Heliostat Tracking Influence on Wind Pattern within a Real-Scale Heliostat Field

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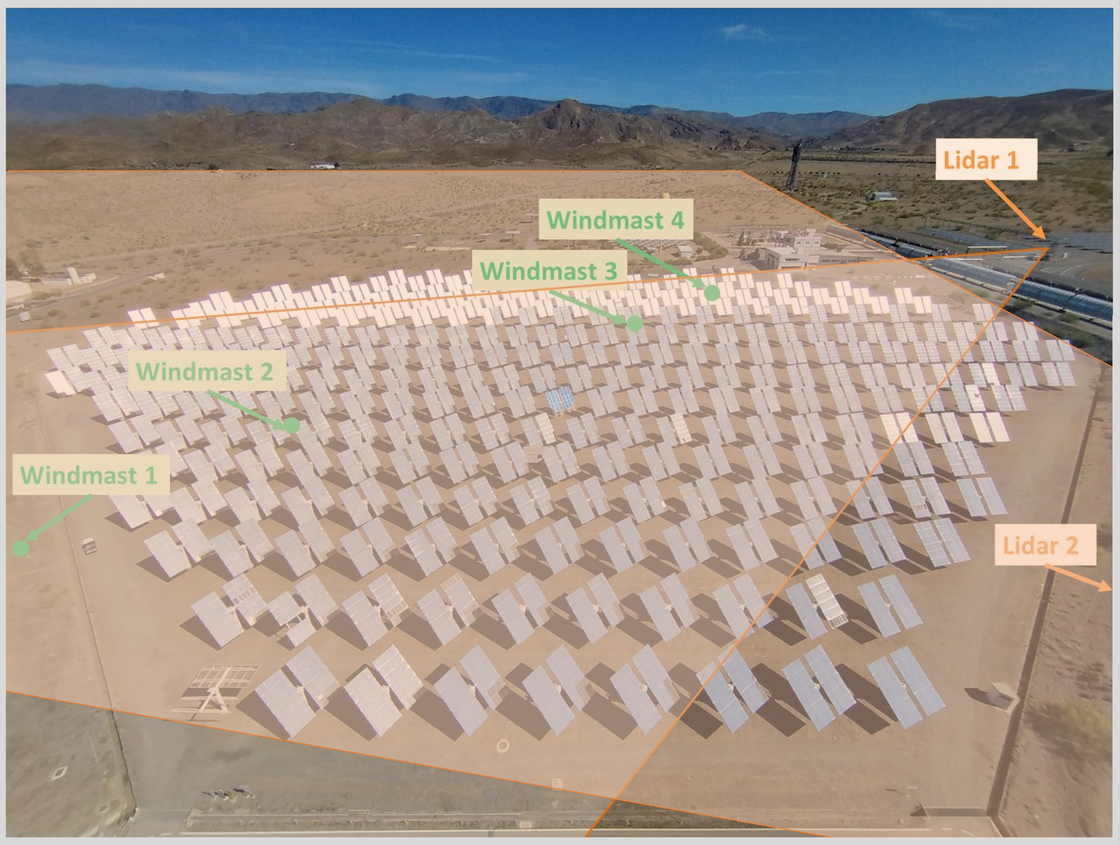
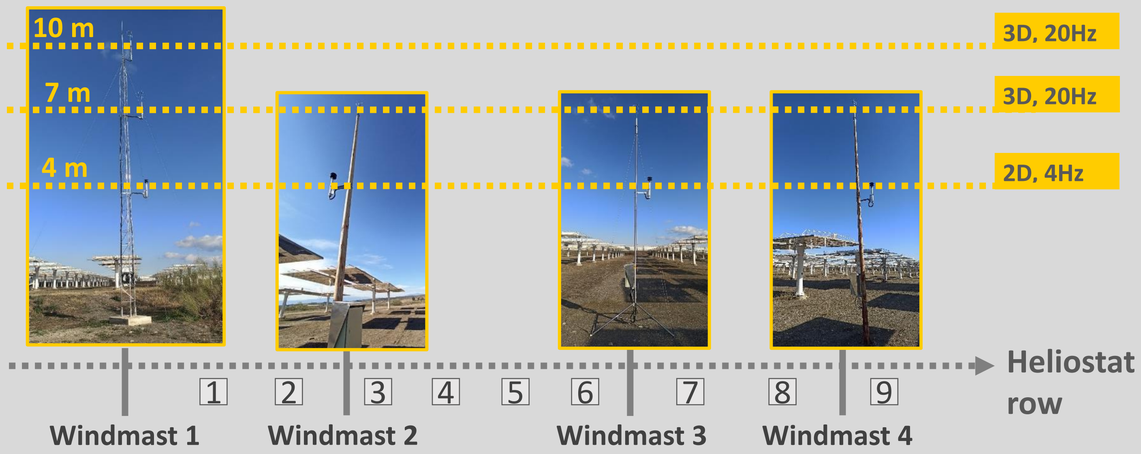
Motivation: Why are aerodynamic conditions in heliostat field important?

- Heliostat field contributes ~ 40% to total investment costs of CST tower plants[1]
- Costs of heliostat field can be optimized if peak wind load can be reduced
- Heliostats in interior of field might be exposed to up to 30% less wind loads than those on edge of field → could be designed slimmer + more cost-effective in interior/strengthen them on edges [2,3]→ <u>One promising approach</u>: adapt heliostat sizing to local flow conditions

Experimental Setup of AdaptedHelio Project:
Measurement campaign (Dec 2021-June 2023) at CIEMAT's Plataforma Solar de Almería (Spain)



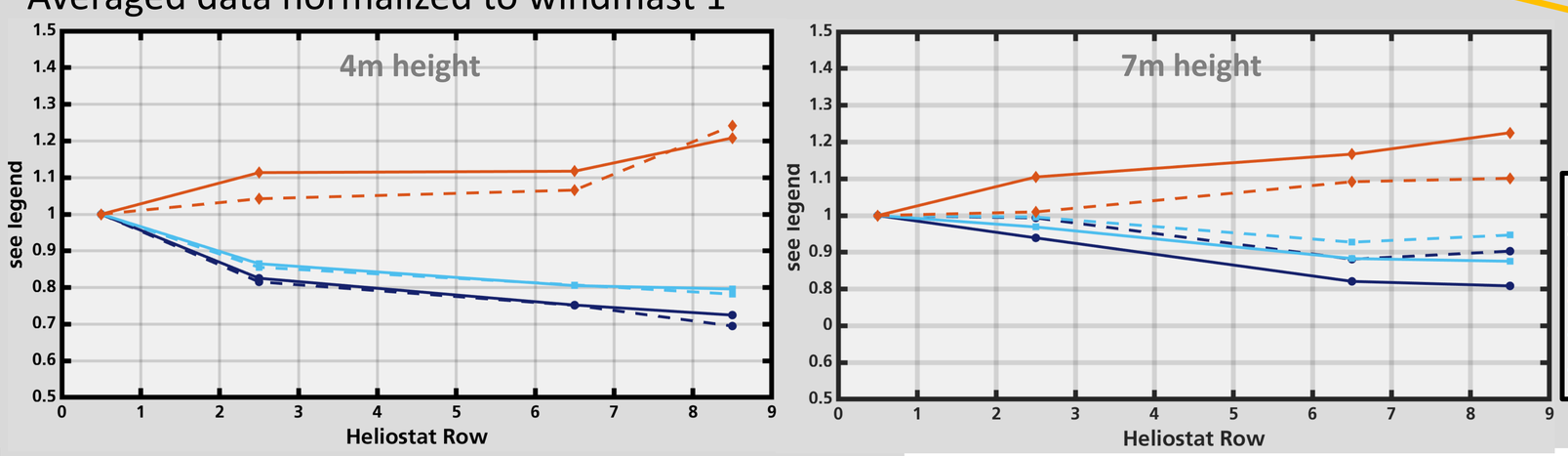


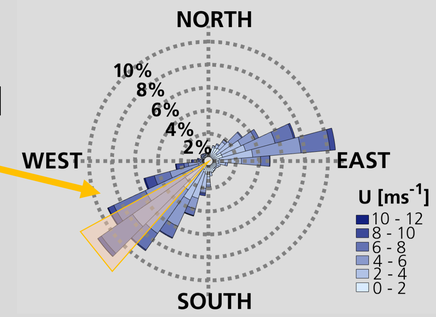
9 ultrasonic anemometers (WindSonic and WindMaster, Gill Instruments) in 4, 7 and 10 m at 4 windmasts → heliostats stow position in ~4 m, upper edge in vertical position in ~7 m

Two scanning wind lidars (WindCube WLS-200S) in ~10m height operating in dual-doppler mode, horizontal scan along 42° above heliostat field, angular resolution of 1.5°/s, radial resolution of ~3m

Results: Changes of Wind Pattern within Heliostat Field

Only data points with wind direction in windmast measurement line (232°±10°) considered
Averaged data normalized to windmast 1

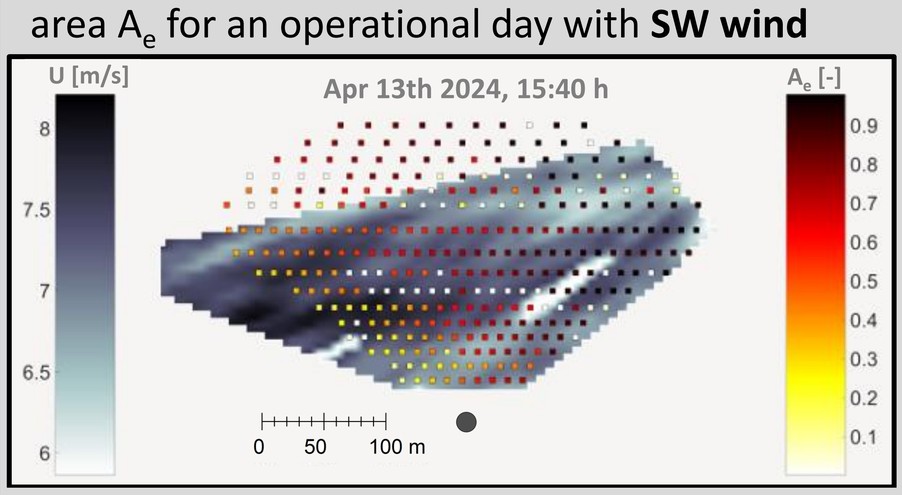




Wind direction and speed distribution at windmast 1 in 7m height between Feb 15th-June 1st 2023, 10 minutes resolution.

- Av. norm. wind speed U (tracked)
- Av. norm. wind speed U (stow/parallel to wind)
- Av. norm. wind gust G (tracked)
- Av. norm. wind gust G (stow/parallel to wind)
- Av. norm. turbulence intensity I (tracked)
- Av. norm. turbulence intensity I (stow/parallel to wind)

Exemplary two-dimensional field plot showing LiDAR data + corresponding normalized heliostat area A_e for an operational day with **SW wind**



- Exposed norm. heliostat area A_e: Surface area of heliostat perpendicular to wind depending on wind direction and orientation of heliostat
- Correlation between increase of A_e and decrease in wind speed within heliostat field

Summary

- Significant differences of wind pattern between outer edge and inner rows due to heliostat orientation and field
- In stow position height (4m):
  → Wind speed decreased by ~ 30%, wind gust decreased by ~ 20%
  → Turbulence intensity increased by ~20%
  → Almost no difference if heliostats are tracked or not
- At upper edge of heliostat in vertical position (7m):
  → Wind speed decreased by 10-20%, wind gust decreased by 5-12%
  → Turbulence intensity increased by 10-22%
  → Less dependency on heliostat row, but stronger influence of heliostat orientation
- Good correlation of anemometer and LiDAR measurements status
- 2D maps of horizontal wind data over heliostat field presented

References
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