Data User Guide

# SBU Doppler LiDAR IMPACTS

## Introduction

The SBU Doppler LiDAR IMPACTS dataset consists of Doppler velocity and backscatter intensity from the Stony Brook University (SBU) Doppler LiDAR. These data were collected during the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) field campaign. IMPACTS was a three-year sequence of winter season deployments conducted to study snowstorms over the U.S Atlantic Coast (2020-2023). The campaign aimed to (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. The dataset files are available in netCDF-4 format from January 1 through February 26, 2020.

## Citation

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## Keywords:

NASA, GHRC, LiDAR, EM, Doppler, IMPACTS, SBU, Doppler velocity, backscatter

## Campaign

The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS), funded by NASA's Earth Venture program, is the first comprehensive study of East Coast snowstorms in 30 years. IMPACTS will fly a complementary suite of remote sensing and in-situ instruments for three 6-week deployments (2020-2023) on NASA's ER-2 high-altitude aircraft and P-3 cloud-sampling aircraft. The first deployment began on January 17, 2020 and ended on March 1, 2020. IMPACTS samples U.S. East Coast winter storms using advanced radar, LiDAR, and microwave radiometer remote sensing instruments on the ER-2 and state-of-the-art microphysics probes and dropsonde capabilities on the P-3, augmented by ground-based radar and rawinsonde data, multiple NASA and NOAA satellites (including GPM, GOES-16, and other polar orbiting satellite systems), and computer simulations. IMPACTS addressed three specific objectives: (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. More information is available from [NASA's Earth Science Project Office's IMPACTS field campaign webpage].

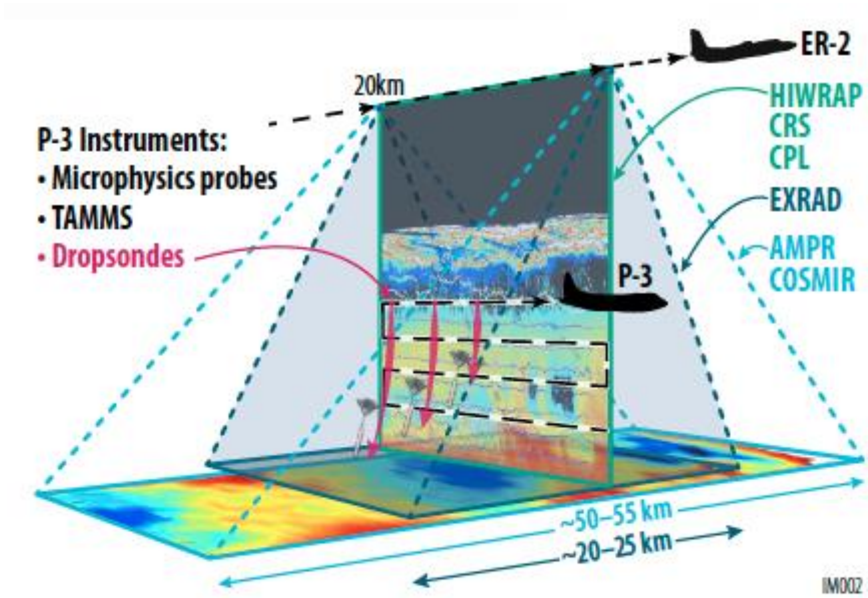


Figure 1: IMPACTS airborne instrument suite
(Image source: NASA IMPACTS ESPO)

## Instrument Description

The Doppler lidar (DL) is an active remote-sensing instrument that provides range- and time-resolved measurements of radial velocity, attenuated backscatter, and signal-to-noise ratio (SNR). The principle of operation is similar to radar in that pulses of electromagnetic energy (infrared in this case) are transmitted into the atmosphere; the energy scattered back to the transceiver is collected and measured as a time-resolved signal. From the time delay between each outgoing transmitted pulse and the backscattered signal, the distance to the scatterer is inferred. The radial or line-of-sight velocity of the scatterers is determined from the Doppler frequency shift of the backscattered radiation. The DL uses a heterodyne detection technique in which the return signal is mixed with a reference laser beam (i.e., local oscillator) of known frequency. An onboard signal-processing computer then determines the Doppler frequency shift from the power spectra of the heterodyne signal. The energy content of the Doppler spectra can also be used to estimate attenuated backscatter.

The DL operates in the near-infrared (IR;1.5 microns) and is sensitive to backscatter from micron-sized aerosols. Aerosols are ubiquitous in the lower troposphere and behave as ideal tracers of atmospheric winds. In contrast to radar, the DL is capable of measuring radial velocities under clear-sky conditions with very good precision (typically ~10 cm/sec). Also, most of the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility DLs have full upper-hemispheric scanning capability, enabling three-dimensional mapping of turbulent flows in the atmospheric boundary layer. When the scanner is pointed vertically the DL provides height- and time-resolved measurements of vertical velocity. Radial velocities are defined to be positive for motion away from the lidar.

The DL is a small self-contained system that is easily portable and has relatively modest power requirements. The instrument is housed in a rugged environmentally controlled container, requires only external electrical power and internet, and will run unattended for weeks or months on end with little or no operator intervention. Control of the system is facilitated through either a direct connection to the onboard instrument computer or remotely via the internet. The control software enables the user to easily modify a variety of instrument settings and schedule a variety of different scans. More information about this Doppler LiDAR can be found at Doppler Lidar (DL) Instrument Handbook, Doppler Lidar | Radar Science, and ARM Research Facility.


Figure 2: SBU Doppler LiDAR
(Image source: SBU Doppler Lidar webpage)

## Investigators

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## Data Characteristics

The SBU Doppler LiDAR IMPACTS dataset is available in netCDF-4 format at a Level 1A processing level. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

| Characteristic | Description |
|---|---|
| Platform | Ground station |
| Instrument | Doppler LiDAR |
| Spatial Coverage | N: 40.889, S: 40.861, E: -72.863, W: -72.891 (New York) |
| Spatial Range | point-6000m |
| Temporal Coverage | January 1, 2020 - February 26, 2020 |
| Temporal Resolution | daily |
| Sampling Frequency | Seconds -< minutes |
| Parameter | Doppler reflectivity |
| Version | 1 |
| Processing Level | 1A |

## File Naming Convention

The SBU Doppler LiDAR IMPACTS dataset files are named using the following convention:

**Data files:** IMPACTS_SBU_dopplerlidar_YYYYMMDD_[rhi|vel_az|vpt]_BNL.nc

Table 2: File naming convention variables

| Variable | Description |
|---|---|
| YYYY | Four-digit year |
| MM | Two-digit month |
| DD | Two-digit day |
| [rhi\|vel_az\|vpt] | rhi: range-height indicator<br>vel_az: velocity-azimuth<br>vpt: vertically-pointing |
| .nc | netCDF-4 format |

## Data Format and Parameters

The SBU Doppler LiDAR IMPACTS dataset consists of Doppler velocity and backscatter data in netCDF-4 format. Tables 3-5 list and describe the data for RHI, VEL, and VPT data, respectively.

Table 3: RHI Data Fields

| Field Name | Description | Unit |
|---|---|---|
| AZIMUTH | Beam azimuth angle measured clockwise from true North | degrees |
| BETA | LiDAR backscatter coefficient | 1/m sr |
| DOPPLER | Doppler velocity | m/s |
| ELEVATION | Beam elevation angle measured from horizontal | degrees |
| FILENAME | Original filename | - |
| FOCUS_RANGE | Range location for the effective focus enhancements | m |
| GATE_LENGTH__PTS_ | The number of pulses for integration per gate | - |
| INTENSITY | Backscatter intensity. Signal-to-Noise Ratio + 1 | - |
| NO__OF_WAYPOINTS_IN_FILE | Number of waypoints in the data file | - |
| NUMBER_OF_AZIMUTHS | Number of azimuth measurements | - |
| NUMBER_OF_GATES | The number of range gates for each ray | - |
| PITCH | pitch | degrees |
| PULSES_RAY | The number of pulses transmitted per ray | - |
| RANGE | Distance from LiDAR to the center of range gate | m |
| RANGE_GATE_LENGTH__M_ | Range-gate spacing | m |
| RESOLUTION__M_S_ | Velocity measurement resolution | m/s |
| ROLL | Roll | degrees |
| SCAN_TYPE | Scan type | - |
| START_TIME | Start time (yyyymmdd hh:mm:ss) | UTC |
| SYSTEM_ID | System ID | - |
| TIME | Hour from midnight | UTC |

Table 4: VEL Data Fields

| Field Name | Description | Unit |
|---|---|---|

| | | |
|---|---|---|
| AZIMUTH | Beam azimuth angle measured clockwise from true North | degrees |
| BETA | LiDAR backscatter coefficient | 1/m sr |
| DOPPLER | Doppler velocity | m/s |
| ELEVATION | Beam elevation angle measured from horizontal | degrees |
| FILENAME | Original filename | - |
| FOCUS_RANGE | Range location for the effective focus enhancements | m |
| GATE_LENGTH__PTS_ | The number of pulses for integration per gate | - |
| INTENSITY | Backscatter intensity. Signal-to-Noise Ratio + 1 | - |
| NO__OF_RAYS_IN_FILE | Number of waypoints in the data file (step positions in the scan) | - |
| NUMBER_OF_AZIMUTHS | Number of azimuth measurements | - |
| NUMBER_OF_GATES | The number of range gates for each ray | - |
| PITCH | pitch | degrees |
| PULSES_RAY | The number of pulses transmitted per ray | - |
| RANGE | Distance from LiDAR to the center of range gate | m |
| RANGE_GATE_LENGTH__M_ | Range-gate spacing | m |
| RESOLUTION__M_S_ | Velocity measurement resolution | m/s |
| ROLL | Roll | degrees |
| SCAN_TYPE | Scan type | - |
| START_TIME | Start time (yyyymmdd hh:mm:ss) | UTC |
| SYSTEM_ID | System ID | - |
| TIME | Hour from midnight | UTC |

Table 5: VPT Data Fields

| Field Name | Description | Unit |
|---|---|---|
| AZIMUTH | Beam azimuth angle measured clockwise from true North | degrees |
| BETA | LiDAR backscatter coefficient | 1/m sr |
| DOPPLER | Doppler velocity | m/s |
| DOPPLER_SKEWNESS | Doppler velocity skewness | - |
| DOPPLER_VARIANCE | Doppler velocity variance | $m^2/s^2$ |

| | | |
|---|---|---|
| ELEVATION | Beam elevation angle measured from horizontal | degrees |
| FILENAME | Original filename | - |
| FOCUS_RANGE | Range location for the effective focus enhancements | m |
| GATE_LENGTH__PTS_ | The number of pulses for integration per gate | - |
| INSTRUMENT_VARIANCE | Contribution of the uncorrelated random noise to the measured variance | - |
| INTENSITY | Backscatter intensity. Signal-to-Noise Ratio + 1 | - |
| NO__OF_RAYS_IN_FILE | The number of rays in file (step positions in the scan) | - |
| NUMBER_OF_AZIMUTHS | Number of azimuth measurements | - |
| NUMBER_OF_GATES | The number of range gates for each ray | - |
| PBL_HEIGHT | Planetary boundary layer height | m |
| PITCH | pitch | degrees |
| PULSES_RAY | The number of pulses transmitted per ray | - |
| RANGE | Distance from LiDAR to the center of range gate | m |
| RANGE_GATE_LENGTH__M_ | Range-gate spacing | m |
| RESOLUTION__M_S_ | Velocity measurement resolution | m/s |
| ROLL | Roll | degrees |
| SCAN_TYPE | Scan type | - |
| START_TIME | Start time (yyyymmdd hh:mm:ss) | UTC |
| SYSTEM_ID | System ID | - |
| TIME | Hour from midnight | UTC |

## Algorithm

The SBU Doppler LiDAR measures the radial velocity and attenuated backscatter of aerosol particles to measure atmospheric winds. The mass of aerosol particles means that they are carried by the wind. Therefore by detecting the movement of the aerosols, you are detecting the wind flows patterns. More information about the algorithms used for this dataset can be found in the Doppler Lidar (DL) Instrument Handbook.

## Quality Assessment

Beam pointing accuracy impacts data quality (e.g., wind direction). The lidar reports the beam elevation and azimuth angles relative to the lidar's coordinate system. The configuration file, maintained by the instrument mentors, contains a history of the system's heading (i.e., the home point azimuth). The process of determining the orientation of the lidar is really a calibration issue. Attenuated backscatter measurements are derived from the range-corrected SNR using a factory-determined calibration curve. The lidar reports the beam azimuth and elevation angle relative to its own internal coordinate system. These angles are then transformed to an Earth-fixed frame of reference such that the azimuth is measured clockwise from true north, and the elevation angle is measured from the horizon. More information about the quality of these data is available in the Doppler Lidar (DL) Instrument Handbook.

## Software

These data are available in netCDF-4 format, so no software is required to view these data; however, you can easily plot these data using Panoply.

## Known Issues or Missing Data

There are no known issues or missing data in these dataset.

## References

ARM. Doppler Lidar (DL) Instrument Handbook.
https://www.arm.gov/publications/tech_reports/handbooks/dl_handbook.pdf

## Related Data

All other datasets collected as part of the IMPACTS campaign are considered related and can be located by searching the term "IMPACTS" in the Earthdata Search.

## Contact Information

To order these data or for further information, please contact:

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