Mesoscale-to-Microscale Coupling for Loads Analysis

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MMC-Sponsored Industry Workshop

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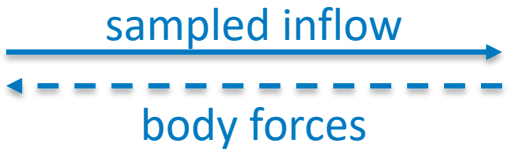
Approaches

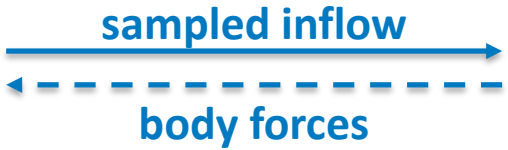
- Inflow Data
  - Mesoscale model
  - Observations
- Driving the microscale
  - Internal coupling
  - Boundary coupling



Aeroelastic model
- Inflow
- Aero
- Structures
- Controls
- Hydro

Current Approach

- Inflow Data
  - Mesoscale model
  - **Observations**
- Driving the microscale
  - **Internal coupling**
  - Boundary coupling

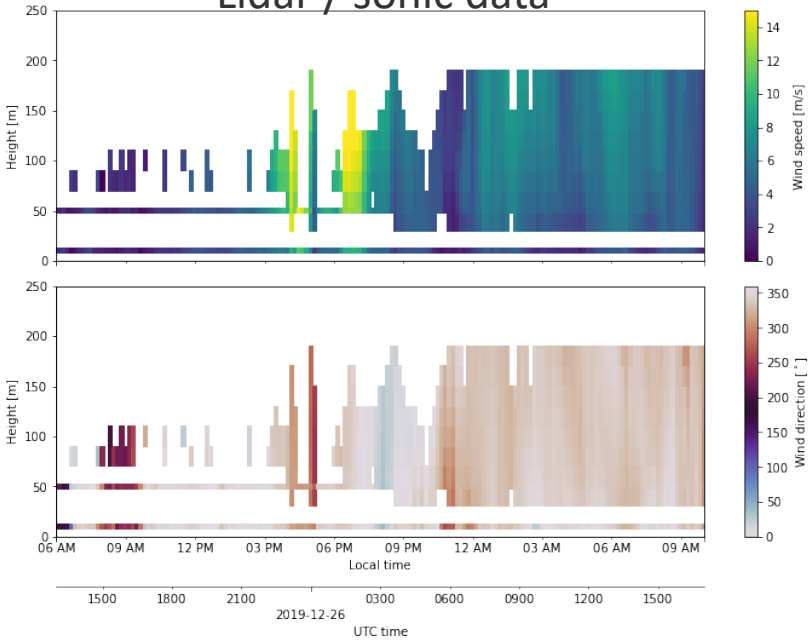


Aeroelastic model
- Inflow
- Aero
- Structures
- Controls
- Hydro

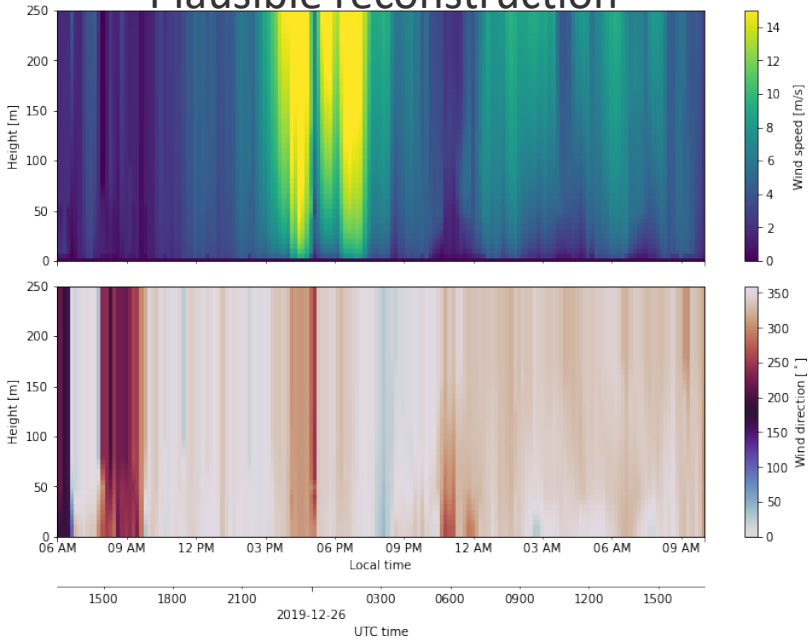
Flow Modeling Challenges

- Incomplete reference data

Lidar / sonic data

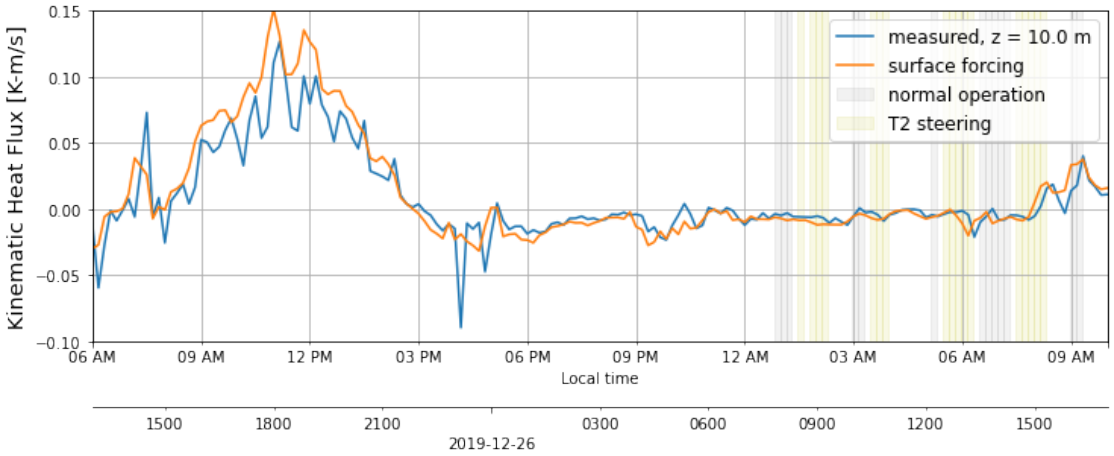


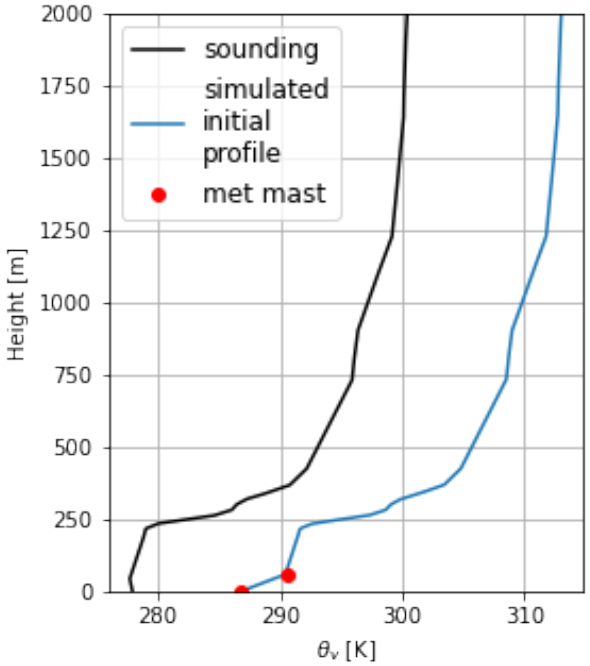
Plausible reconstruction



Flow Modeling Challenges

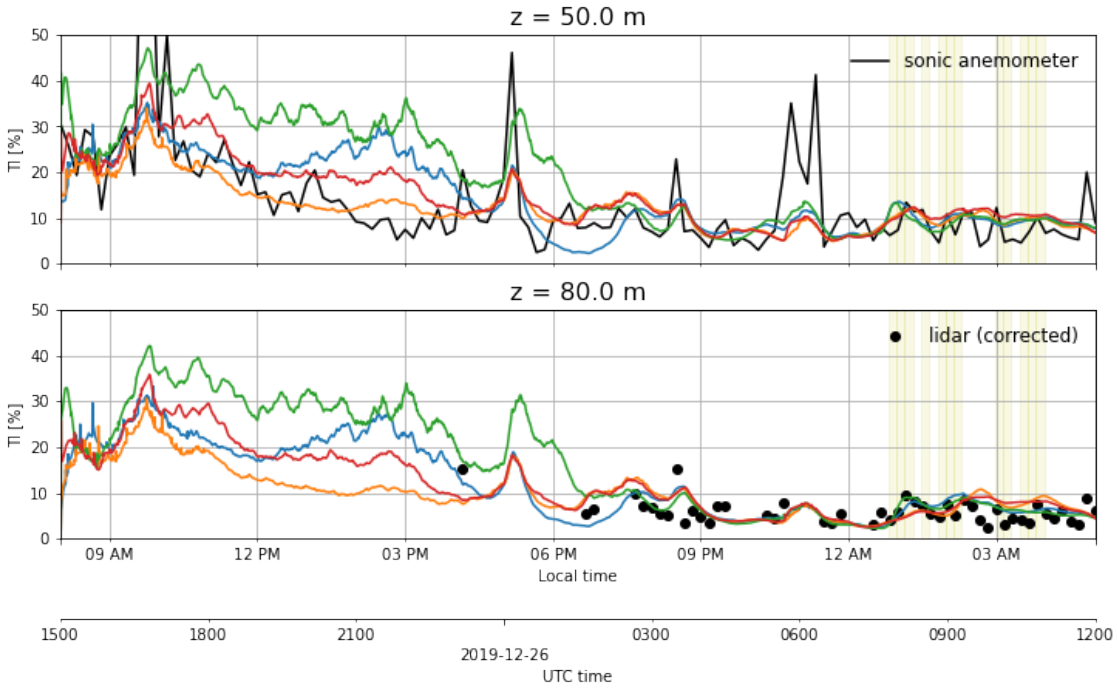
- Missing information
  - Initial conditions
  - Surface conditions





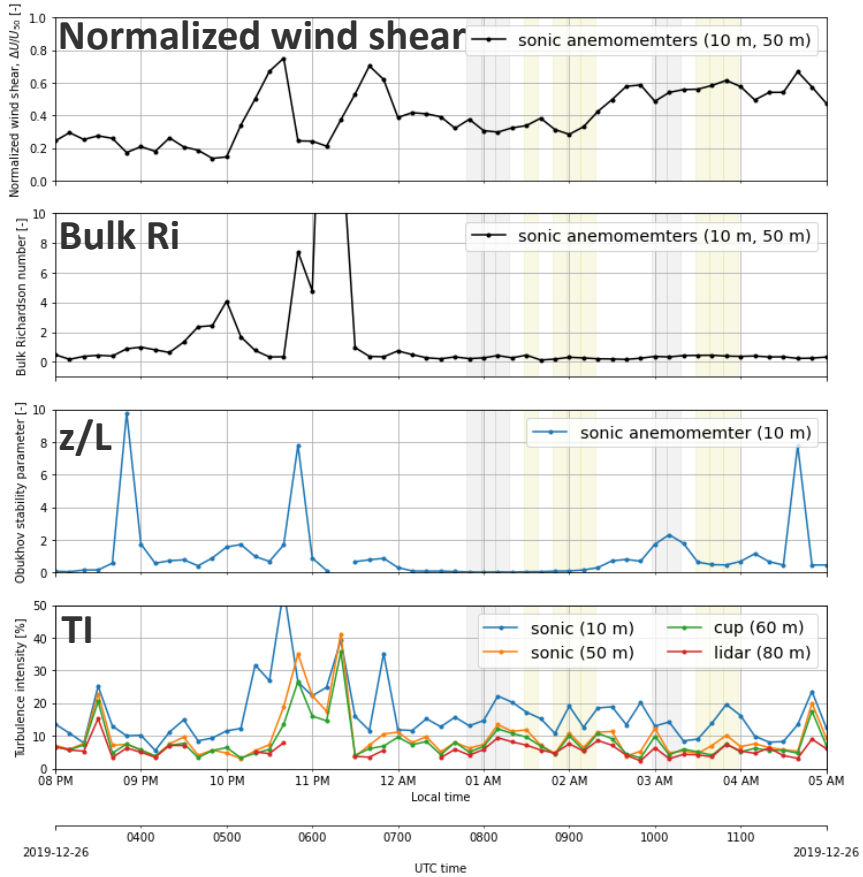
Flow Modeling Challenges

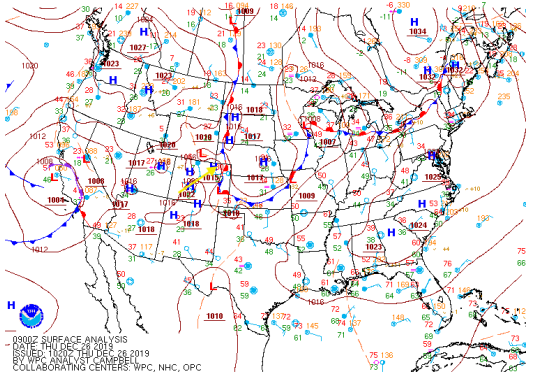
- Sensitivity to initial conditions

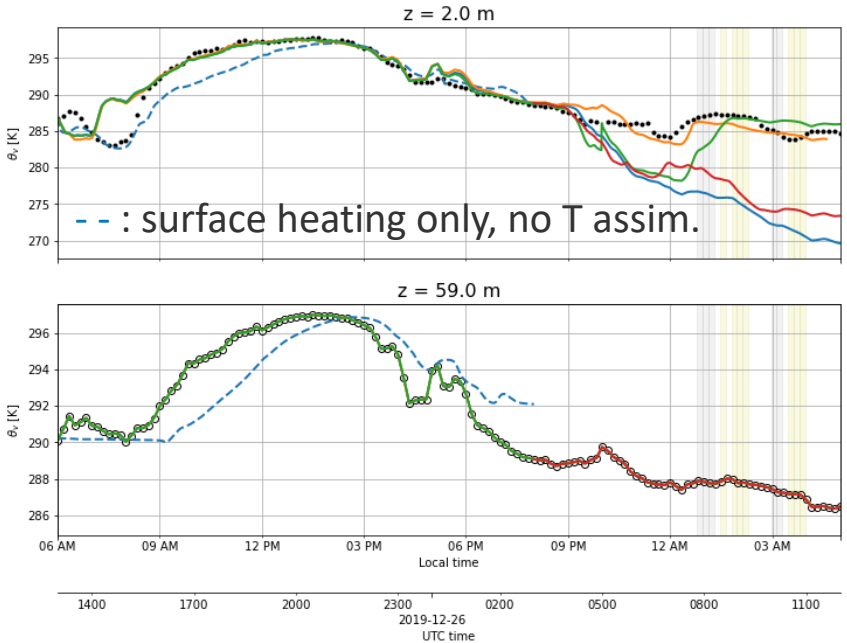


- 2x initial profiles
- 2 surface BCs

Case Study

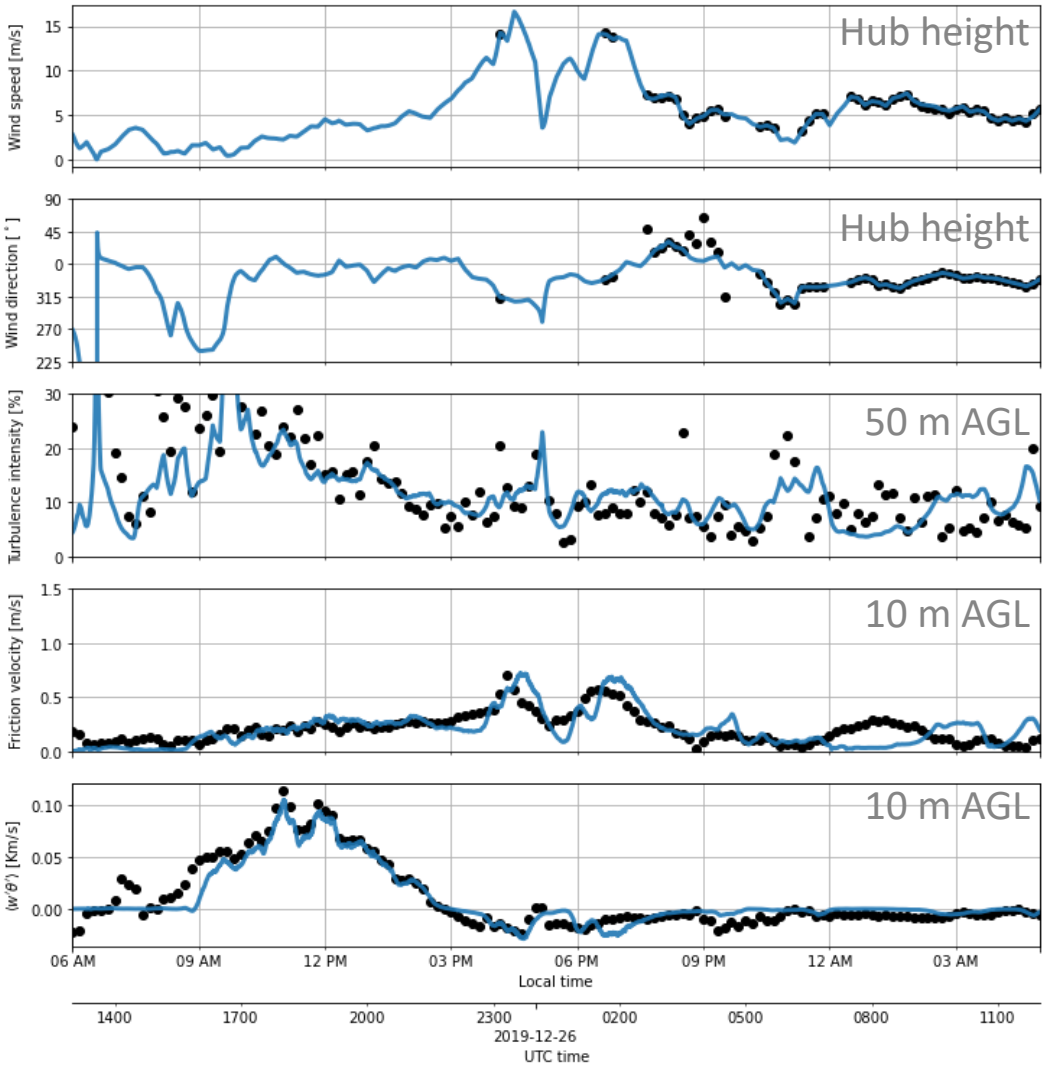

Normalized wind shear
sonic anemomemters (10 m, 50 m)
Normalized wind shear, $\Delta U/U_{50}$ [-]
Bulk Ri
sonic anemomemters (10 m, 50 m)
Bulk Richardson number [-]
z/L
sonic anemomemter (10 m)
Obukhov stability parameter [-]
TI
sonic (10 m)
sonic (50 m)
cup (60 m)
lidar (80 m)
Turbulence intensity [%]
08 PM
09 PM
10 PM
11 PM
12 AM
01 AM
02 AM
03 AM
04 AM
05 AM
Local time
0400
0500
0600
0700
0800
0900
1000
1100
2019-12-26
2019-12-26
UTC time


0900Z SURFACE ANALYSIS
DATE: THU DEC 26 2019
ISSUED: 1000Z THU DEC 26 2019
BY WPC ANALYST CAMPBELL
COLLABORATING CENTERS: WPC, NHC, OPC

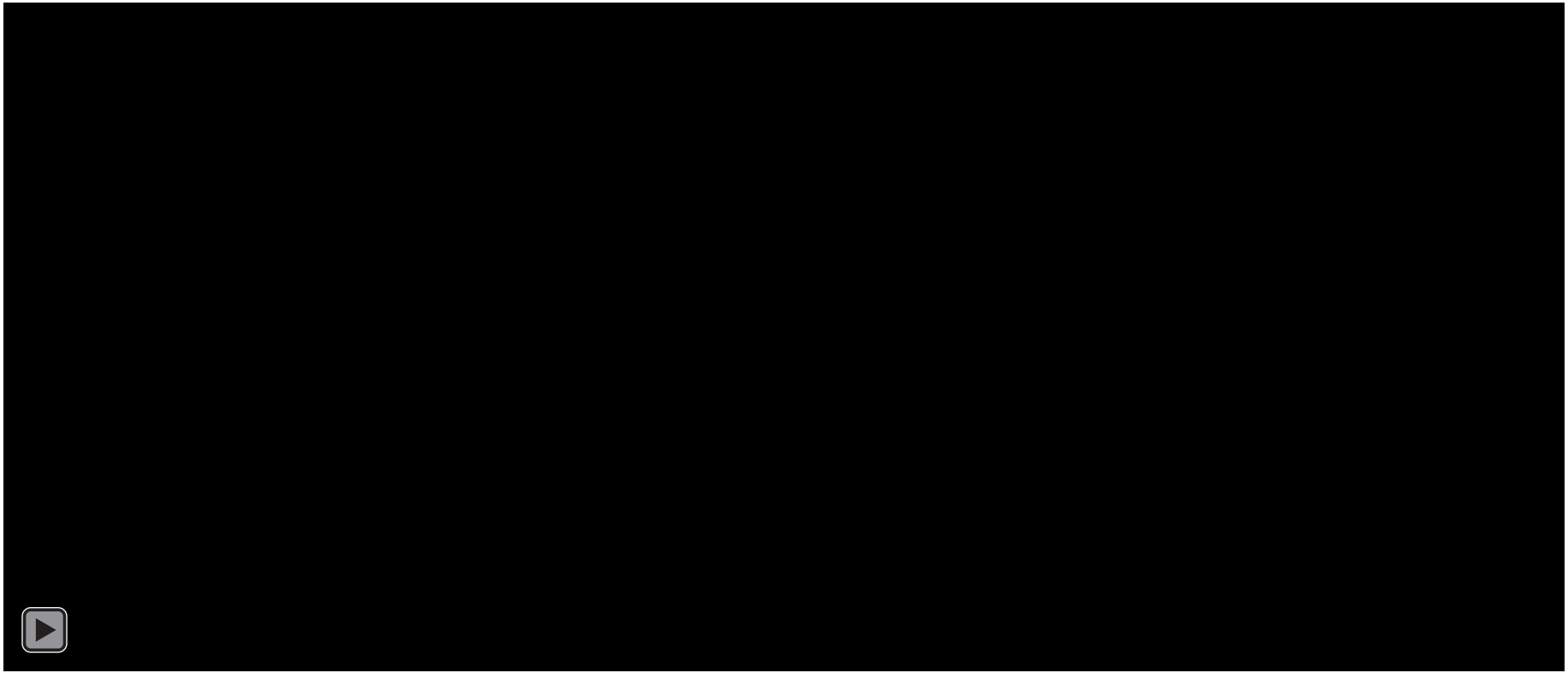

z = 2.0 m
θ_v [K]
- - : surface heating only, no T assim.
z = 59.0 m
θ_v [K]
06 AM
09 AM
12 PM
03 PM
06 PM
09 PM
12 AM
03 AM
Local time
1400
1700
2000
2300
0200
0500
0800
1100
2019-12-26
UTC time

Simulation Example: Inputs/Outputs

- Large-eddy simulation (SOWFA)
  - ABL on 10-m grid
  - Actuator disk model, 5-m refinement
- Coupled to turbine aeroelastic model (OpenFAST)
- 23 hours simulated



Simulation Example: Results



Discussion & Outlook

- High fidelity MMC needed to capture relevant phenomena
- Many different tools/approaches
- Experts still needed
- Other challenges: how to V&V, data sharing (esp. SCADA)
- Current work:
  - Assessment of loads during a canonical diurnal cycle, in comparison with IEC
  - Assessment of loads with wake steering

Thank you!

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