Task 46 - Erosion of wind turbine blades: WP#2 Climatic conditions

Purpose of WP2:

Improve description of the atmospheric properties believed to be drivers of LEE.

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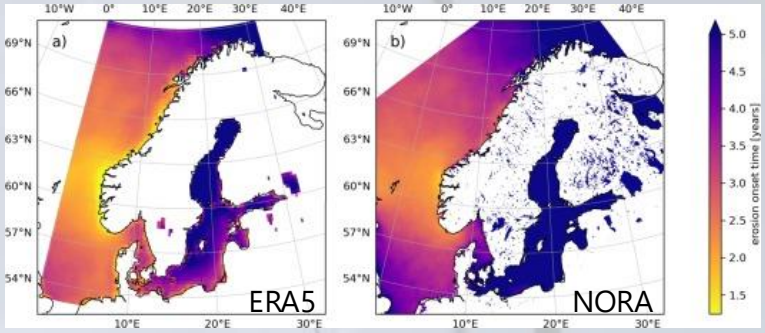
1. Priority areas for mapping LEE potential – focus on hydrometeors
2. Identify (other) crucial parameters (e.g. dust, freezing rain, sea-spray, UV, temperature variation (diurnal & seasonal))
3. Lit rev: Hail, rain & dust in priority areas
4. Lit. rev. Hydrometeor size dist. As f(climate)
5. Data quality/availability update
6. Roadmap for LEE atlas
7. Recommended Practice for measurement of LEE drivers
8. Methods to perform model V&V on LEE drivers

Roadmap for LEE atlas

- GOAL: Tool for a priori assessment of LEE potential to inform mitigation
- ACTIONS: 0-th order assessment of relative erosion. Use WP4 product
  - VH curve based to time series from member sites
    - Hourly average WS & RR
    - 2 VH param. from RET. For D = 2.4 mm implementing variable param as f(RR)
    - Implemented IEA 15 MW for tip-speed

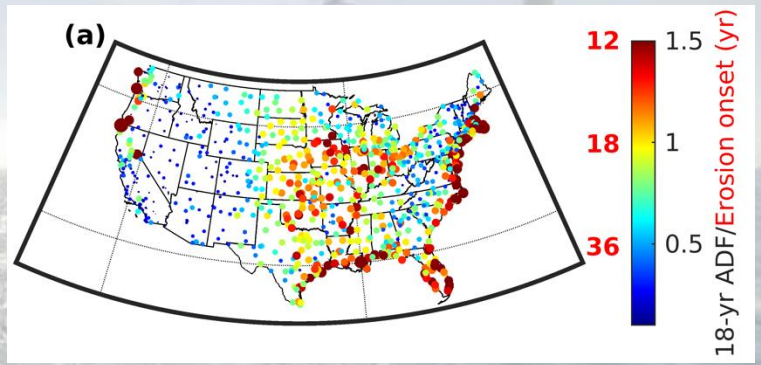
Possible templates….

- DTU-UBergen – Scandinavian-waters (VH curve, reanalysis)



Hannesdóttir et al. (2024): *Res. In Engineering*

- Cornell – CONUS (multi-layer Springer, in situ obs)

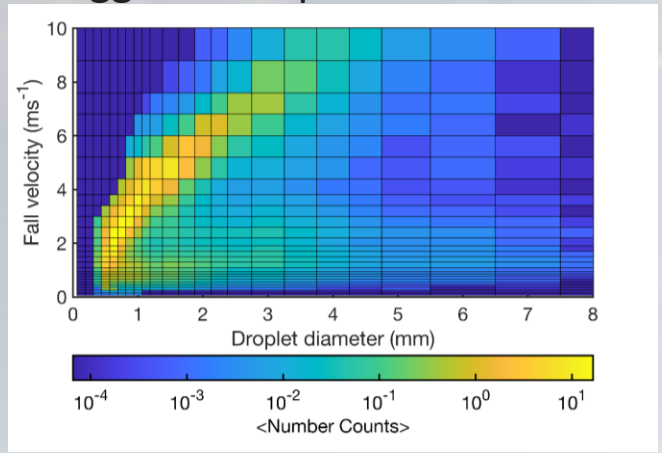


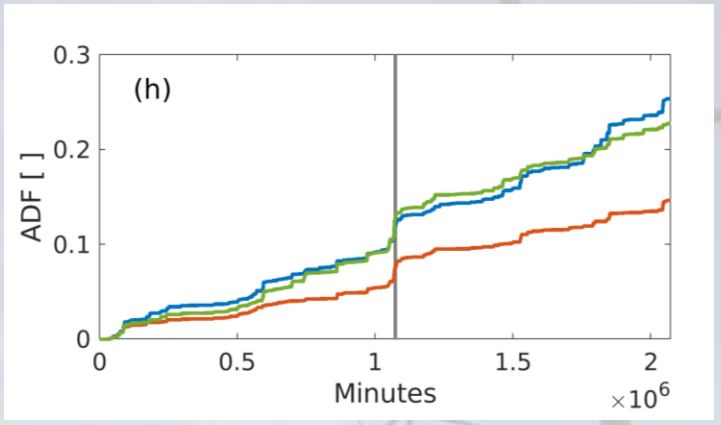
Pryor et al. (2025): *Energies* **18**, 425; doi: 10.3390/en18020425

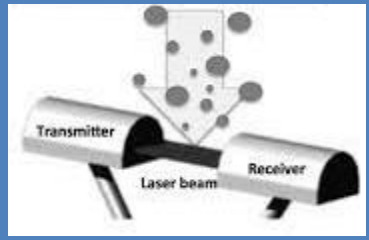
Recommended Practice for measurement of LEE drivers

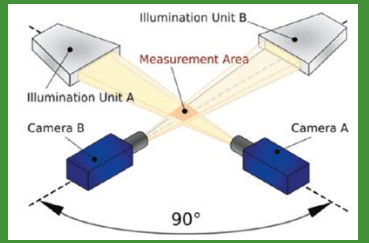
- GOAL: Understand why disdrometers (& rain gauges) disagree.

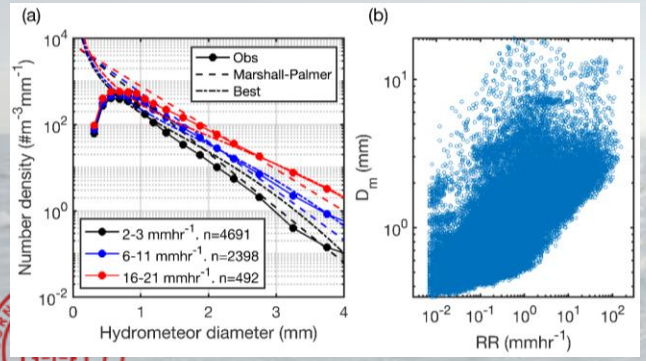
Suggest best practice for instrument deployment & data processing.









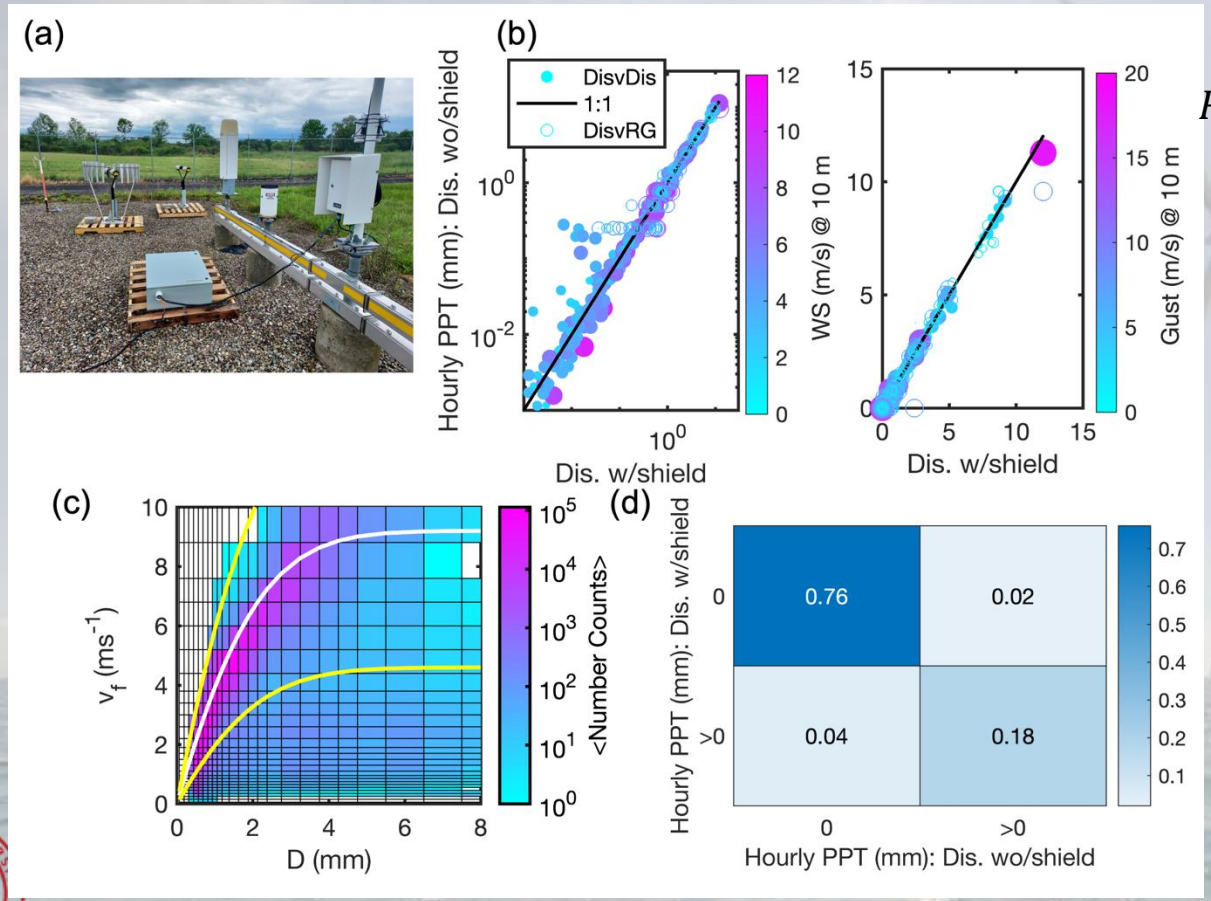


Letson & Pryor (2023): *Energies.* **16,** 3906; doi: 10.3390/en16093906

Pryor et al. (2022): *Energies.* ***15***, 8553; doi: 10.3390/en15228553

ACTIONS: Coordinated research Cornell U, DTU, AIST, WEICan. Presentation at Sandia Blade Workshop (Sept 2024)

Recommended Practice for measurement of LEE drivers

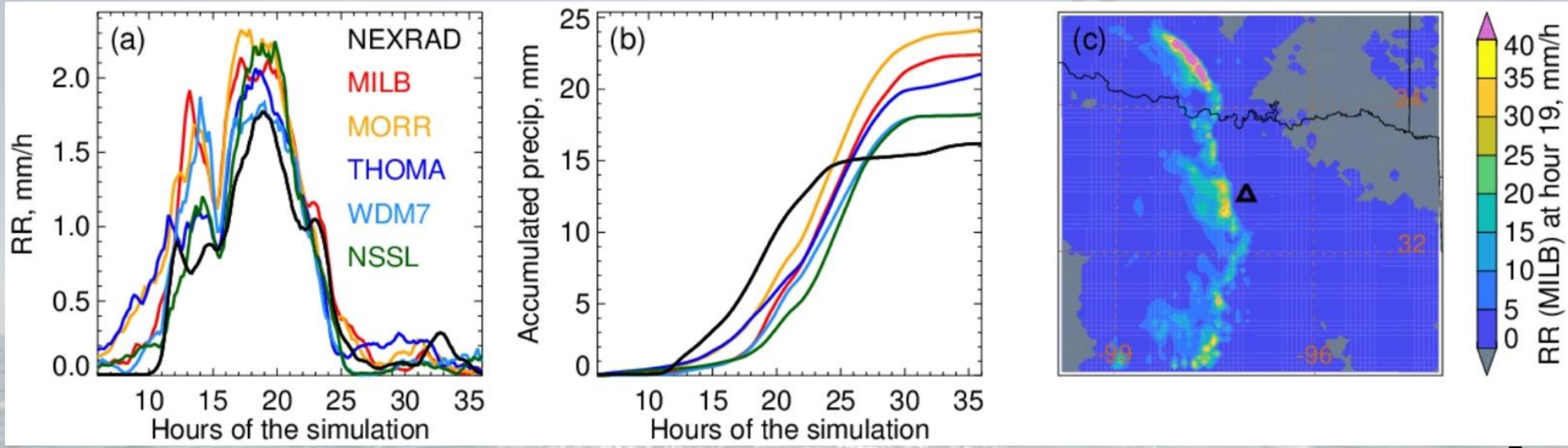


$$RR = \frac{\pi}{6}\frac{3.6}{10^3}\frac{1}{Ft}\sum N(D_i){D_{eq,i}}^3$$

Pryor et al. (2024): *Energies* **17**, 6285; https://doi.org/10.3390/en17246285

Model verification and validation (V&V) framework

- GOAL: Quantify fidelity of model-based forecasts of highly erosive conditions (short-term to multi-decadal). Research nascent! Complex!
- ACTIONS: Cornell (& DTU via AIRE project); (1) quantifying model (WRF) set-up dependence of fidelity for periods with high RR (and hail) AND high wind speeds and (2) evolving application-specific 'skill metrics'



Pryor et al. (2024): *Energies* **17**, 6285; https://doi.org/10.3390/en17246285

Plan for task renewal: 4 ‘actions’

2.1 Perform a Phenomena Identification and Ranking Table (PIRT) analysis to identify meteorological parameters of critical importance to LEE and to quantitatively assess current measurement and modelling capabilities. Mn: 1-6 (preliminary version already developed and tested that we can leverage/expand*).

*Pryor et al. (2024): *Energies* **17**, 6285; https://doi.org/10.3390/en17246285 . *Presentation at LEE conf. in Feb 2025 @ DTU*

- *Verify we agree on priorities & research needs!*

2.2 Recommended Practice for measurement of LEE drivers. Mn: 7-18

- *Conclude and make (& release) a robust workflow!*

2.3 Assessment of modelling capabilities to represent key atmospheric drivers of LEE (V&V exercise). Mn: 19-30

- *Prediction requires simulation! Quantify current level of skill for e.g. hail prediction with regional models (e.g. WRF for varying model configurations). (and JPD: RR & U)*

2.4 Roadmap for LEE atlas. Mn: 31-46

- *Integrative with other WP & information from actions 2.1-2.3 to develop an advanced framework for translating measurements and modelling to robust geospatial descriptions of LEE potential.*