WHEN TRUST MATTERS

IEA Wind Task 32

Initiative for Round Robin on turbulence estimates from nacelle mounted Lidar systems

Documentation

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Motivation

During the past years measurements from remote sensing (RS) devices became more and more important for the wind industry. In offshore measurements, especially the use of nacelle-mounted lidar systems becomes one of the key technologies for different applications such as power performance and turbine optimization campaigns. The success of nacelle lidar systems is caused by their great advantages compared to traditional instruments (e.g. cup anemometer mounted on met. masts). Especially offshore, nacelle lidars are a cost-effective tool and in most cases the only option to assess the wind conditions around a wind turbine.

It has been shown that nacelle lidars are able to measure first order wind field quantities, e.g. horizontal wind speed and wind direction, with great accuracy, so these measurands are widely accepted by the wind industry. Second order quantities such as turbulence intensity (TI) does not have the maturity to be accepted yet, even though they play a key role in applications like mechanical loads measurements.

In parallel to working groups like CFARS (Consortium for Advancement of Remote Sensing) or DNV's joint industry project on turbulence measurements from lidars which put their focus on the acceptance of TI measurements from ground-based lidar systems, this work focusses on investigations related to turbulence estimates from nacelle lidars.

The first phase of the project focuses on volume-averaging effect of lidar systems. Although the volume has a very positive effect on capturing turbulence over the rotor, the goal is to develop methods to get a good agreement to the turbulence intensity in line-of-sight direction from a met mast.

The second phase of the project focuses on the wind field reconstruction effect of lidar systems. The goal is to develop methods to get to a good agreement to the turbulence intensity measured by two met-masts.

The Round Robin is planned to be extended. The final goal is to prove that lidar systems are a better instruments to capture the TI relevant for wind turbines.

Scope of work

The data used for this round robin was recorded during two different lidar verification campaigns conducted at the DNV nacelle lidar test site in Janneby, Northern Germany. The first dataset was recorded in 2017 and consists of data from a continuous wave nacelle lidar (ZX DM/TM). The second dataset was recorded in 2020 and consists of data from a pulsed nacelle lidar (Windcube Nacelle). For both datasets two periods of data will be provided.

The first period (~1 day) consists of the lidar and concurrently measured mast data. The second period (~4 days) consists of the lidar data only. The scope of the participants of the round robin is to apply their in-house TI calculation algorithms to the data from the second period. The data from the first period can be used freely and independent from the second period, e.g. to test the participants in-house TI calculation method or to train a machine learning model.

A summary of the workflow is given below:

1) DNV/OWC will provide 4x datasets (2x datasets for a CW lidar, 2x datasets for a pulsed lidar). In each case, the first dataset (~1 day) includes the lidar and concurrent mast data. The second dataset (~4 days) consists of the lidar data only.

2) The participants are requested to apply their in-house TI calculation methods to the data from the second dataset. Please note that its up to the participants either to work with one or the other dataset (e.g. CW or pulsed data) or apply their in-house TI calculation methods to the data from both lidar types. The first dataset can be used freely (e.g. for crosschecks or for training of a machine learning model).

3) In the next step, the participants are requested to send back the calculated lidar TI estimates from the second dataset. Please note that there will be two types of TI comparison (see detailed on next slide). The participants can either participate in one of the comparison exercise (i.e. 1-D white box or 2-D black box comparison) or both.

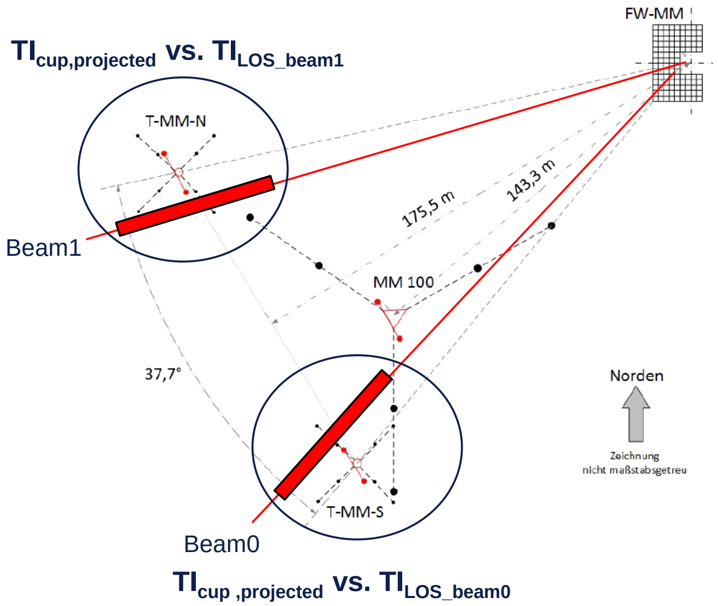
4) DNV will compare the calculated lidar TI estimates against traditional TI measurements from Cup and Sonic anemometer.

5) Presentation of the results at an IEA workshop

Two types of TI comparison

1-dimensional “white box” comparison

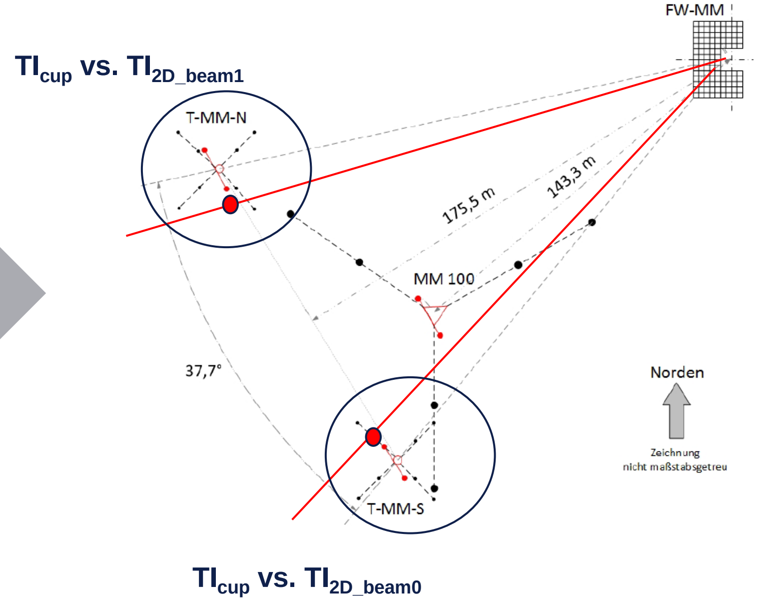
Turbulence along a single line-of-sight (LOS) measurement / group of LOS measurements is compared against a projected reference TI.



For the **white box comparison** the participants are requested to send back the calculated 1-dimensional LOS_TI for each laser beam (target range: 178 m)

2-dimensional “black box” comparison

Reconstructed turbulence value (2-dimensions) from the lidar device is compared against TI from traditional measurement instruments.



For the **black box comparison** the participants are requested to send back the calculated 2-dimensional TI for each laser beam (target range: 178 m)

Test site

FW-MM

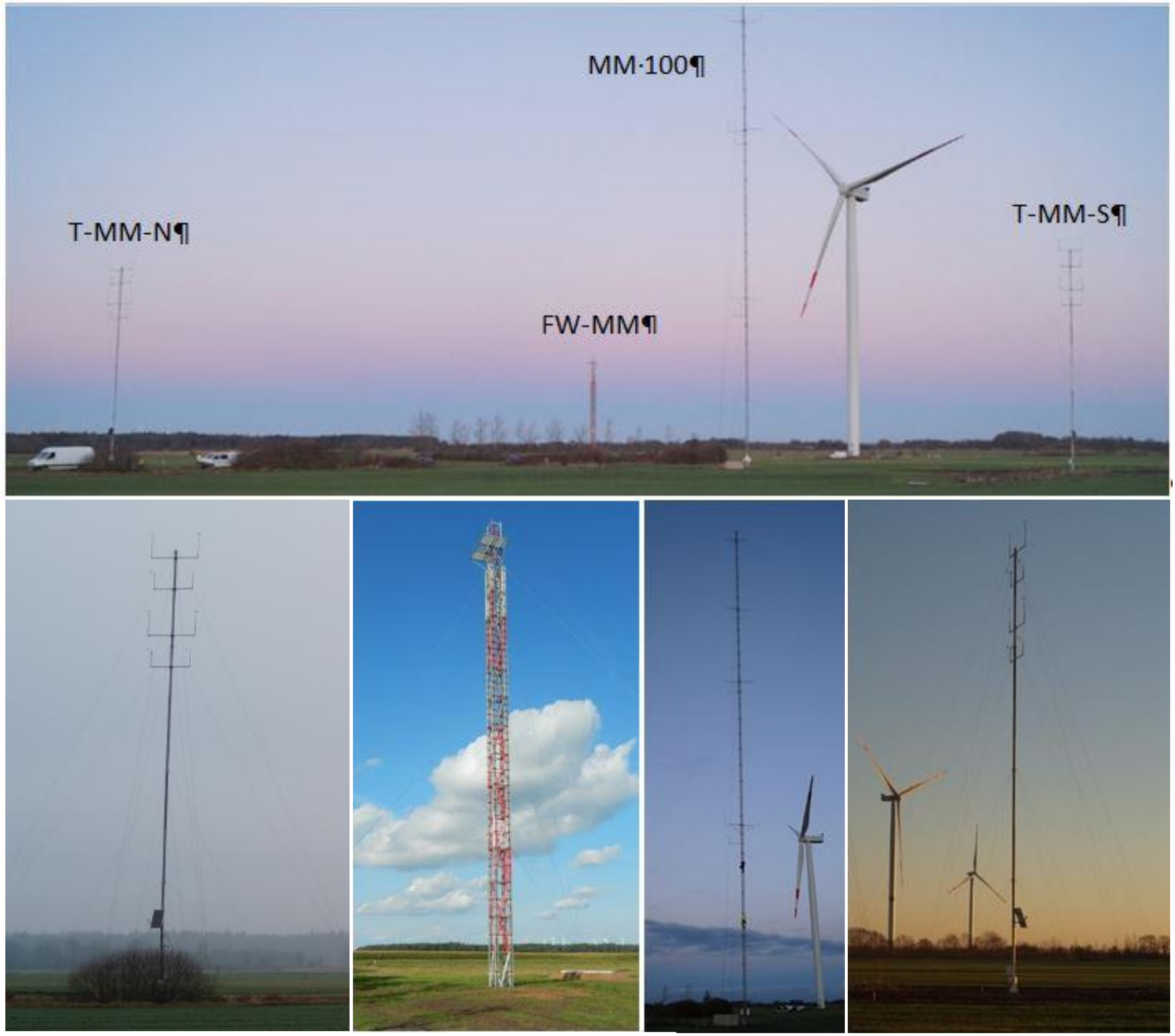
- Lattice mast with platform for LiDAR installation
- Height: 30 m

T-MM-N and T-MM-S

- Two (2) reference masts
- Equipped with traditional sensors (e.g. anemometers and wind vanes)
- Height: 30 m

MM 100

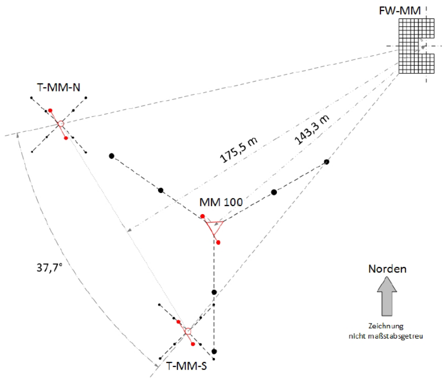
- Additional met mast
- Heights: 30, 57, 76, 100 m

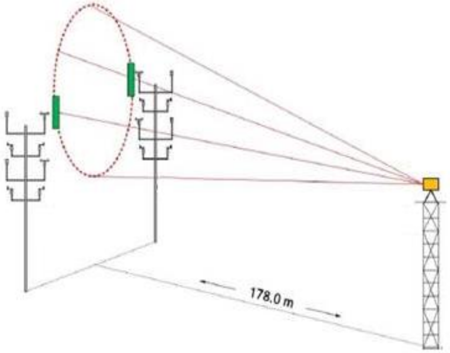


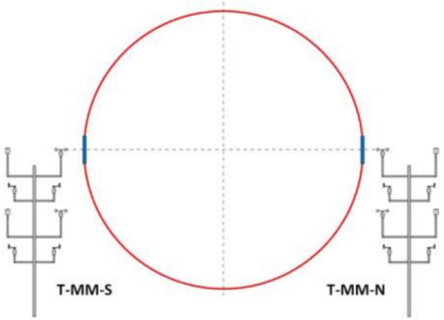
T-MM-N FW-MM MM100 T-MM-S

Test setup

- Selection of suitable data sets for two lidar types
  - Data from a ZDM/ZX TM unit







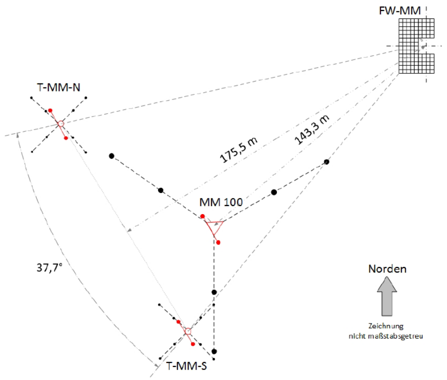
What will be shared:

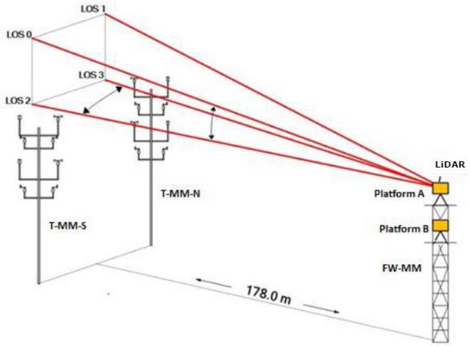
- Two periods of lidar data
- One concurrent set of reference data

System	10 min	1Hz	High freq. LOS data	Spectra
TMMN	X	X		
TMMS	X	X		
MM100	X	X		
ZDM 351	X	X	X	On request

Test setup

- Selection of suitable data sets for two lidar types
  - Data from a Windcube Nacelle (2-beam mode)





What will be shared:

- Two periods of lidar data
- One concurrent set of reference data

System	10 min	1Hz
TMMN	X	X
TMMS	X	X
MM100	X	X
WCN (LOS2/3)	X	X

Leosphere data package

Period 1: 2020/09/03 19:00 - 2020/09/04 18:59 (1 day)	Data type	Period 2: 2020/10/20-2020/10/24 (4 days)
Lidar_20200903-20200904_1Hz_LOS2_178m.csv	WindCube Nacelle 1Hz data (LOS2, 178m)	Lidar_20201020-20201024_1Hz_LOS2_178m.csv
Lidar_20200903-20200904_1Hz_LOS3_178m.csv	WindCube Nacelle 1Hz data (LOS3, 178m)	Lidar_20201020-20201024_1Hz_LOS3_178m.csv
Lidar_20200903-20200904_10min.csv	WindCube Nacelle 10min data	Lidar_20201020-20201024_10min.csv
TMMN_20200903_20200904_1Hz.csv	T-MM-N 10 min data	-
TMMN_20200903_20200904_stats.csv	T-MM-N 1Hz data	-
TMMS_20200903_20200904_1Hz.csv	T-MM-S 10 min data	-
TMMS_20200903_20200904_stats.csv	T-MM-S 1Hz data	-

Leosphere data package

- Header description

Leosphere 1 Hz data

Real time data	N°	Description	Unit / Format	Resolution	Value Min	Value Max
Date and Time	1	Timestamp of the current measurement	yyyy/mm/dd hh:mm:ss:000	NA	NA	NA
LOS	2	Current line of sight	NA	1	0	3
Distance	3	Measurement plan distance	m	10^{-2}	0	460
RWS	4	Radial wind speed along the current line of sight	m/s	10^{-2}	-20	50
DRWS	5	Radial wind speed standard deviation	m/s	10^{-2}	-20	50
CNR	6	Carrier to noise ratio along the line of sight	dB	10^{-2}	-50	50
Tilt	7	Tilt angle of the system	°	10^{-2}	-45	45
Roll	8	Roll angle of the system	°	10^{-2}	-45	45
RWS status	9	Radial wind speed status	NA	1	0	1
Overrun status	10	Real time performance status	NA	1	0	1

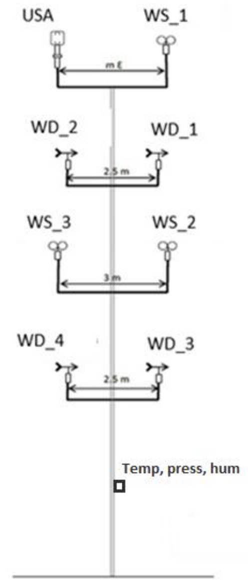
Leosphere 10 min data

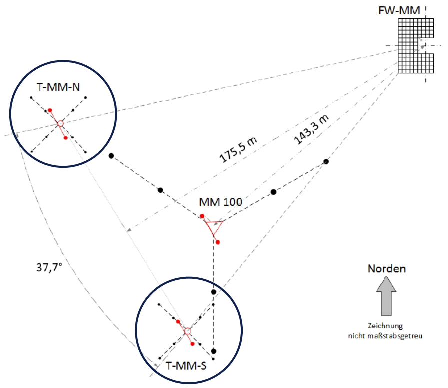
Average data	N°	Description	Unit / Format	Resolution	Value Min	Value Max
Date and Time	1	End date and time of the 10min data sample	yyyy/mm/dd hh:mm	NA	NA	NA
Distance	2	Measurement plan distance	m	10^{-2}	0	460
HWS_{hub}	3	Horizontal wind speed at hub height	m/s	10^{-2}	0	50
$Direction_{hub}$	4	Horizontal wind direction at hub height	°	10^{-2}	-180	180
HWS_{hub} Availability	5	Availability of the reconstruction at hub height	%	10^{-2}	0	100
RWS_0 Availability	6	Availability of the radial measurement along LOS0	%	10^{-2}	0	100
RWS_1 Availability	7	Availability of the radial measurement along LOS1	%	10^{-2}	0	100
RWS_2 Availability	8	Availability of the radial measurement along LOS2	%	10^{-2}	0	100
RWS_3 Availability	9	Availability of the radial measurement along LOS3	%	10^{-2}	0	100
TI_{hub}	10	Turbulence intensity at hub height	NA	10^{-2}	-1	1
Shear	11	Vertical wind shear coefficient	NA	10^{-2}	-1	1
Veer	12	Vertical wind veer coefficient	°/m	10^{-2}	-10	10
TI_{gain}	13	Turbulence intensity gain	NA	10^{-2}	-1	1
RWS_0	14	Radial wind speed along LOS0	m/s	10^{-2}	-20	50
RWS_1	15	Radial wind speed along LOS1	m/s	10^{-2}	-20	50
RWS_2	16	Radial wind speed along LOS2	m/s	10^{-2}	-20	50
RWS_3	17	Radial wind speed along LOS3	m/s	10^{-2}	-20	50
TI_0	18	Turbulence intensity along LOS0	NA	10^{-2}	-1	1
TI_1	19	Turbulence intensity along LOS1	NA	10^{-2}	-1	1
TI_2	20	Turbulence intensity along LOS2	NA	10^{-2}	-1	1
TI_3	21	Turbulence intensity along LOS3	NA	10^{-2}	-1	1
CNR_0	22	Carrier to noise ratio along LOS0	dB	10^{-2}	-50	50
CNR_1	23	Carrier to noise ratio along LOS1	dB	10^{-2}	-50	50
CNR_2	24	Carrier to noise ratio along LOS2	dB	10^{-2}	-50	50
CNR_3	25	Carrier to noise ratio along LOS3	dB	10^{-2}	-50	50
Tilt	26	Tilt angle of the telescope	°	10^{-2}	-15	15
Roll	27	Roll angle of the telescope	°	10^{-2}	-15	15
U_{high}	28	Longitudinal component of the wind above hub	m/s	10^{-2}	-20	50
U_{low}	29	Longitudinal component of the wind below hub	m/s	10^{-2}	-20	50
V_{high}	30	Transversal component of the wind above hub	m/s	10^{-2}	-50	50
V_{low}	31	Transversal component of the wind below hub	m/s	10^{-2}	-50	50
$Height_{high}$	32	Measurement height of the beams from the top	m/s	10^{-2}	0	200
$Height_{ow}$	33	Measurement height of the bottom beams	m/s	10^{-2}	0	200
HWS_{high}	34	Horizontal wind speed above hub	m/s	10^{-2}	0	50
HWS_{low}	35	Horizontal wind speed below hub	m/s	10^{-2}	0	50
$Direction_{high}$	36	Horizontal wind direction above hub	°	10^{-2}	-180	180
$Direction_{low}$	37	Horizontal wind direction below hub	°	10^{-2}	-180	180
TI_{high}	38	Turbulence intensity above hub	NA	10^{-2}	-1	1
TI_{low}	39	Turbulence intensity below hub	NA	10^{-2}	-1	1
HWS_{high} Availability	40	Availability of the reconstruction above hub	%	10^{-2}	0	100
HWS_{low} Availability	41	Availability of the reconstruction below hub	%	10^{-2}	0	100

Leosphere data package

- Header description: 1Hz data for T-MM-S and T-MM-N

Signal Name	Instrument	Height [m]	Orientation [°]		Unit	Add. description
			T-MM-S	T-MM-N		
TIMESTAMP						Timestamp
WD1	Thies wind vane	27	330	150	Deg	Wind direction
WD2	Friedrichs wind vane	27	150	330	Deg	Wind direction
Temp	Weather station	5	-	-	°C	Temperature
Hum	Weather station	5	-	-	%	Humidity
Press	Weather station	5	-	-	hPa	Pressure
WS1	Thies First Class Advanced X	30	330	150	m/s	Primary wind speed
WS2	Thies First Class Advanced	24	330	150	m/s	Horizontal wind speed
WS3	Thies First Class Advanced	24	150	330	m/s	Horizontal wind speed
USA_U	Thies 3D Sonic Anemometer	30	150	330	m/s	U component
USA_V	Thies 3D Sonic Anemometer	30	150	330	m/s	V component
USA_W	Thies 3D Sonic Anemometer	30	150	330	m/s	W component
USA_WShorizontal	Thies 3D Sonic Anemometer	30	150	330	m/s	Horizontal wind vector from U & V components
USA_WSvector	Thies 3D Sonic Anemometer	30	150	330	m/s	3D wind vector from U, V & W components
USA_WD	Thies 3D Sonic Anemometer	30	150	330	Deg	Primary wind direction signal
USA_FlowAngle	Thies 3D Sonic Anemometer	30	150	330	Deg	Flow inclination angle
USA_Error	Thies 3D Sonic Anemometer	30	150	330	-	Quality signal (0=valid, 1=not valid)
USA_CRCstatus_OK	Thies 3D Sonic Anemometer	30	150	330	-	Quality signal (0=valid, 1=not valid)

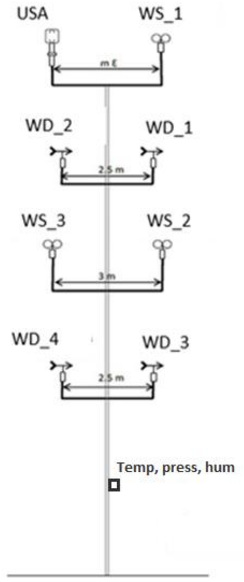


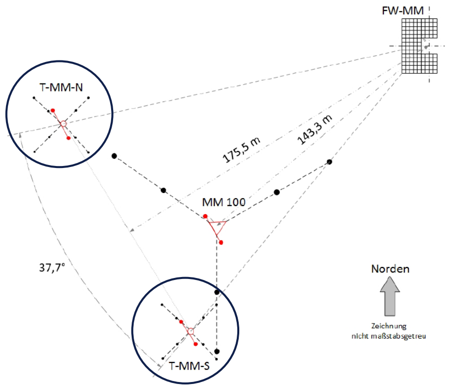


Leosphere data package

- Header description: 10 min data for T-MM-S and T-MM-N

Signal Name	Instrument	Height [m]	Orientation [°]		Unit	Suffices	Add. description
			T-MM-S	T-MM-N			
TimeStamp	-	-	-	-	-	-	Timestamp
counter_Max	-	-	-	-	-	-	Number of data entries within 10min period (max = 600)
Hum_	Weather station	5	-	-	%	Avg, Max, Min, Std	Humidity
Press_	Weather station	5	-	-	hPa	Avg, Max, Min, Std	Pressure
Temp_	Weather station	5	-	-	°C	Avg, Max, Min, Std	Temperature
USA_CRCstatus_OK_Avg	Thies 3D Sonic Anemometer	30	150	330	-	-	Quality signal (0=valid, 1=not valid)
USA_Error_Avg	Thies 3D Sonic Anemometer	30	150	330	-	-	Quality signal (0=valid, 1=not valid)
USA_FlowAngle_	Thies 3D Sonic Anemometer	30	150	330	Deg	Avg, Max, Min, Std	Flow inclination angle
USA_U_	Thies 3D Sonic Anemometer	30	150	330	m/s	Avg, Max, Min, Std	U component
USA_V_	Thies 3D Sonic Anemometer	30	150	330	m/s	Avg, Max, Min, Std	V component
USA_W_	Thies 3D Sonic Anemometer	30	150	330	m/s	Avg, Max, Min, Std	W component
USA_WDVecDir_Avg	Thies 3D Sonic Anemometer	30	150	330	Deg	-	Vector averaged wind direction (Avg)
USA_WDVecDir_Std	Thies 3D Sonic Anemometer	30	150	330	Deg	-	Vector averaged wind direction (Std)
USA_WShorizontal_	Thies 3D Sonic Anemometer	30	150	330	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed
USA_WSvector_	Thies 3D Sonic Anemometer	30	150	330	m/s	Avg, Max, Min, Std	Vector averaged horizontal wind speed
WD1_VecDir_Avg	Thies wind vane	27	330	150	Deg	-	Vector averaged wind direction (Avg)
WD1_VecDir_Std	Thies wind vane	27	330	150	Deg	-	Vector averaged wind direction (Std)
WD2_VecDir_Avg	Friedrichs wind vane	27	150	330	Deg	-	Vector averaged wind direction (Avg)
WD2_VecDir_Std	Friedrichs wind vane	27	150	330	Deg	-	Vector averaged wind direction (Std)
WS1_	Thies First Class Advanced X	30	330	150	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed
WS2_	Thies First Class Advanced	24	330	150	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed
WS3_	Thies First Class Advanced	24	150	330	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed





ZX data package

Period 1: 2017/02/16 04:00 -2017/02/17 04:00 (1 day)	Data type	Period 2: 2017/02/25 00:00 -2017/02/28 23:59 (4 days)
Raw_351@20170216_20170217_filtered_without_FFTbins_left_sector.csv	ZDM raw data “left beam”	Raw_351@20170225_20170228_filtered_without_FFTbins_left_sector_178m.csv
Raw_351@20170216_20170217_filtered_without_FFTbins_right_sector.csv	ZDM raw data “right beam”	Raw_351@20170225_20170228_filtered_without_FFTbins_right_sector_178m.csv
Wind_351@20170216_20170217.csv	ZDM 1Hz data	Wind_351@20170225_20170228.csv
Wind10_ZTM351@20170216_20170217.csv	ZDM 10 min data	Wind10_351@20170225_20170228.csv
Raw_Spectral data (256 bins) can be shared on request	ZDM spectral data	Raw_Spectral data (256 bins) can be shared on request
T-MM-N_20170216_20170217_10min.csv	T-MM-N 10 min data	-
T-MM-N_20170216_20170217_1Hz.csv	T-MM-N 1Hz data	-
T-MM-S_20170216_20170217_10min.csv	T-MM-S 10 min data	-
T-MM-S_20170216_20170217_1Hz.csv	T-MM-S 1Hz data	-

Please note that the ZX datasets (10-min files) are averaged for the first sample of the 10-minute averaging period (e.g. 25/02/2017 04:50) whereas the 10-minute mast data is averaged for the last sample of the 10-minute averaging period (e.g. 25/02/2017 05:00). To merge the two data sources, it is therefore required to shift the 10 min periods by 10-minute (e.g. ZX timestamp at 25/02/2017 04:50 fits to the mast timestamp at 25/02/2017 05:00).

Please note that 999X values in the Wind10 and Wind files are associated with high uncertainties and should be excluded from the analysis.

ZX data package

- Header description

Raw file:
The Raw file contains the contains the low level lidar measurements, normally sampled at a 48.8 Hz. Note some standard Raw file outputs and samples have been excluded for the purposes of the RR exercise.

Reference
Each Raw measurement has an associated reference.   The reference starts at zero and increments by one with each measurement. If the unit's internal storage is cleared, the reference resets to zero.

Time and date
Self explanatory, but note the times are UTC times in ISO 8601 format

Timestamp
The system time (expressed as the number of seconds since 2000-01-01T00:00:00.000)

Range
The measurement range associated with the LOS measurement. Note the range is the distance from the lidar window to the centre of the scan, not the distance along the beam.

Phase
The azimuthal angle of the circular scan. 0 phase it at the top of the scan.

Line of sight wind speed [note it is a scalar, so should not really be called velocity]
Sometime called the radial wind speed, this is the wind vector's wind speed component along the direction of the lidar beam. This is proportional to the measured Doppler shift

Spectral spread
The standard deviation of the spectral data.

Inclination angle
The angle of the lidar optical axis from horizontal. A positive value indicates that the lidar beam is inclined upwards.

Roll angle
The angle by which the lidar is rolled i.e. the rotation around its optical axis. The phase angle reported (see above) includes the effect of roll.

ZX data package

- Header description

Wind file:

The wind file contains the unaveraged outputs of the wind field reconstruction algorithms at the 1s level. Note some standard Wind file outputs have been excluded for the purposes of the RR exercise.

Reference
Each Raw measurement has an associated reference. The reference starts at zero and increments by one with each measurement. If the unit's internal storage is cleared, the reference resets to zero.

Time and date
Self explanatory, but note the times are UTC times in ISO 8601 format

Timestamp
The system time (expressed as the number of seconds since 2000-01-01T00:00:00.000)

FD quantities
These refer to the outputs of the fit-derived algorithm, where all the measurements from around the lidars circular scan are used to determine the wind field quantities. FD assumes a power law shear profile and no veer.

PD quantities
These refer to the outputs of the pair-derived wind field reconstruction algorithm, where horizontal pairs of measurements on opposite sides of the scan are used to determine the wind field quantities. PD makes no assumptions about veer or shear profiles.

Met air temperature, pressure and humidity
The measurements derived from the lidar's meteorological station located on top of its shell. Humidity is relative humidity.

Horizontal wind speed
The wind speed output from the appropriate wind field reconstruction algorithm

Wind yaw misalignment
The wind direction, in plan view, relative to the lidar's optical axis, determined from the appropriate wind field reconstruction algorithm

FD flow complexity
A numerical measure of the spatial flow complexity derived from the FD wind field reconstruction algorithm. It quantifies the deviation of the FD algorithm outputs from to the LOS measurements around the lidar scan.

Wind shear exponent
The wind shear exponent, assuming a power law vertical shear profile, determined from the appropriate wind field reconstruction algorithm

Range
The measurement range associated with the wind speed measurement. Note the range is the distance from the lidar window to the centre of the scan, not the distance along the beam.

Inclination angle mean
The mean angle of the lidar optical axis from horizontal during the 1 s measurement period. A positive value indicates that the lidar beam is inclined upwards.

Roll angle
The mean angle by which the lidar is rolled i.e. the rotation around its optical axis during the 1 s measurement period. The phase angle reported (see above) includes the effect of roll.

Left and right LOS speeds
The left and right measured LOS speeds at the specified height and range

FD Backscatter.
The atmospheric backscatter coefficient (β) determined using the strength of the lidar return signal. Units are $m^{-1}\ sr^{-1}$

ZX data package

- Header description

Wind10 file:

The Wind10 file contains the 10 minute averaged outputs of the wind field reconstruction algorithms. The mean, minimum, maximum and standard deviation are reported for many quantities.
Note some standard Wind10 file outputs have been excluded for the purposes of the RR exercise, for example the TI outputs.

Reference
Each Raw measurement has an associated reference. The reference starts at zero and increments by one with each measurement. If the unit's internal storage is cleared, the reference resets to zero.

Time and date
Self explanatory, but note the times are UTC times in ISO 8601 format

Timestamp
The system time (expressed as the number of seconds since 2000-01-01T00:00:00.000)

FD quantities
These refer to the outputs of the fit-derived wind field reconstruction algorithm, where all the measurements from around the lidar's circular scan are used to determine the wind field quantities. FD assumes a power law shear profile and zero veer.

PD quantities
These refer to the outputs of a pair-derived wind field reconstruction algorithm, where horizontal pairs of measurements on opposite sides of the scan are used to determine the wind field quantities. PD makes no assumptions about veer or vertical shear profiles.

Flow Complexity mean
The mean of the 1 s FD Flow Complexity

Packets in average
The number of valid unaveraged wind field reconstruction outputs included in the 10 minute average

Met air temperature, pressure and humidity
The 10 minute means of the measurements derived from the lidar's meteorological station located on top of its shell.

Horizontal wind speed
Wind speed output from the appropriate wind field reconstruction algorithm

Wind yaw misalignment
The wind direction, in plan view, relative to the lidar's optical axis, determined from the appropriate wind field reconstruction algorithm

Wind shear exponent
The wind shear exponent, assuming a power law vertical shear profile, determined from the appropriate wind field reconstruction algorithm

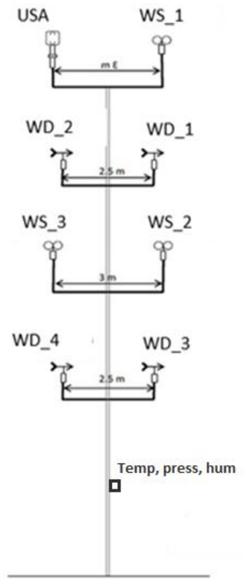
Left and right LOS speeds
The left and right averaged measured LOS speeds at the specified height and range.

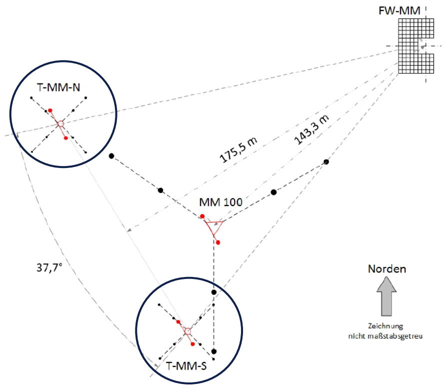
FD Backscatter
The 10 minute mean of the atmospheric backscatter coefficient (β) determined using the strength of the lidar return signal. Units are m^{-1} sr^{-1}

ZX data package

- Header description: 1Hz data for T-MM-S and T-MM-N

Signal Name	Instrument	Height [m]	Orientation [°]		Unit	Add. description
			T-MM-S	T-MM-N		
TIMESTAMP						Timestamp
WD1	Thies wind vane	27	330	150	Deg	Wind direction
WD2	Friedrichs wind vane	27	150	330	Deg	Wind direction
Temp	Weather station	5	-	-	°C	Temperature
Hum	Weather station	5	-	-	%	Humidity
Press	Weather station	5	-	-	hPa	Pressure
WS1	Thies First Class Advanced	30	330	150	m/s	Primary wind speed
WS2	Thies First Class Advanced	24	330	150	m/s	Horizontal wind speed
WS3	Thies First Class Advanced	24	150	330	m/s	Horizontal wind speed
USA_U	Gill WindMaster USA	30	150	330	m/s	U component
USA_V	Gill WindMaster USA	30	150	330	m/s	V component
USA_W	Gill WindMaster USA	30	150	330	m/s	W component
USA_WShorizontal	Gill WindMaster USA	30	150	330	m/s	Horizontal wind vector from U & V components
USA_WSvector	Gill WindMaster USA	30	150	330	m/s	3D wind vector from U, V & W components
USA_WD	Gill WindMaster USA	30	150	330	Deg	Primary wind direction signal
USA_FlowAngle	Gill WindMaster USA	30	150	330	Deg	Flow inclination angle
USA_Error	Gill WindMaster USA	30	150	330	-	Quality signal (0=valid, 1=not valid)
USA_CRCstatus_OK	Gill WindMaster USA	30	150	330	-	Quality signal (1=valid, 0=not valid)

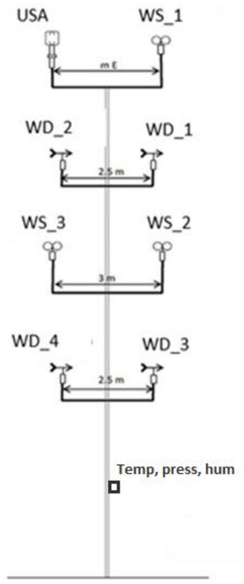


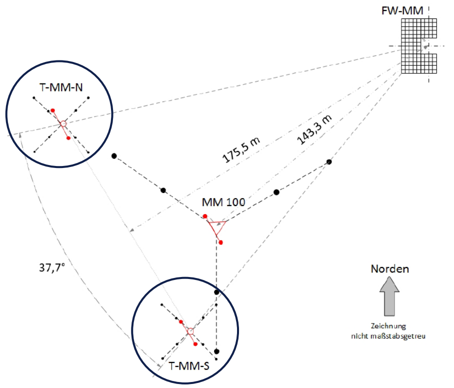


ZX data package

- Header description: 10 min data for T-MM-S and T-MM-N

Signal Name	Instrument	Height [m]	Orientation [°] T-MM-S	Orientation [°] T-MM-N	Unit	Suffices	Add. description
TimeStamp	-	-	-	-	-	-	Timestamp
counter_Max	-	-	-	-	-	-	Number of data entries within 10min period (max = 600)
Hum_	Weather station	5	-	-	%	Avg, Max, Min, Std	Humidity
Press_	Weather station	5	-	-	hPa	Avg, Max, Min, Std	Pressure
Temp_	Weather station	5	-	-	°C	Avg, Max, Min, Std	Temperature
USA_CRCstatus_OK_Avg	Gill WindMaster USA	30	150	330	-	-	Quality signal (1=valid, 0=not valid)
USA_Error_Avg	Gill WindMaster USA	30	150	330	-	-	Quality signal (0=valid, 1=not valid)
USA_FlowAngle_	Gill WindMaster USA	30	150	330	Deg	Avg, Max, Min, Std	Flow inclination angle
USA_U_	Gill WindMaster USA	30	150	330	m/s	Avg, Max, Min, Std	U component
USA_V_	Gill WindMaster USA	30	150	330	m/s	Avg, Max, Min, Std	V component
USA_W_	Gill WindMaster USA	30	150	330	m/s	Avg, Max, Min, Std	W component
USA_WDVecDir_Avg	Gill WindMaster USA	30	150	330	Deg	-	Vector averaged wind direction (Avg)
USA_WDVecDir_Std	Gill WindMaster USA	30	150	330	Deg	-	Vector averaged wind direction (Std)
USA_WShorizontal_	Gill WindMaster USA	30	150	330	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed
USA_WSvector_	Gill WindMaster USA	30	150	330	m/s	Avg, Max, Min, Std	Vector averaged horizontal wind speed
WD1_VecDir_Avg	Thies wind vane	27	330	150	Deg	-	Vector averaged wind direction (Avg)
WD1_VecDir_Std	Thies wind vane	27	330	150	Deg	-	Vector averaged wind direction (Std)
WD2_VecDir_Avg	Friedrichs wind vane	27	150	330	Deg	-	Vector averaged wind direction (Avg)
WD2_VecDir_Std	Friedrichs wind vane	27	150	330	Deg	-	Vector averaged wind direction (Std)
WS1_	Thies First Class Advanced	30	330	150	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed
WS2_	Thies First Class Advanced	24	330	150	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed
WS3_	Thies First Class Advanced	24	150	330	m/s	Avg, Max, Min, Std	Scalar averaged horizontal wind speed





Schedule

- Start of the RR by providing documentation and data package via mail/SharePoint (Mo, 15/11/2021)
- Presentation of the RR on the IEA Lidar Task 32 – General Meeting (Wed, 17/11/2021)
- Work in progress phase 1 (17/11/2021 –17/12/2021)
- Progress meeting (Fr, 17/12/2021)
- Optional
  - Work in progress phase 2 (18/12/2021 –14/01/2022)
  - Progress meeting (Fr, 14/01/2022)
- Assessment phase (04/02/2022)
- Presentation of results on an IEA meeting (TBD)

How to get involved?

For further information please reach out to:

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