This document briefly describes the 32 variables that were added in COSPv2.0 concerning the lidar simulator (April 2018). They can be separated in 3 groups.

I – New « OPAQ » variables for the CALIPSO simulator (16 variables)

The first group of new variables corresponds to GOCCP v3 observations (OPAQ product [*Guzman et al.* 2017, *Vaillant de Guélis et al.* 2017a]), which allows to separate clouds in 2 types :

- Opaque clouds (visible optical depth > 3~5), which drive to the first order both SW and LW radiation at the Top Of Atmosphere (TOA)
- Thin clouds (visible optical depth < 3~5)

16 new CALIPSO simulator variables in COSPv2 correspond to the GOCCP OPAQ product :

variable name	*variable description*	*dimensions*
clopaquecalipso	= CALIPSO Opaque Cloud Cover	(lon, lat)
clthincalipso	= CALIPSO Thin Cloud Cover	(lon, lat)
clzopaquecalipso	= CALIPSO z_opaque Altitude	(lon, lat)
clcalipsoopaque	= CALIPSO Opaque Cloud Fraction	(lon, lat, alt)
clcalipsothin	= CALIPSO Thin Cloud Fraction	(lon, lat, alt)
clcalipsozopaque	= CALIPSO z_opaque Fraction	(lon, lat, alt)
clcalipsoopacity	= CALIPSO opacity Fraction	(lon, lat, alt)
clopaquetemp	= CALIPSO Opaque Cloud Temperature	(lon, lat)
clthintemp	= CALIPSO Thin Cloud Temperature	(lon, lat)
clzopaquetemp	= CALIPSO z_opaque Temperature	(lon, lat)
clopaquemeanz	= CALIPSO Opaque Cloud Altitude	(lon, lat)
clthinmeanz	= CALIPSO Thin Cloud Altitude	(lon, lat)
clthinemis	= CALIPSO Thin Cloud Emissivity	(lon, lat)
clopaquemeanzse	= CALIPSO Opaque Cloud Altitude with respect to SE	(lon, lat)
clthinmeanzse	= CALIPSO Thin Cloud Altitude with respect to SE	(lon, lat)
clzopaquecalipsose	= CALIPSO z_opaque Altitude with respect to SE	(lon, lat)

where SE = Surface Elevation.

To add these 16 variables, the following files where modified :

driver/src/cosp2_io.f90
driver/src/cosp2_output_nl.txt
driver/src/cosp2_test.f90
src/cosp.F90
src/cosp_config.F90
src/simulator/actsim/lidar_simulator.F90

In the “lidar_simulator.F90” file, subroutine “COSP_OPAQ” has been added.

In all modified files, lines added or changed have one of the comments below at the end of each line (except where big chunks of code were added, where it is specified at the beginning and at the end of the chunk that it was added for “!OPAQ”) :
!OPAQ (1st phase of development)
!TIBO (2nd phase of development)
!TIBO2 (3rd phase of development)

II – New « GROUND LIDAR » simulator (8 variables)

The second group of new variables corresponds to ground-based lidar observations [*Chiriaco et al.* 2018].

8 variables from the new GROUND LIDAR simulator in COSPv2 correspond to these observations :

variable name	*variable description*	*dimensions*
lidarBetaMol532gr	= GROUND LIDAR Molecular Backscatter (532 nm)	(lon, lat, alt)
atb532gr	= GROUND LIDAR Total Backscatter (532 nm)	(lon, lat, col, alt)
cfadLidarsr532gr	= GROUND LIDAR Scattering Ratio CFAD	(lon, lat, alt, SRbin)
clgroundlidar	= GROUND LIDAR Cloud Fraction	(lon, lat, alt)
clhgroundlidar	= GROUND LIDAR High Level Cloud Cover	(lon, lat)
cllgroundlidar	= GROUND LIDAR Low Level Cloud Cover	(lon, lat)
clmgroundlidar	= GROUND LIDAR Mid Level Cloud Cover	(lon, lat)
cltgroundlidar	= GROUND LIDAR Total Cloud Cover	(lon, lat)

To add these 8 variables, the following files were added :

src/simulator/cosp_groundlidar_interface.F90
src/simulator/actsim/groundlidar_simulator.F90

To add these 8 variables, the following files were modified :

driver/src/cosp2_io.f90
driver/src/cosp2_output_nl.txt
driver/src/cosp2_test.f90
src/cosp.F90
src/cosp_config.F90
src/simulator/actsim/lidar_simulator.F90
build/Makefile
subsample_and_optics_example/optics/cosp_optics.F90

In the “cosp_optics.F90” file, subroutine “groundlidar_optics” has been added.

In all modified files, lines added or changed have the comment “!GLID” at the end of each line (except where big chunks of code were added, where it is specified at the beginning and at the end of the chunk that it was added for “!GLID”).

III – New « ATLID LIDAR » simulator (8 variables)

The third group of new variables corresponds to future ATLID lidar observations [*Reverdy et al.* 2015] onboard the EarthCare satellite to be launched in 2019.

8 variables from the new ATLID lidar simulator in COSPv2 correspond to these observations :

variable name	*variable description*	*dimensions*
LidarBetaMol355	= ATLID LIDAR Molecular Backscatter (355 nm)	(lon, lat, alt)
atb355	= ATLID LIDAR Total Backscatter (355 nm)	(lon, lat, col, alt)
cfadLidarsr355	= ATLID LIDAR Scattering Ratio CFAD	(lon, lat, alt, SRbin)
clatlid	= ATLID LIDAR Cloud Fraction	(lon, lat, alt)
clhatlid	= ATLID LIDAR High Level Cloud Cover	(lon, lat)
cllatlid	= ATLID LIDAR Low Level Cloud Cover	(lon, lat)
clmatlid	= ATLID LIDAR Mid Level Cloud Cover	(lon, lat)
cltatlid	= ATLID LIDAR Total Cloud Cover	(lon, lat)

To add these 8 variables, the following files were added :

src/simulator/cosp_atlid_interface.F90
src/simulator/actsim/atlid_simulator.F90

To add these 8 variables, the following files were modified :

driver/src/cosp2_io.f90
driver/src/cosp2_output_nl.txt
driver/src/cosp2_test.f90
src/cosp.F90
src/cosp_config.F90
build/Makefile
subsample_and_optics_example/optics/cosp_optics.F90

In the “cosp_optics.F90” file, subroutine “atlid_optics” has been added.

In all modified files, lines added or changed have the comment “!ATLID” at the end of each line (except where big chunks of code were added, where it is specified at the beginning and at the end of the chunk that it was added for “!ATLID”).

References

Guzman, R., Chepfer, H., Noel, V., Vaillant de Guelis, T., Kay, J.E., Raberanto, P., Césana, G., Vaughan, M.A. and Winker, D.M., 2017. Direct atmosphere opacity observations from CALIPSO provide new constraints on cloud-radiation interactions. *Journal of Geophysical Research: Atmospheres, 122(2),* pp.1066-1085.

Vaillant de Guélis, T., Chepfer, H., Noel, V., Guzman, R., Dubuisson, P., Winker, D.M. and Kato, S., 2017a. The link between outgoing longwave radiation and the altitude at which a spaceborne lidar beam is fully attenuated. *Atmospheric Measurement Techniques*, *10*(12), p.4659.

Chiriaco M., Dupont J.-C., Bastin S., Badosa J., Lopez J., Haeffelin M., Chepfer H. and Guzman R., 2018. ReOBS: a new approach to synthetize long-term multi-variable dataset and application to the SIRTA supersite. *Earth System Science Data*, accepted.

Reverdy, M., Chepfer, H., Donovan, D., Noël, V., Césana, G., Hoareau, C., Chiriaco, M. and Bastin, S., 2015. An EarthCARE/ATLID simulator to evaluate cloud description in climate models. *Journal of Geophysical Research: Atmospheres*, *120*(21).