

# On Wind Turbine Loads assessment

-  
... in the Scandinavian inland



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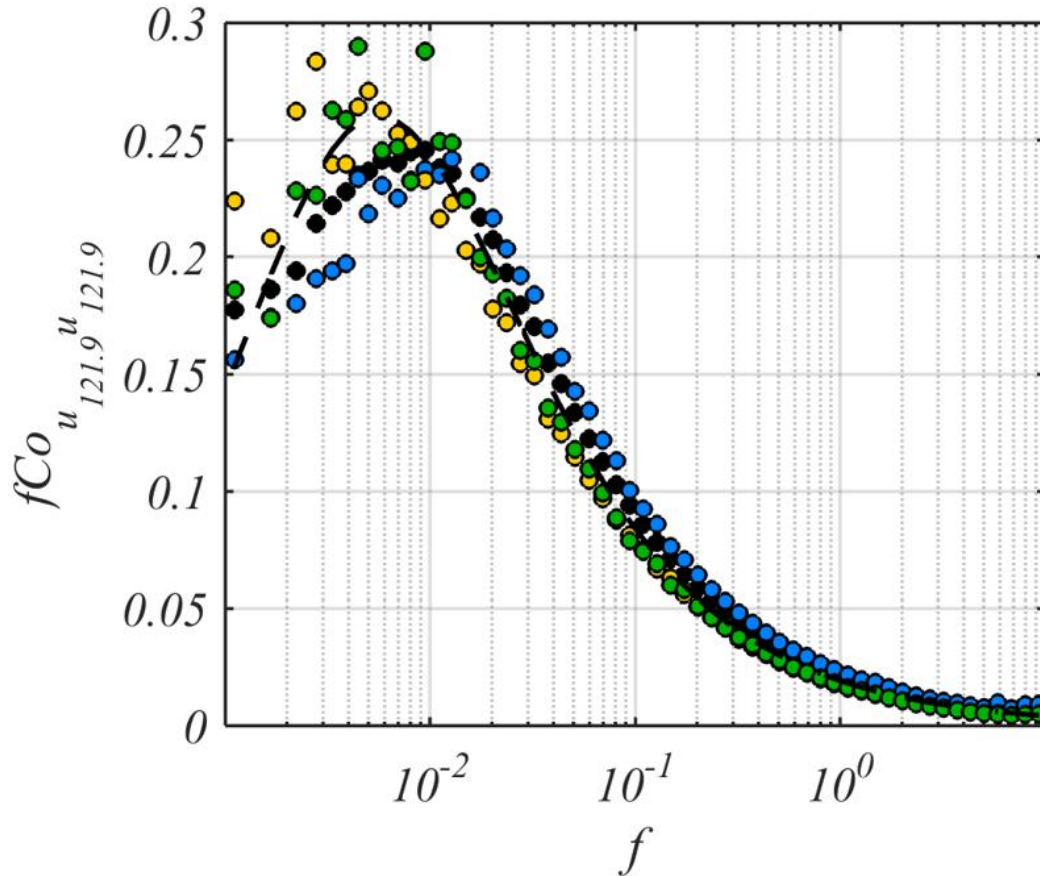
## Wind farm fatigue loads assessment – state of the art

- Synthetic turbulence modelling (Mann / Kaimal)
- Time domain aeroelastic simulation – medium fidelity
- Pre-generated look-up table for selected components / cross-sections
- Load assessment based on wind speed distribution, inclination, wind shear and turbulence intensity - per turbine position and sector
- Comparison with certified loads

## Additional characteristics of turbulence – forest/inland

- Atmospheric stability
- Phase profiles
- Spatial correlation
- Cross-couplings
- Wind veer

## Turbulent length scales in Hornamossen

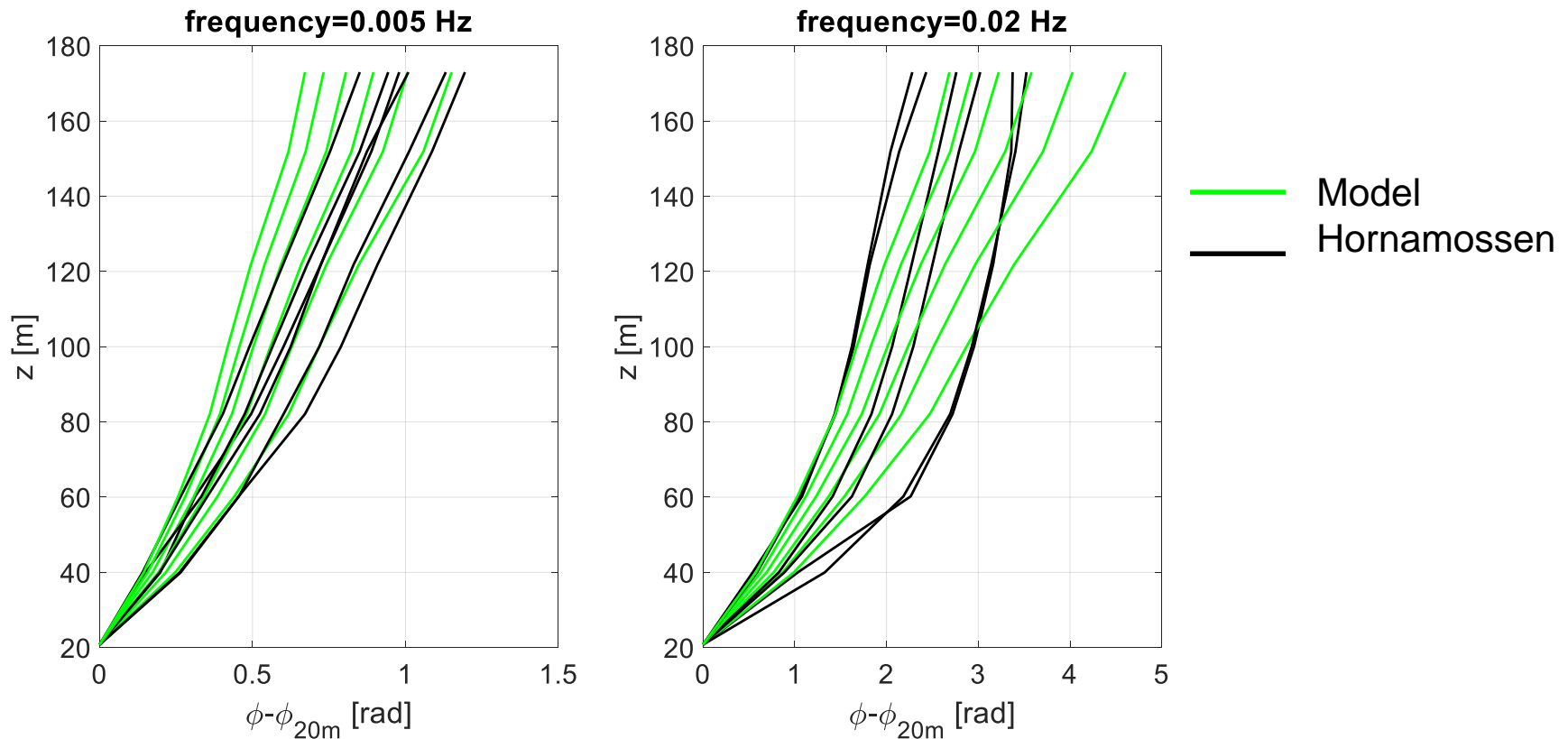


$$L_{night} \sim 0.55 * L_{day}$$

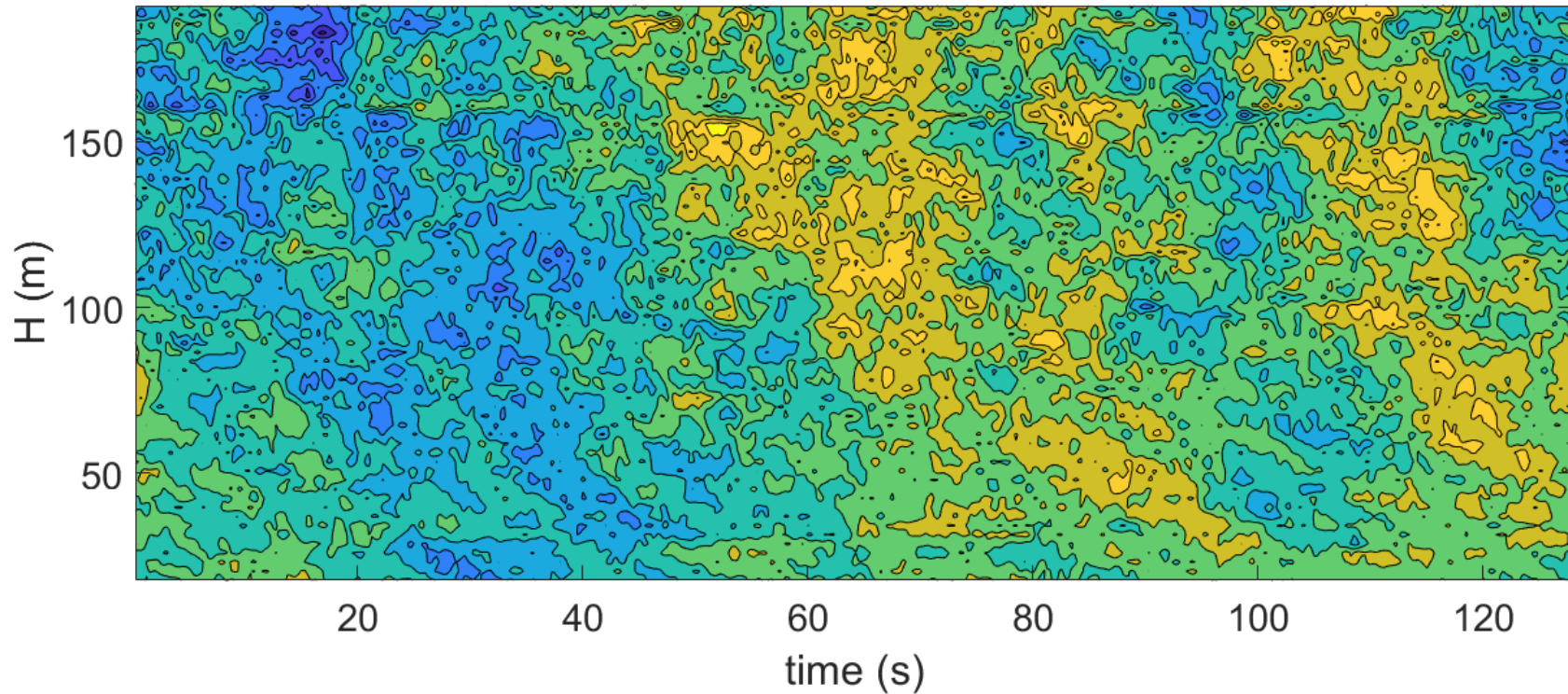
- Day
- Night
- Neutral
- All

## Phase profile - model

$$\Delta\theta(f, U_j, U_k, z_j, z_k) = K \frac{2\pi f(z_k - z_j)}{(U_k + U_j)(z_k + z_j)}, \quad K = 260$$



## Phase profile - implementation

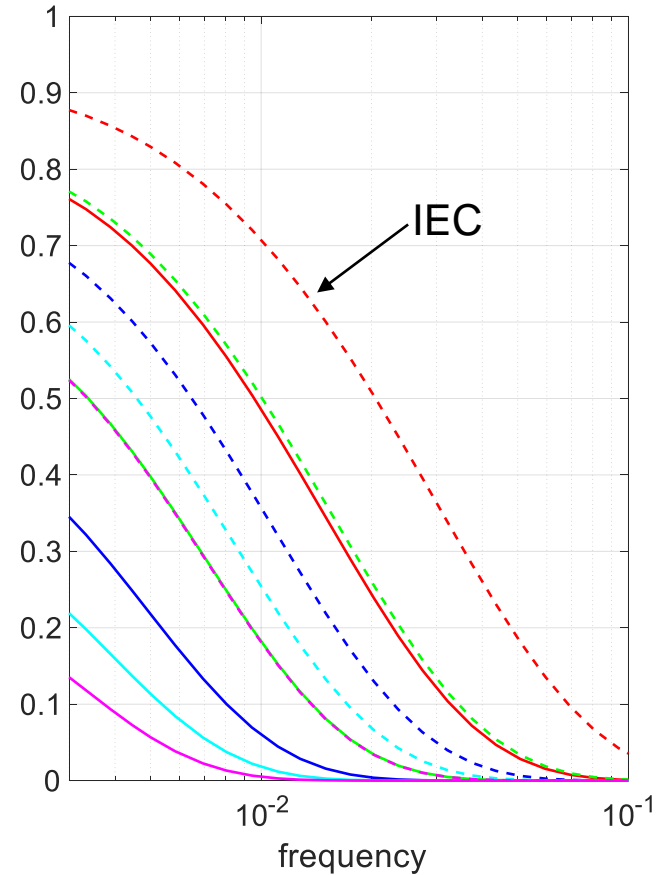
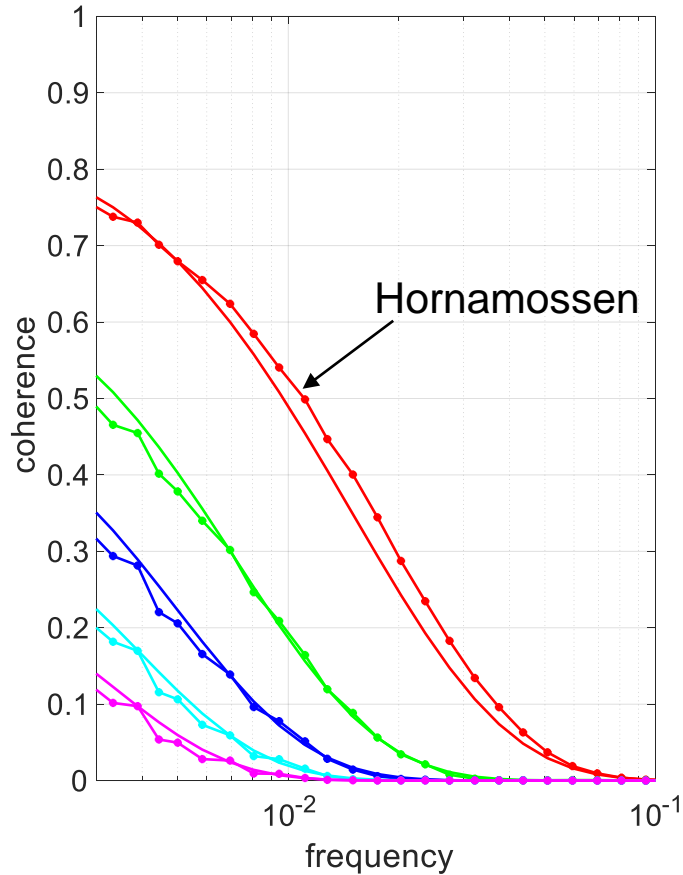


## Spatial correlation – coherence proposed model

$$Coh_{jk} = \exp \left[ -12 \left( \left( \frac{r_{jk}^\beta f}{U_m} \right)^2 + \left( \frac{0.12 r_{jk}^\beta}{L_c} \right)^2 \right)^{1/2} \right], \quad U_m = \frac{U_j + U_k}{2}$$

IEC:  $\beta=1.0$  , Hornamossen vertical:  $\beta=1.24$

## Spatial correlation - coherence



Hornamossen – several separations



## Loads assessment over forest - recommendations

- ❑ Investigate the impact of forest specific turbulence characteristics on loads/performance for new turbine types/sizes
- ❑ Implement new models in *advanced* procedures for wind farm loads assessment.
- ❑ Interact with IEC working groups to disseminate knowledge about wind conditions in the Scandinavian inland (use *complex terrain* and *operation with ice* as examples !?)