Quasi retrieving method V2 (QV2)

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TROPOS
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Outline

- Methodology
- Evaluation
  - Cirrus (AE=0, COD~0.3)
  - Mixed-Phase Cloud (AE=0, COD>1.2)
  - Dust (AE=0)
  - Pollution (AE=2)
- Error analysis
- Implementation

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QV2

Elastic signal:

$$P(\lambda_0, z) = \frac{C_0 P_0 O_0(z)}{z^2}\left[\beta_p(\lambda_0, z) + \beta_m(\lambda_0, z)\right] \exp\left\{-2\int_0^z \left[\alpha_p(\lambda_0, z') + \alpha_m(\lambda_0, z')\right] \mathrm{d}z'\right\}$$

Raman signal:

$$P(\lambda_R, z) = \frac{C_R P_0 O_R(z)}{z^2} N(z) \frac{\mathrm{d}\sigma_R(\pi)}{\mathrm{d}\Omega} \exp\left\{-\int_0^z \left[\alpha_p(\lambda_0, z') + \alpha_p(\lambda_R, z') + \alpha_m(\lambda_0, z') + \alpha_m(\lambda_R, z')\right] \mathrm{d}z'\right\}$$

$$C_R P_0 N(z) * \frac{\mathrm{d}\sigma_R(\pi)}{\mathrm{d}\Omega} = C_R^* P_0 N(z) * \frac{\mathrm{d}\sigma_0(\pi)}{\mathrm{d}\Omega}$$
$$= C_R^* P_0 * \beta_m(\lambda_0, z)$$

$C_R^* P_0$ can be obtained from polly processing program

$$P(\lambda_R, z) = \frac{C_R^* P_0 O_R(z)}{z^2} \beta_m(\lambda_0, z) \exp\left\{-\int_0^z \left[\alpha_p(\lambda_0, z') + \alpha_p(\lambda_R, z') + \alpha_m(\lambda_0, z') + \alpha_m(\lambda_R, z')\right] \mathrm{d}z'\right\}$$

aerosol backscatter coeff.

$$\beta_p(\lambda_0, z) = \left\{\frac{P(\lambda_0, z) z^2}{P(\lambda_R, z) z^2} * \frac{C_R^* P_0}{C_0 P_0} * \exp\left\{\left[1 - \left(\frac{\lambda_0}{\lambda_R}\right)^{\text{Å}_p}\right]\int_0^z \alpha_p(\lambda_0, z')\mathrm{d}z' + \left[1 - \left(\frac{\lambda_0}{\lambda_R}\right)^4\right]\int_0^z \alpha_m(\lambda_0, z')\mathrm{d}z'\right\} - 1\right\}\beta_m(\lambda_0, z)$$

Measurements | Well-known | Assumption

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QV2 vs QV1 (H.Baars et al, AMT, 2017)

QV2: Angstroem exponent is the main contributor for bias (Å~0, no bias)

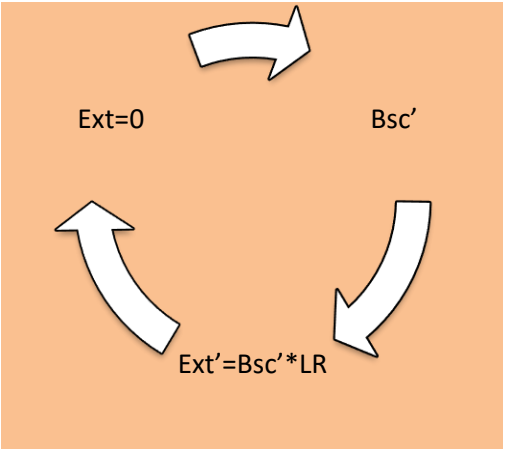
Low SNR at daytime and Far-Range

$$\beta_p(\lambda_0,z)=\left\{\frac{\boldsymbol{P(\lambda_0,z)z^2}}{\boldsymbol{P(\lambda_R,z)z^2}}*\frac{\boldsymbol{C_R^*P_0}}{\boldsymbol{C_0P_0}}*\exp\left\{\left[1-\left(\frac{\lambda_0}{\lambda_R}\right)^{Å_p}\right]\int_0^z\alpha_p(\lambda_0,z')\mathrm{d}z'+\left[1-\left(\frac{\lambda_0}{\lambda_R}\right)^4\right]\int_0^z\alpha_m(\lambda_0,z')\mathrm{d}z'\right\}-1\right\}\beta_m(\lambda_0,z)$$

QV1: AOD is the main contributor for bias (AOD > 0.2, relative bias > 20%)

$$\beta_p(\lambda_0,z)=\frac{\boldsymbol{P(\lambda_0,z)z^2}}{\boldsymbol{O_0(z)C_0P_0}}\exp\left\{2\int_0^z\alpha_p(\lambda_0,z')\mathrm{d}z'+2\int_0^z\alpha_m(\lambda_0,z')\mathrm{d}z'\right\}-\beta_m(\lambda_0,z)$$

QV2 has no influence from laser energy fluctuation and overlap



Ext iterations

Formula for 1064 nm

$$\beta_{par}^{1064}(R)+\beta_{mol}^{1064}(R)=C^*\frac{P^{1064}(R)N_{mol}^{387}(R)}{P^{387}(R)}\frac{\exp\left(2\left(\frac{355}{1064}\right)^{Å}\int_{R_0}^{R}\left[\alpha_{par}^{355}(r)\right]dr\right)}{\exp\left(\left(1+\left(\frac{355}{387}\right)^{Å}\right)\int_{R_0}^{R}\left[\alpha_{par}^{355}(r)\right]dr\right)}\frac{\exp\left(2\int_{R_0}^{R}\left[\alpha_{mol}^{1064}(r)\right]dr\right)}{\exp\left(\int_{R_0}^{R}\left[\alpha_{mol}^{387}(r)\right]dr\right)\exp\left(\int_{R_0}^{R}\left[\alpha_{mol}^{355}(r)\right]dr\right)}$$

(from H. Baars)

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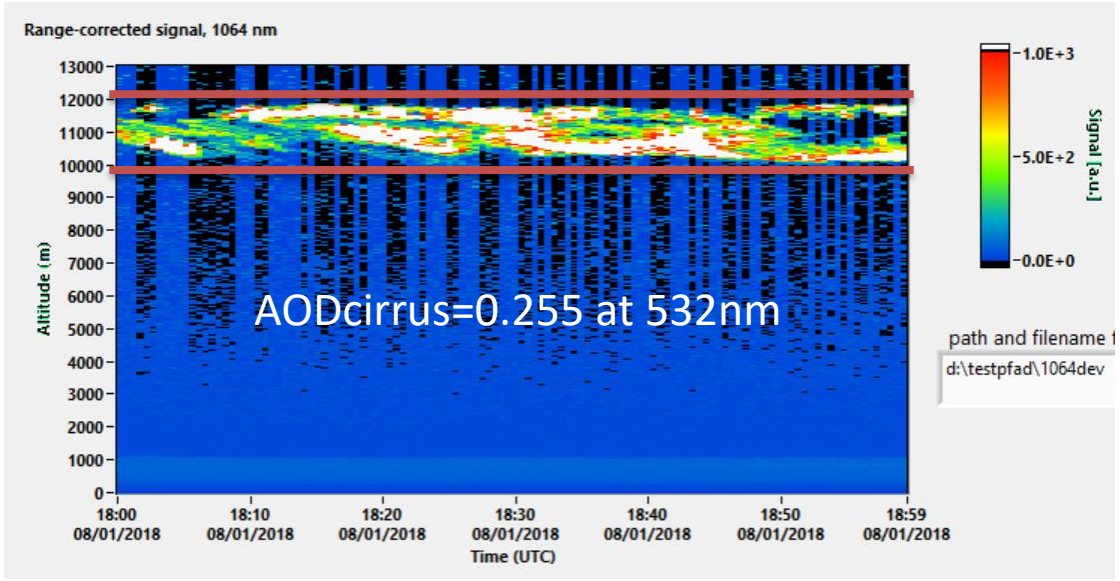
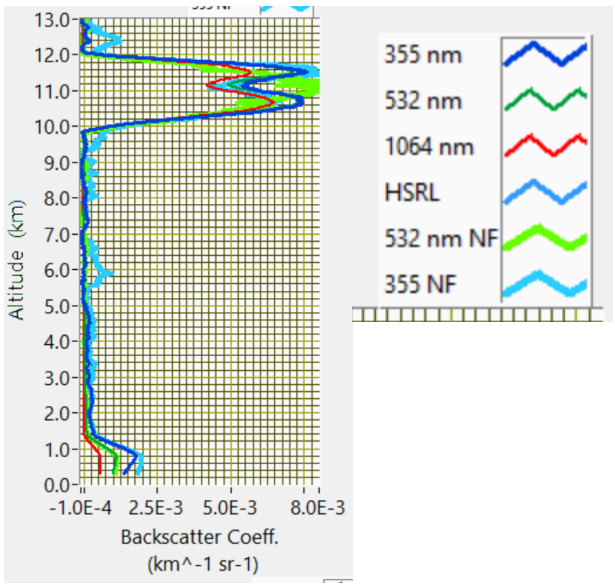
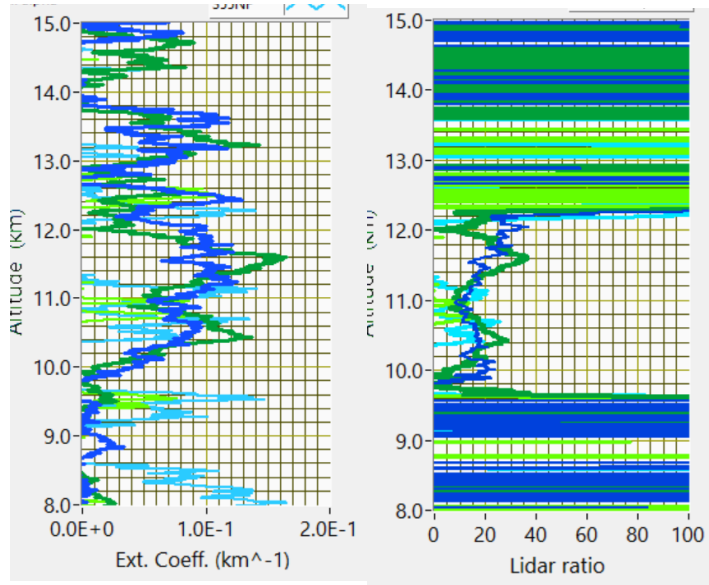
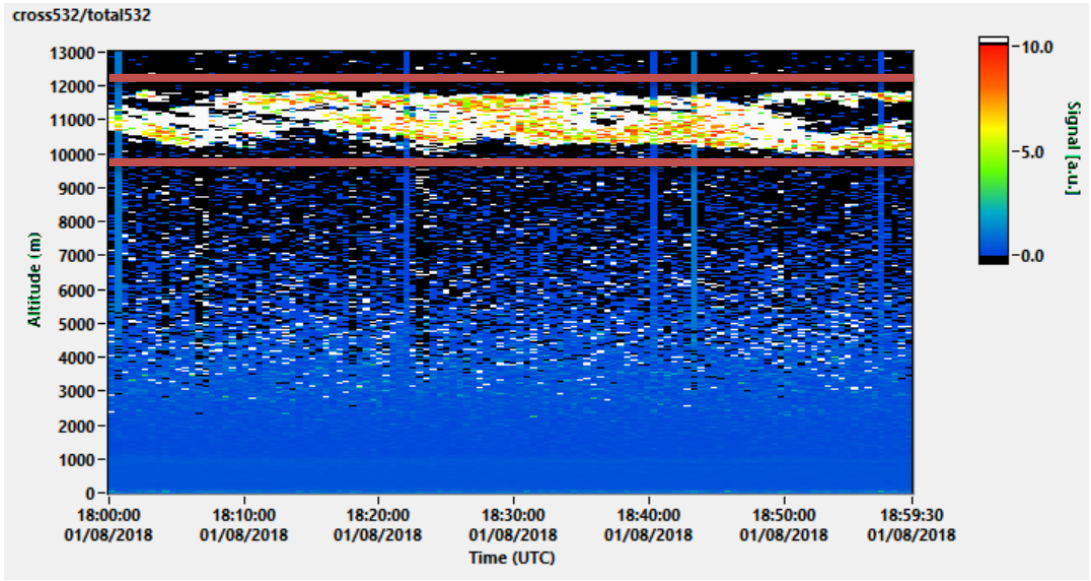
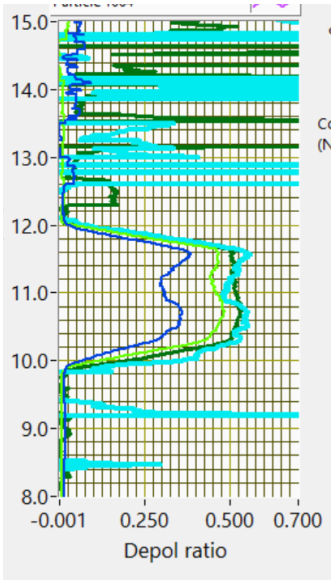
Evaluations: Cirrus











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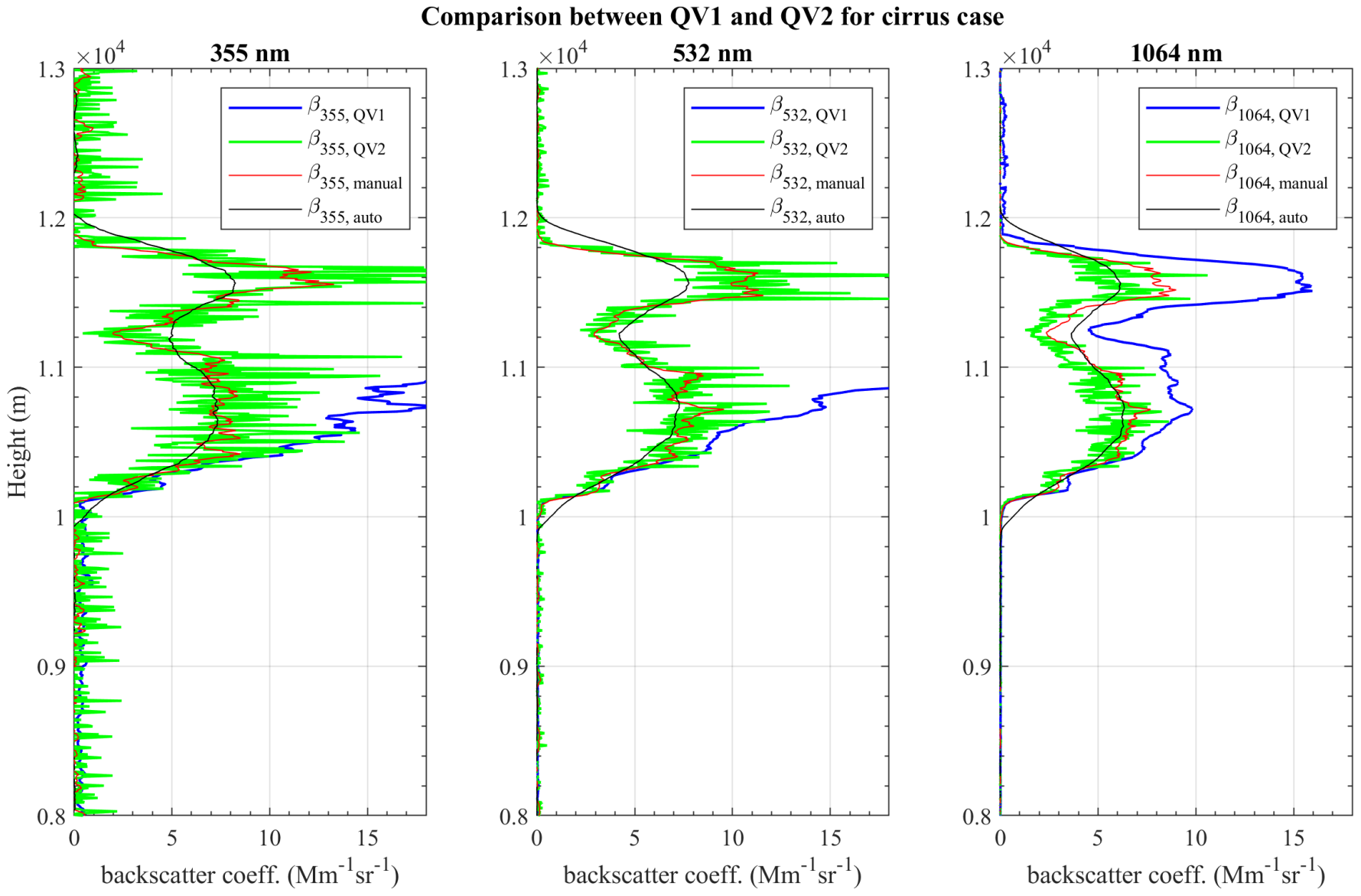
Evaluations: Cirrus



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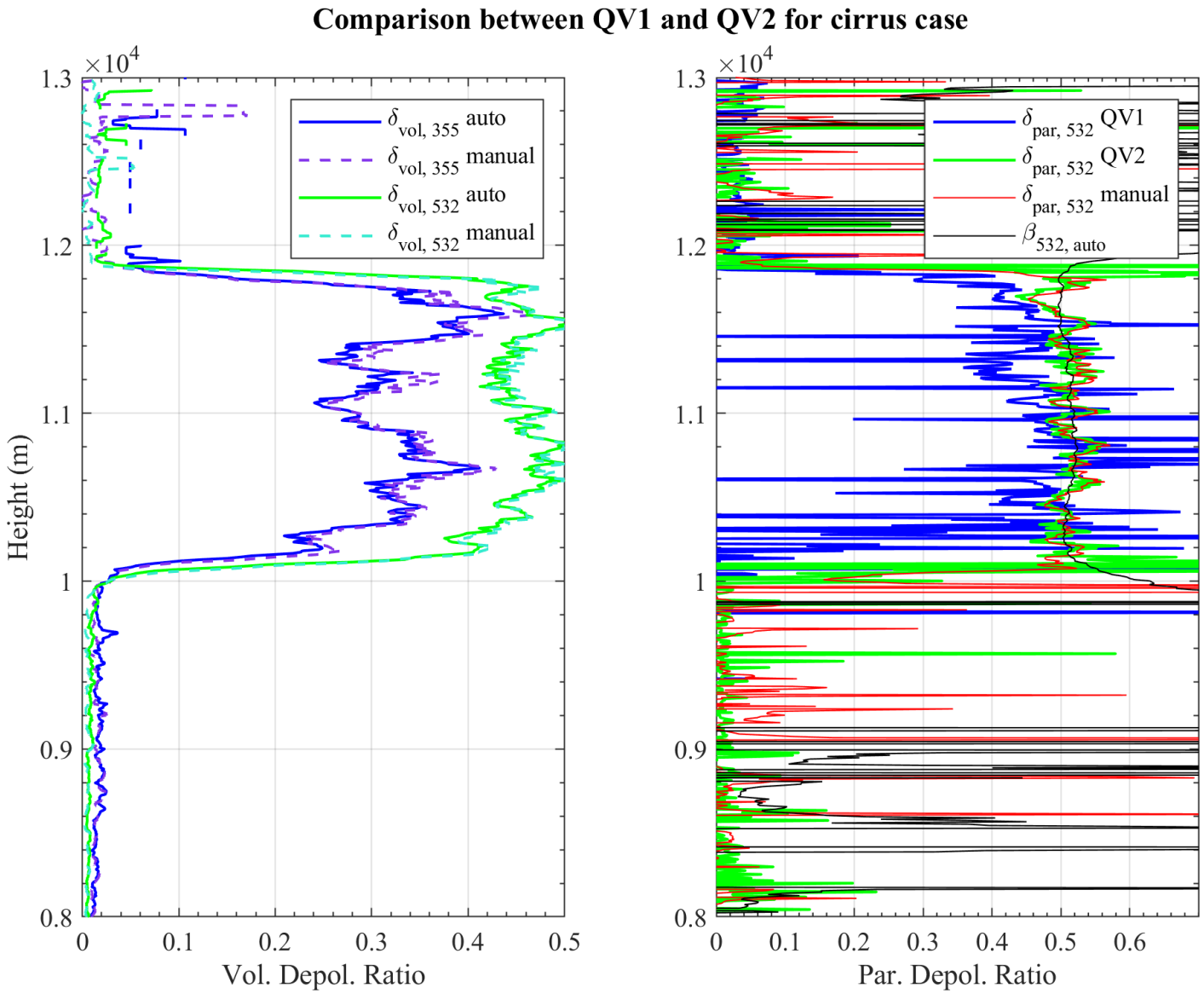
Evaluations: Cirrus



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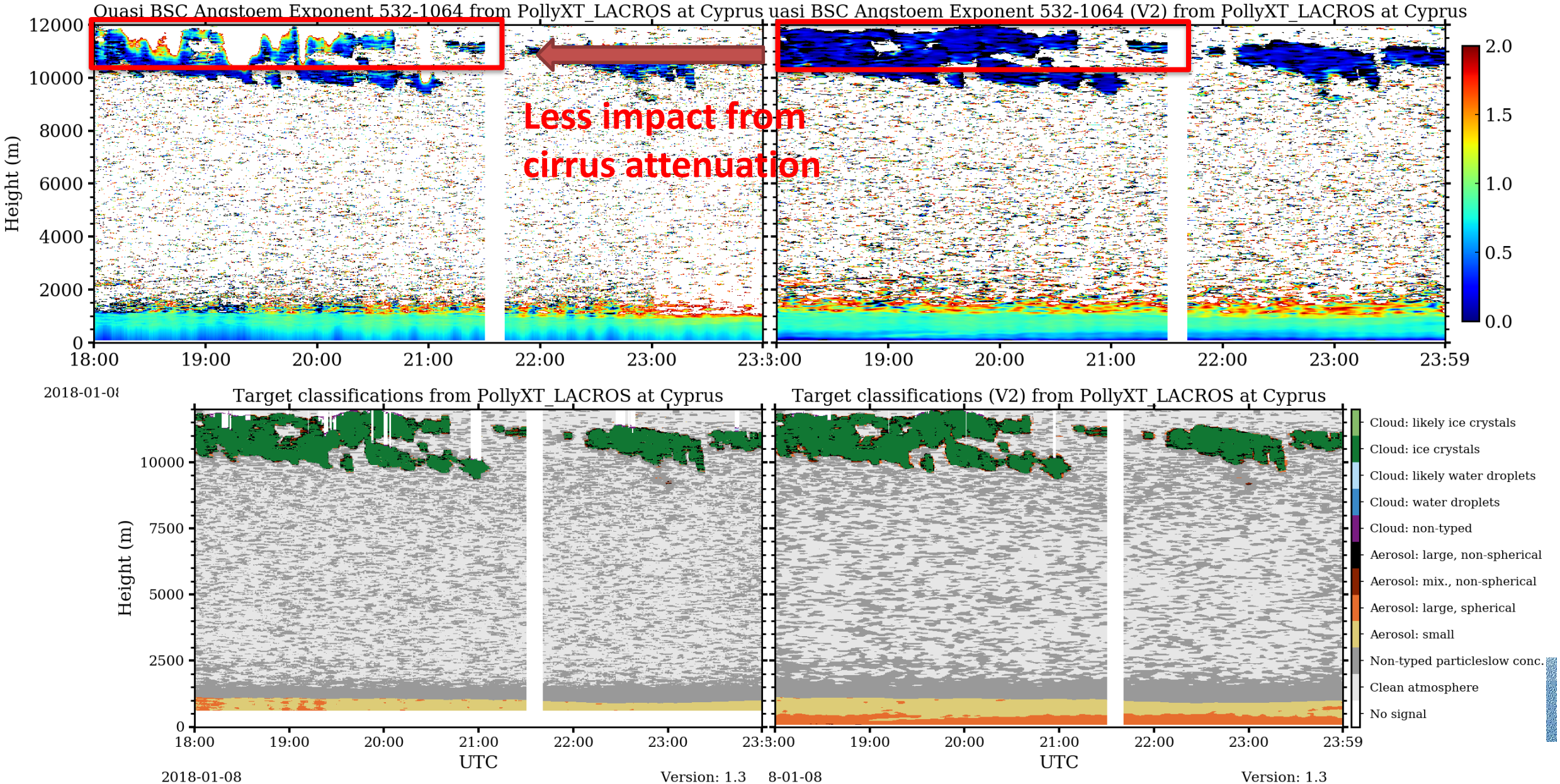
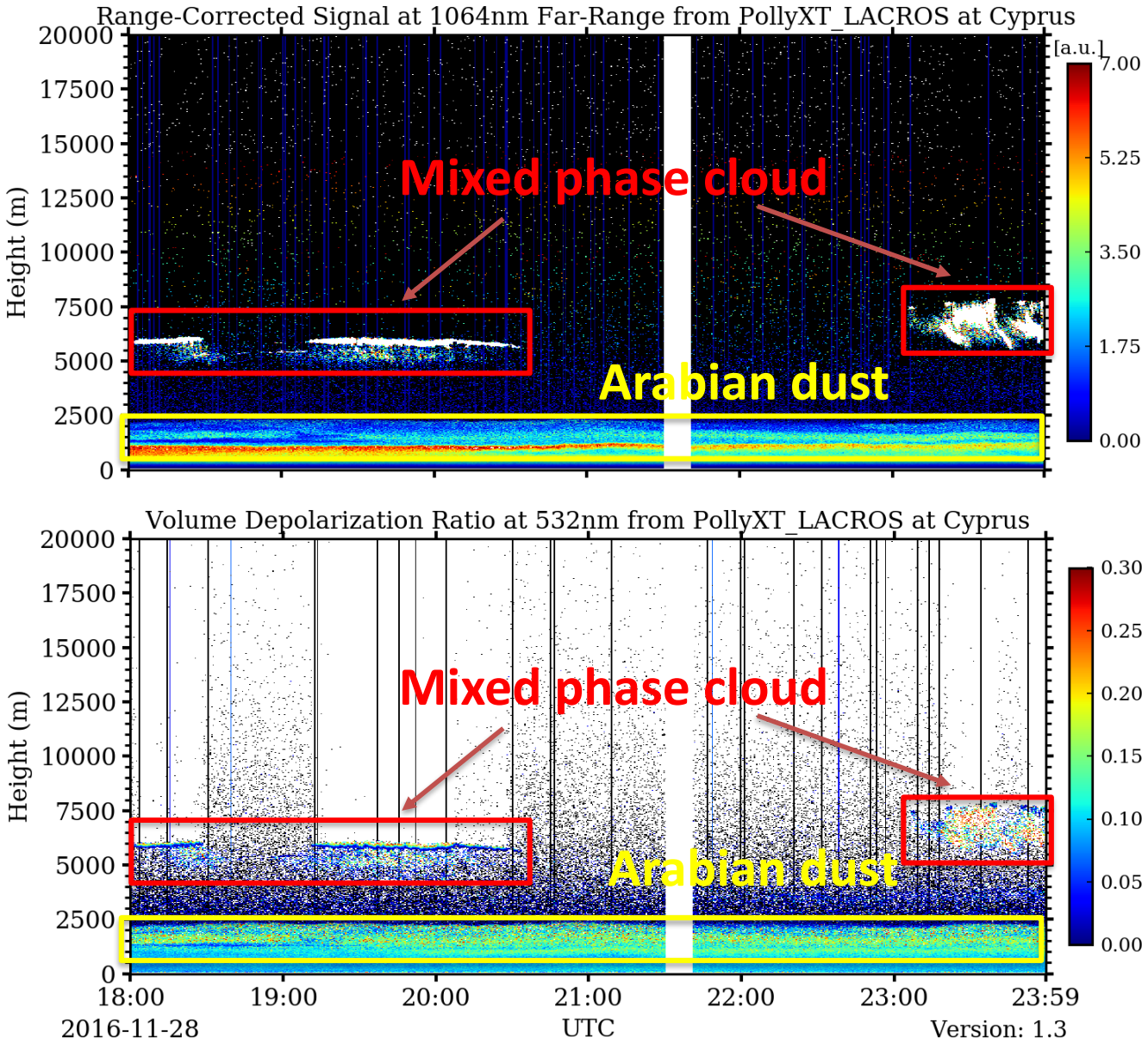
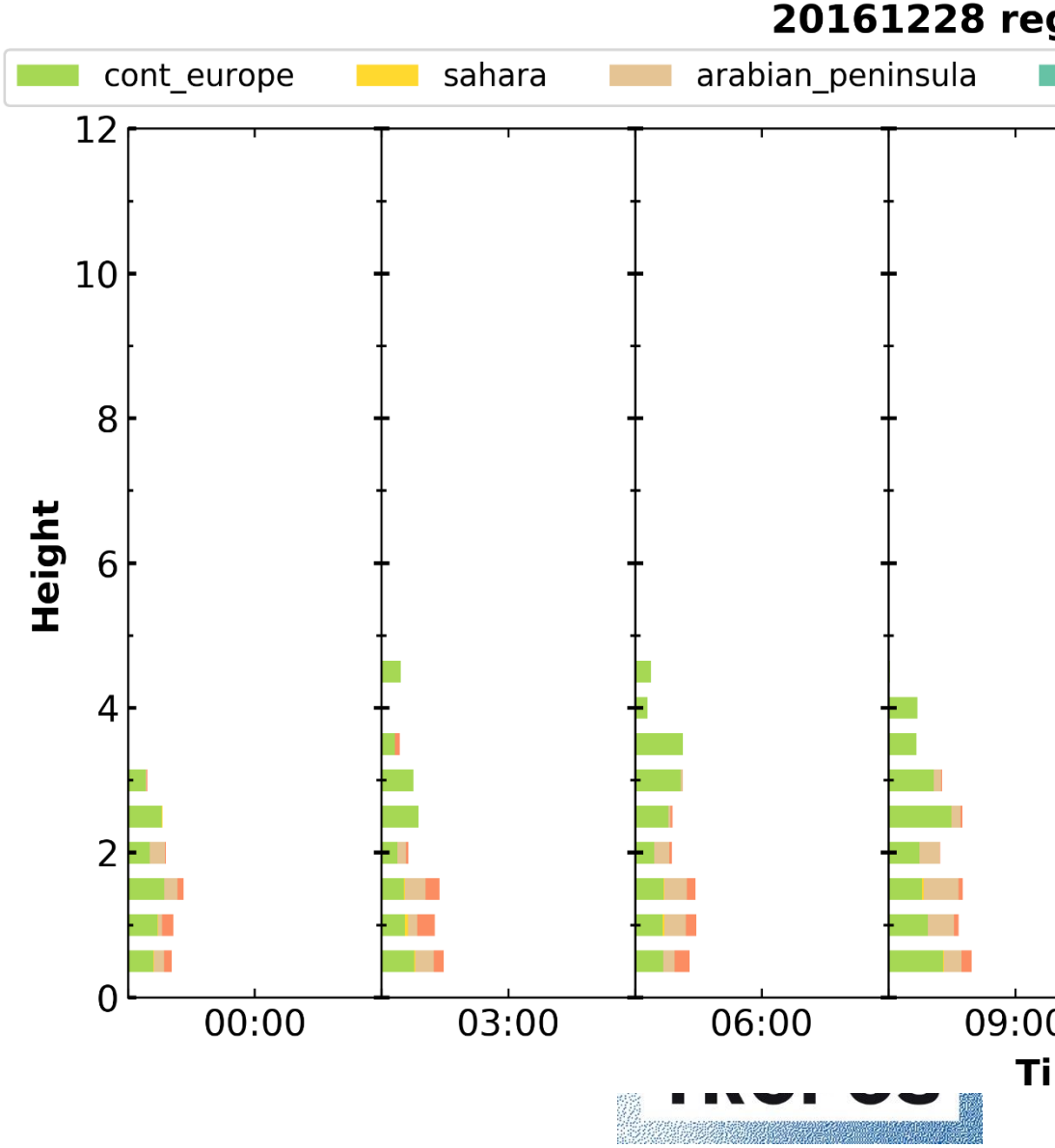
Evaluations: Cirrus

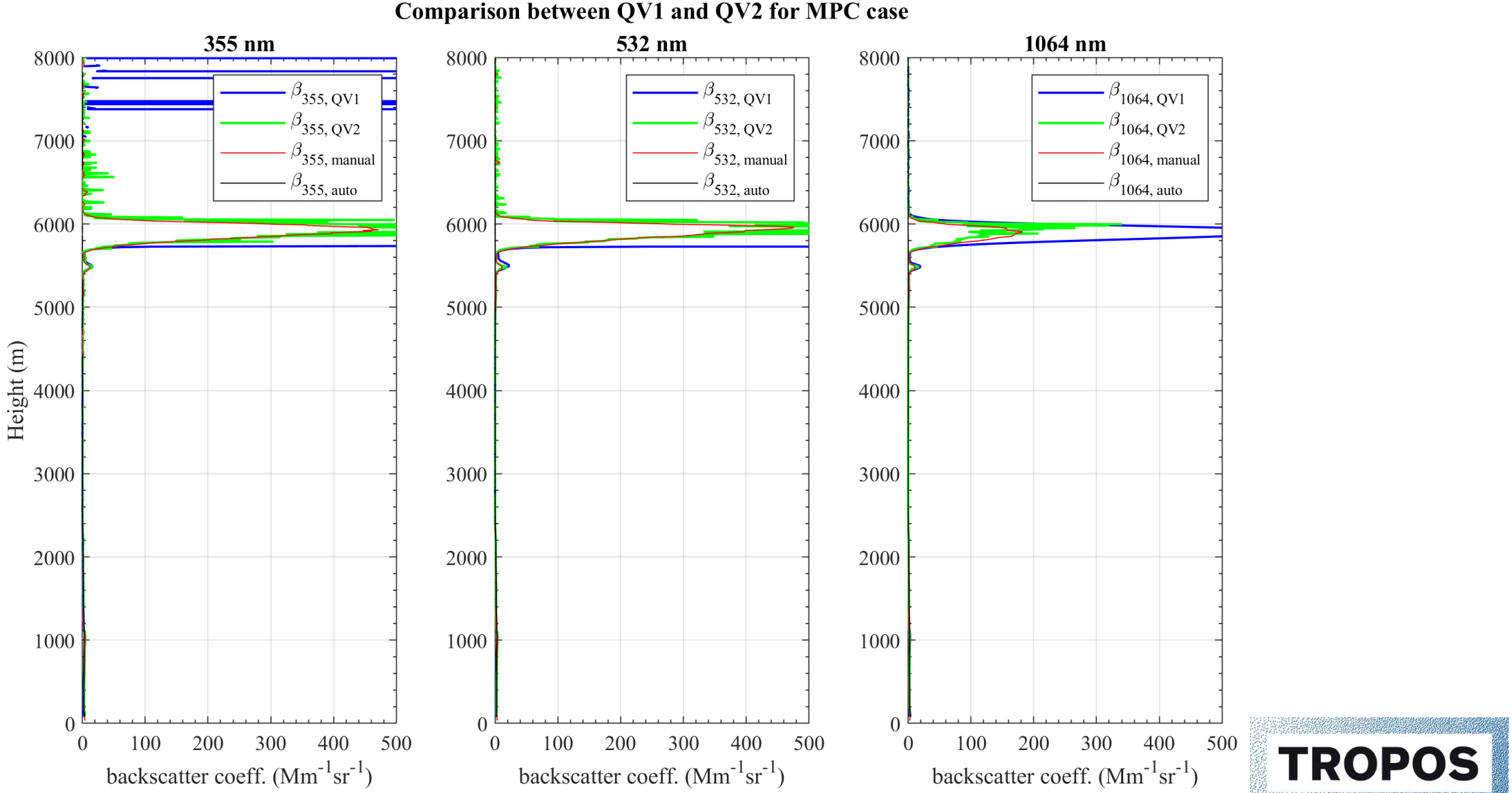


Evaluations: Mixed-Phase Cloud





Evaluations: Mixed-Phase Cloud



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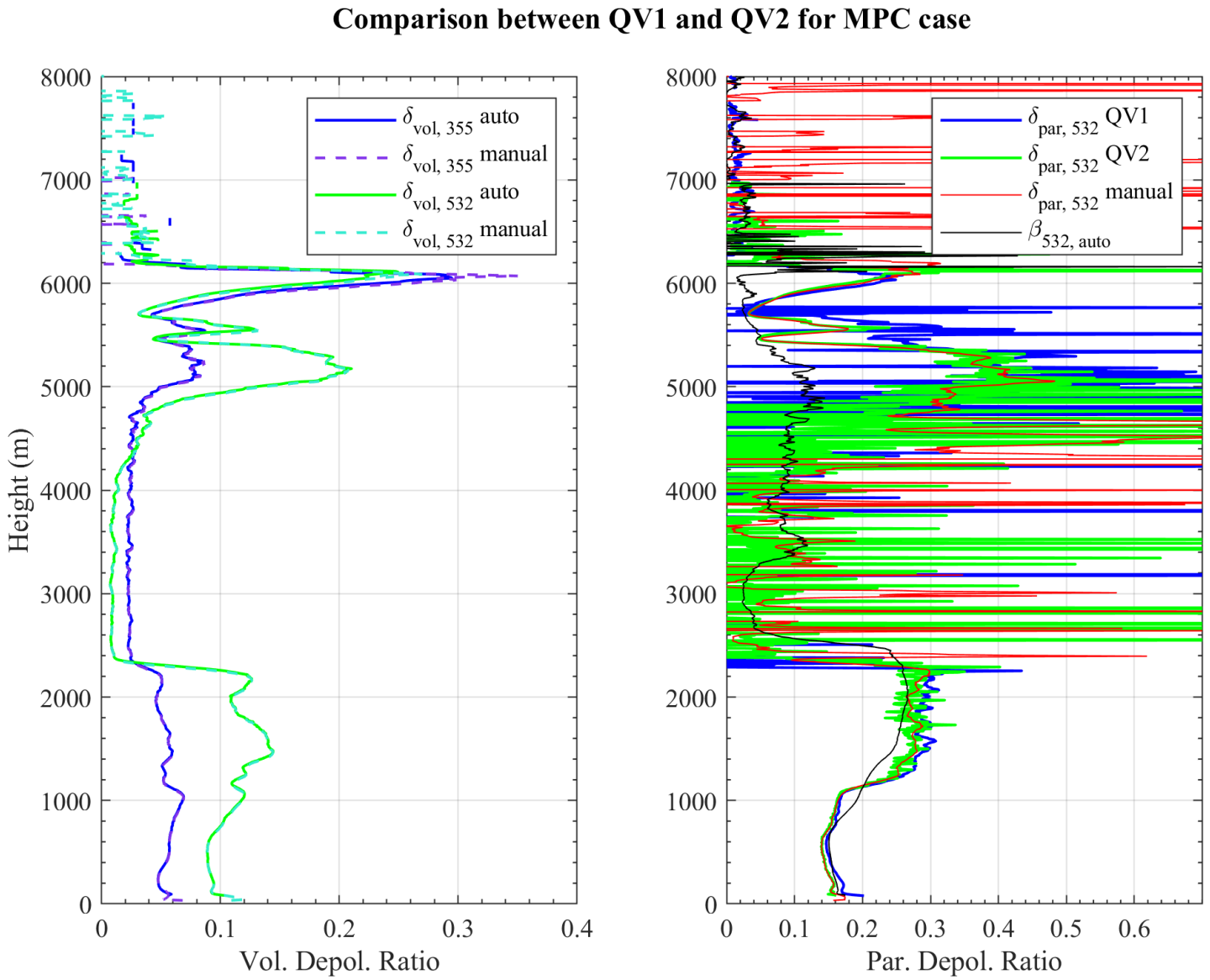
Evaluations: Mixed-Phase Cloud



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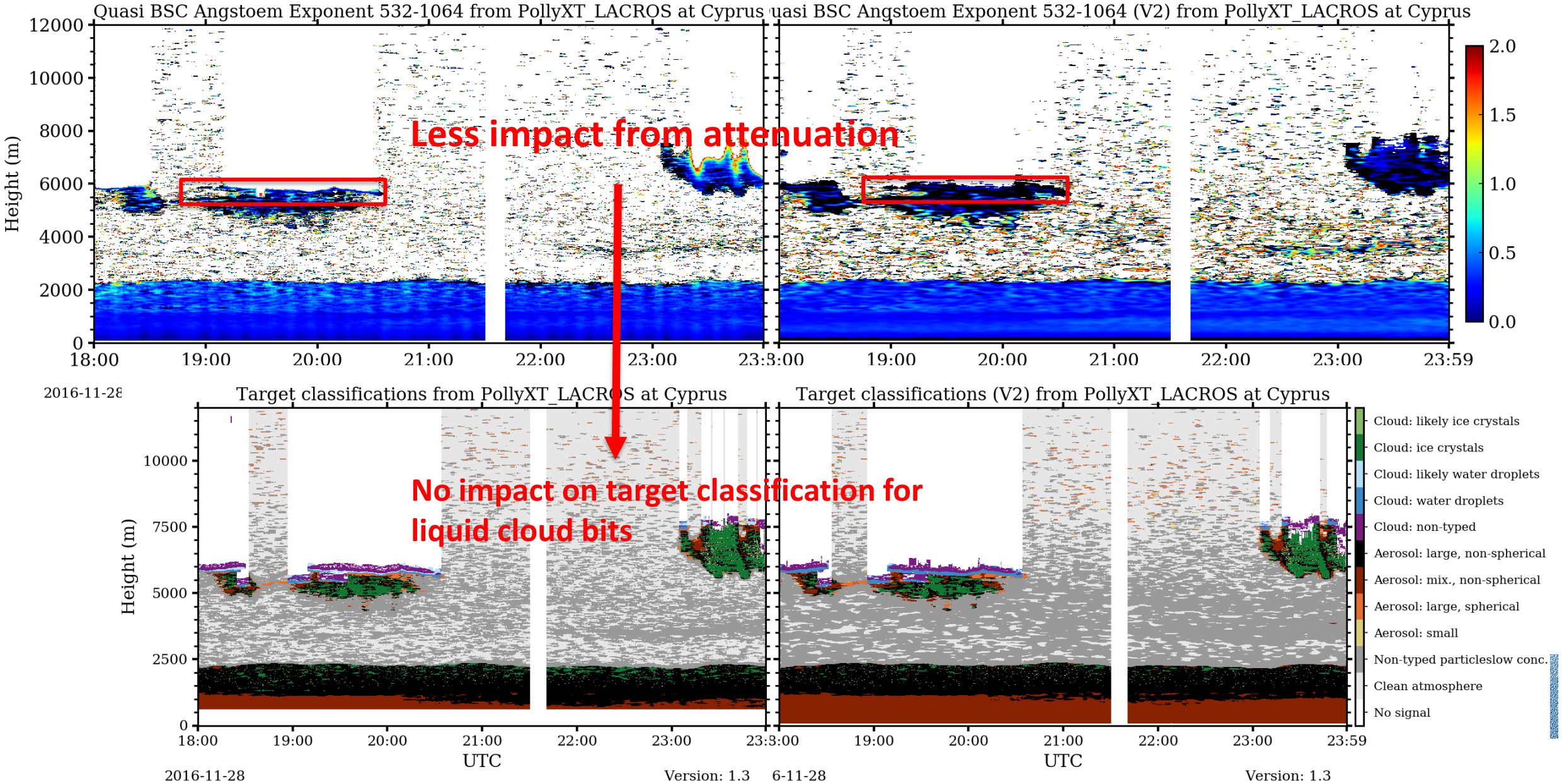
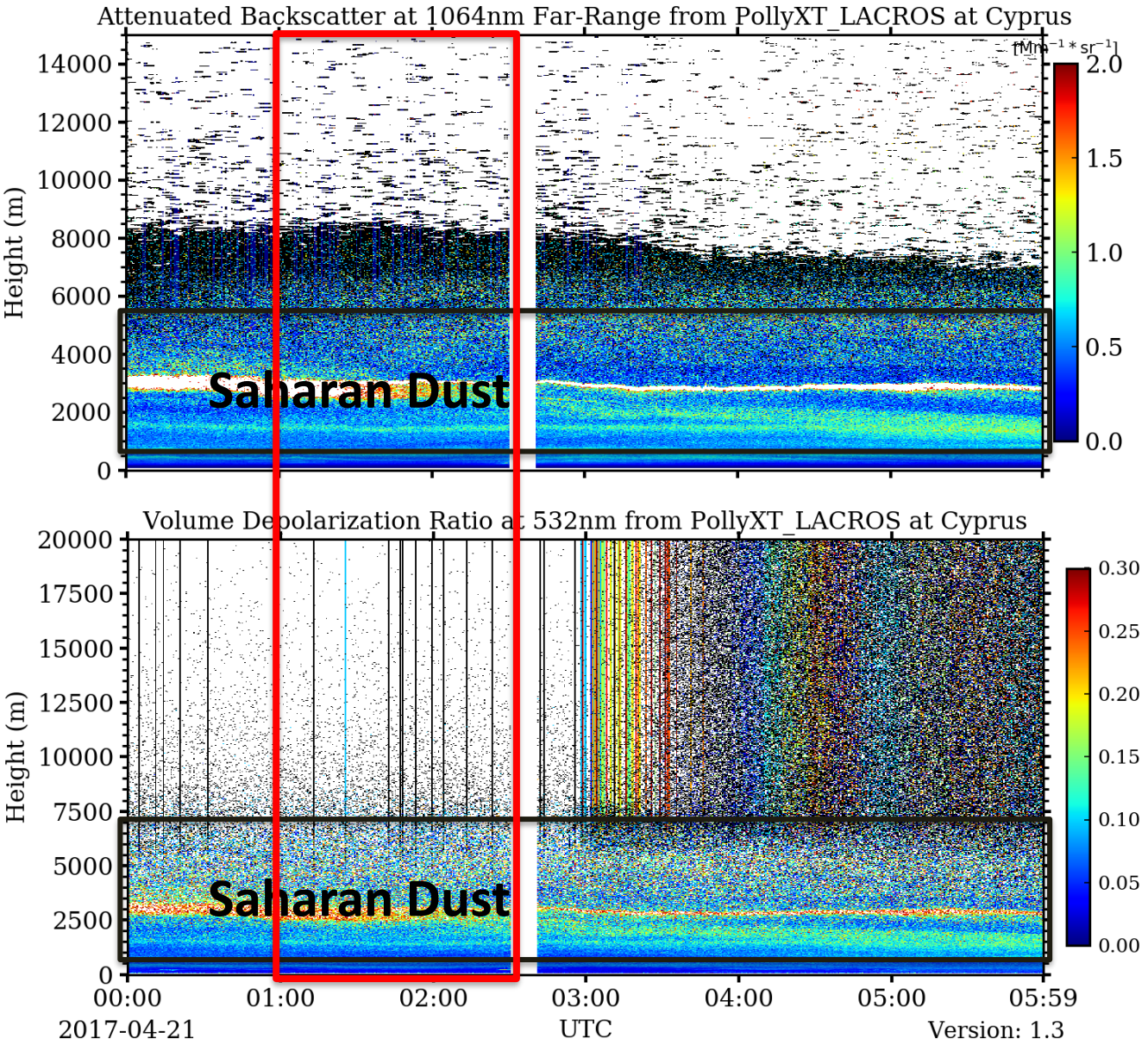
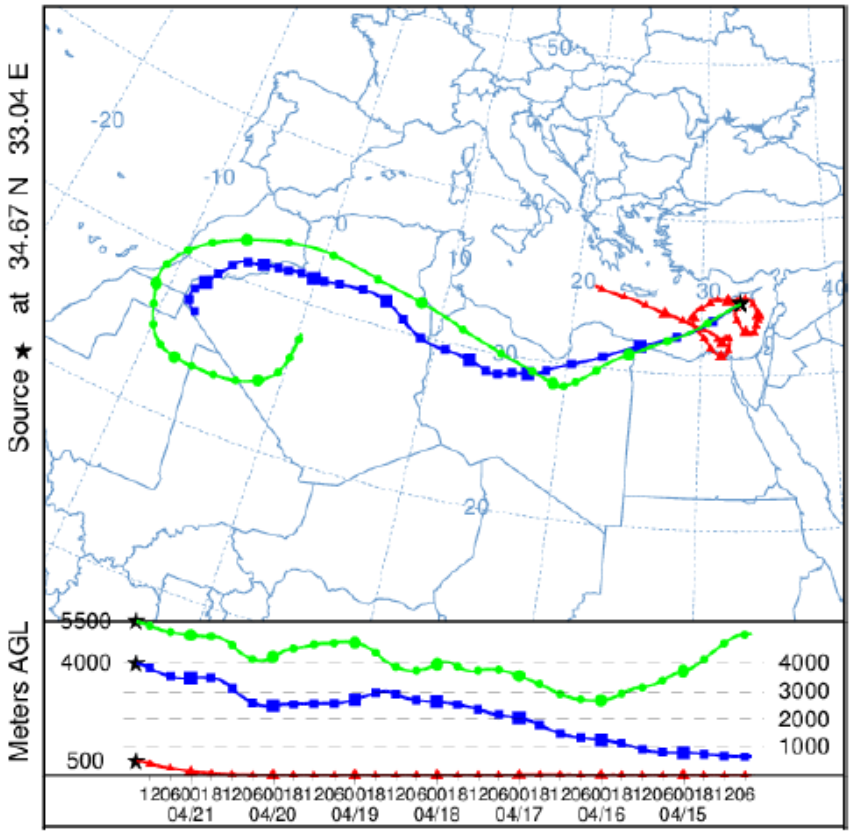
Evaluations: Mixed-Phase Cloud



Evaluations: Saharan Dust





From Claudia's thesis

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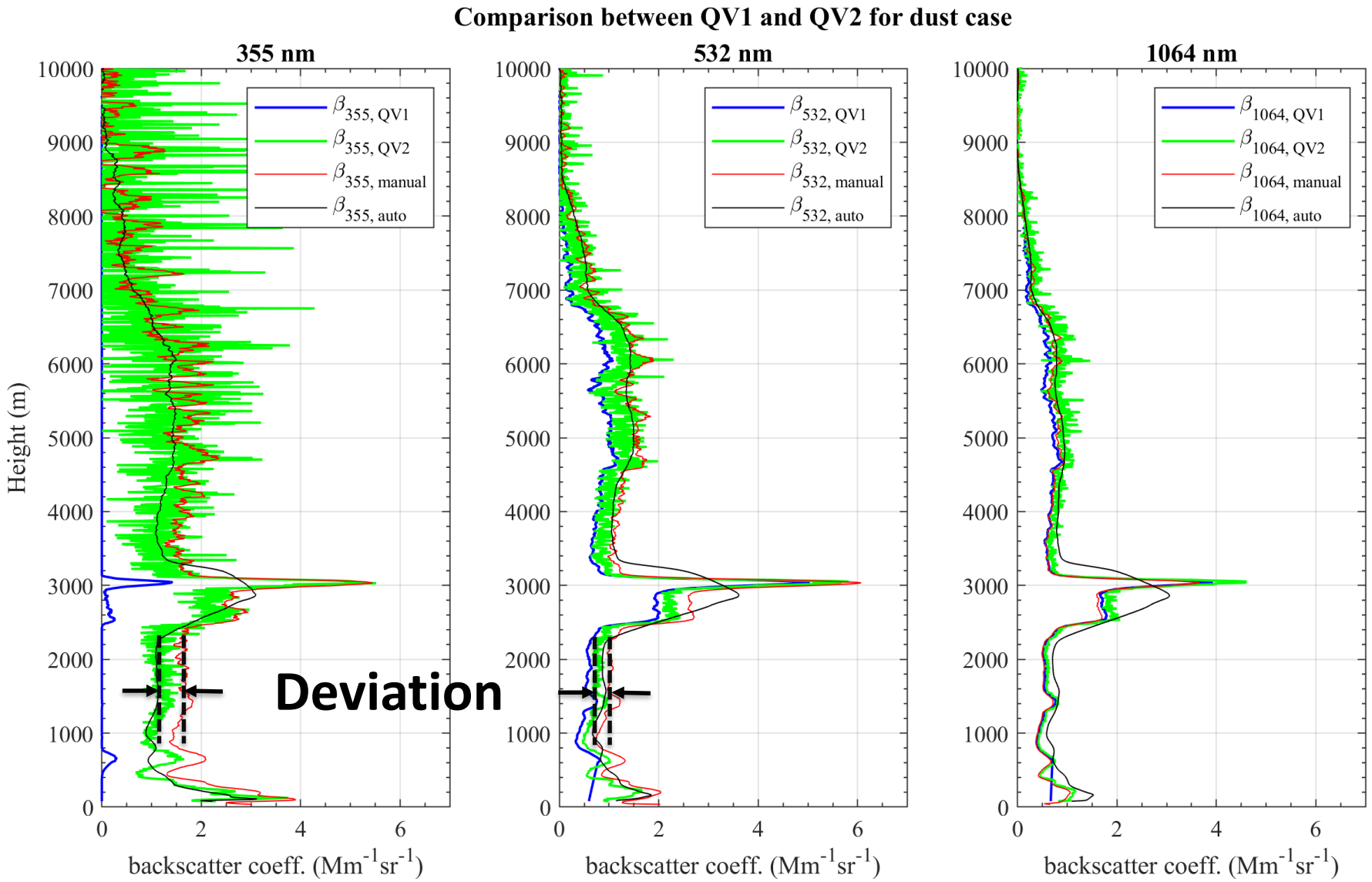
Evaluations: Saharan Dust



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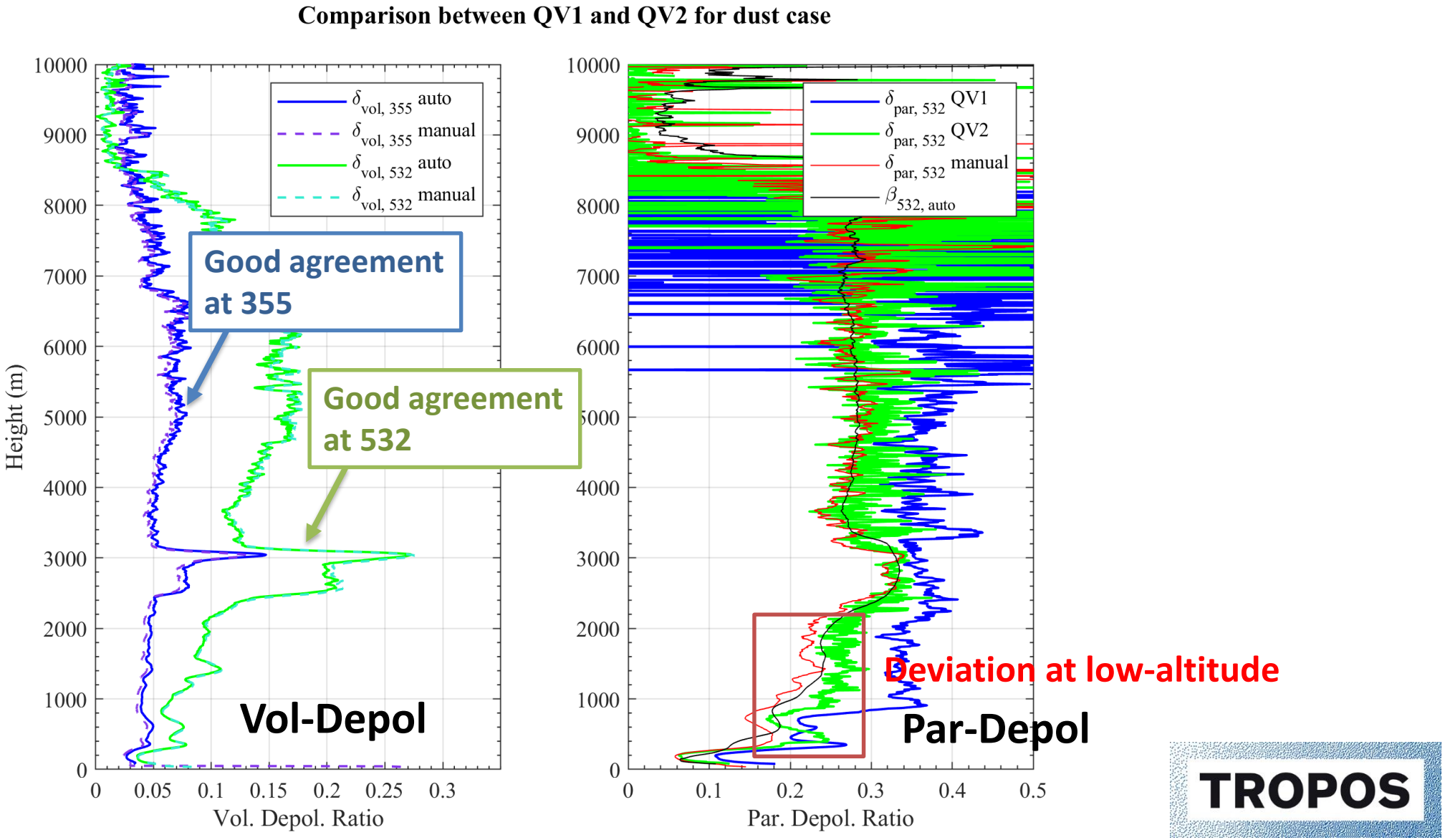
Evaluations: Saharan Dust



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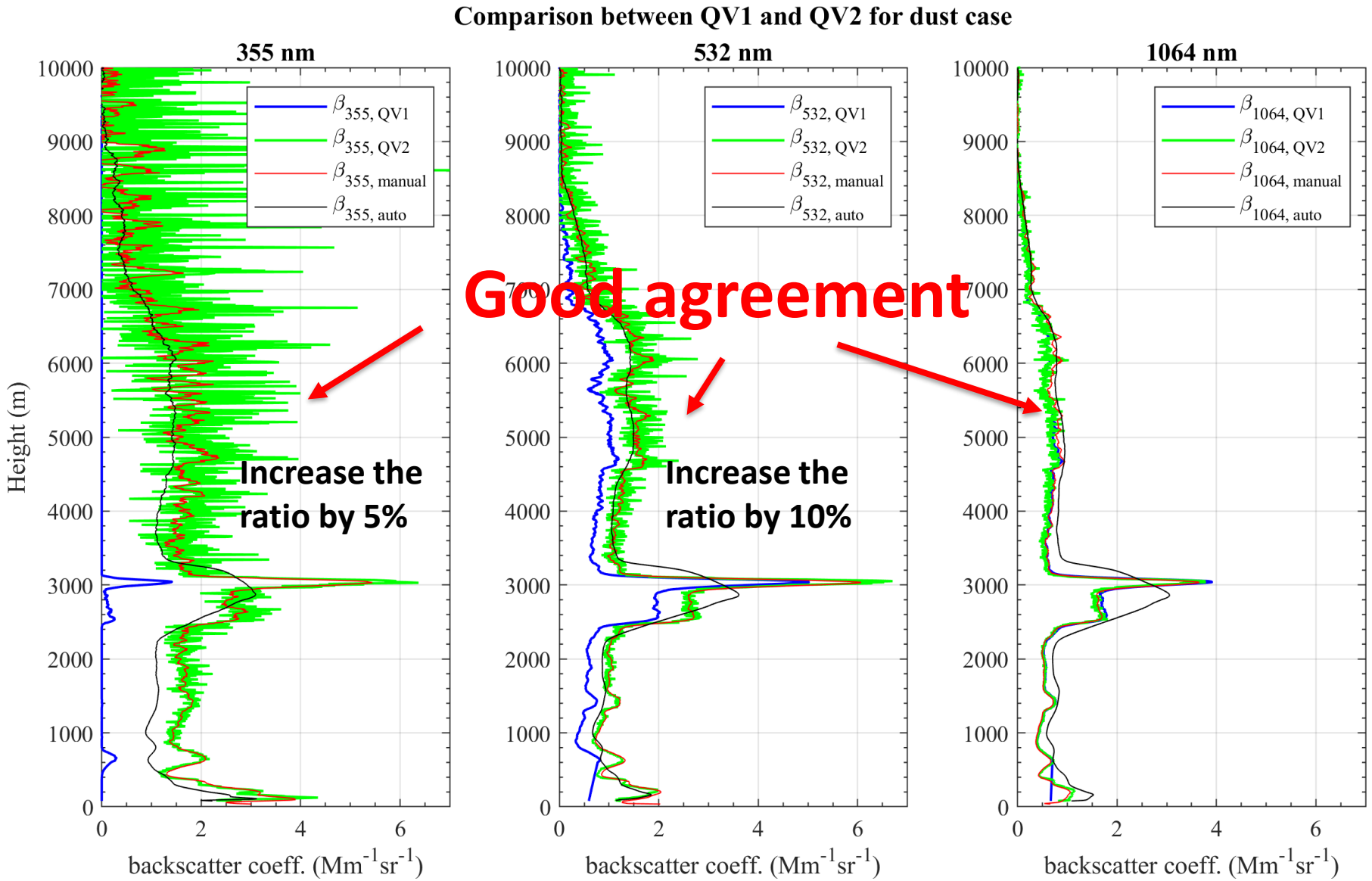
Evaluations: Saharan Dust



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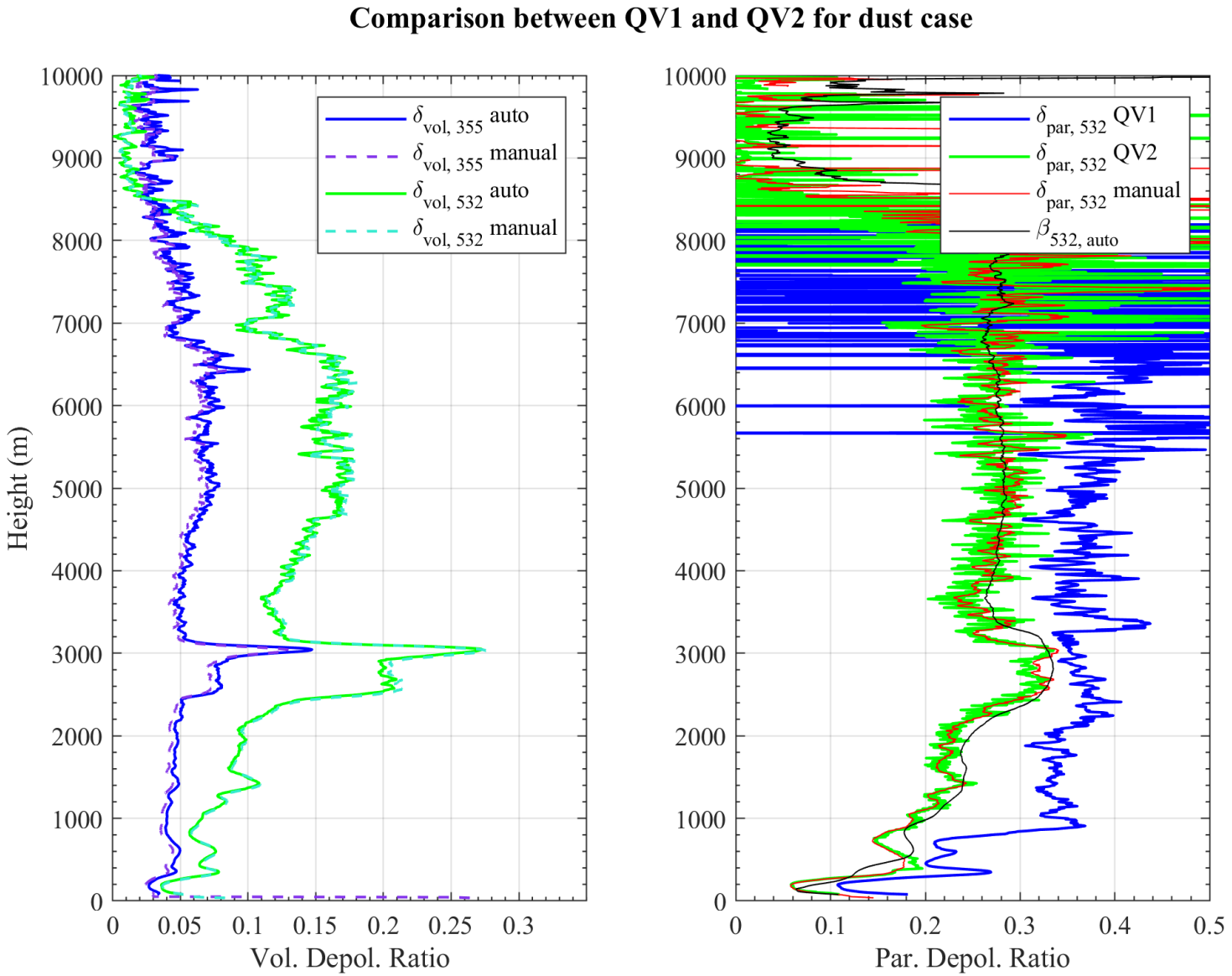
Evaluations: Saharan Dust



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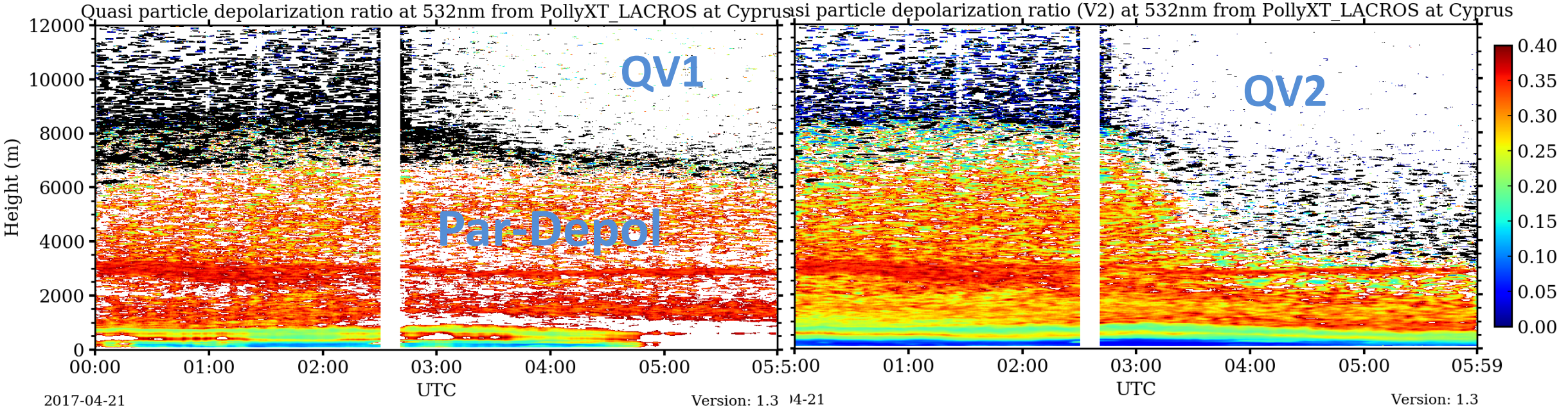
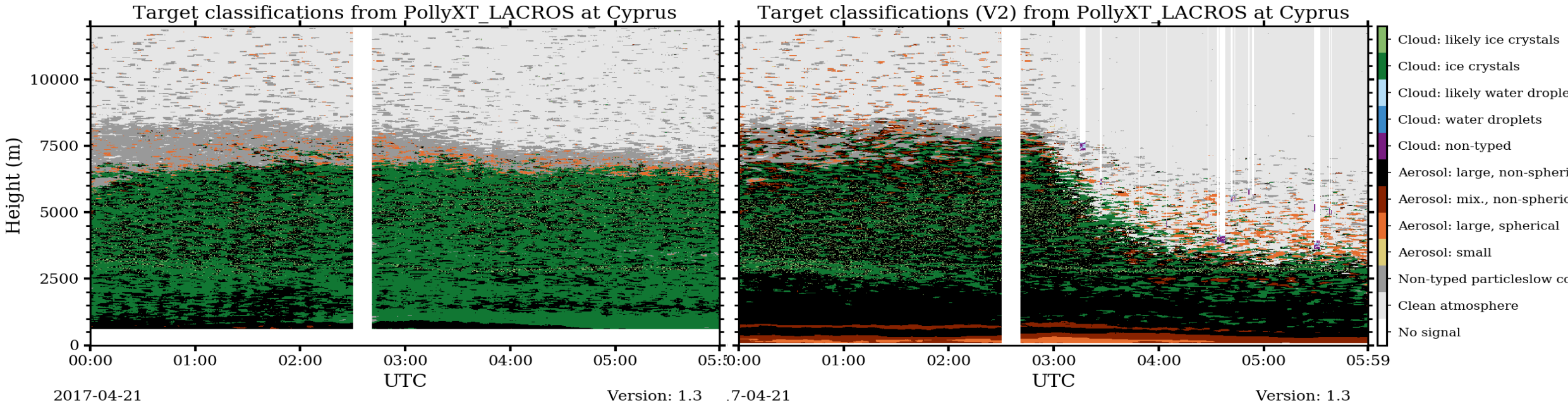
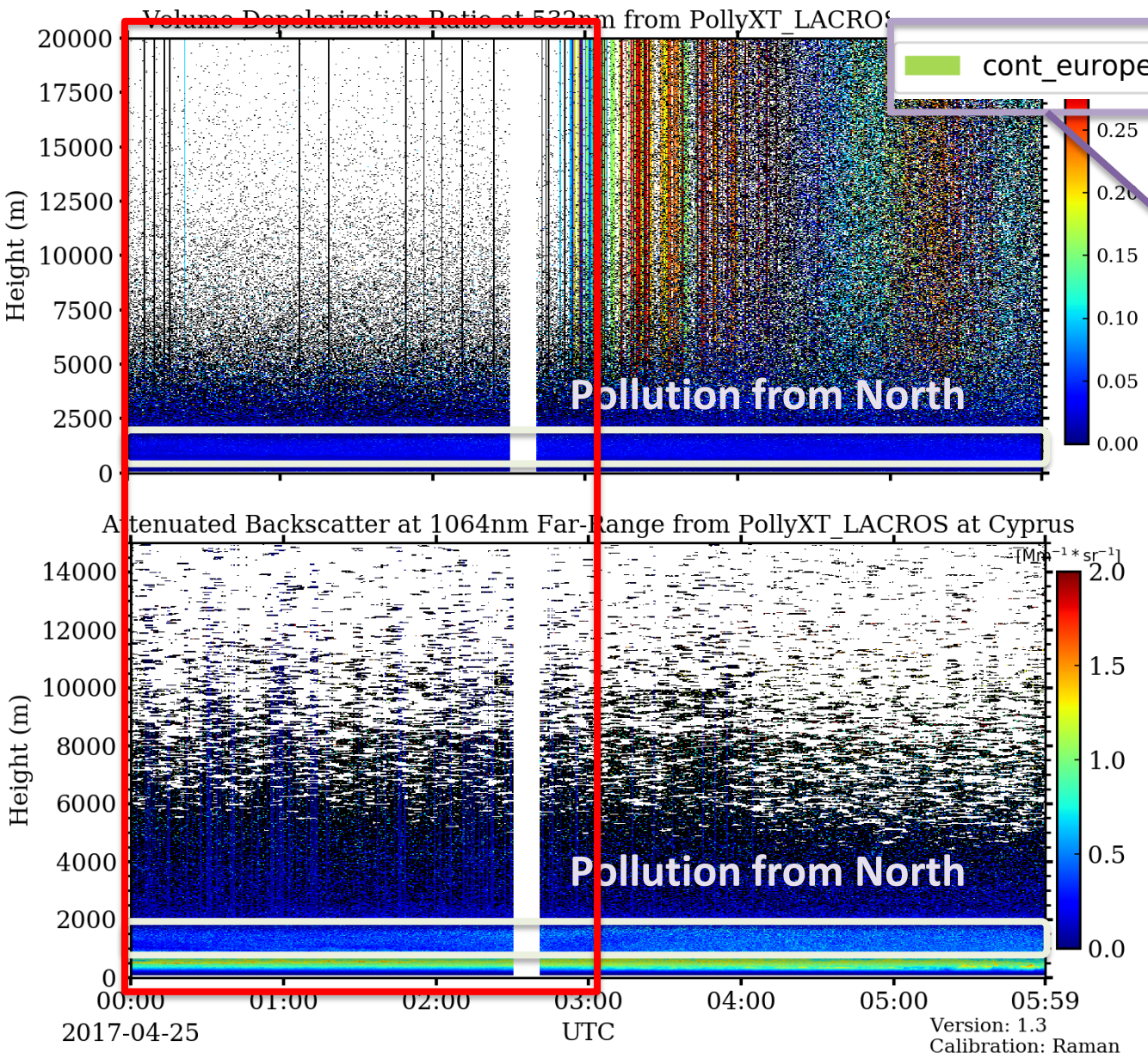
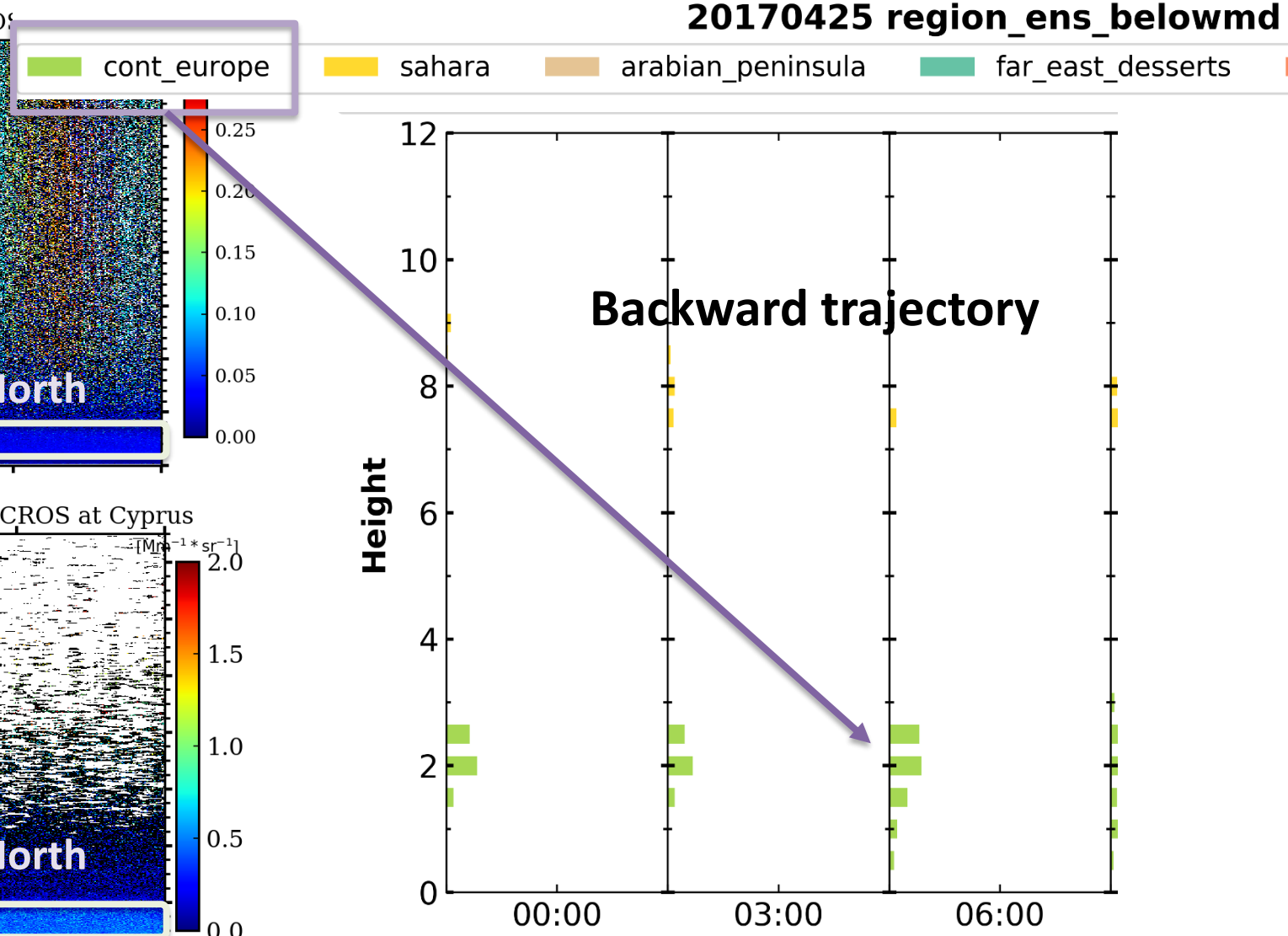
Evaluations: Saharan Dust



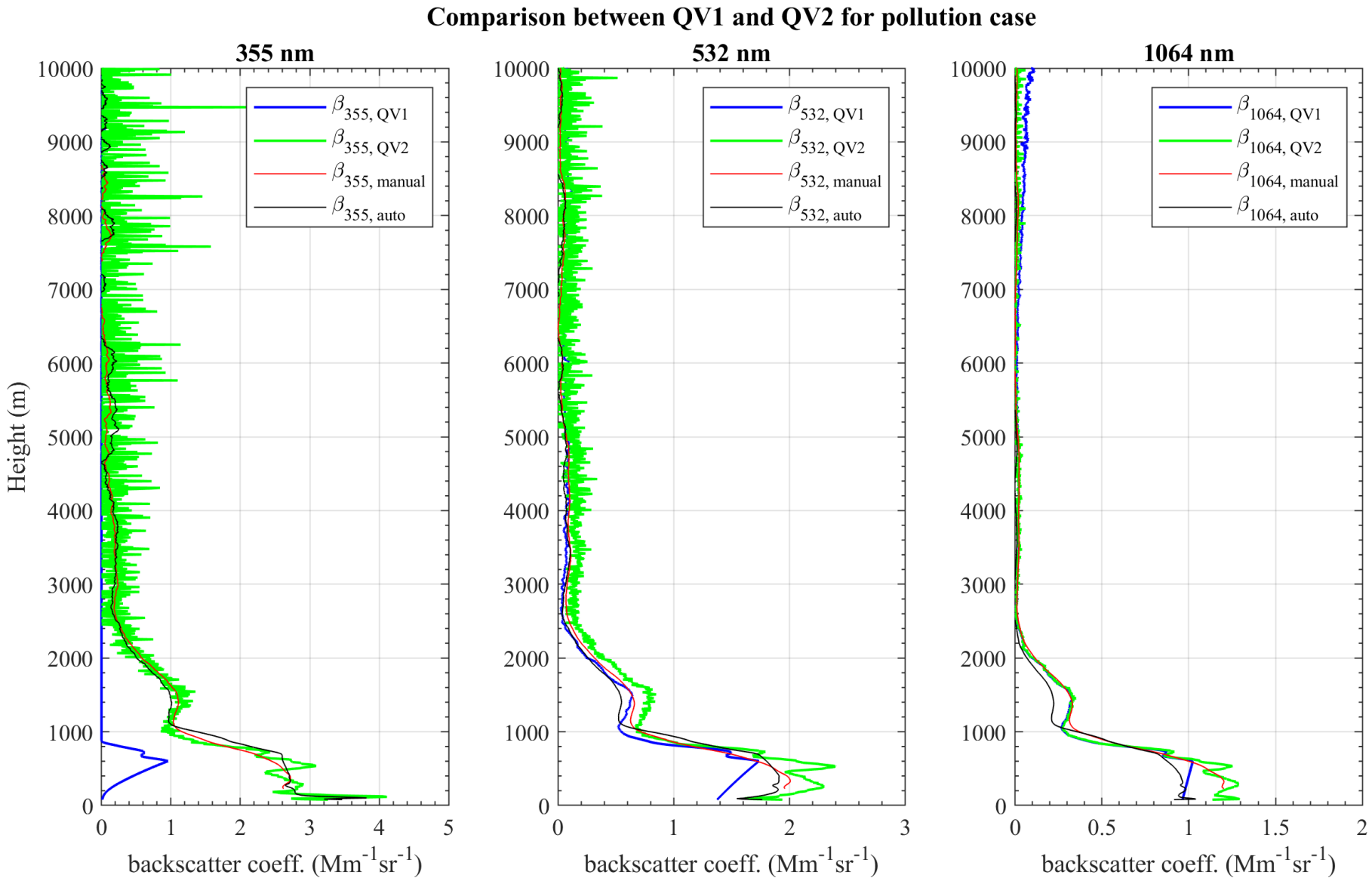


Evaluations: Pollution





Evaluations: Pollution



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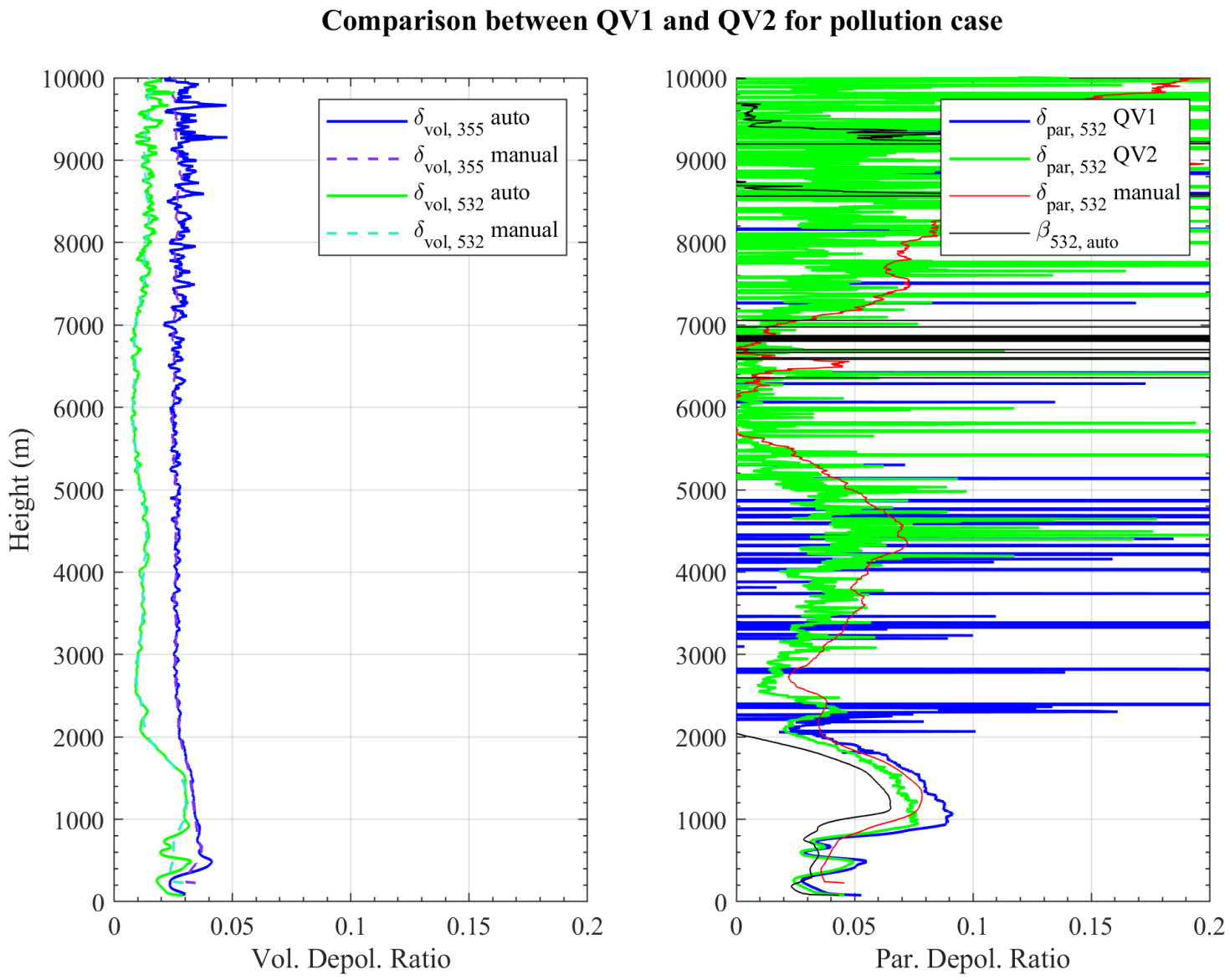
Evaluations: Pollution



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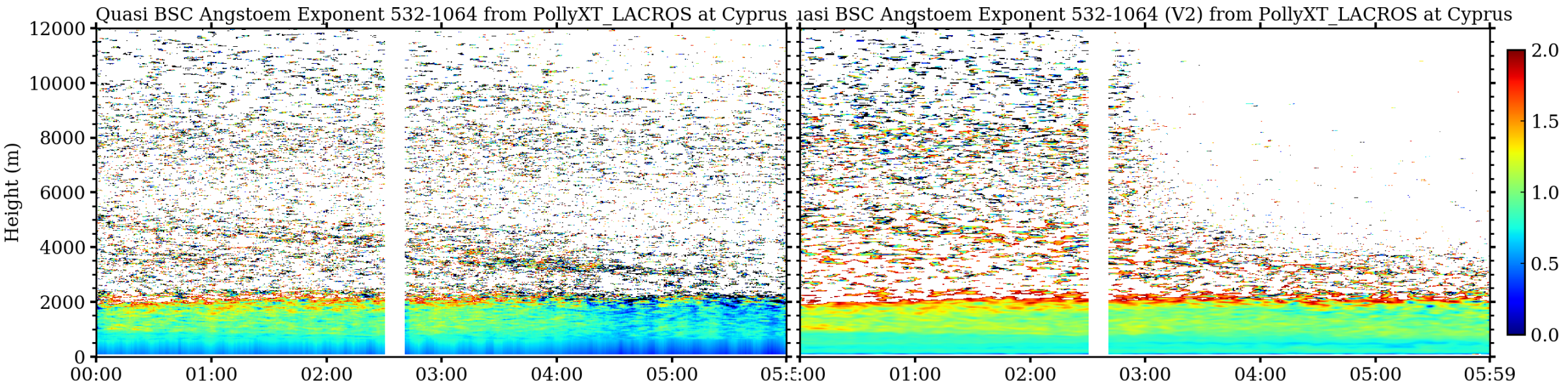
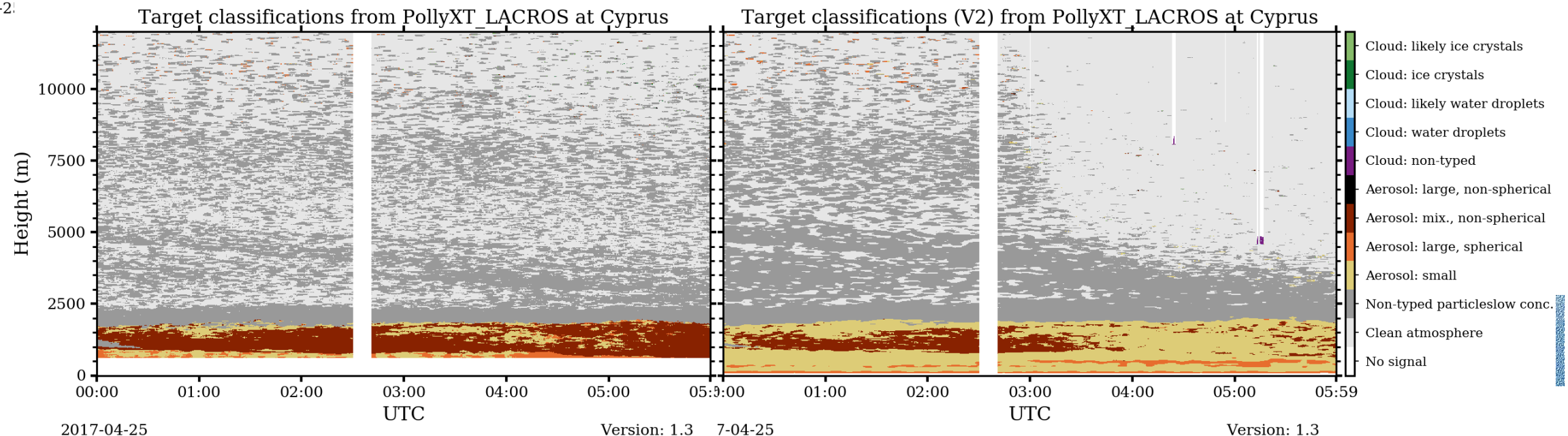
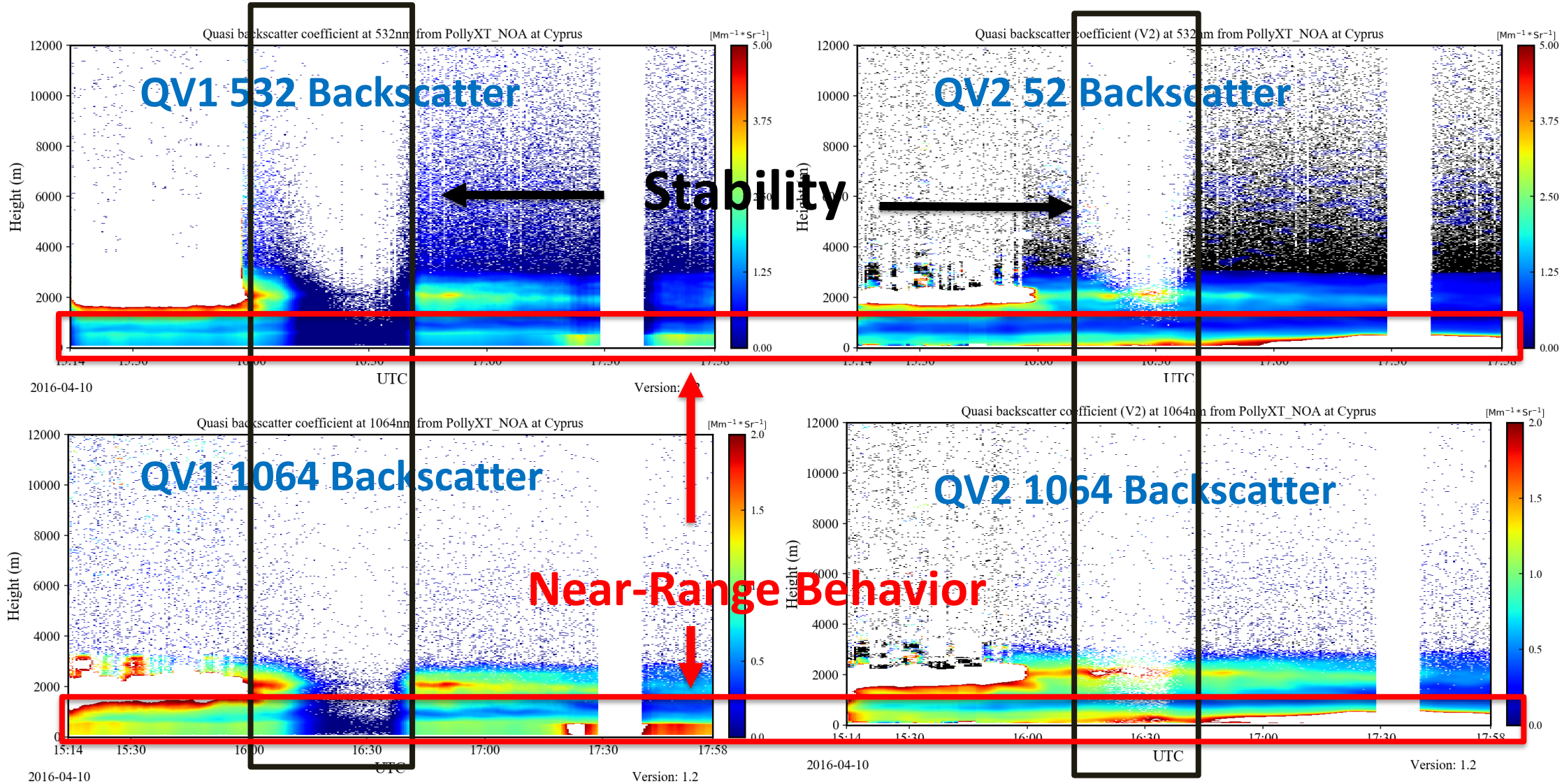
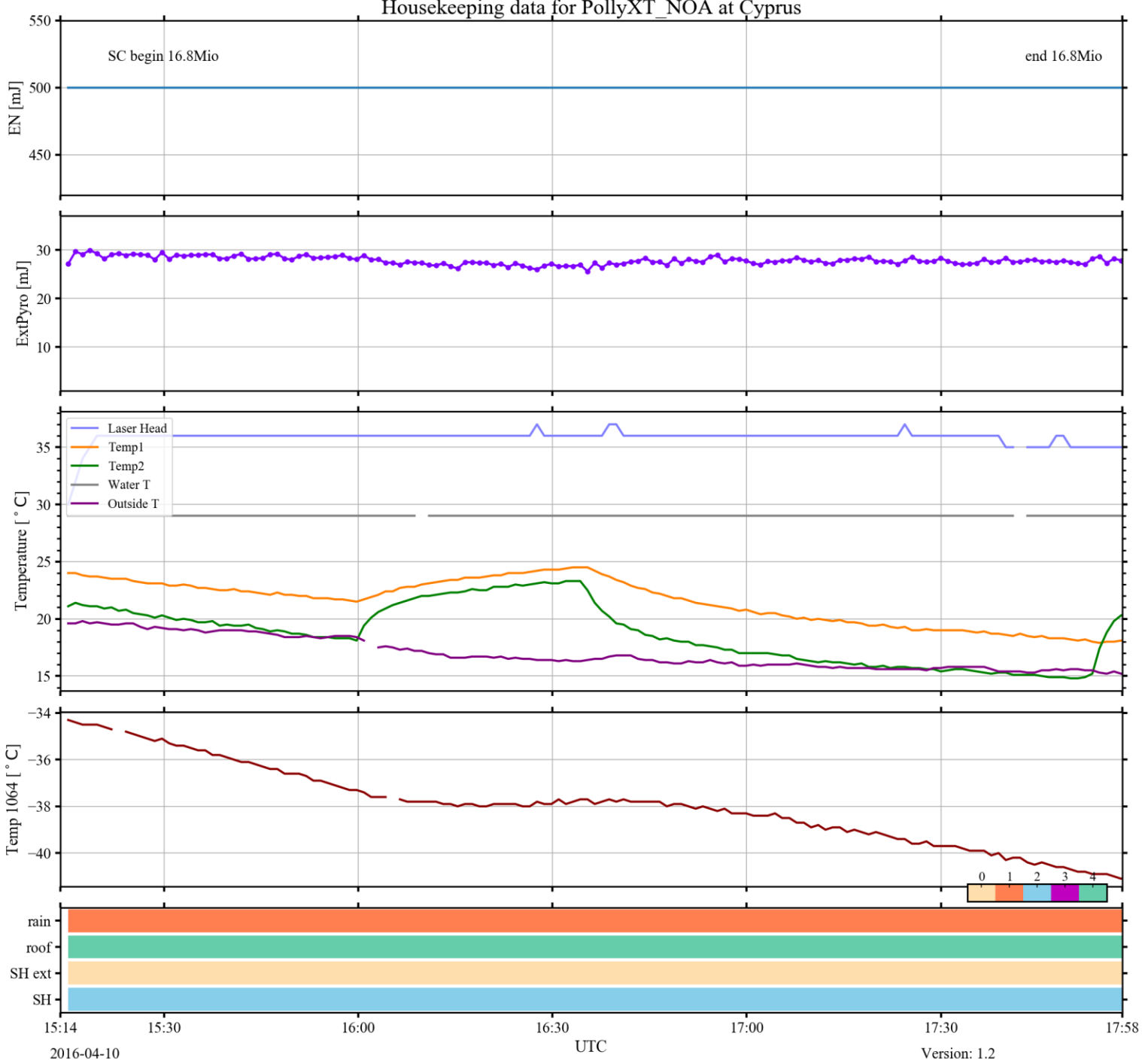
Evaluations: Pollution





QV2 vs QV1


QV1 532 Backscatter
QV2 52 Backscatter
Stability
QV1 1064 Backscatter
QV2 1064 Backscatter
Near-Range Behavior
Height (m)
UTC
2016-04-10
Version: 1.2


Housekeeping data for PollyXT_NOA at Cyprus
SC begin 16.8Mio
end 16.8Mio
EN [mJ]
ExtPyro [mJ]
Laser Head
Temp1
Temp2
Water T
Outside T
Temperature [° C]
Temp 1064 [° C]
rain
roof
SH ext
SH
15:14
15:30
16:00
16:30
17:00
17:30
17:58
2016-04-10
UTC
Version: 1.2

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Error analysis

$$\beta_p(\lambda_0, z) = \left\{ \frac{\boldsymbol{P(\lambda_0, z) z^2}}{\boldsymbol{P(\lambda_R, z) z^2}} * \frac{\boldsymbol{C_R^* P_0}}{\boldsymbol{C_0 P_0}} * \exp\left\{ \left[1 - \left(\frac{\lambda_0}{\lambda_R} \right)^{\mathring{A}_p} \right] \int_0^z \alpha_p(\lambda_0, z')\mathrm{d}z' + \left[1 - \left(\frac{\lambda_0}{\lambda_R} \right)^4 \right] \int_0^z \alpha_m(\lambda_0, z')\mathrm{d}z' \right\} - 1 \right\} \beta_m(\lambda_0, z)$$

(1) **(2)** **(3)**

$$\text{rel. err. } \beta_p(\lambda_0, z, K) = \frac{|\beta_p(\lambda_0, z, K') - \beta_p(\lambda_0, z, K)|}{\beta_p(\lambda_0, z, K)},$$ K represents error factor (1), (2), (3)

1. Error from calibration
2. Error from unrealistic representation of Ångström exponent
3. Error from aerosol/cloud attenuation

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Error from calibration

$$\beta_p(\lambda_0, z) = \left\{ \frac{\boldsymbol{P(\lambda_0, z) z^2}}{\boldsymbol{P(\lambda_R, z) z^2}} * \frac{\boldsymbol{C_R^* P_0}}{\boldsymbol{C_0 P_0}} * \exp\left\{ \left[1 - \left(\frac{\lambda_0}{\lambda_R} \right)^{\text{Å}_p} \right] \int_0^z \alpha_p(\lambda_0, z')\mathrm{d}z' + \left[1 - \left(\frac{\lambda_0}{\lambda_R} \right)^4 \right] \int_0^z \alpha_m(\lambda_0, z')\mathrm{d}z' \right\} - 1 \right\} \beta_m(\lambda_0, z)$$

$$\text{rel. err.}\, \beta_p(K_1) = \text{rel. err.}\, K_1$$

If calibration error was less than 10%, the relative error of backscatter is less than **10%**

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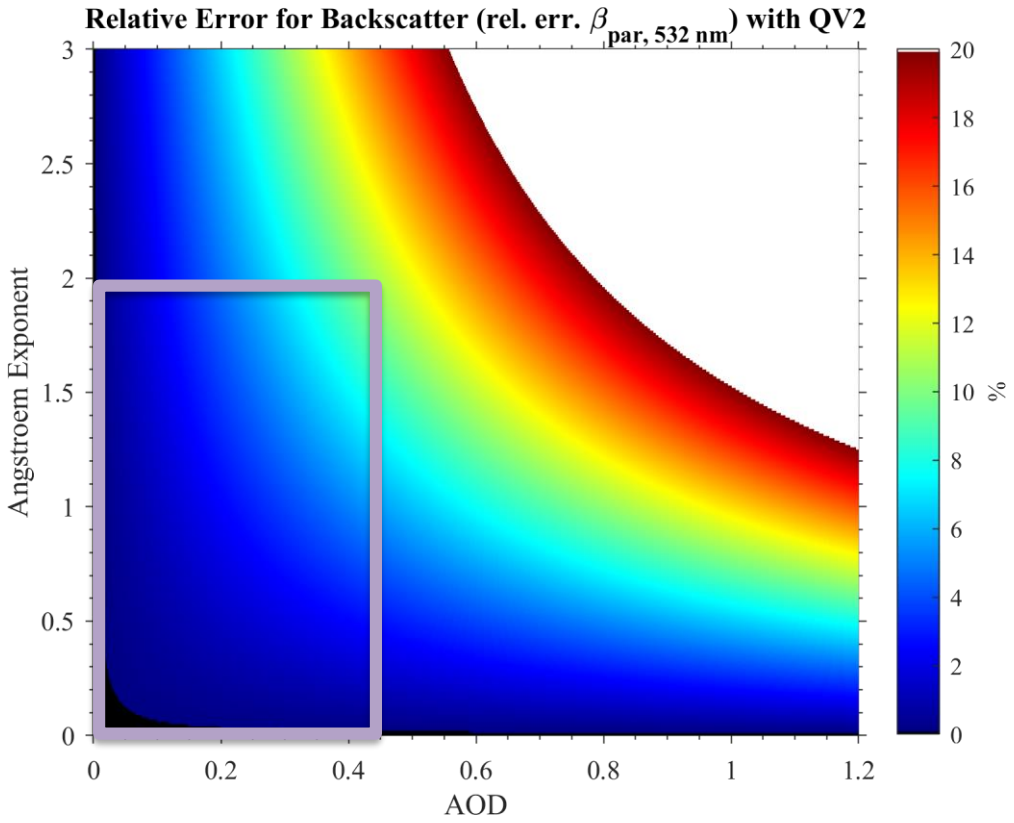
Error from Ångström exponent

$$\beta_p(\lambda_0, z) = \left\{ \frac{\boldsymbol{P(\lambda_0, z) z^2}}{\boldsymbol{P(\lambda_R, z) z^2}} * \frac{\boldsymbol{C_R^* P_0}}{\boldsymbol{C_0 P_0}} * \exp\left\{ \left[1 - \left(\frac{\lambda_0}{\lambda_R} \right)^{\text{Å}_p} \right] \int_0^z \alpha_p(\lambda_0, z')\mathrm{d}z' + \left[1 - \left(\frac{\lambda_0}{\lambda_R} \right)^4 \right] \int_0^z \alpha_m(\lambda_0, z')\mathrm{d}z' \right\} - 1 \right\} \beta_m(\lambda_0, z)$$



$$\text{rel. err.}\, \beta_p(K_2) = \exp\left\{ \left[\left(\frac{\lambda_0}{\lambda_R} \right)^{\text{Å}'_p} - \left(\frac{\lambda_0}{\lambda_R} \right)^{\text{Å}_p} \right] \int_0^z \alpha_p(\lambda_0, z')\mathrm{d}\,z' \right\} - 1$$

AOD

We take $\text{Å}'_p = 0$ for the retrieval

If Pollution AOD was less than **0.45**, the relative error of backscatter is less than **10%**

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Conclusions

	QV2	vs	QV1
Advantage	less dependence on aerosol attenuation		High dependence on aerosol attenuation
	High stability of calibration constant		Less stability of calibration constant
	Good behavior at near-range		Need overlap-func to characterize the near-range
Disadvantage	Low SNR at daytime		High SNR at daytime

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Backup

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Two Quasi methods 2016-04-26 Cyp