DTU WPPctrl

EU AIRE T4.3: Integrated wind farm control toolbox for optimised design and operation including erosion safe mode

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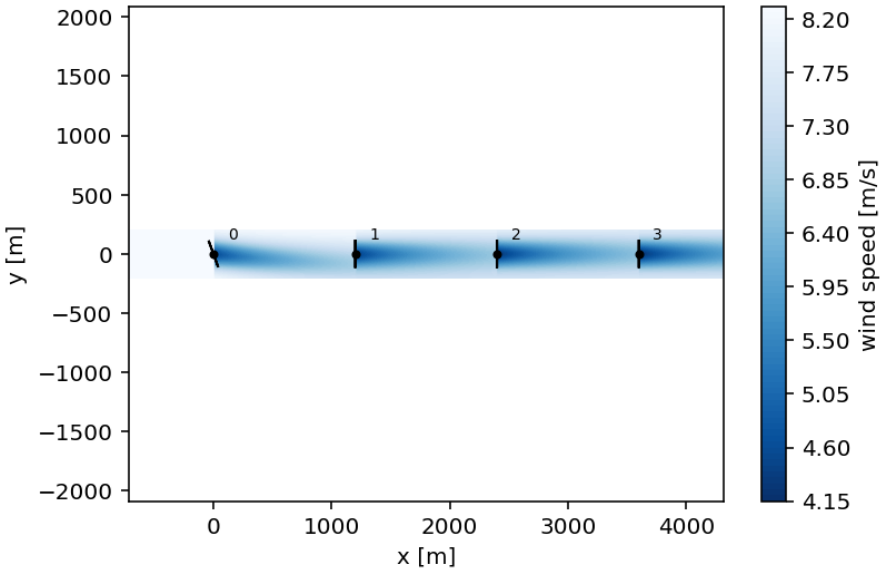
Motivation

On a wind farm level:

- Impact of erosion
- Impact of erosion safe mode
- Impact of yaw misalignment control

Include:

- dynamic effects of farm flow
- realistic WT_ctrl, WPP_ctrl, WFF_ctrl, servos

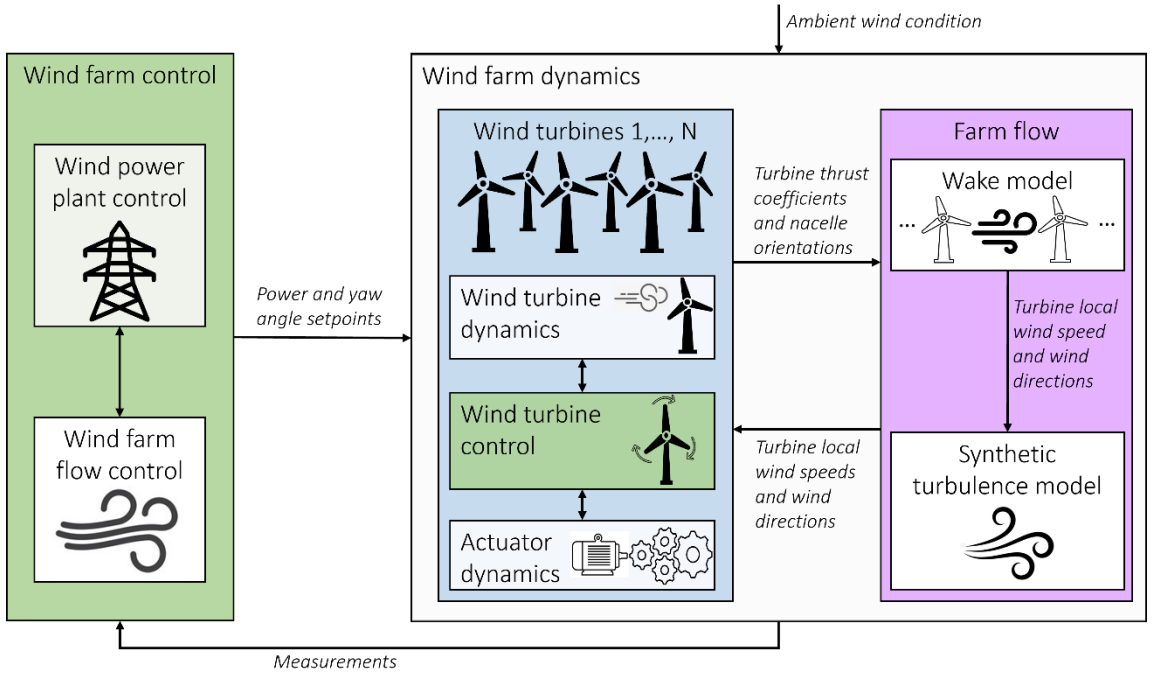


'Why not just use a tool like FLORIDyn or Dynamiks'

- Focus on integrated WPP controller
- Need for flexibility in Cp/Ct = f(TSR,pitch,yaw,erosion)
- Explore future use the WPP controller with DWM (Dynamiks)

Overview

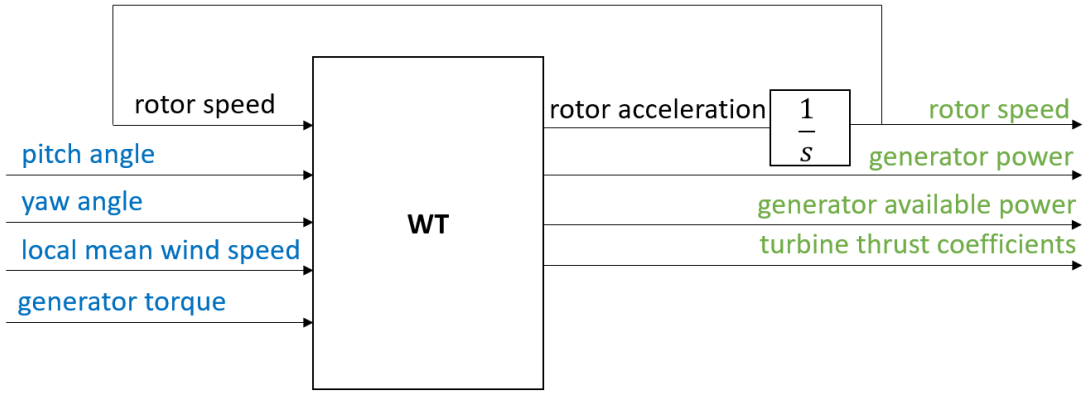
- Control framework for WPPC and WFFC
- Time domain
- Realistic WTC (DTU-WEC)
- Realistic WPPC (MPPT, balance, delta)
- Flexibility for realistic WFFC
- Earlier Simulink model in EU-FarmConners (with FLORIS)
- New Python implementation (with PyWake)

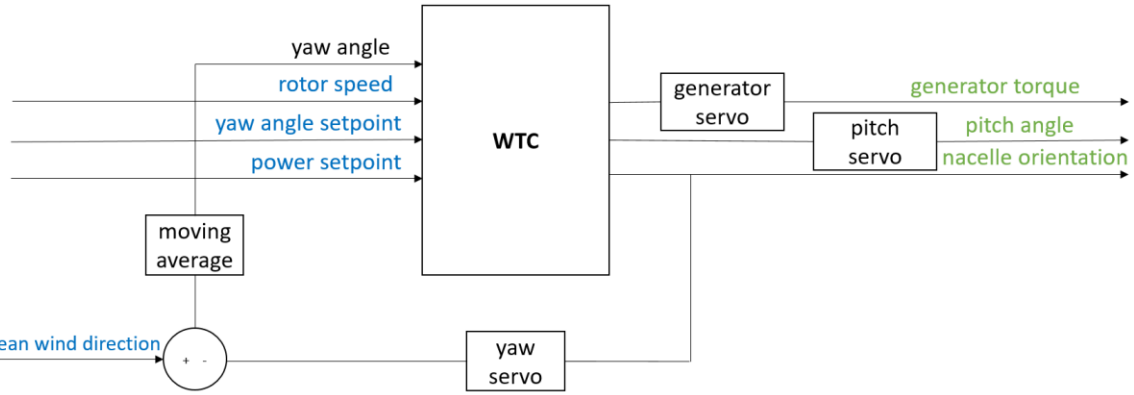


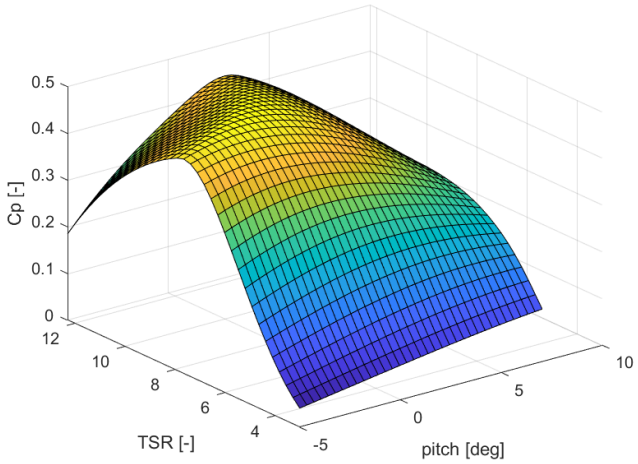
DTU WPPctrl modules

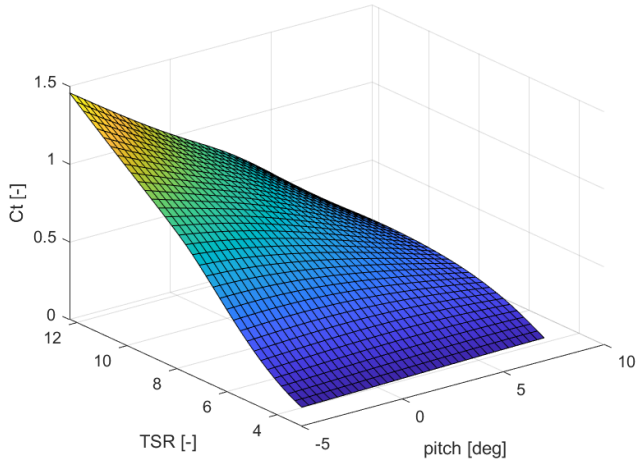
WT and WTC

Cp/Ct = f(TSR,pitch,yaw,erosion)



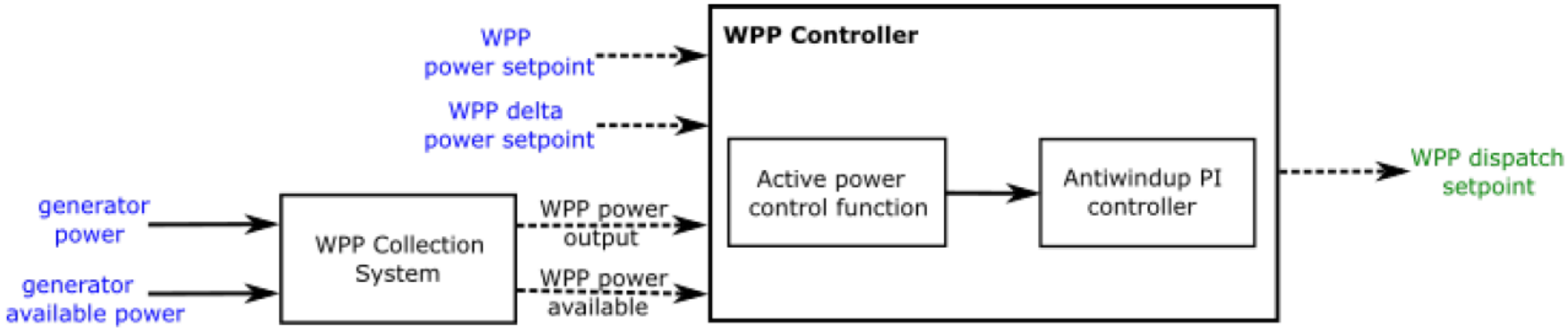




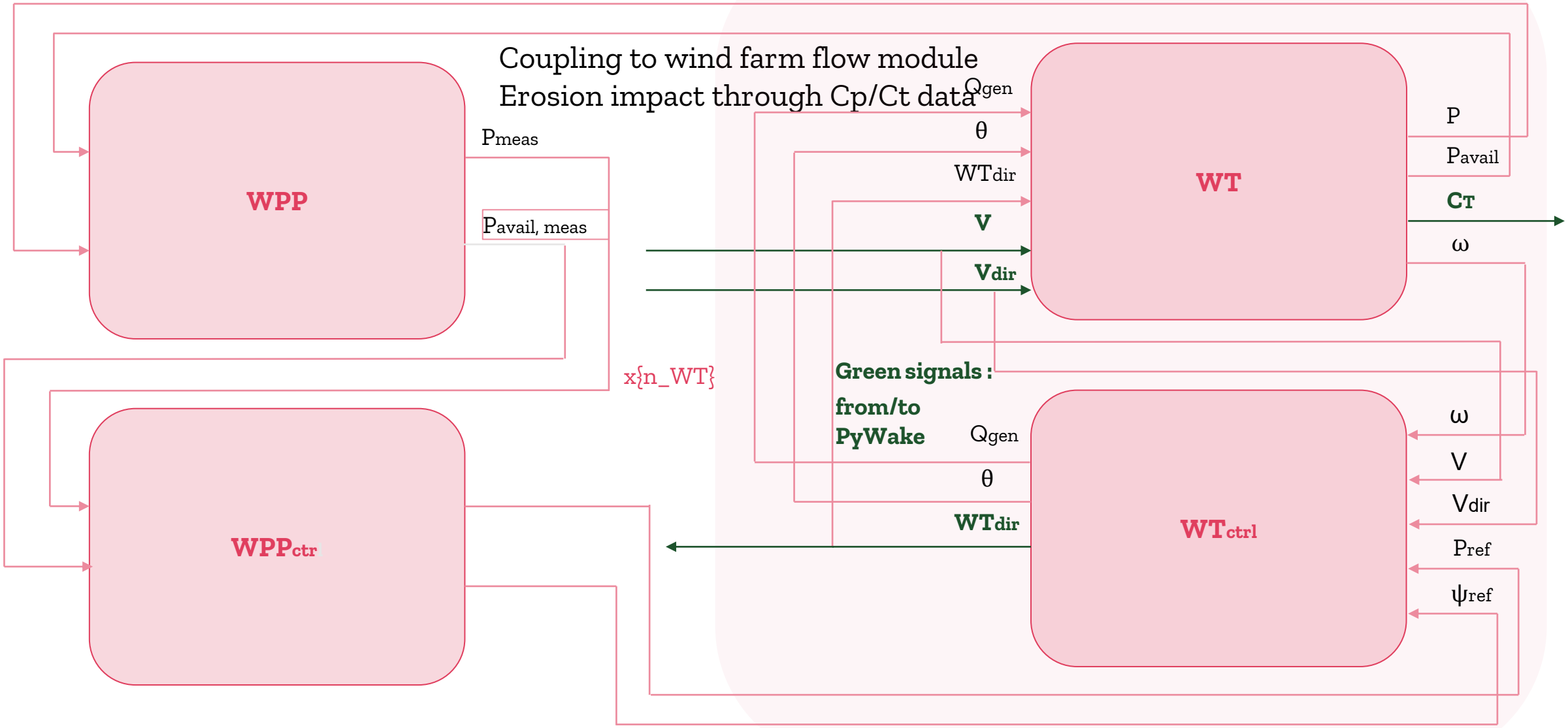


DTU WPPctrl modules

- WPP and WPPC/WFFC
- Dispatch of power and yaw setpoints (WFFC)



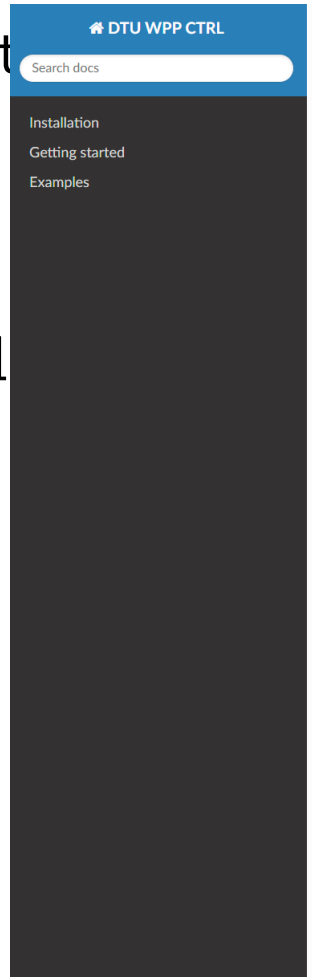
DTU WPPctrl modules integration

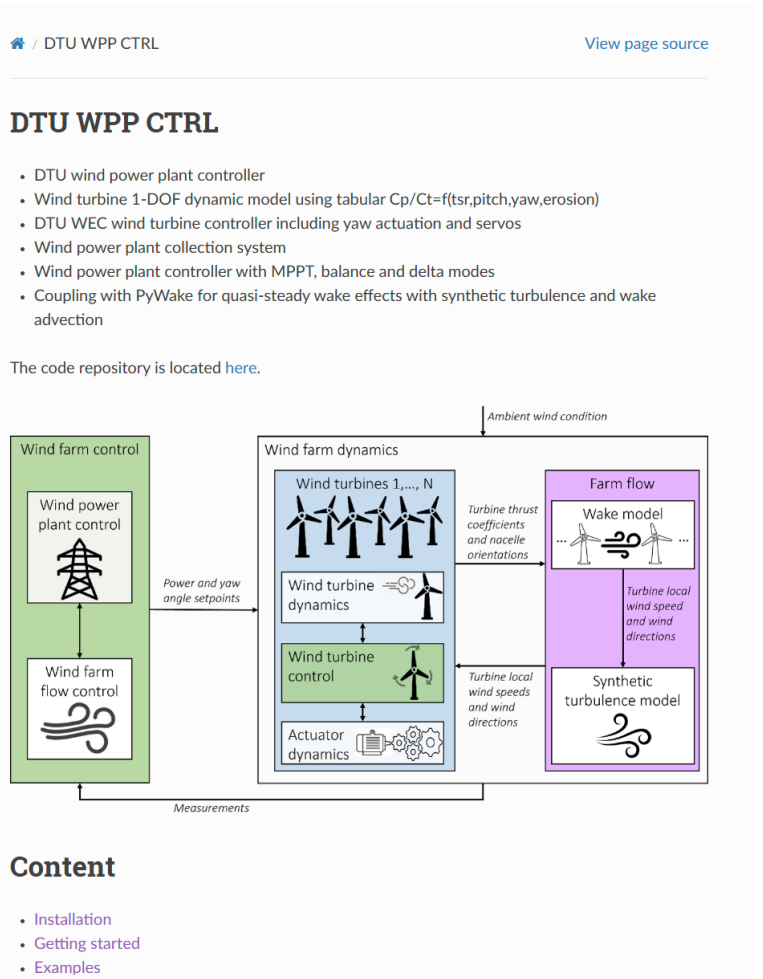


DTU WPPctrl updates/status

Coupling with PyWake for quasi-steady wake effect
with synthetic turbulence and wake advection

The code repository is shared here:
https://gitlab.windenergy.dtu.dk/aire/dtu-wpp-ctrl





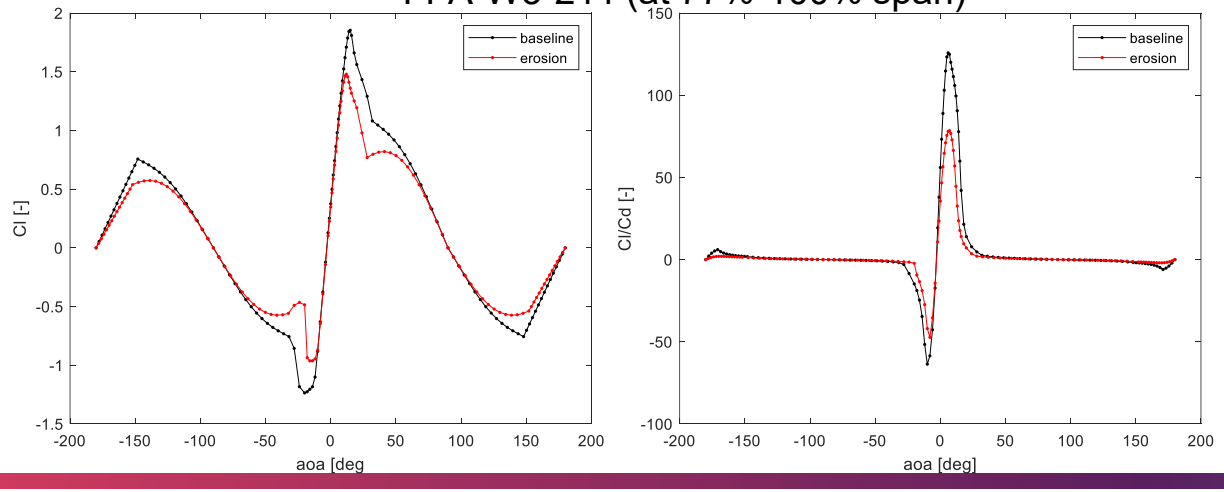
Results

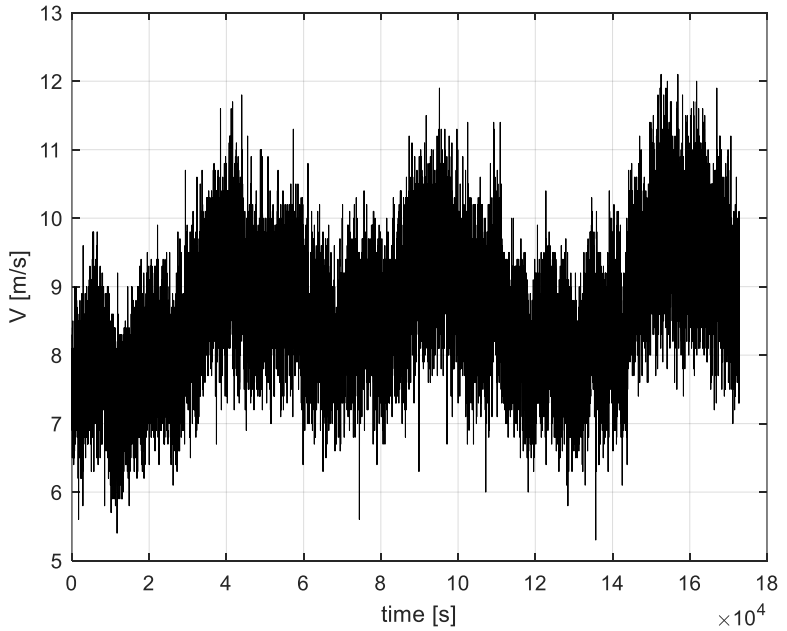
- Array of 4 IEA-15MW-RWT at 5D
- 48h 1Hz inflow data from Horns Rev
- Erosion Cp/Ct from LEARCat (cat 3)

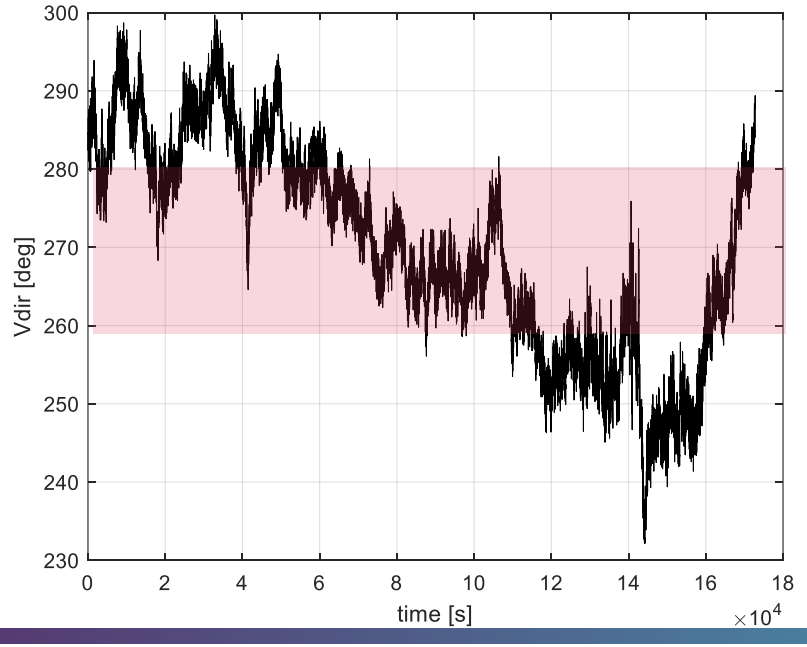
Cases:

- ➢Baseline
- ➢Erosion
- ➢Erosion safe mode (ESM)
- ➢ESM and yaw misalignment control (Yaw_ctrl)

FFA-W3-211 (at 77%-100% span)

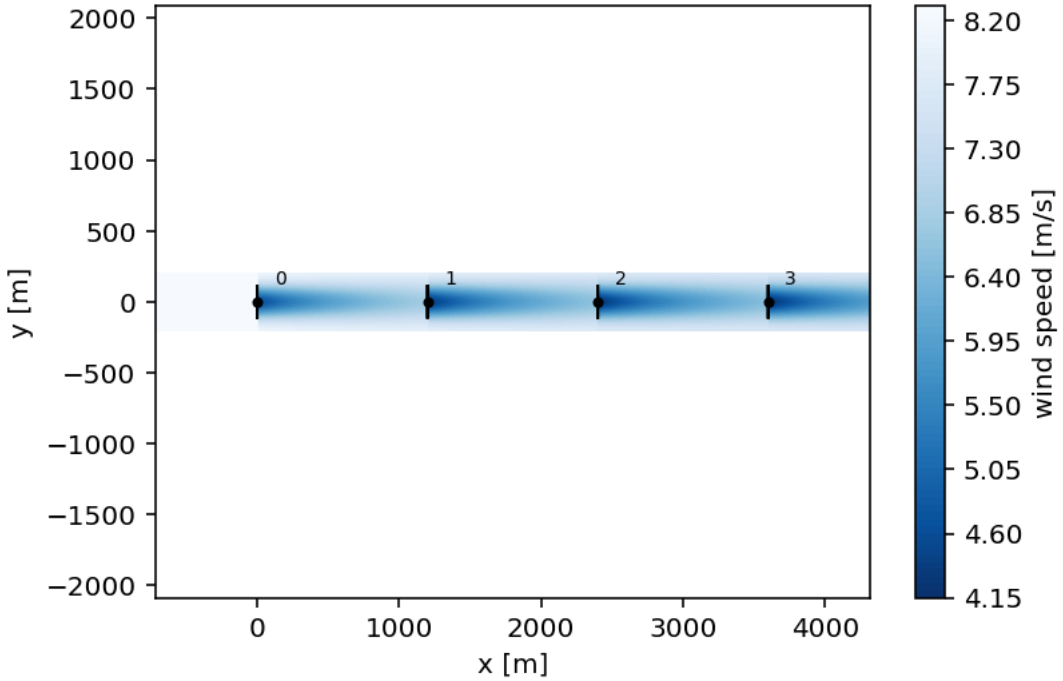


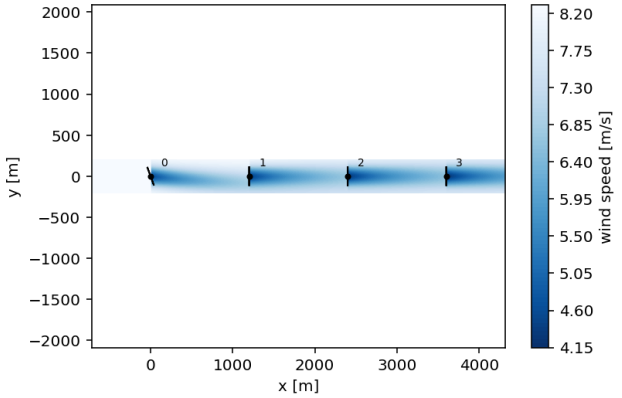


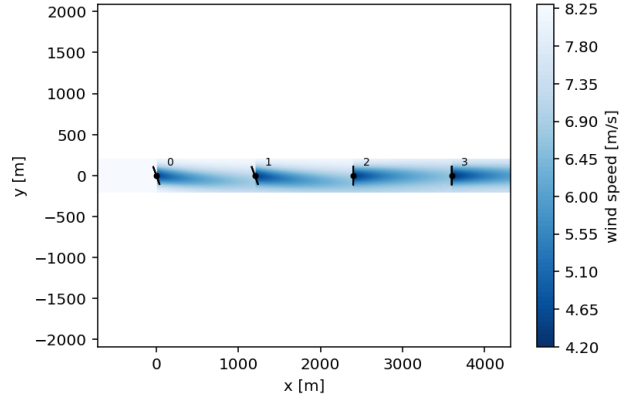


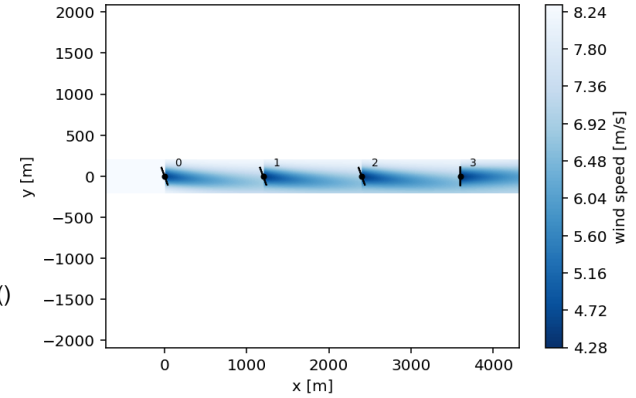
Results

- Flow maps with yaw misalignment
- V_{dir} sector 270°±11.3°
- Example yaw 20°









PyWake models:
wake_deficitModel=IEA37SimpleBastankhahGaussianDeficit()
superpositionModel=SquaredSum()
deflectionModel=JimenezWakeDeflection()
turbulenceModel=CrespoHernandez()
rotorAvgModel=CGIRotorAvg(7)

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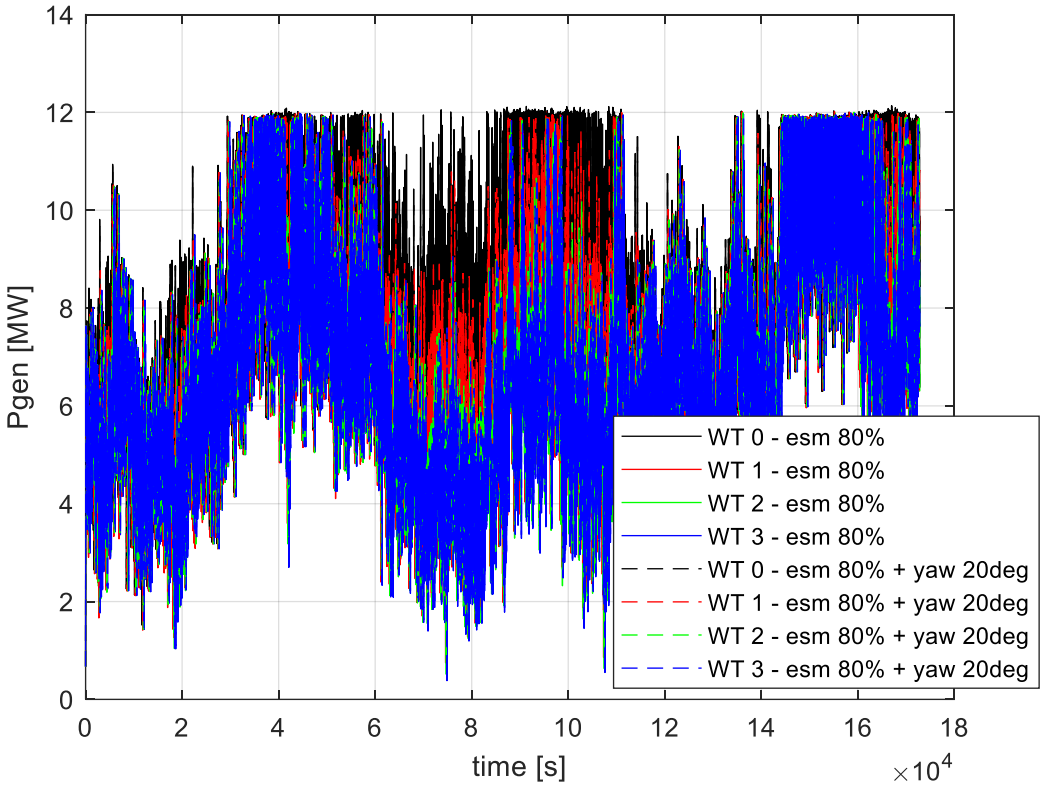
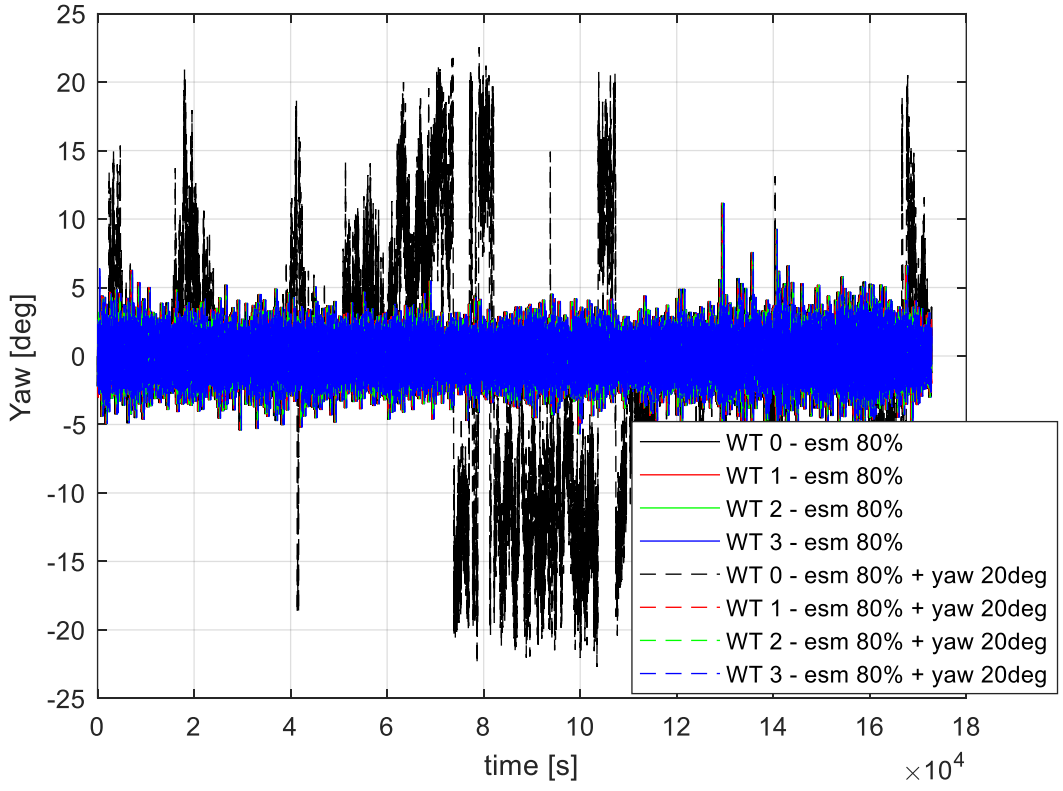
Results

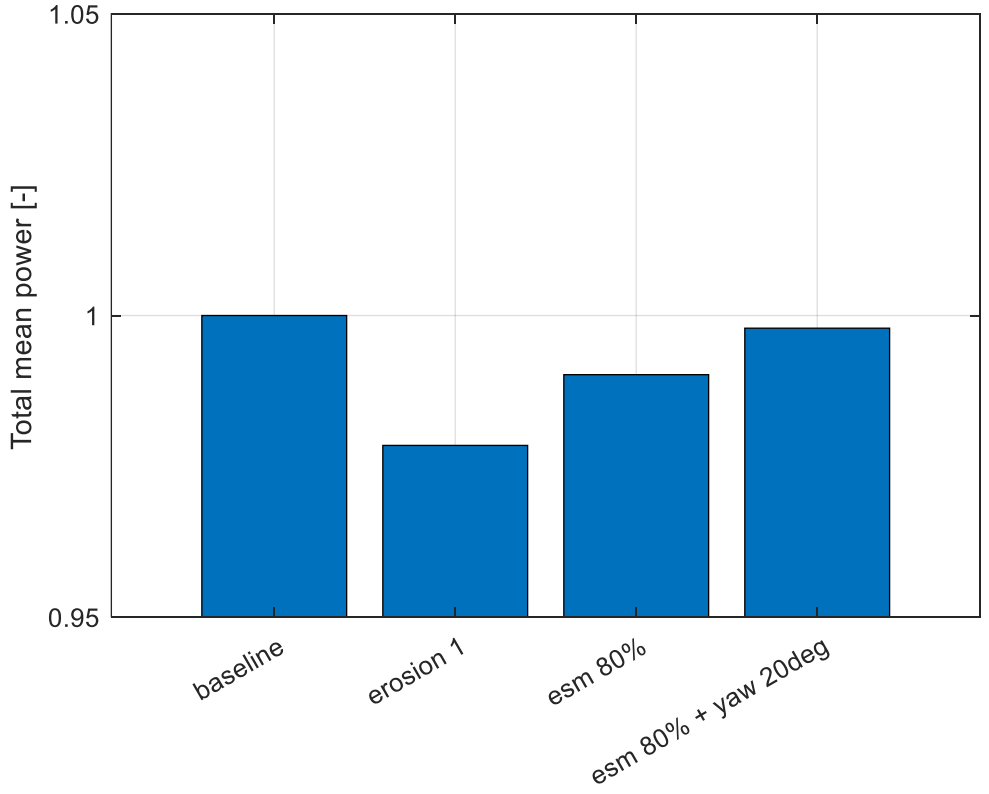
- Power/yaw response for ESM+Yaw_ctrl
- ESM: 80% derating
- Yaw_ctrl: ±20deg in sector

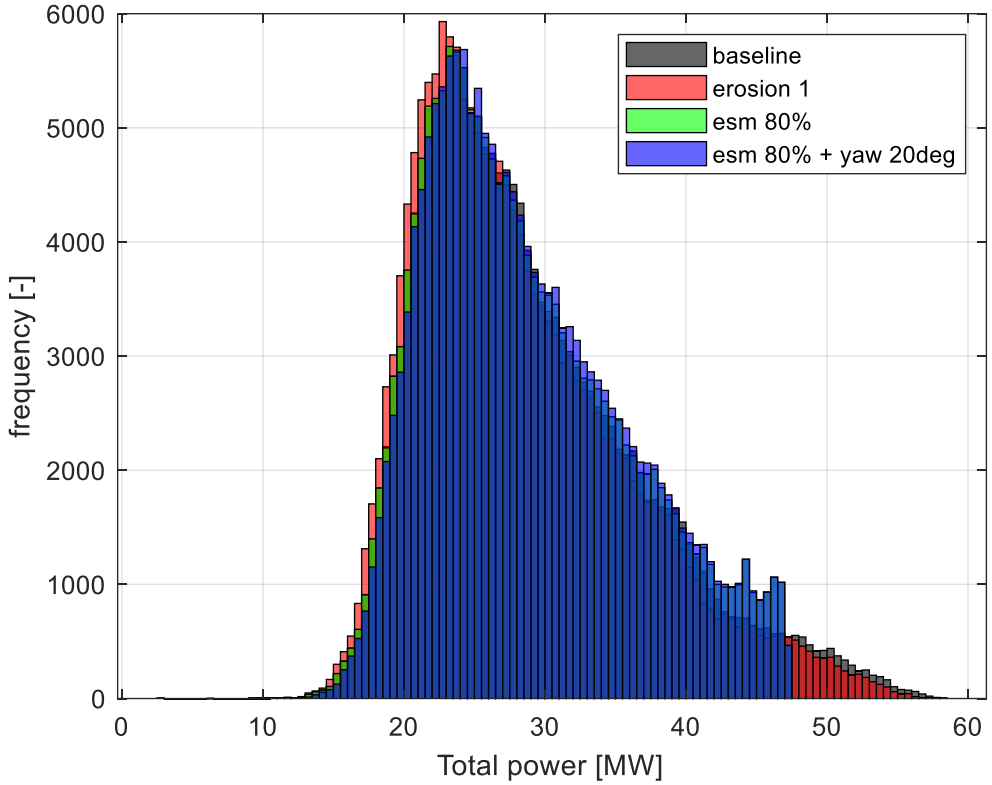




Results

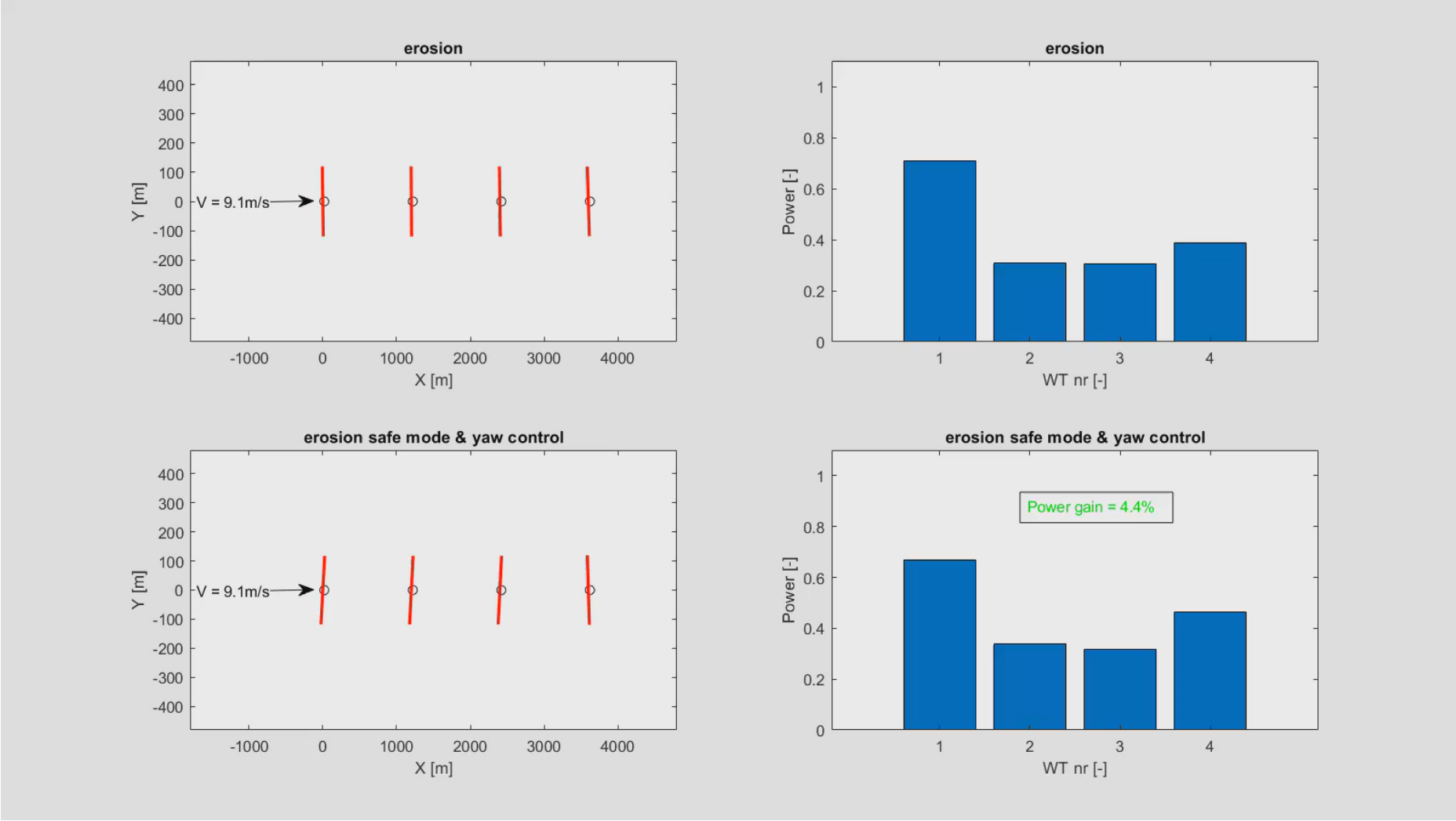
- Power impact of erosion (-2.2%), ESM (-1.0%)
- Potential power recovery with ESM+yaw (-0.2%)
- Steady-state prediction with ESM+yaw: +0.8%





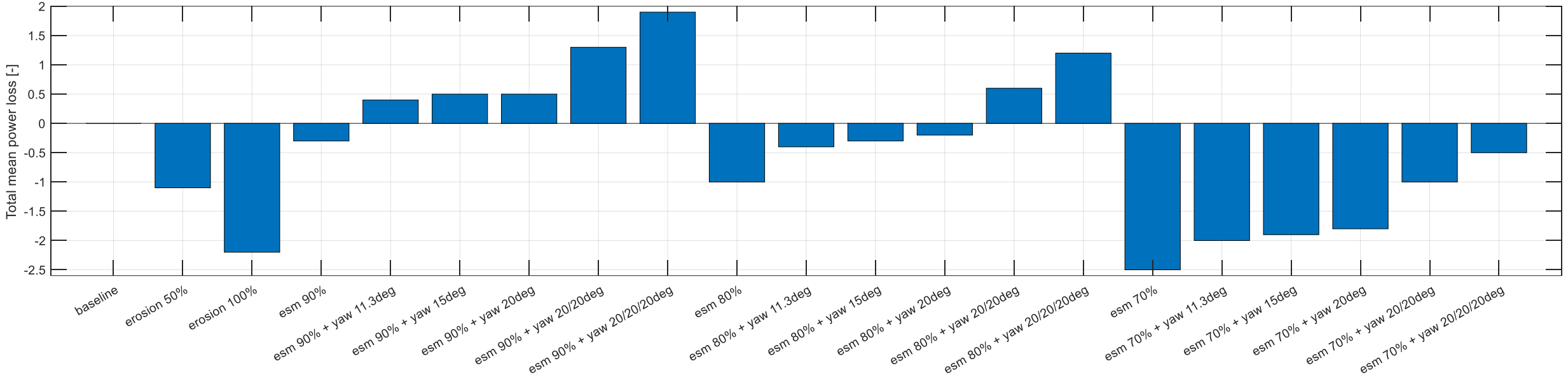
Results

Animation of simulation case with erosion vs ESM+Yaw_Ctrl



Results

- Sensitivity to erosion, ESM, Yaw_ctrl
- Feasible power recovery/gain with Yaw_ctrl down to 80% derating in ESM



Conclusion

- Control framework for WPPC and WFC
- Erosion impact through Cp/Ct data
- Derating and Yaw_ctrl capabilities
- Python implementation (with PyWake)
- Impact of erosion, ESM, Yaw_ctrl

Next steps:

- ➢ Study effect of different erosion levels
- ➢ Support implementation in FLORIS/FOXES
- ➢ Test coupling to DWM (Dynamiks)

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Thank you.

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https://gitlab.windenergy.dtu.dk/aire/dtu-wpp-ctrl

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