WINDSIM USERS MEETING 2022

# WINDSIM RSCT CASE STUDIES WITH ZX300

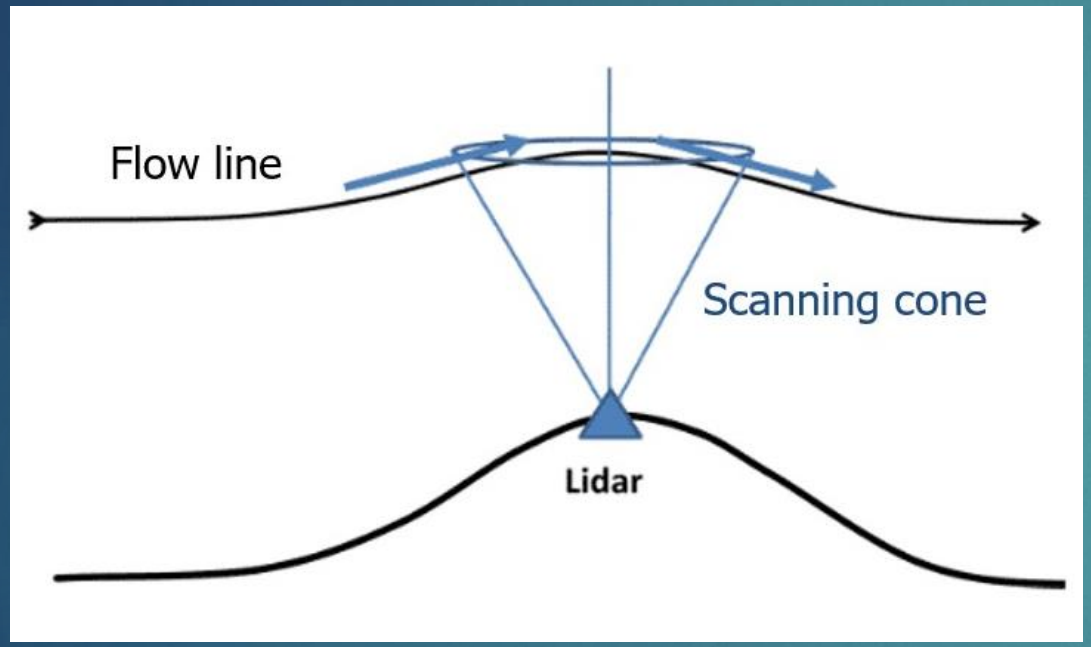
## CORRELATION WITH CALIBRATED MASTS & COMPARISON WITH DYNAMICS

PETROS THEODOROPOULOS, TECHNICAL MANAGER OF ISTOS RENEWABLES

ASPASIA ANASTASIOU, MECHANICAL ENGINEER NTUA, ISTOS RENEWABLES

WULSTAN NIXON, ZXLIDARS

# RSD SYSTEMATIC ERRORS SOURCES (1)

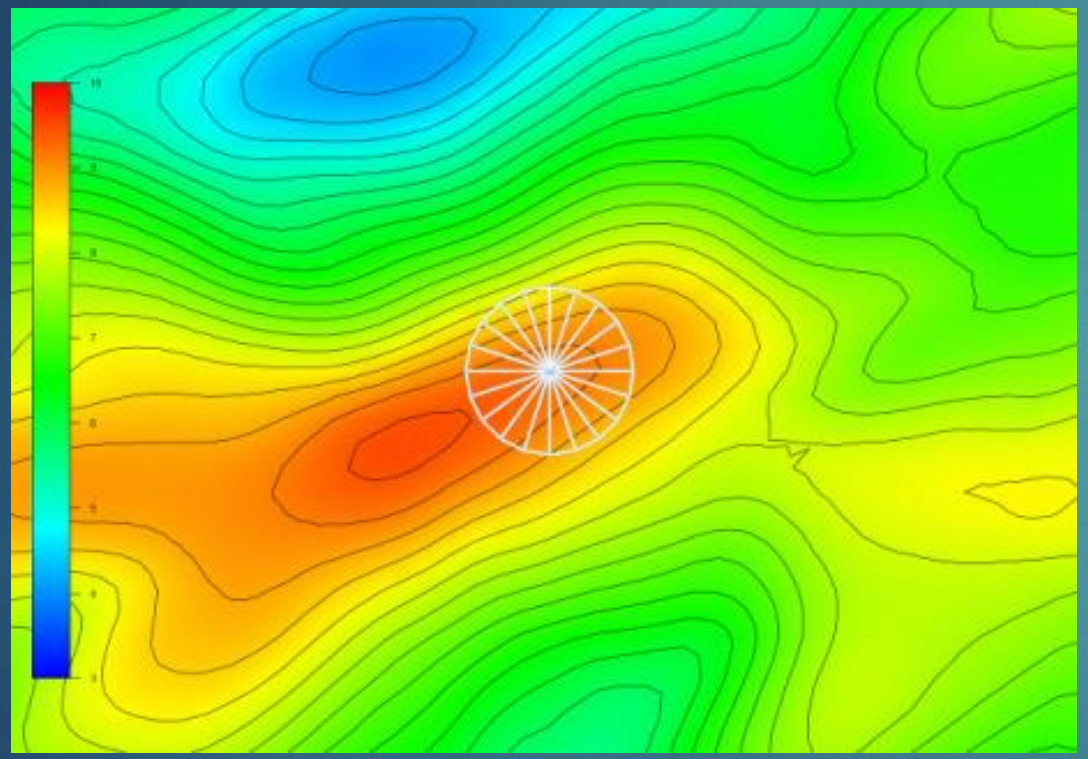



- *Systematic errors in Lidar measurements in complex sites come mainly from:*

  A. The intersection of the scanning cone with the flow lines, with positive inflow angle upwind and negative inflow angle downwind.

  *In both cases the component of wind velocity along the laser beam is reduced compared to the speed at the top of the hill. Thus, horizontal speed is usually underestimated.*

# RSD SYSTEMATIC ERRORS SOURCES (2)



*B. Calculation of instant point wind speed in the center of the scan disk → assumption: "the flow is homogenous along the scan disk".*

*In fact, in complex sites, wind speed is not the same at different points along the disk. Usually wind speed upwind and downwind is lower than at hill top due to the hill speed-up effect.*

# SYSTEMATIC ERROR CORRECTION

IMPORTANT FOR:

- LOW TO HIGH TERRAIN COMPLEXITY SITES
- SITE ASSESSMENT BASED ON MEASUREMENTS FROM LOWER HEIGHT MASTS AND LDA DEVICES OR STAND-ALONE LDA DEVICES

As a result there is a need for fast, reliable and consistent methodology / tool to perform this correction.

# COMMERCIAL AVAILIABLE CORRECTION TOOLS

- ALL BASED ON RANS models:
  - **DYNAMICS** ®, BASED ON VENTOS® CFD PLATFORM (two-equations TI closure model k-ε)
  - METEODYN ®, (one-equation TI closure scheme based on Yamada et al)
  - **WINDSIM** ®, (two-equations TI closure models – k-ε, k-ω, YAP etc + thermal stability)
  - ZEPHYCFS ® FROM ZEPHY-SCIENCE, BASED ON OPENFOAM (two-equations TI closure models – k-ε)

# MAIN FEATURES OF WINDSIM RSCT

- ADD-ON MODULE
- USES LIDAR 10-min AVERAGES  (raw data input)
- THE USER CAN DEFINE THE SCAN ANGLE AND THE MEASUREMENTS HEIGHTS
- FOR OPTIMUM PERFORMANCE → RULES:
  - Vertical resolution:  ≤10m
  - Horizontal resolution: 10m X 10m
  - No smoothing
  - No orthogonalization

# METHODOLOGY OF OUR TEST-RUNS (1)

- DTM source: EU_DEM V1.1 (25m x 25m) & CLC2018
- TERRAIN MODEL: 5km x 5km extension & 10m x 10m resolution in the refined area
- Standard k-ε turbulence model & GCV solver
- 36 simulations of 10° sectors
- No thermal stability

# METHODOLOGY OF OUR TEST-RUNS (2)

- SETTINGS IN REMOTE SENSING CORRECTION TOOL:
  - No RAW data file given
  - Scan angle for ZX300 = 30°
  - LEVELS: Different measurement heights according to the setup of each campaign
  - Number of sectors: 36

# METHODOLOGY OF OUR TEST-RUNS (3)

- ZX300 measurements correction of magnetic deviation (Magnetic North → True North)
- A Python scrip is used to implement the correction to the available LIDAR measurements (mean, maximum and minimum speed and standard deviation).
- Corrected measurements are analyzed and correlated with mast measurements using WindRose*.
- The correlation results obtained with different correction tools and without correction were compared.

*Method*: *y=a*x*
*Number of Wind Speed bins*: *32*
*Width of bins*: *0.5m/s*

*Software provided by CRES

ISTOS RENEWABLES ZX Lidars

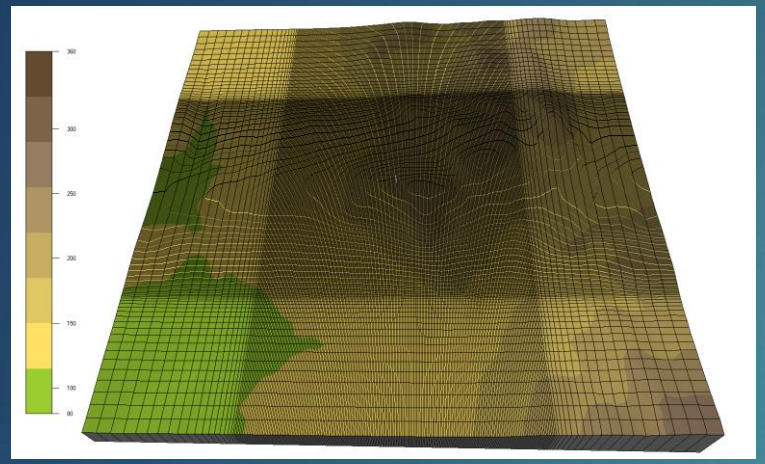
# MAIN RESULTS

| Site Name | Terrain Complexity Category (IEC 61400-1) | Site characteristics | Before Correction | | | Correction With Dynamics | | | Correction With WindSim | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Slope | Relative Abs. Bias | R^2 | Slope | Relative Abs. Bias | R^2 | Slope | Relative Abs. Bias | R^2 |
| *KILKIS-70m* | *-* | *flat* | 0.967 | 3.30% | 0.996 | 0.973 | 2.73% | 0.995 | 0.9903 | 0.97% | 0.996 |
| *ANDROS-40m* | ***L*** | *low to medium complexity* | 0.971 | 2.92% | 0.991 | 1.002 | 0.23% | 0.992 | 1.006 | 0.63% | 0.991 |
| *KEFALONIA-40m* | ***M*** | *medium to high complexity* | 0.930 | 6.96% | 0.988 | 0.980 | 2.01% | 0.984 | 1.016 | 1.57% | 0.987 |
| *AKARNANIA-1-31m* | ***M*** | *medium to high complexity* | 0.943 | 5.75% | 0.997 | 0.987 | 1.27% | 0.997 | 0.995 | 0.46% | 0.997 |
| *RODOPI-1-40m* | *-* | *flat* | 0.977 | 2.32% | 0.988 | 0.979 | 2.08% | 0.997 | 0.978 | 2.17% | 0.988 |
| *RODOPI-2-40m* | ***L*** | *low complexity with forest* | 0.965 | 3.51% | 0.989 | 0.989 | 1.08% | 0.990 | 1.001 | 0.08% | 0.989 |
| *ACHAIA-31m* | ***L*** | *low complexity* | 0.971 | 2.89% | 0.993 | 0.998 | 0.22% | 0.992 | 1.009 | 0.90% | 0.993 |
| *AKARNANIA-2-31m* | ***L*** | *low to medium complexity* | 0.963 | 3.74% | 0.994 | 0.982 | 1.84% | 0.993 | 0.996 | 0.39% | 0.993 |
| *AKARNANIA-3-31m* | ***M*** | *medium complexity* | 0.973 | 2.66% | 0.988 | 0.990 | 1.05% | 0.987 | 0.990 | 1.02% | 0.989 |
| | | ***AVERAGE of Abs. Bias*** | | **3.72%** | | | **1.39%** | | | **0.93%** | |
| | | ***STD. DEVIATION of Abs. Bias*** | | **1.47%** | | | **0.85%** | | | **0.61%** | |

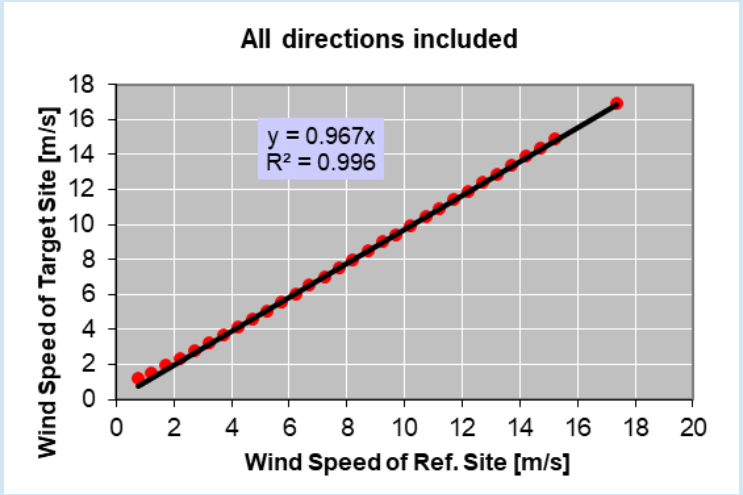
- The relative Absolute Bias is calculated based on the ideal slope (1.0) for the correlation.
- For all the cases the bias before any correction is greater.
- Overall, the WindSim RSCT yields better correlation results.

ISTOS RENEWABLES ZX Lidars

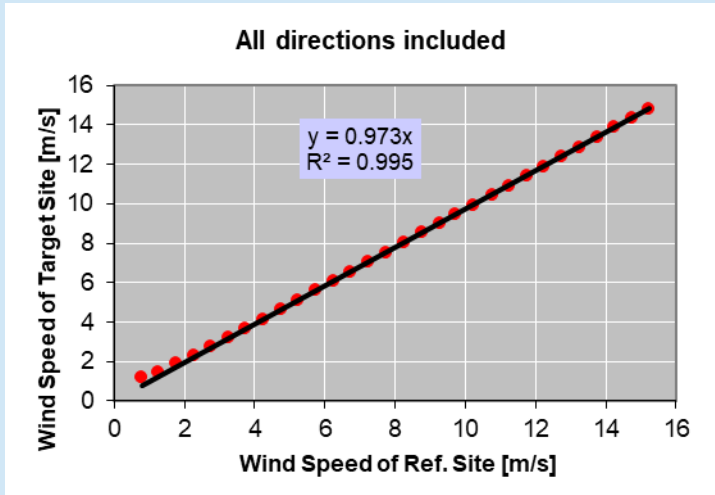
# KILKIS



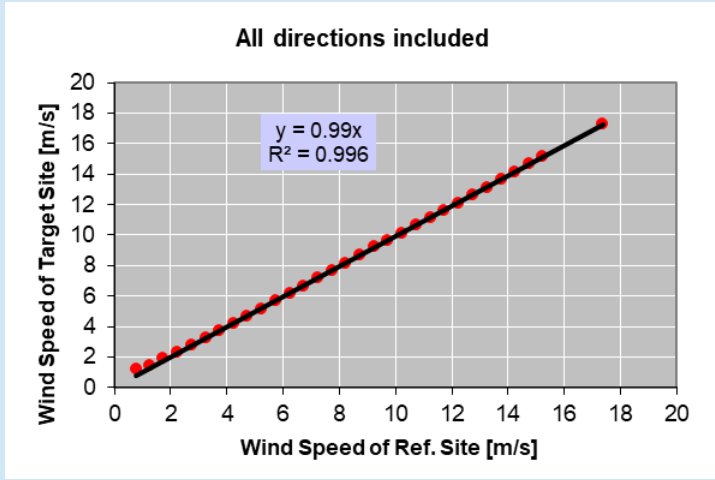
## Without correction




## Dynamics Correction




## WindSim Correction



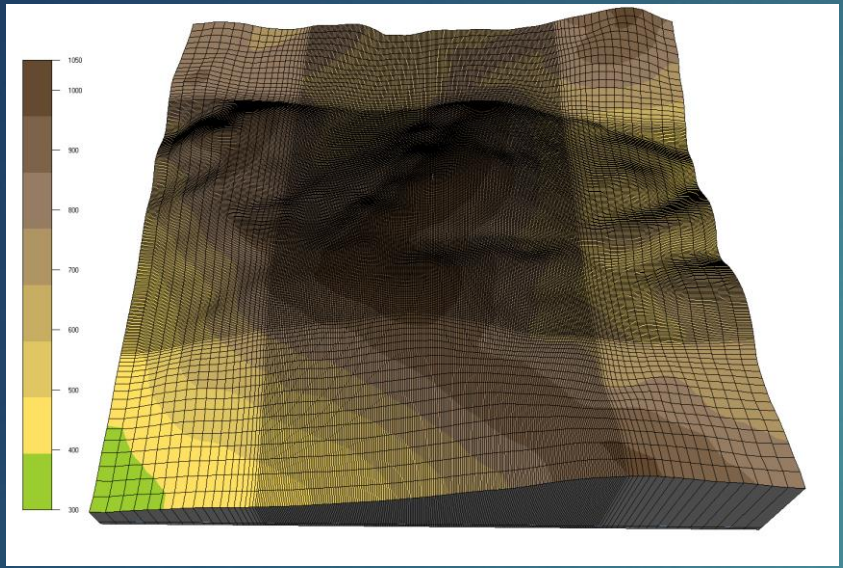

- FLAT terrain

Installation of LIDAR measuring up to 180m next to a 70m mast.

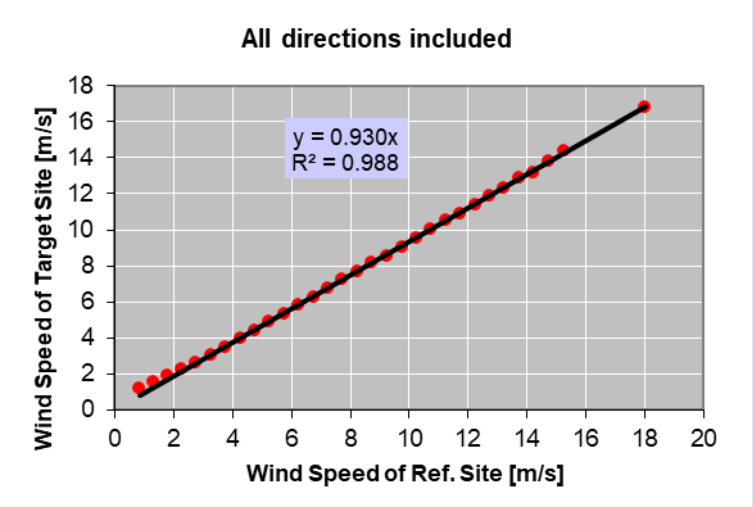
ISTOS RENEWABLES

ZX Lidars

# KEFALONIA



## Without correction

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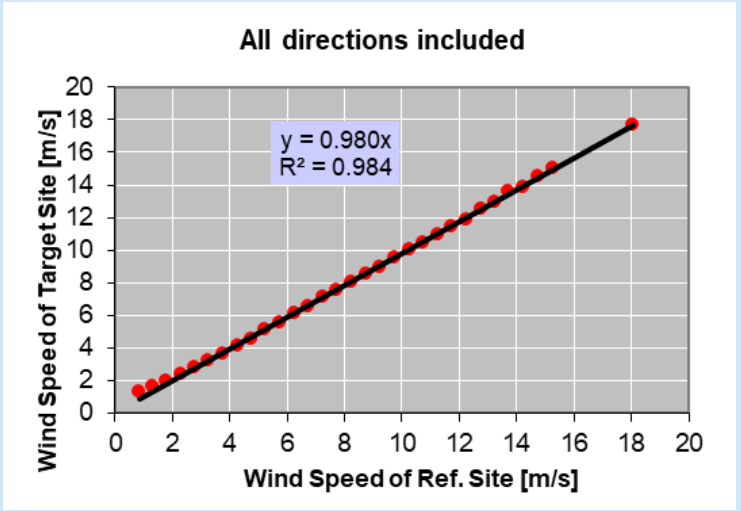
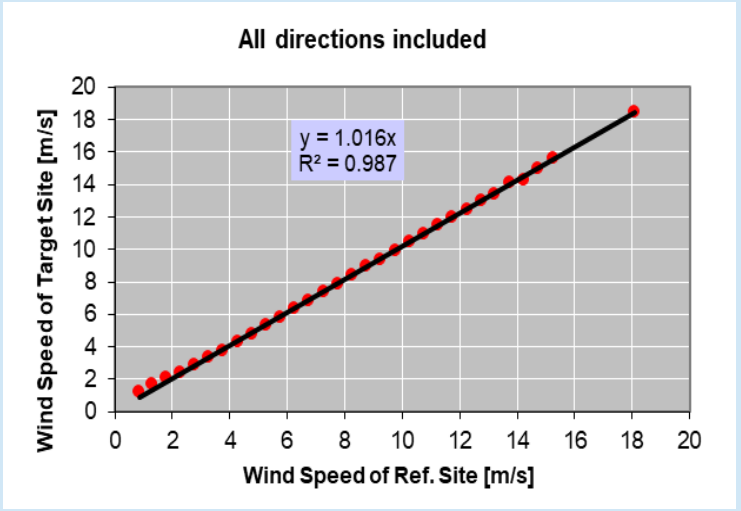



## WindSim Correction



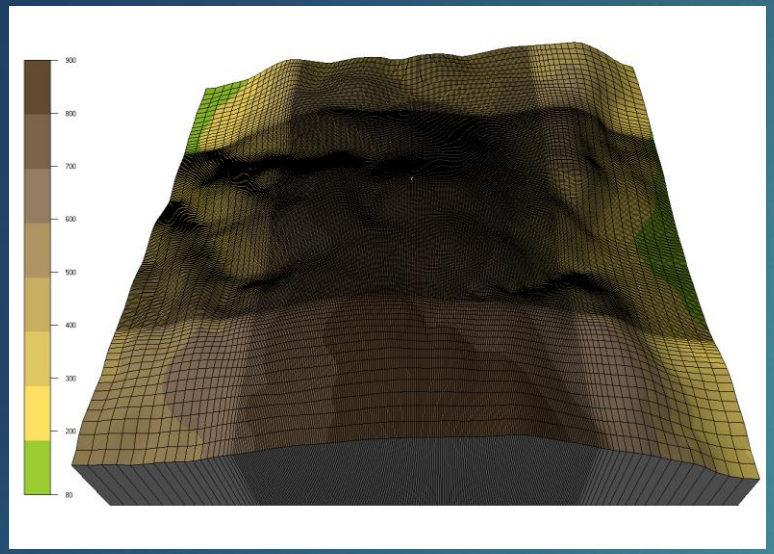

- Medium to high complexity

Installation of LIDAR measuring up to 125m next to a 40m mast.

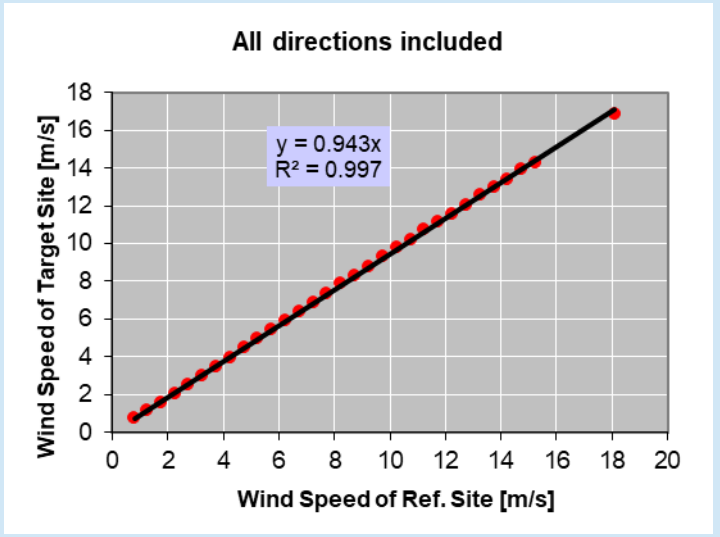
ISTOS RENEWABLES

ZX Lidars

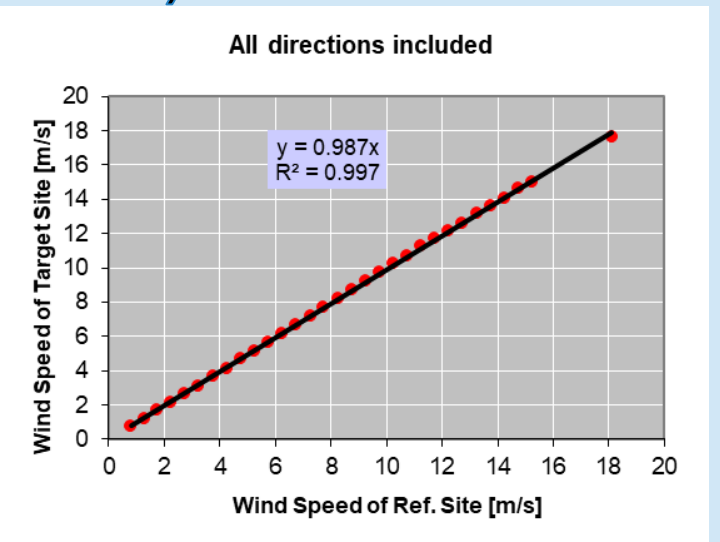
# AKARNANIA-1



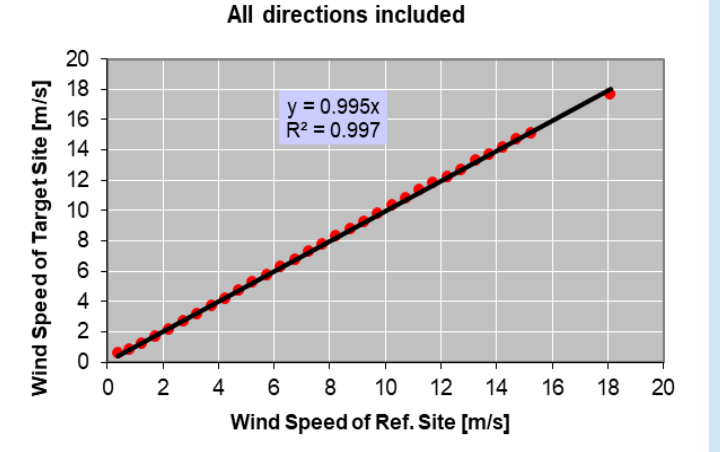
## Without correction




## Dynamics Correction




## WindSim Correction




- Medium to high complexity

Installation of LIDAR measuring up to 180m next to a 31m mast.

ISTOS RENEWABLES

ZX Lidars

# RECOMMENDATIONS

- CALCULATION OF DIRRECTION CORRECTION FACTORS TOO
- → EXPORT THEM IN A SECOND .txt FILE

- POST-PROCESSING TOOL TO EXPORT CORRECTED DATA SUITABLE FOR OTHER LIDAR MODELS

# FUTURE WORK

- COMPARISON OF MORE CFD BASED CORRECTION TOOLS
- ADD MORE AND HIGHER MASTS IN THE COMPARISON SCHEME

# THANK YOU