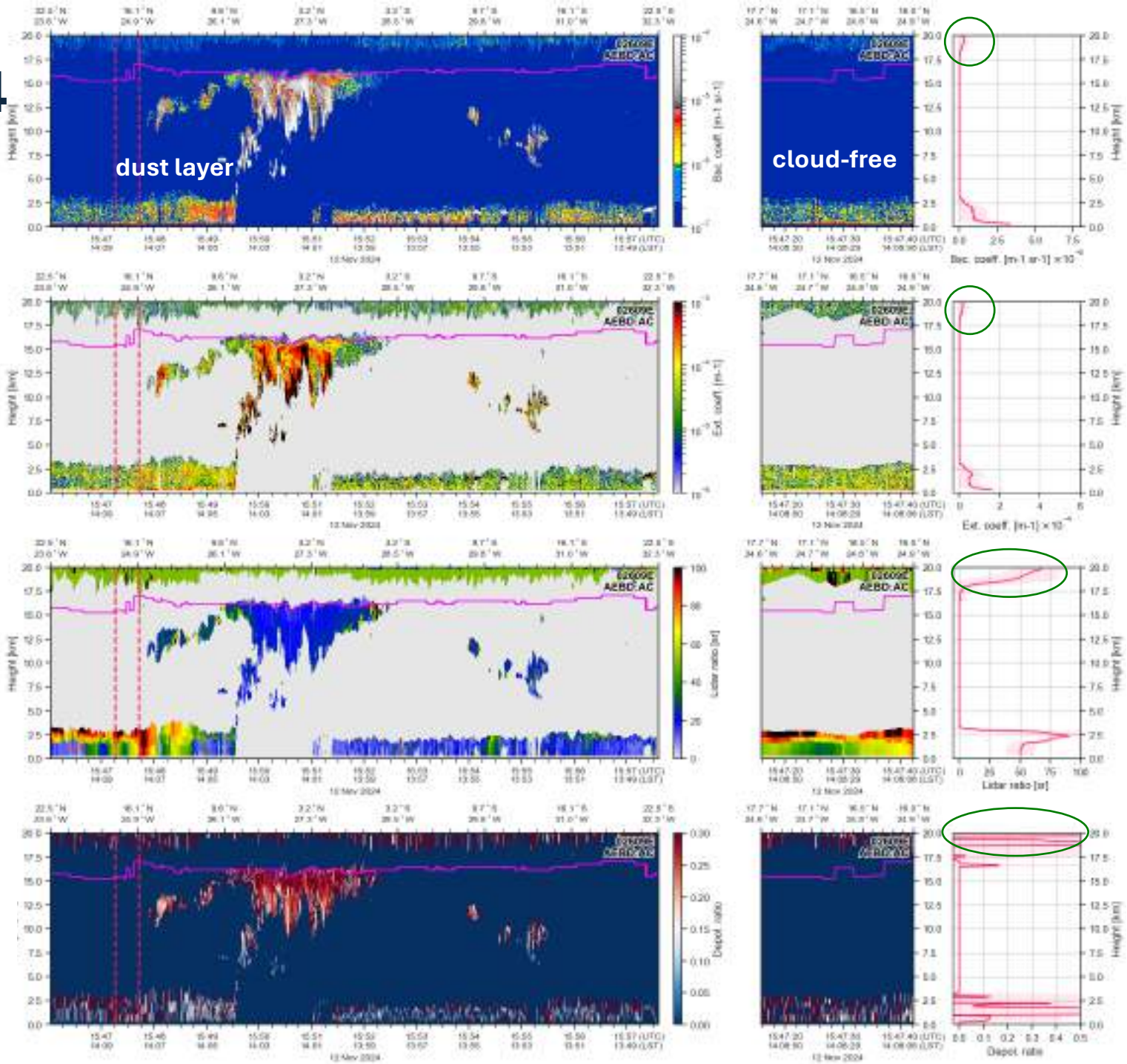
Baseline AC

Frame 02609E

100 km radius
28 km distance







volcanic layer?

TROPOS

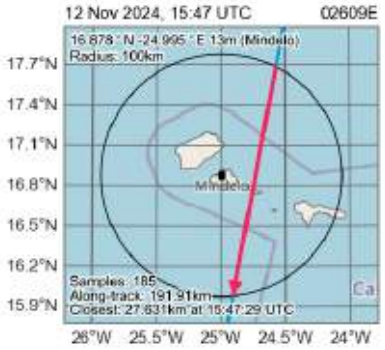
12 Nov 2024

- step in lidar ratio → more pronounced for smaller radii
- strange behaviour in the depol! …

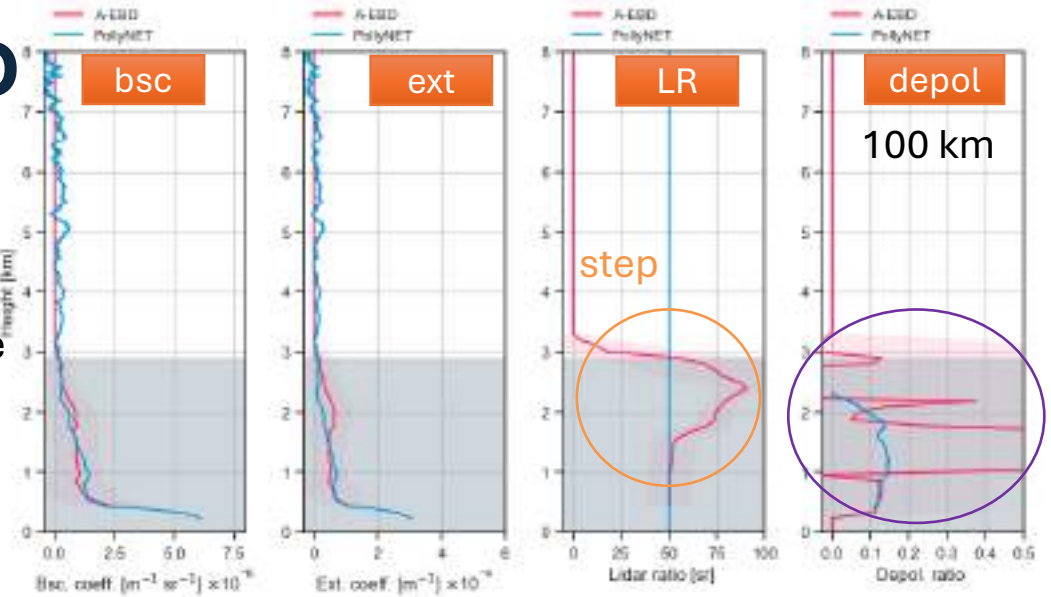
ATLID A-EBD

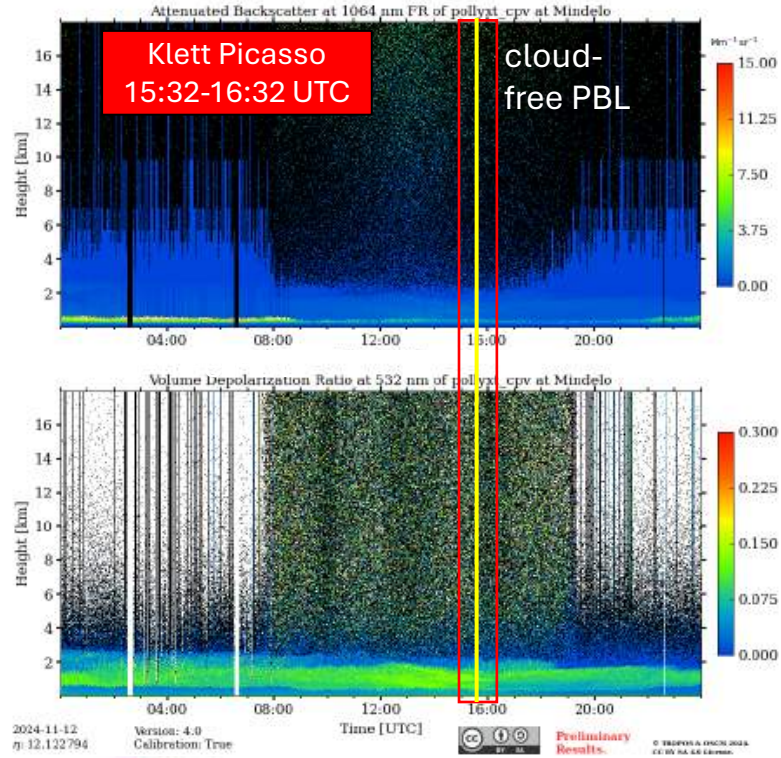
Baseline AC

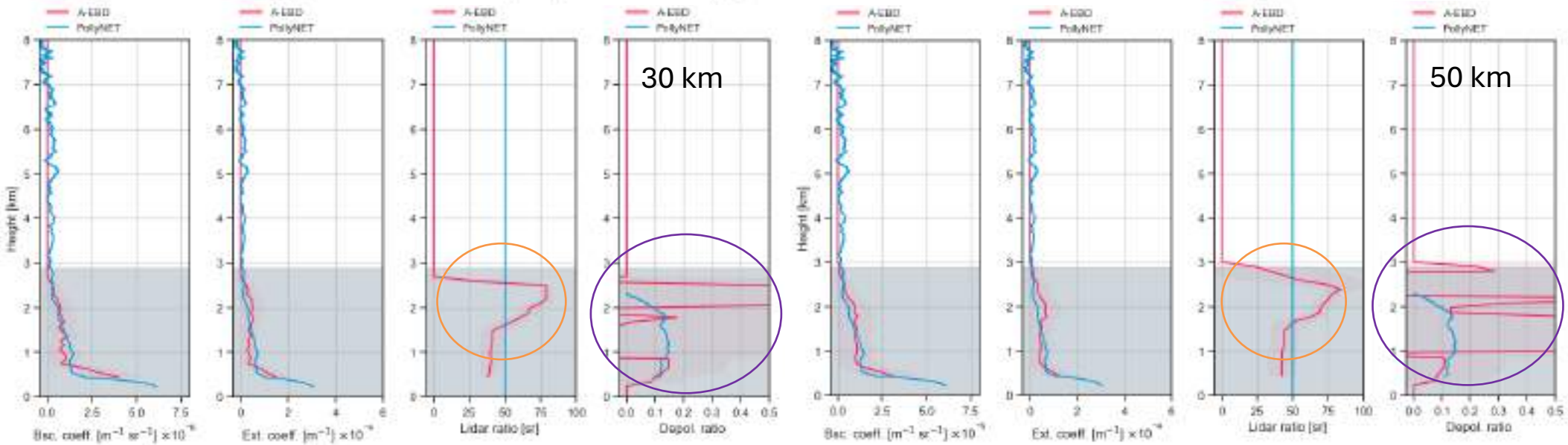
Frame 02609E



28 km distance







TROPOS

ATLID highest resolution averaged over radius around ground-site

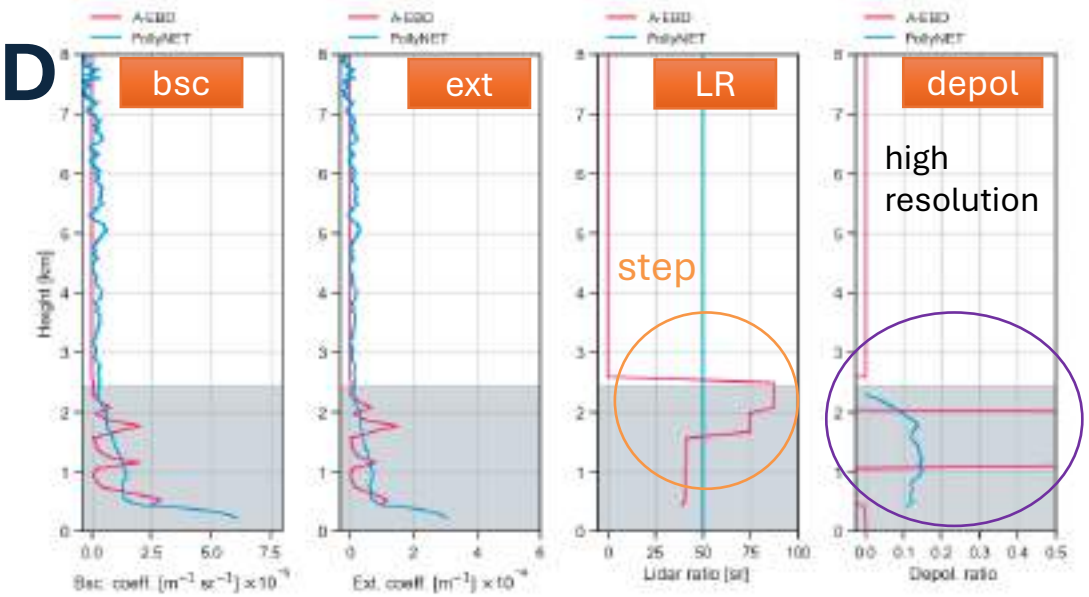
12 Nov 2024

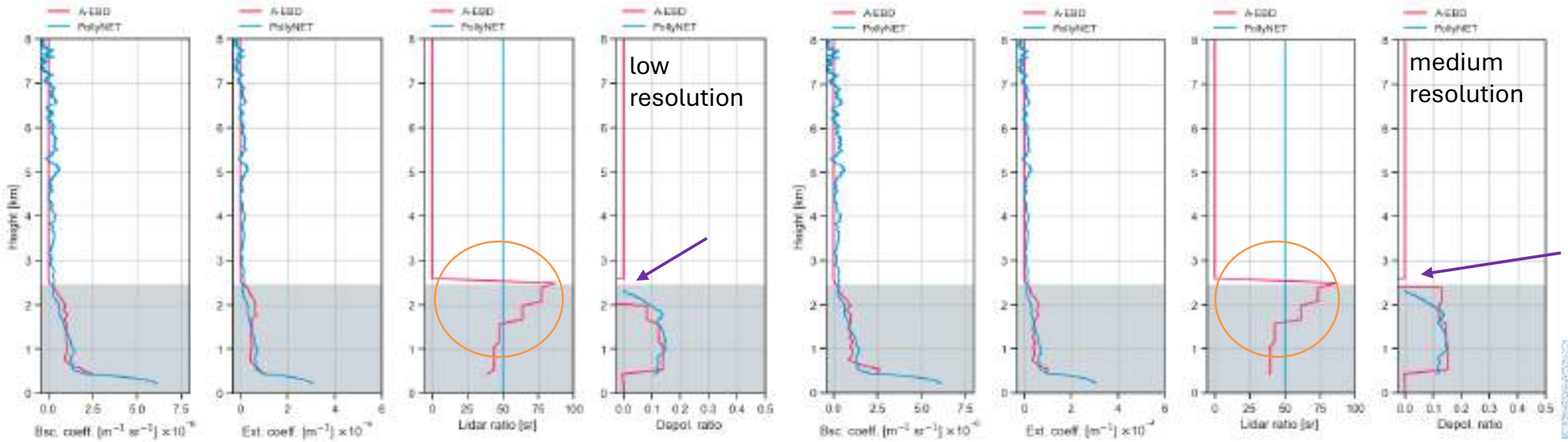
ATLID A-EBD

Baseline AC

Frame 02609E

28 km distance





- step in lidar ratio → more pronounced for higher resolution
- … also strange behaviour at highest resolution → low and medium resolution much more reasonable
- but negative at top of the dust layer

negative depol

only closest ATLID profile

TROPOS

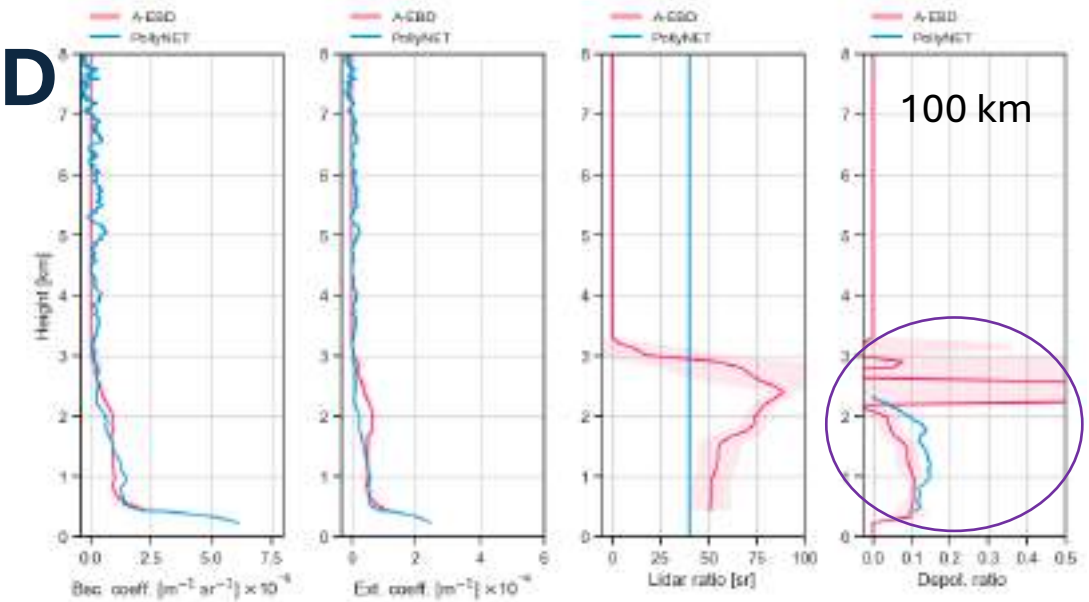
12 Nov 2024

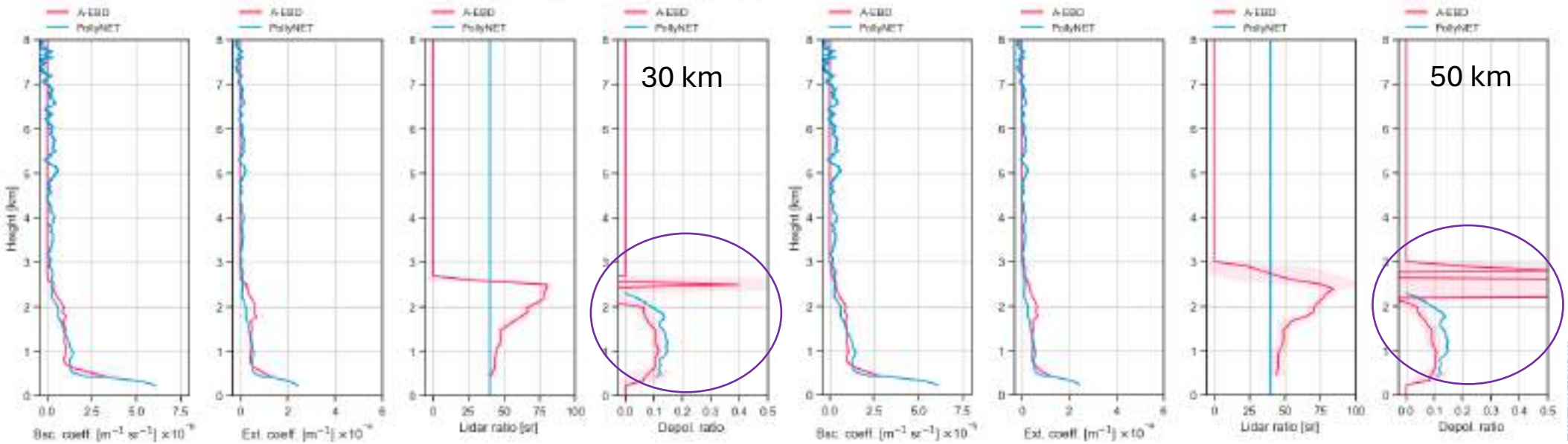
ATLID A-EBD

Baseline AC

Frame 02609E

28 km distance





➢ depol better for low and medium resolution

ATLID lowest resolution averaged over radius around ground-site

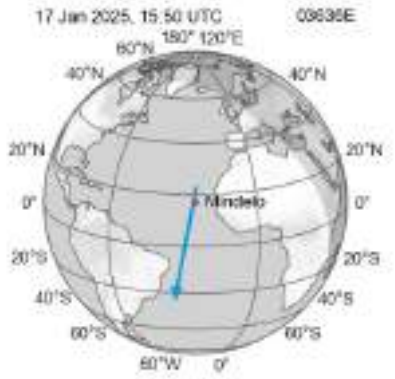
17 Jan 2025

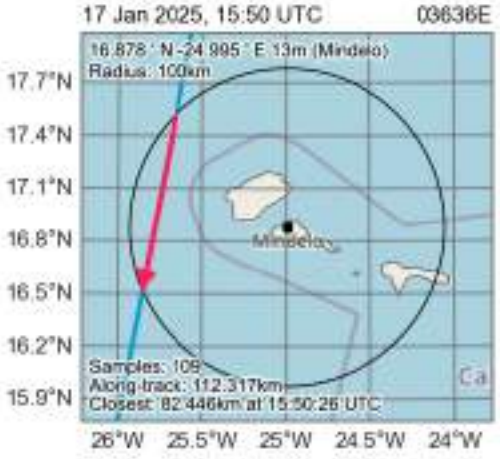
ATLID A-EBD

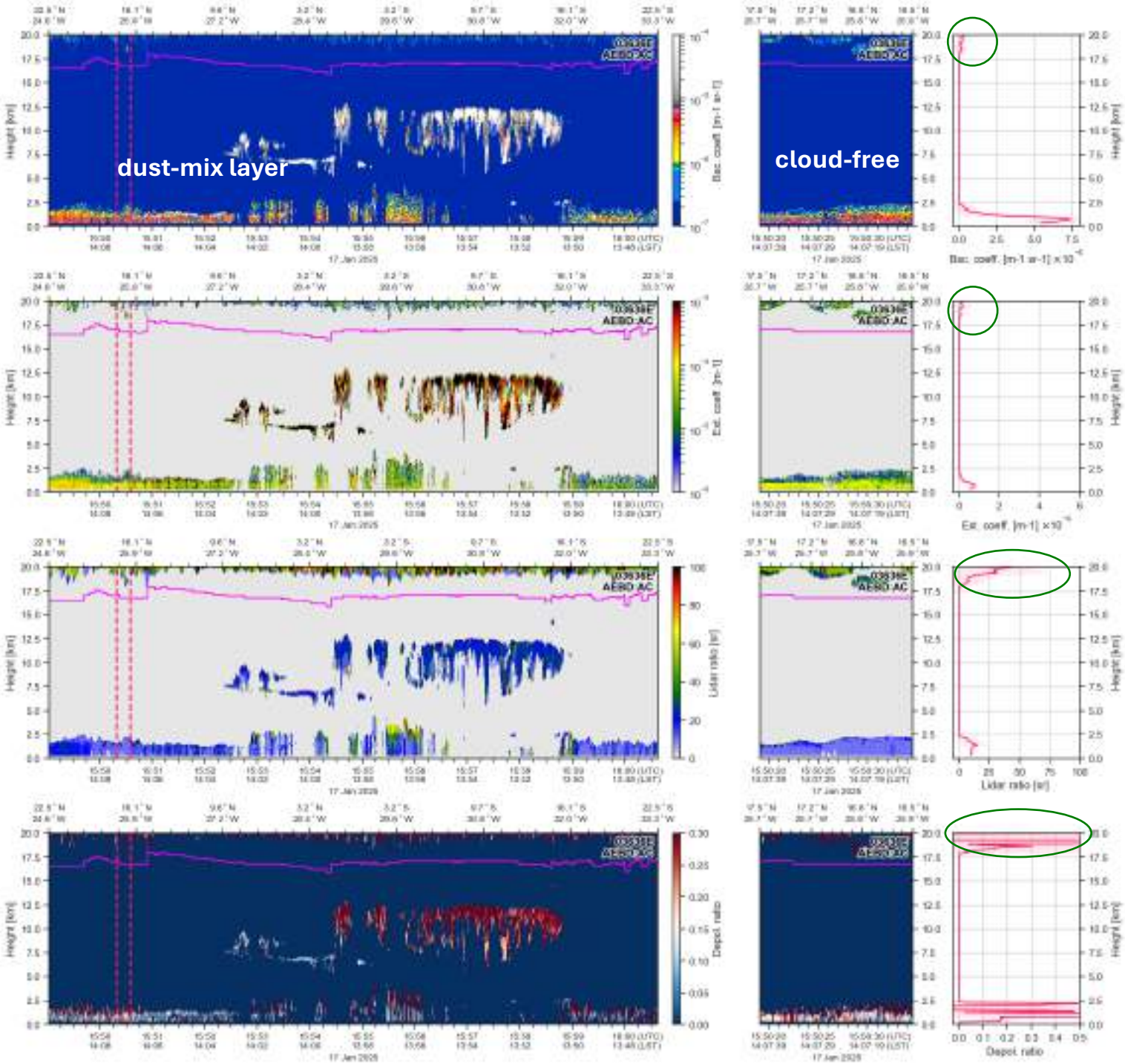
Baseline AC

Frame 03636E

100 km radius
82 km distance







volcanic layer?

TROPOS