ACTIVATE 2020 HSRL-2 ReadMe

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Organization: NASA Langley Research Center
Instrument Name: HSRL-2
Mission: ACTIVATE
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Platform: NASA UC12
Location: GPS Lat, Lon, and Alt included in the Nav_Data records
Associated Data: Additional folders provide information used to process and locate the HSRL-2 data products

- /State: parameters interpolated to HSRL-2 curtains from MERRA2 (see http://gmao.gsfc.nasa.gov/)
  - Temperature, K, atmospheric temperature
  - Pressure, atm, atmospheric pressure
  - Number_Density, per cubic meter, molecular number density
- /Nav_Data: other navigational data is also included besides what is listed below
  - gps_time, time of the data products from 0 UT on the flight day
  - gps_alt, m, aircraft altitude from GPS
  - gps_lat, degrees, latitude N from GPS
  - gps_lon, degrees, longitude E from GPS

Data Info: 10 second profiles, higher resolution files are available upon request. All data products have been interpolated to the same uniform altitude grid (DataProducts/Altitude) and horizontally averaged or interpolated to the GPS times (Nav_Data/gps_time). Horizontal and vertical resolutions of the data products are found in the attributes of each scientific data set.
Instrument Info: High Spectral Resolution Lidar (HSRL-2), see https://science-data.larc.nasa.gov/lidar/instruments.html
Uncertainty: Uncertainty values are not included in this release, they will be provided in the next release
DM Contact Info: richard.a.ferrare@nasa.gov, sharon.p.burton@nasa.gov, marta.a.fenn@nasa.gov, amy.jo.scarino@nasa.gov
Stipulations on Use: This is Final data. Users are strongly encouraged to consult the PI and/or DM prior to use.
Revision: R4

Comments on Data:
Within each full data file (ACTIVATE-HSRL2_UC12_yyyymmdd_RX.h5) there a '000_Readme', but additional the following should be considered:

R1: Change the vertical resolution of extinction and lidar ratio to 225 m. Aerosol ID limited to regions having aerosol depolarization systematic uncertainty < 0.05.
R2: Changed cloud screening, adjusted 1064 timing, added calculation of extinction and AOT from backscatter. Limit Total Attenuated Backscatter to beyond 1.5 km range.
R3: Adjust 355 nm Lidar Ratio

Aerosol_ID classification of Ice is highly suspect on all flights. During ACTIVATE, nonspherical aerosols within about 1 km of the ocean surface are more likely nonspherical sea salt, rather than dust, as described in the article http://journal.frontiersin.org/article/10.3389/frsen.2023.1143944/full?&utm_source=Email_to_authors_&utm_medium=Email&utm_content=T1_11.5e1_author&utm_campaign=Email_publication&field=&journalName=Frontiers_in_Remote_Sensing&id=1143944 In such cases the parameters with dust or spherical in the name should be ignored, since they assume that non-spherical aerosols are dust. See Sugimoto, N., and C. H. Lee (2006), Characteristics of dust aerosols inferred from lidar depolarization measurements at two wavelengths, *Appl Optics, 45*(28), 7468-7474. doi: 10.1364/AO.45.007468.

A 2.3-minute signal oscillation was introduced by the automatic beam alignment process. The effect became much less evident after the first few flights but continued to be apparent especially at low signal counts. No remedy is applied.

A new vector has been added to the datafile in the folder UserInput. The value stored in SignalAtt will be a one for each record where the 532nm and 1064nm laser output was attenuated for eye safety reasons. Expect the signal to noise ratio to suffer in these records

During the ACTIVATE campaigns, HSRL-2 sometimes measured anomalously low aerosol extinction values (355 and 532 nm) which appear to be related to atmospheric turbulence near or at the top of the marine boundary layer. These low values, which are particularly apparent for the winter cases when the aerosol loading is low, are currently thought to be associated with strong wind shear that enhances the lidar signals through changes in the index of refraction near the top of marine boundary layer. This effect impacted the ability to use the 532 nm and 355 nm molecular channels to derive aerosol extinction and the Aerosol Optical Thicknesses (AOT-hi) in these regions using the standard method as discussed by Hair et al (2008). This interference, when present, produces a low bias in the AOT as well as in the aerosol extinction; this AOT bias was typically less than 0.05. We are investigating methods to detect the condition as well as evaluate the impacts of the biases. In the meantime, additional methods are used to compute additional aerosol extinction and AOT products which are provided in this archive for both wavelengths. This method uses aerosol cloud screened aerosol backscatter profiles (532_bsc_cloud_screened) and estimates of the extinction-to-backscatter ratio (i.e., lidar ratio) (532_Sa) to derive extinction profiles (532_ext_from_backscatter) and AOT (532_AOT_from_bsc). This is done similarly for 355nm. Since the HSRL method derives the aerosol backscatter as a ratio of two channels, it is unaffected by this effect. The additional extinction products 532_ext_from_backscatter and 355_ext_from_backscatter was generated from the 10 second resolution cloud screened backscatter profiles and estimated lidar ratios. These lidar ratios were estimated as a function of altitude using the lidar ratios measured in regions unaffected by this atmospheric turbulence. The AOT products 532_AOT_from_bsc were generated from the 10 second 532_ext_from_backscatter and cover the same altitude region as the AOT products derived using the standard method (AOT_from_bsc_StandardRange). AOT_from_bsc_FullRange products cover the altitude range that extends to the topmost backscatter altitude. This procedure was also used to compute the corresponding products at 355 nm. A conservative error estimate for the uncertainty in the assumed lidar ratio is the greater of +/-30% or +/-20 sr. This translates approximately linearly to uncertainties in these additional aerosol extinction and AOT products.

Questions about these procedures and dataset can be directed to chris.a.hostetler@nasa.gov or johnathan.w.hair@nasa.gov or other members of the HSRL-2 team at NASA LaRC.

ICARTT format files are provided that include:

Aerosol Optical Thickness (AOT); Revision R0 at both 355nm and 532nm. Both clear-sky AOT and above cloud AOT are included. Cloud top height is available in these files.

Mixed Layer Heights (MLH); Revision R0 derived from 532nm cloud screened aerosol backscatter profiles when the aircraft is higher than 2km. MLH is reported in meters, above ground level. Given the variety of ways to define, retrieve, and use MLH, as well as the difficulty in determining MLH in complex atmospheric conditions, the MLH provided in these files may or may not be useful for a given application. We strongly recommend that users consult the introduction and methodology found in Scarino, A. J. et al. (2014).

Within the algorithm to determine the MLH, there are two parameters (threshold and dilation) that can be the same across the mission or can vary from flight to flight. These values can be adjusted for each campaign depending on factors such as aerosol loading, anticipated MLH (over water MLH are expected to be much lower than over land), day vs. night, etc. The default dilation value is set for 900 over land and 360 over water. This was used for all the flights in 2020. The default threshold value is 0.0001. This value did vary from flight to flight in 2020. In the table below is the threshold values used.

Date(s)	**Threshold Value**
3/6/2020, 3/11/2020, 8/13/2020, 8/28/2020, 9/2/2020	0.00001

8/21/2020, 8/26/2020	0.00003
2/28/2020 F1	0.000035
8/17/2020, 8/20/2020, 8/25/2020	0.00005
2/29/2020	0.0001 (default)
2/17/2020, 3/2/2020, 3/9/2020, 3/12/2020 F1 & F2, 9/3/2020, 9/10/2020, 9/11/2020, 9/23/2020, 9/29/2020, 9/30/2020	0.00011
2/28/2020 F2	0.00015
3/8/2020 F1, 9/15/2020	0.0002
2/14/2020, 2/15/2020, 2/27/2020, 3/1/2020 F1 & F2, 3/8/2020 F2	0.0005
9/21/2020, 9/22/2020	0.001

There have also been times when changing the threshold still doesn't get the MLH value, so we have manually selected a height. For 2020, we manual adjusted the MLH for 15 flights. Dates with manual input include 2/17/2020, 2/28/2020 F1 & F2, 2/29/2020, 3/1/2020 F2, 3/2/2020, 3/6/2020, 3/8/2020 F1 & F2, 3/12/2020 F1 & F2, 8/13/2020, 8/17/2020, 8/26/2020, and 9/2/2020. Section 2.1 of Scarino et al. (2014) describes how the manual heights are factored into the final MLH.

DEM altitude is provided in this file, which is the ground altitude above mean sea level based on the 1km GLOBE Digital Elevation Map dataset based on the GPS latitude and longitude. Also included in this file are mean 532 nm backscatter and extinction at three different layers: lowest 300m, within the MLH, and a 500m above MLH.

A quality assurance flag is included for the detection of the mixed layer heights, based on the index referenced by de Haij, Wauben & Baltink (2006). The magnitude in jump in backscatter, centered on the MLH is used as a quality of detection. A difference between the averaged backscatter from 360m below MLH (B_d) and the average backscatter from 360m above MLH (B_u) is used as a quantity for the quality index (see table below). The de Haij group used 150m above/below the MLH and slightly different threshold values for the quality index. The threshold values for the different quality index classes have been estimated by assessing cases from the initial MLH processing.

Color Code/QA Flag Value	**Threshold**	**Description**
White – 2	$B_d – B_u < 0.000025$	Poor MLH Detection
Blue – 1	$0.000025 < B_d – B_u < 0.0002$	Weak MLH Detection
Pink – 0	$B_d – B_u > 0.0002$	Good MLH Detection

Compressed folder ('**ACTIVATE-HSRL2- images_UC12_2020_R0_MLH.zip**') contains MLH plots for all flights. There are three plots for each flight – backscatter curtain with MLH, backscatter curtain with MLH colored by QA flag, and flight track colored by MLH.

References

Scarino, A. J. et al.: Comparison of Mixed Layer Heights from Airborne High Spectral Resolution Lidar, Ground-based Measurements, and the WRF-Chem Model during CalNex and CARES, Atmos. Chem. Phys., 14, 5547-5560, https://doi.org/10.5194/acp-14-5547-2014, 2014.

Marijn de Haij, Wiel Wauben, Henk Klein Baltink, "Determination of mixing layer height from ceilometer backscatter profiles," Proc. SPIE 6362, Remote Sensing of Clouds and the Atmosphere XI, 63620R (11 October 2006); https://doi.org/10.1117/12.691050