TUFO – Influence of humidity fluxes on turbulence and static stability of the marine atmospheric boundary layer

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TUFFO - Influence of humidity fluxes on turbulence and static stability of the marine atmospheric boundary layer

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Impact of the vertical turbulent humidity flux on the MABL

- Known from near surface measurements
- Destabilises the MABL
- How high does it reach?
- How strong is it?
- How does it change turbulence?
- Does it influence wind profiles?
- ...and wakes?
• At least one year measurement at both heights

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- corrosion
- lightning hit the sonic
- memory card

41.5 m

81.5 m
size of turbulent humidity fluxes

- turbulent humidity fluxes have equal sign and size at both heights
- nearly all fluxes upward

upward fluxes

downward fluxes
atmospheric stability

Measure of atmospheric stability:

\[
\frac{z}{L} = -\frac{g\kappa z}{u^3 \theta_v} \bar{w'T'} - 0.61 \frac{g\kappa z \theta}{u^3 \theta_v} \bar{w'q'} = \frac{z}{L_H} + \frac{z}{L_{LE}}
\]

- Turbulent humidity flux nearly always contributes to instability
- Shifts line of neutrality to the right
- Strongest contribution for unstable stratification (left)
The impact of the turbulent humidity flux is much stronger in summer than in winter.
atmospheric stability

comparison to fluxes from WRF model
Grenier–Bretherton–McCaa (GBM) boundary layer mixing scheme
the impact of the turbulent humidity flux on the level of turbulent kinetic energy is stronger for unstable stratification.
The impact of the turbulent humidity flux on the vertical wind profile is strongest for stable stratification (4% less wind speed at 100 m when extrapolating from 40 m).

i.e. vertical wind shear is slightly reduced.
The impact of the turbulent humidity flux on the length of a wake behind a very large wind farm is strongest for unstable stratification. Here the wake is about 10% shorter.

(Emeis 2012)
Turbulent Humidity Fluxes:
- at 81.5 m as strong as seen in earlier studies at much lower heights
- nearly always directed upwards, destabilise the marine boundary layer
- impact much larger in summer than in winter
- contributes to an increase of tke of up to 20% under unstable conditions
- modify vertical wind profiles up to 4% under stable conditions (less shear)
- contributes to a shortening of farm wakes by about 10% (reduced especially for unstable conditions)

fast-response humidity measurements are important for offshore wind energy
trade-off between higher turbulence and less shear and shorter wakes
especially important over warmer water (summer, lower latitudes)
Vielen Dank für Ihre Aufmerksamkeit