CALIOP Uncertainty Estimates

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Aerosol Layer Product

Table 34: Lidar 5 km Layer Descriptor Record: Aerosols

Parameter	Data Type	Units	Nominal Range	Elem/ Rec	Bytes
Feature_Optical_Depth_532	Float_32	NoUnits	0.0…3.0	8	32
Feature_Optical_Depth_Uncertainty_532	Float_32	NoUnits	0.0…TBD	8	32
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Feature_Optical_Depth_1064	Float_32	NoUnits	0.0…3.0	8	32
Feature_Optical_Depth_Uncertainty_1064	Float_32	NoUnits	0.0…TBD	8	32
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ExtinctionQC_532	UInt_16	NoUnits	0…65,535	8	16
ExtinctionQC_1064	UInt_16	NoUnits	0…65,535	8	16
CAD_Score	Int_8	NoUnits	-101…105	8	8

Column Properties

Table 33: Lidar 5 km Column Descriptor Record: Aerosols

Parameter	Data Type	Units	Nominal Range	Elem/ Rec	Bytes
Column_Optical_Depth_Aerosols_532	Float_32	NoUnits	0.0…3.0[M]	1	4
Column_Optical_Depth_Aerosols_Uncertainty_532	Float_32	NoUnits	0.0…99.99	1	4
Column_Optical_Depth_Stratospheric_532	Float_32	NoUnits	0.0…3.0[M]	1	4
Column_Optical_Depth_Stratospheric_Uncertainty_532	Float_32	NoUnits	0.0…99.99	1	4
Column_Optical_Depth_Aerosols_1064	Float_32	NoUnits	0.0…3.0[M]	1	4
Column_Optical_Depth_Aerosols_Uncertainty_1064	Float_32	NoUnits	0.0…99.99	1	4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Aerosol Profile Product

Table 37: Lidar 5 km Aerosol Profile Record

Parameter	Data Type	Units	Nominal Range	Elem/ Rec	Bytes
Extinction_Coefficient_532	Float_32	km^{-1}	0.0…1.25	399	1,596
Extinction_Coefficient_Uncertainty_532	Float_32	km^{-1}	0.0…99.99	399	1,596
Aerosol_Multiple_Scattering_Profile_532	Float_32	NoUnits	1.0	399	1,596
Backscatter_Coefficient_1064	Float_32	sr^{-1} km^{-1}	0.0…0.03	399	1,596
Backscatter_Coefficient_Uncertainty_1064	Float_32	sr^{-1} km^{-1}	0.0…99.99	399	1,596
Extinction_Coefficient_1064	Float_32	km^{-1}	0.0…1.0	399	1,596
Extinction_Coefficient_Uncertainty_1064	Float_32	km^{-1}	0.0…99.99	399	1,596

- **There are two retrieval algorithms used in the standard products**
  - **Constrained retrieval**
    - **Lidar ratio derived from layer transmittance measurement and used as constraint on the extinction retrieval**
  - **Unconstrained retrieval**
    - **Lidar ratio needed by the extinction retrieval is estimated by an aerosol typing algorithm**
    - **Daytime aerosol retrievals are almost always unconstrained**

The extinction retrieval solves for the particulate backscatter coefficient, $\beta_p(r)$:

$$\beta_P(r) = \beta'_N(r) \big/ (T_M^2(r_N, r) T_P^2(r_N, r)) - \beta_M(r)$$

Which is a simple re-formulation of the lidar equation:

$$\beta'_N(r) = \beta'(0, r) / C_N(r_N) = \left[\beta_M(r) + \beta_P(r)\right] T_M^2(r_N, r) T_P^2(r_N, r)$$

These equations are the basis for an error propagation analysis of the estimated error sources

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The Retrieval of Profiles of Particulate Extinction from *Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations* (*CALIPSO*) Data: Uncertainty and Error Sensitivity Analyses

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Error Estimation

Sources of error considered

- Calibration
- Aerosol lidar ratio
- SNR

Sources of error not considered

- Misclassification of aerosol and cloud
- Misclassification of aerosol type
- Failure to detect layers

Standard propagation of errors techniques are used to estimate:

- Aerosol extinction at each level
- AOD of each aerosol layer
- Column AOD

Error Estimates

Error in extinction due to an error in calibration:

$$\varepsilon[\sigma_P(r)] = S_P \beta_T(r) \left[\alpha \frac{T_P^2(0,r)}{\hat{T}_P^2(0,r)} - 1 \right], \qquad (30)$$

Error in optical depth :

$$\varepsilon[\tau_P(0,r)] = -0.5 \ln \left[\frac{\hat{T}_P^2(0,r)}{T_P^2(0,r)} \right]$$

$$= -0.5 \ln \left\{ 1 + \frac{\varepsilon[T_P^2(0,r)]}{T_P^2(0,r)} \right\}. \qquad (31)$$

Error in extinction due to an error in lidar ratio:

$$\varepsilon[\sigma_P(r)] = (\psi - 1) S_P \beta_P(r) + \psi S_P \beta_T(r) \left[\frac{T_P^2(0,r)}{\hat{T}_P^2(0,r)} - 1 \right],$$

(39)