APPLICATION OF CFD FOR TURBULENCE RELATED OPERATIONAL RISKS ASSESSMENT OF WIND TURBINES IN COMPLEX TERRAIN

RESOURCE ASSESSMENT PART 1

2013·2·5

EWEA 2013 VIENNA

Contributors

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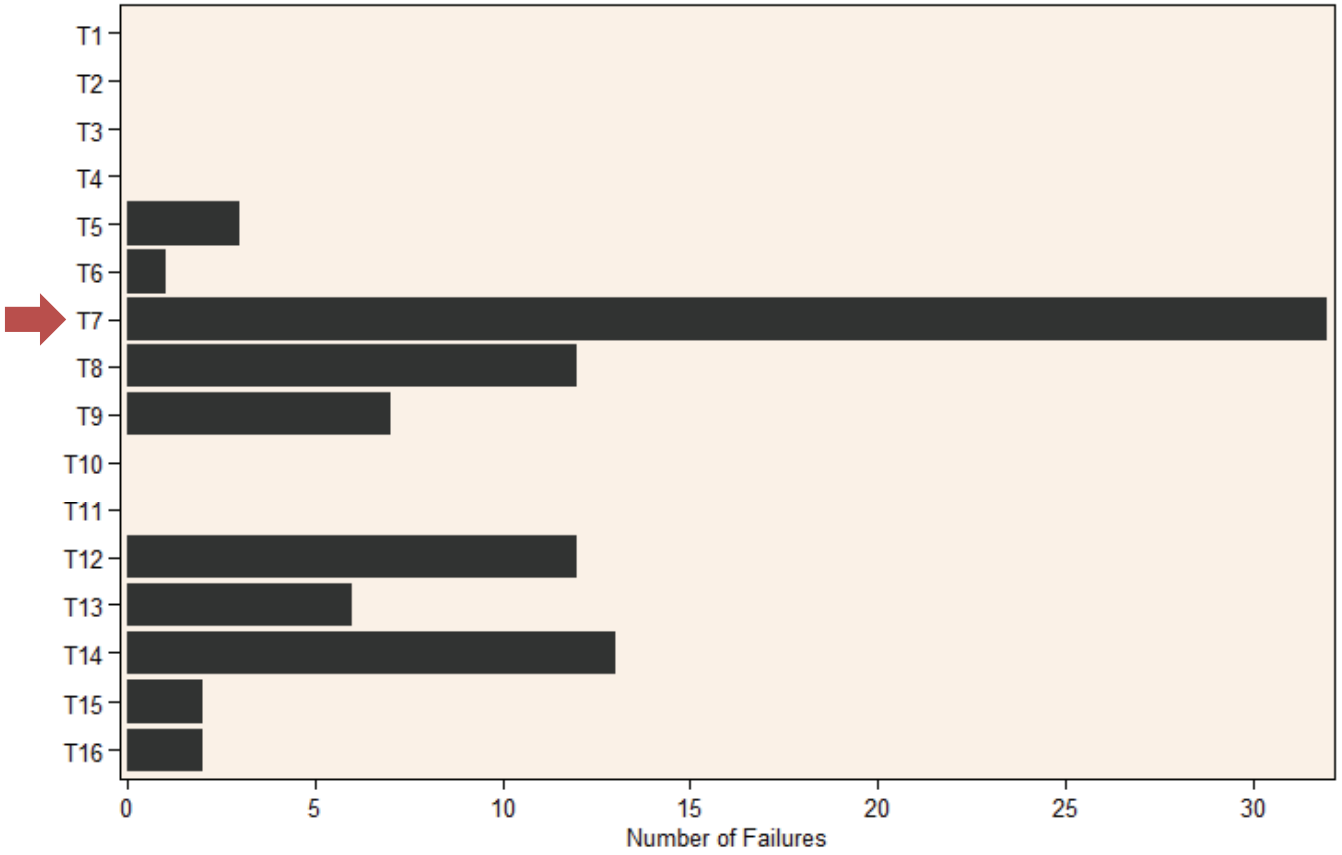
Developer of CFD Software RIAM-COMPACT

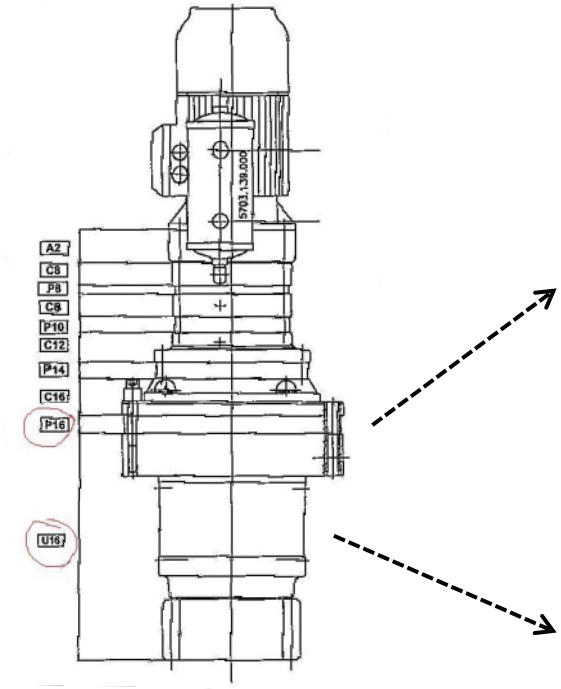
Case

Turbine T7 registered a particular high frequency of yaw related failures

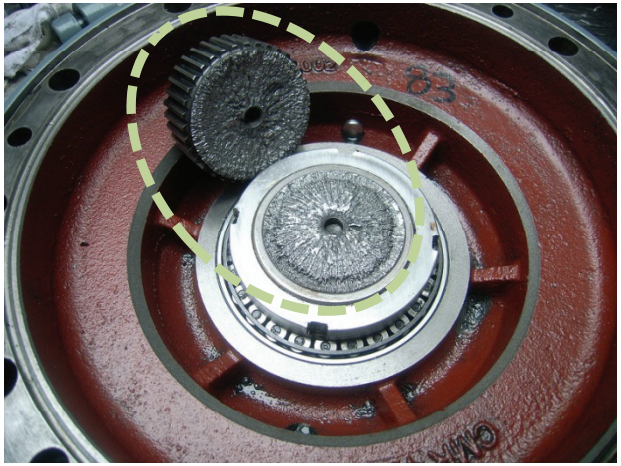


7 years since the start of operation

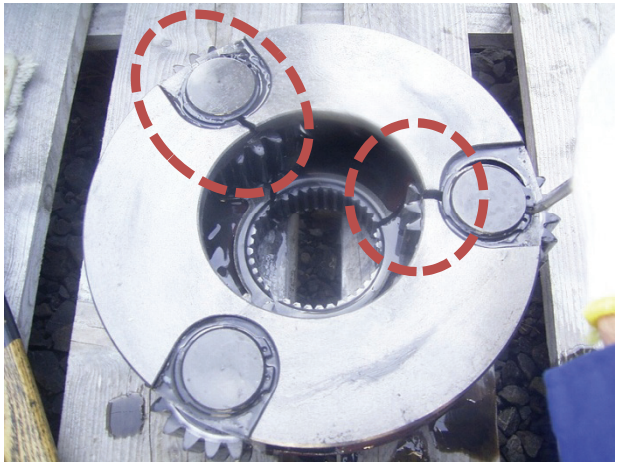
Damages



Yaw Motor・Yaw Gear



Broken Shaft

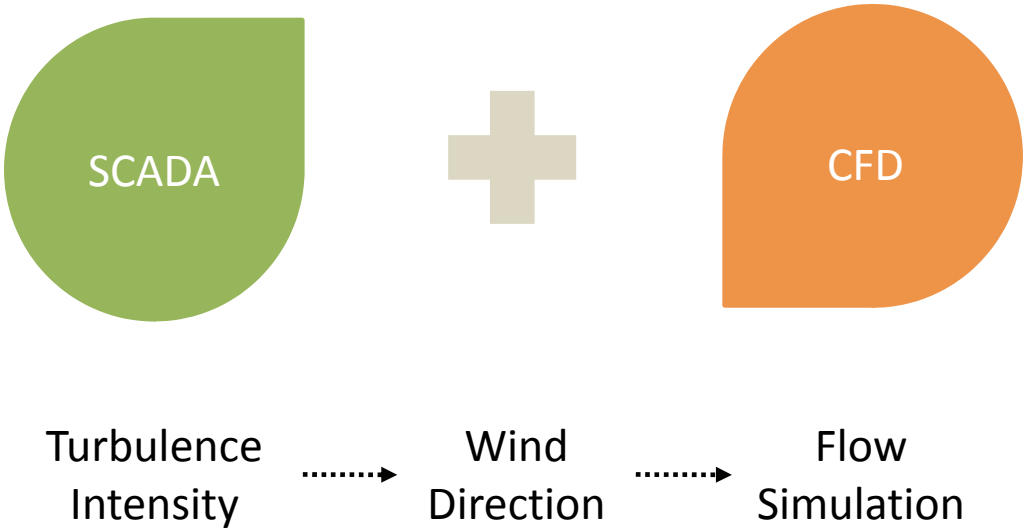


Cracks

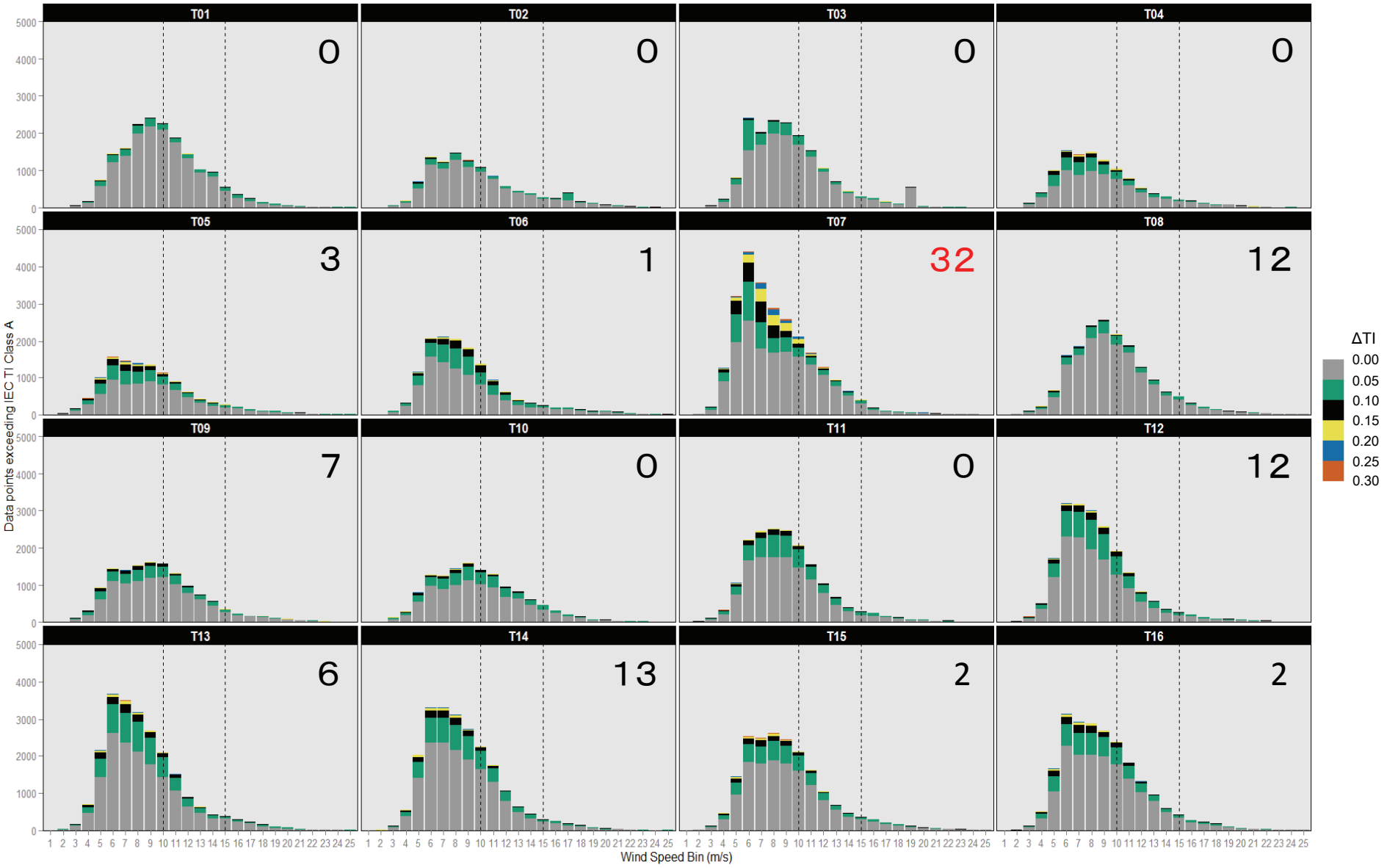
Windfarm


Siemens SWT1.3-62 x 16
Hub Height 60m
Rotor Diameter 62m
IEC Class 1A
Operation since February 2004
Kihoku Windfarm
Kagoshima Prefecture, Kyushu, Japan

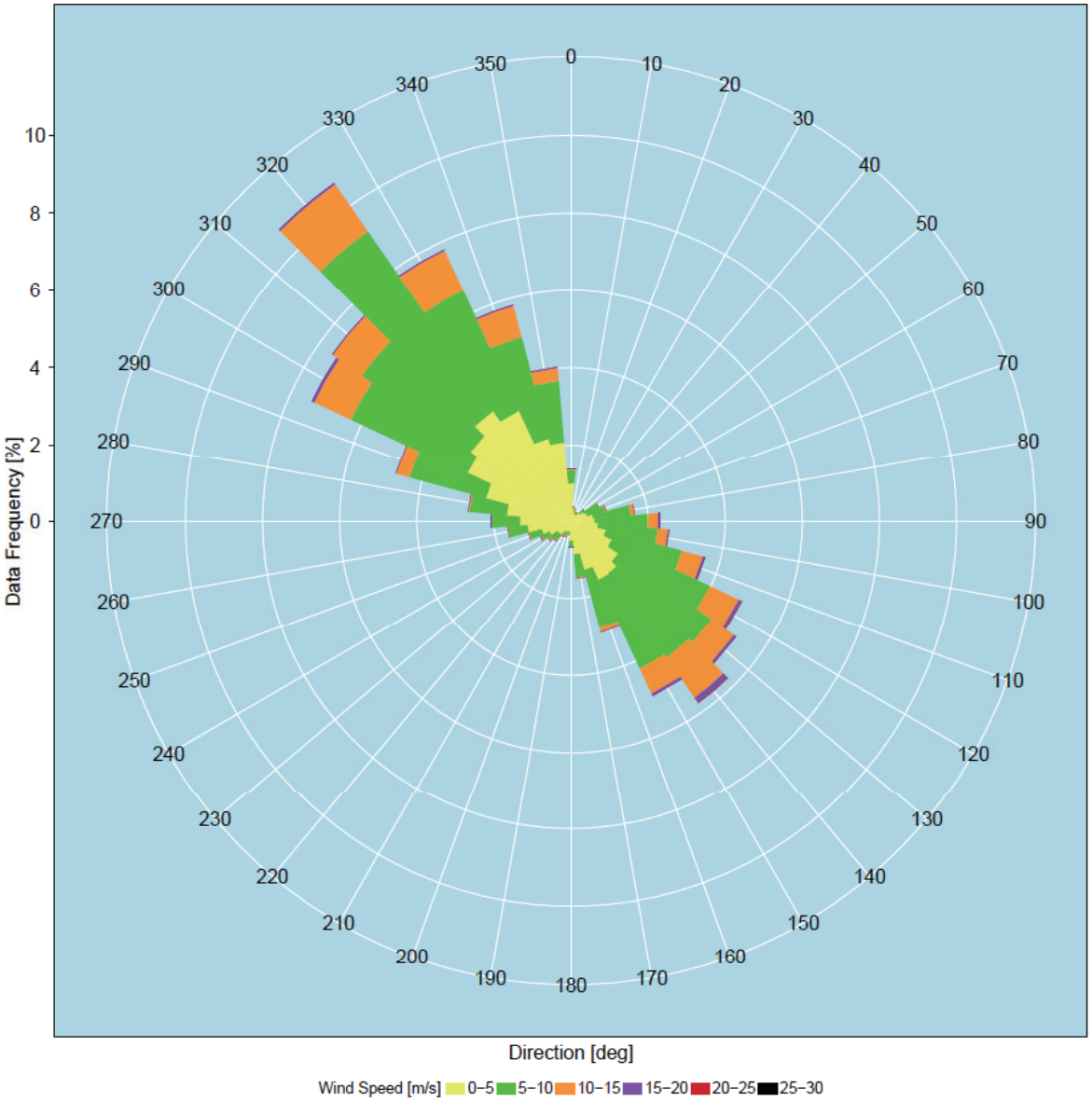
Approach


SCADA
CFD
Turbulence Intensity
Wind Direction
Flow Simulation

SCADA · TI_{Raw} minus TI_{IEC}

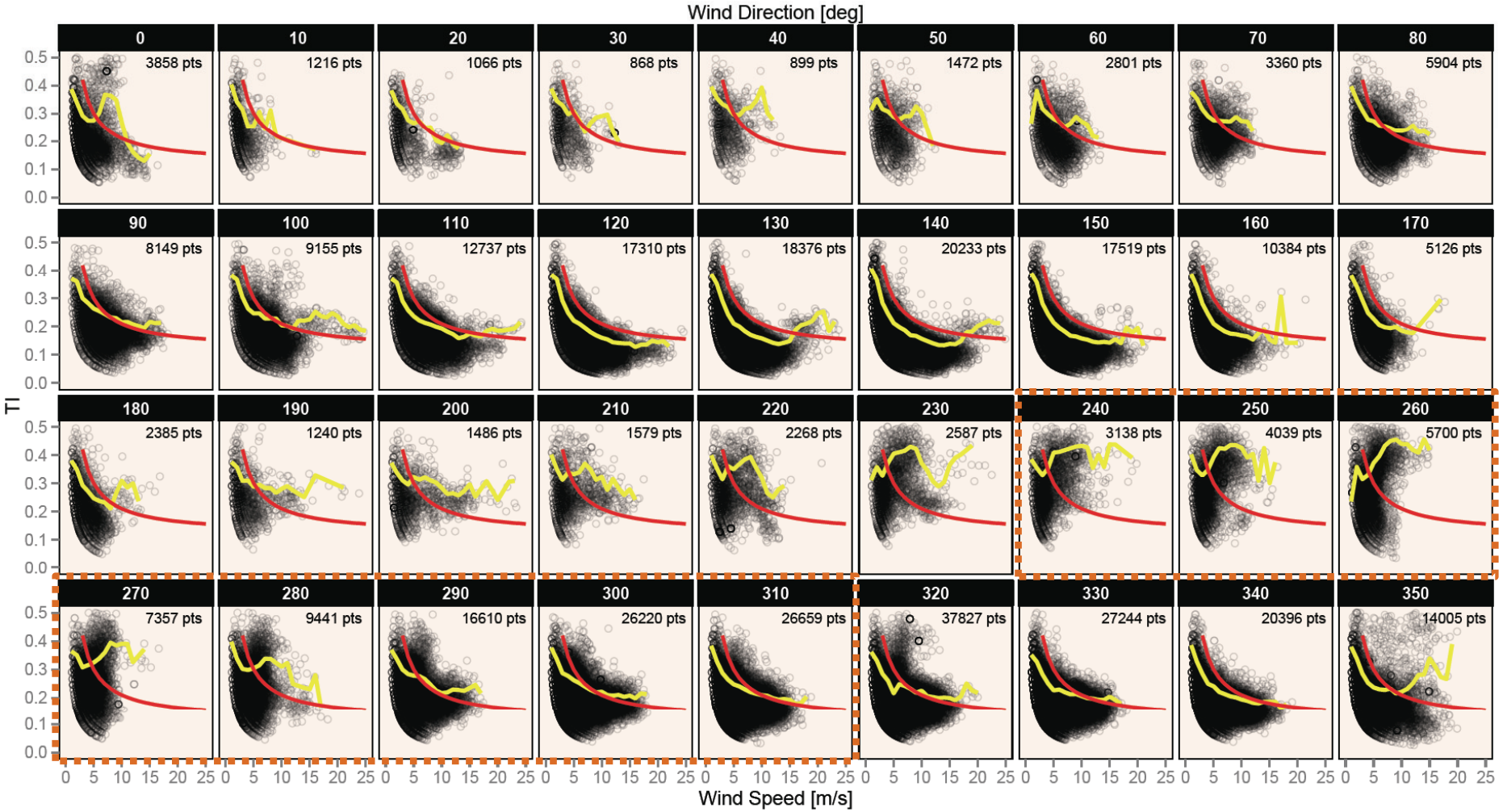


SCADA ▪ T7 ▪ Rose

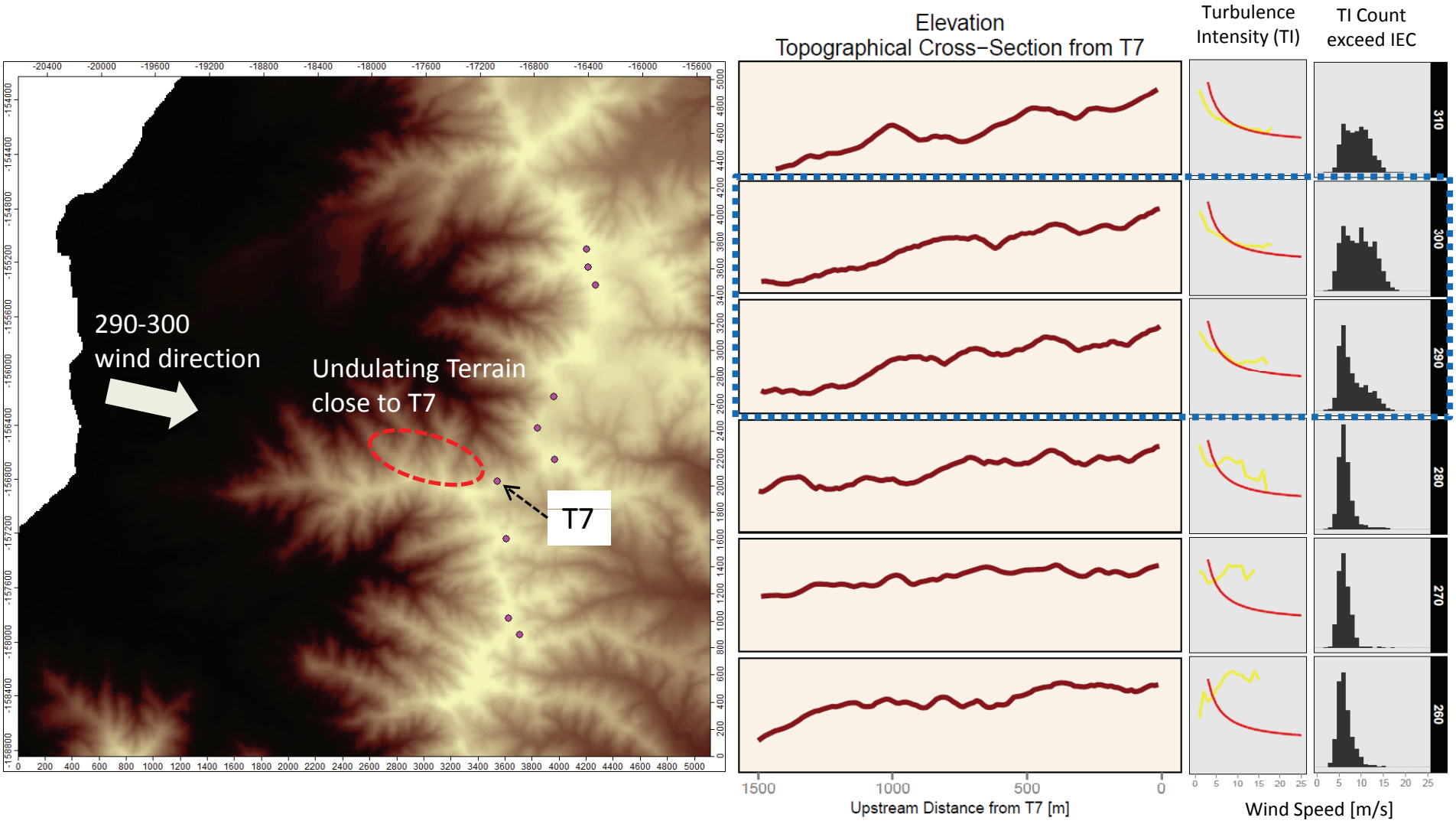


SCADA ▪ T7 ▪ TI

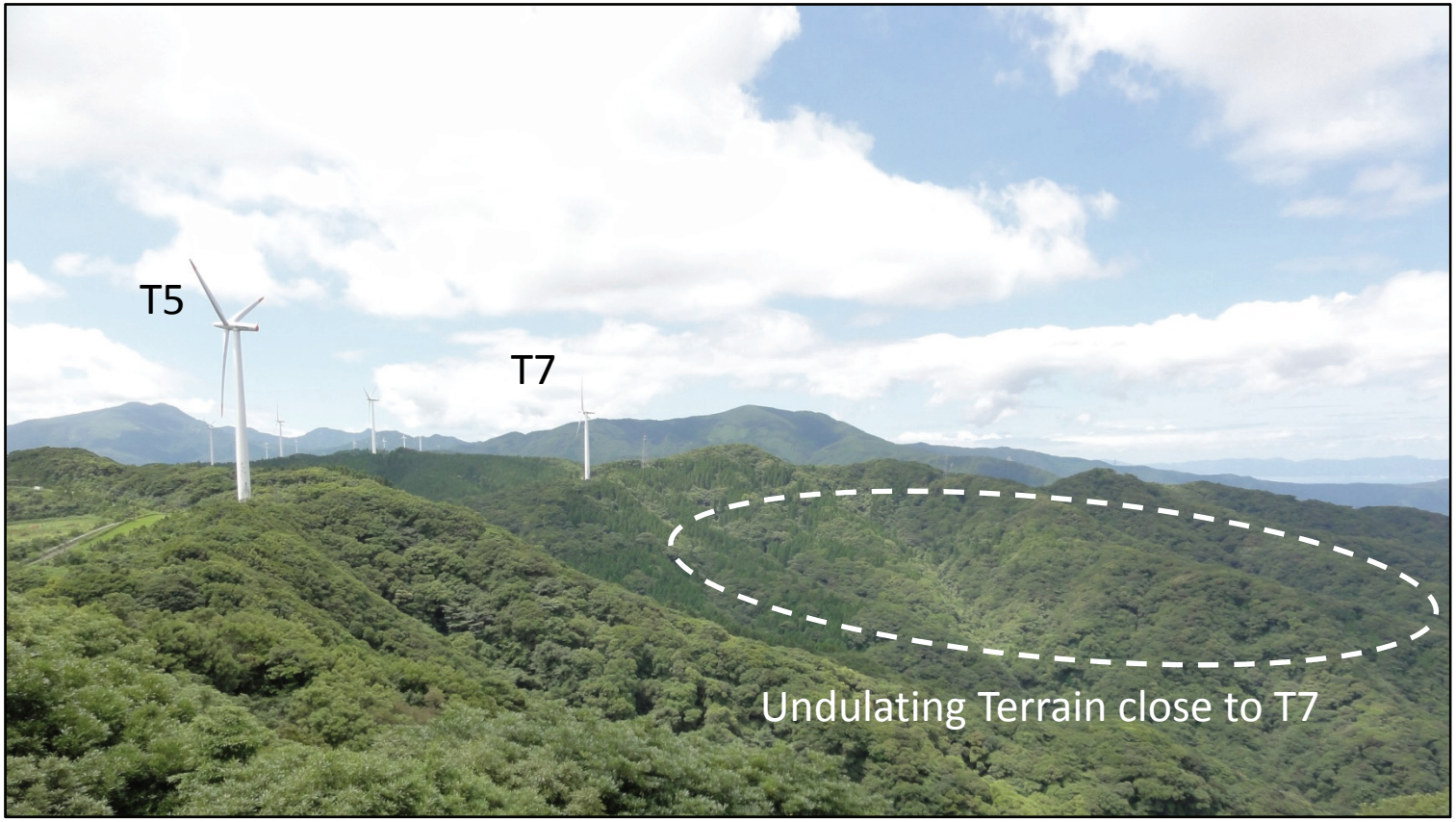
Yellow Line - measured data (characteristic TI)
Red Line - IEC Class A Standard (2nd Edition)



SCADA ▪ T7 ▪ Topography ▪ TI



Topography



CFD・Model

Software
RIAM-COMPACT

Turbulence Model
LES Smagorinsky

Calculation Area (km)
5.6(x) × 6.3(y) × 3.1(z)

Mesh Size
x : 10m ~ 50m
y: 10m
z: 1m (minimum)

Mesh Grid
401(x) × 631(y) × 61(z)

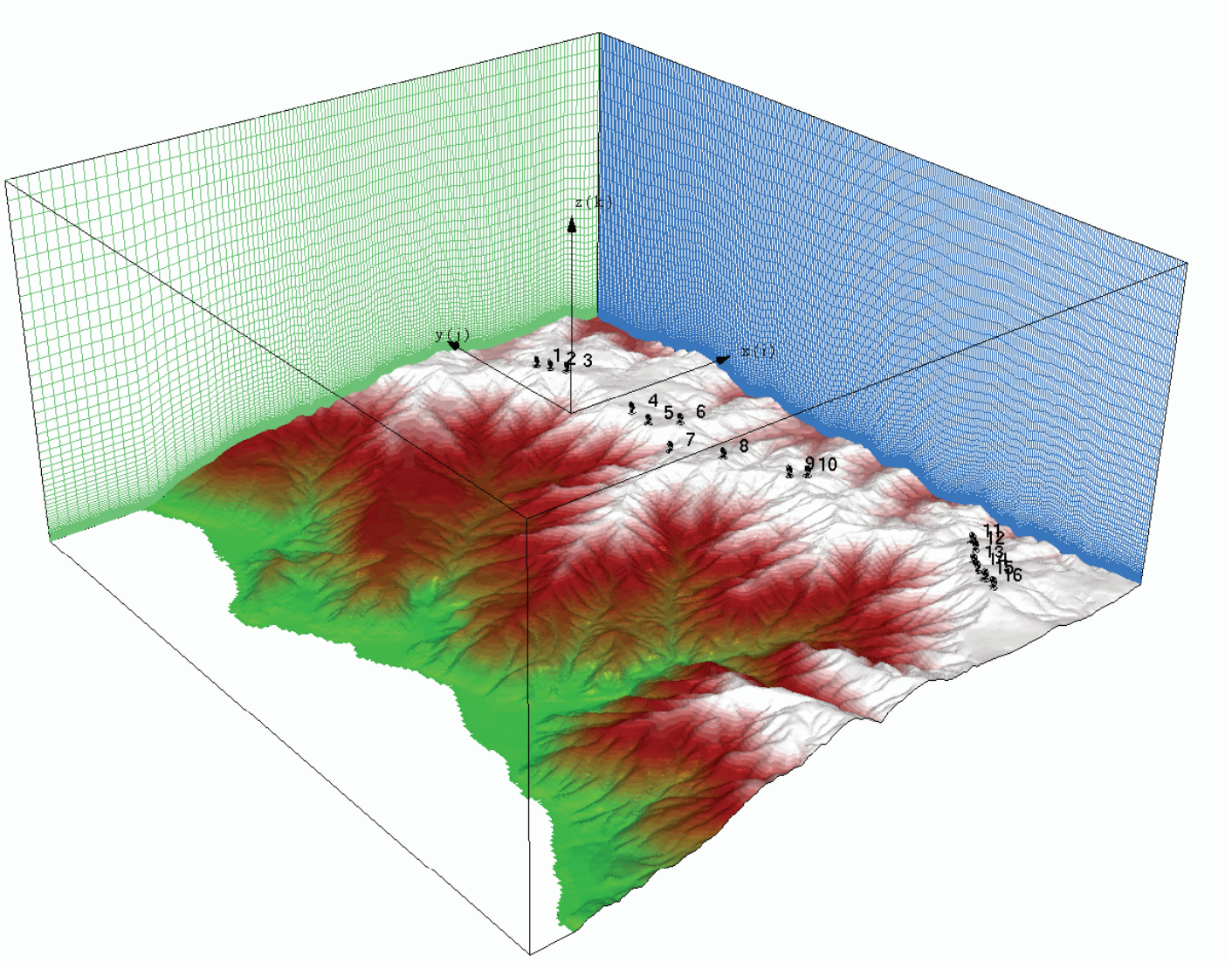
Total Grid Points
15,430,000

Inflow Wind Direction
290 degree

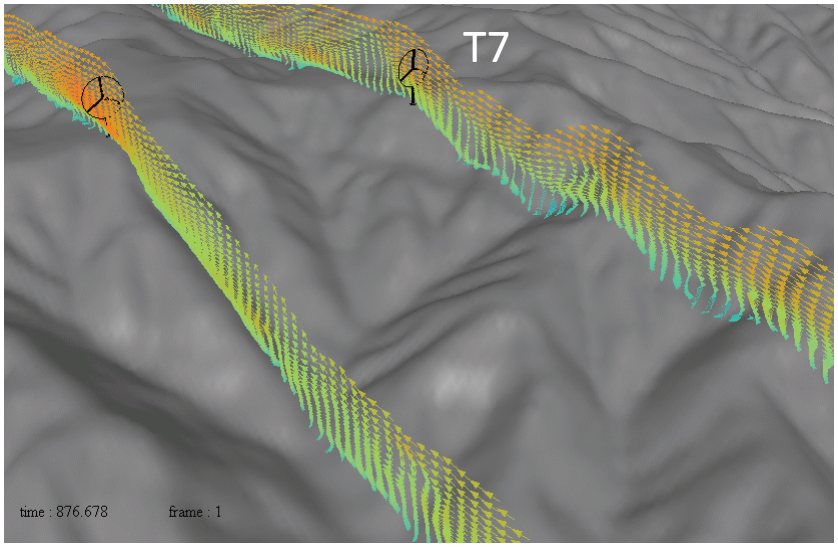
Inflow Wind Speed
7m/s

Inflow Shear Exponent
0.14

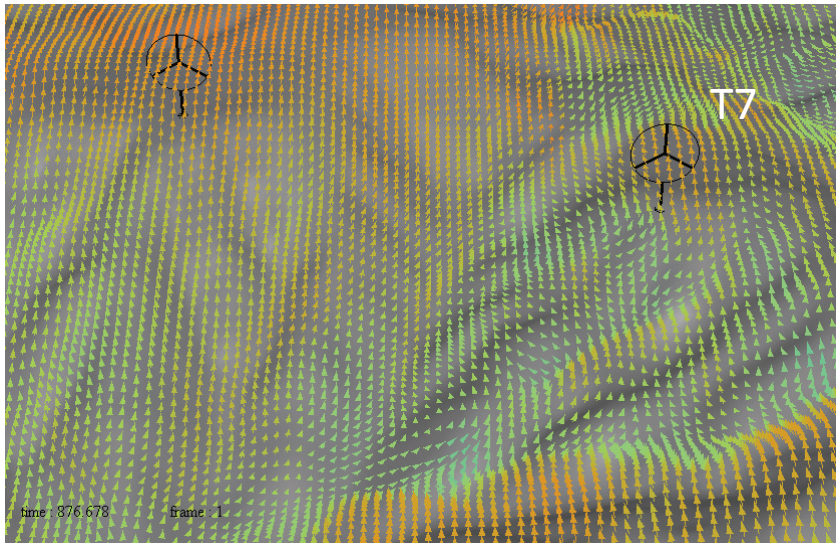
Atmospheric Stability
Neutral



CFD・Vector

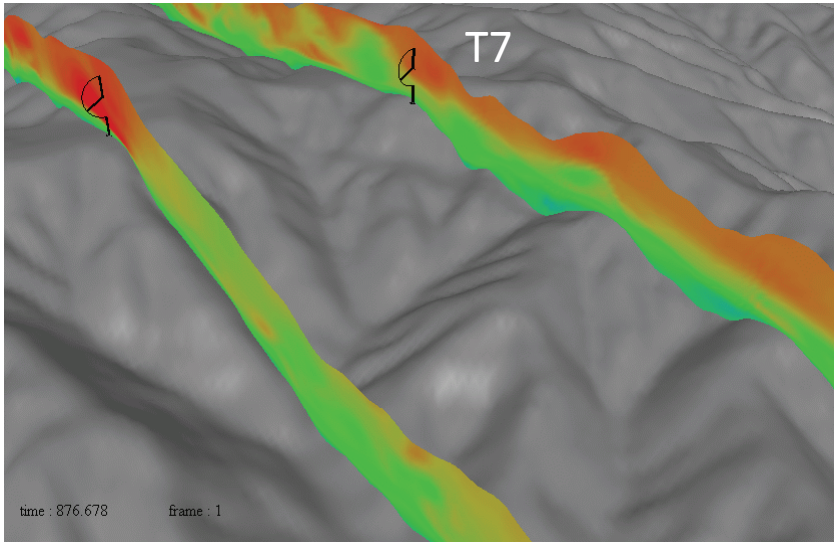


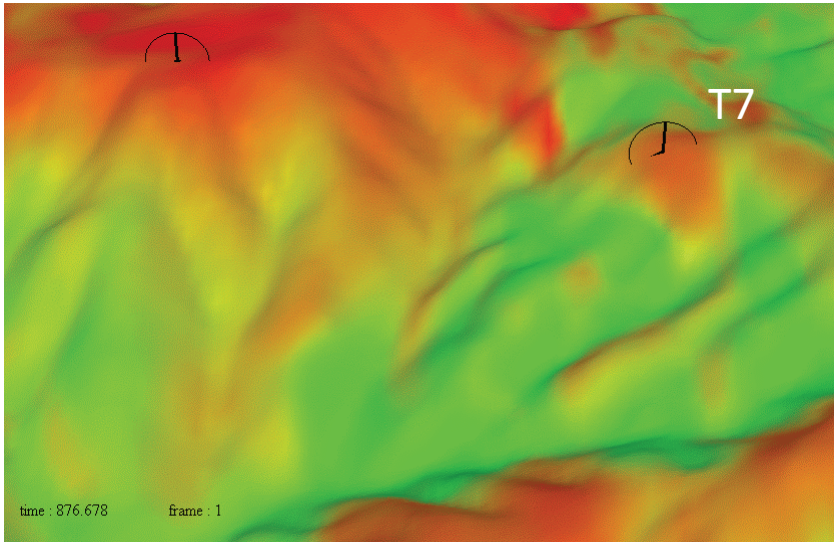
Flow Separation upstream of T7



Wind Direction Fluctuation at T7

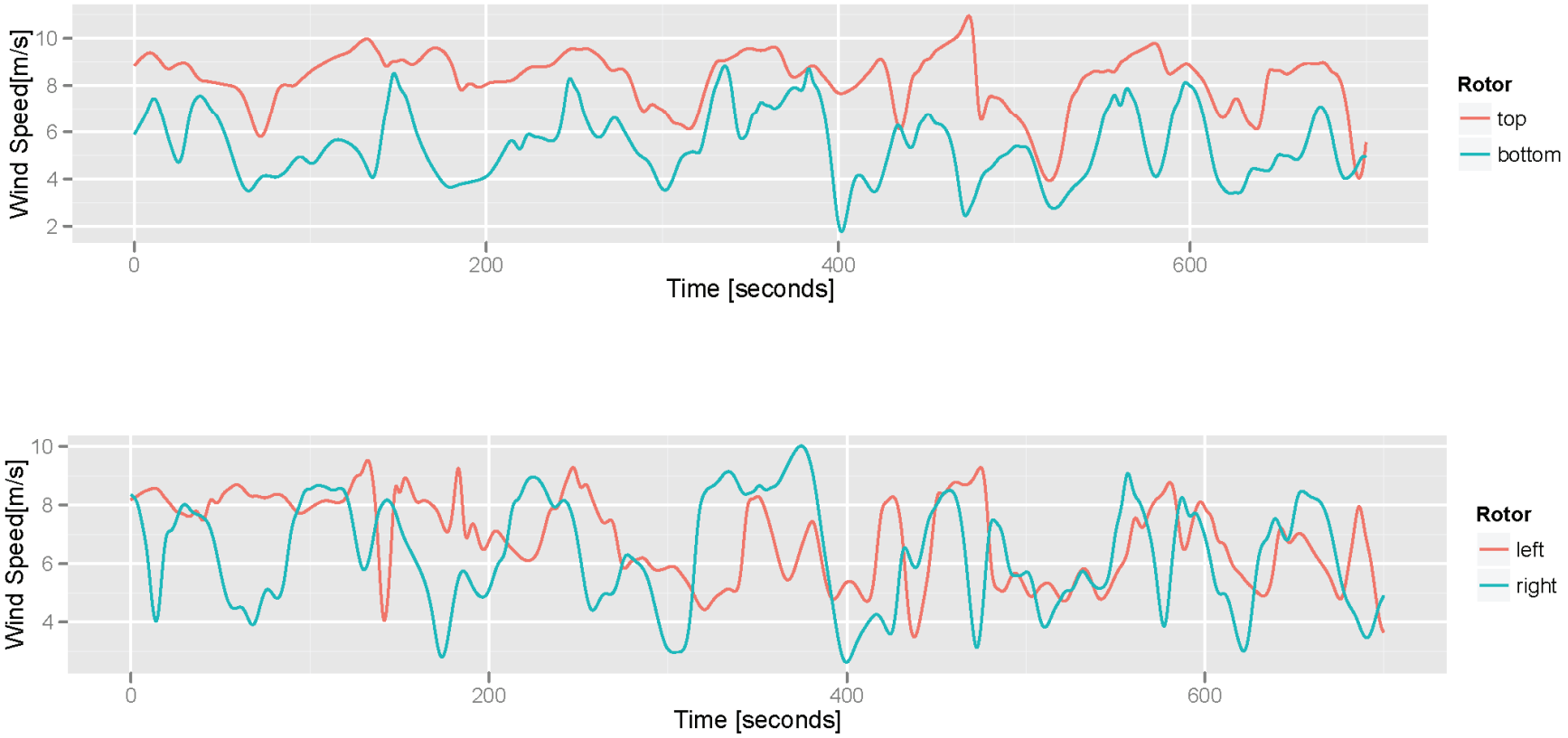
CFD ▪ Shading



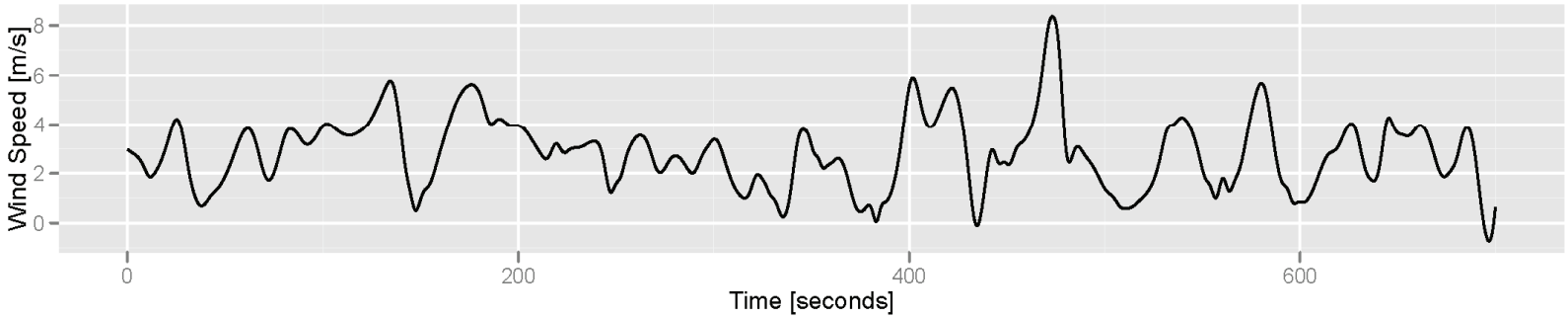


Large and Fluctuating Wind Speed Difference
across Rotor Face of T7

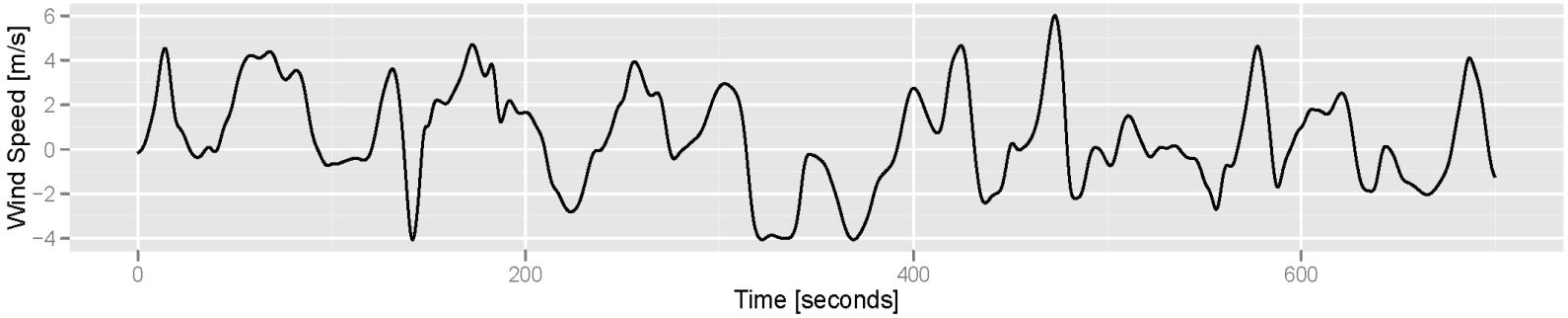
CFD ▪ Time Series



CFD ▪ Time Series

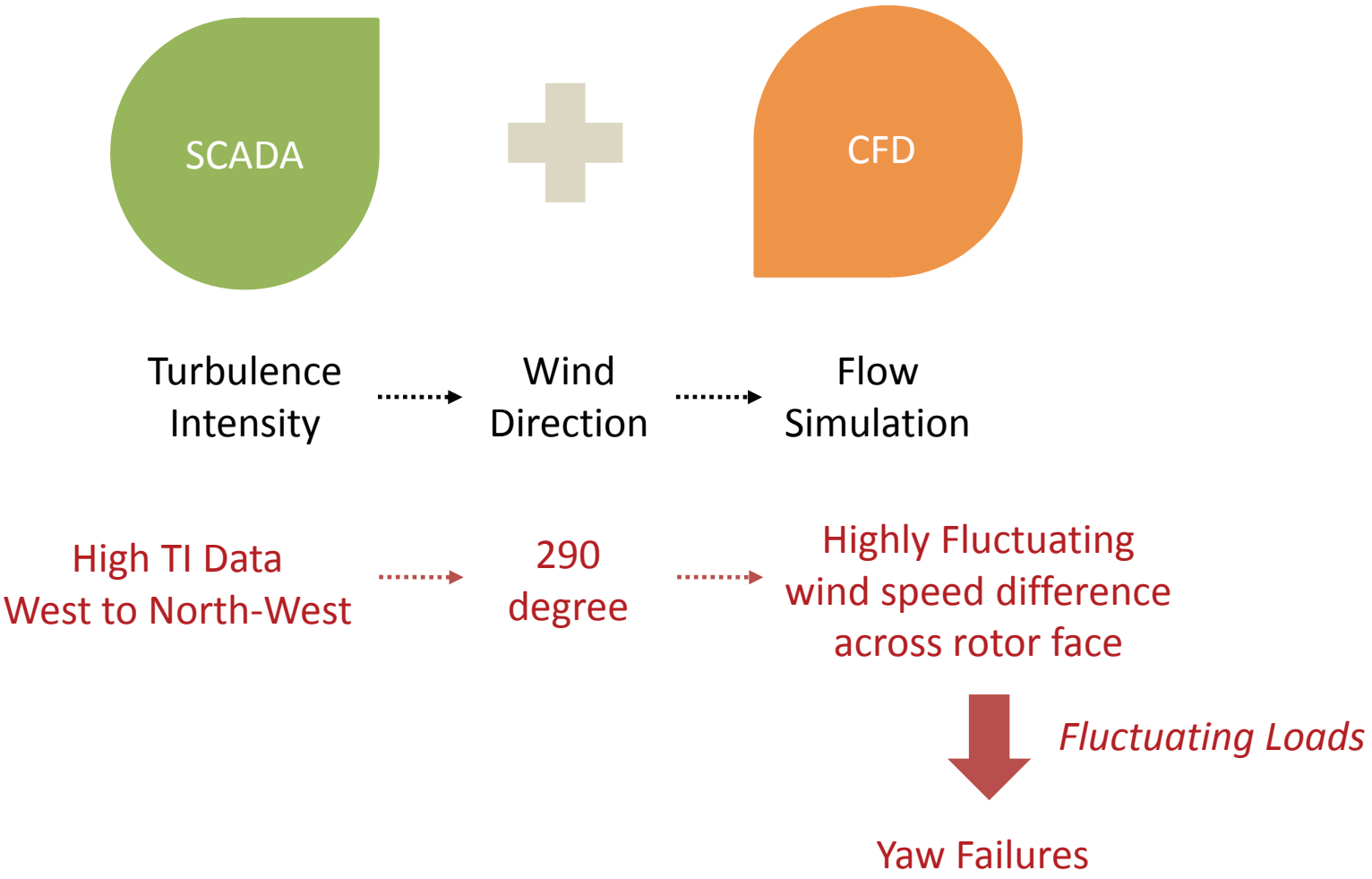


Top
Minus
Bottom



Left
Minus
Right

Summary


SCADA
CFD
Turbulence Intensity
Wind Direction
Flow Simulation
High TI Data
West to North-West
290 degree
Highly Fluctuating wind speed difference across rotor face
Fluctuating Loads
Yaw Failures

Implications▪Future

- The same approach has been applied to other existing wind farms with satisfactory results.

- The temporal and spatial wind speed distribution provides useful information about turbulent wind conditions and can be used as inputs for load calculation.

- LES-based CFD simulation thus has the potential for assessing the operational risk associated with turbulent wind conditions for both existing operational wind farms and new wind farms under planning.

Thank you for Listening !