Wind Farms and Agriculture

Physical basis of the effect of wind farms on downstream atmospheric conditions

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1. Objectives

Increasing frost frequencies in Australia and New Zealand in the last decade are associated with a shift in large scale weather systems resulting in more anticyclones. Complex terrain (including new roughness elements like wind farms) at the local scale can spatially control and/or enhance minimum temperature variability.
The presence of a wind farm introduces surface roughness elements which impact near-surface air temperatures differently depending on the wind farm wake position and atmospheric stability.

Can wind farm wakes reduce surface temperature during frost events and lead to significant microclimate variability around agricultural areas in complex terrain?

2. Results

- Both onshore and offshore wind farms can affect the local meteorology up to 18 to 60 km downwind of the wind turbines
- In general the wake of a wind farm will increase the downwind turbulence in the atmosphere and result in +0.5°C warming
- There is also experimental evidence of near surface air cooling in areas downwind where the wind speed has dropped due to the energy extraction process of wind turbine. This can reduce air temperature by -0.3°C

3. Conclusion

The physics of atmosphere-surface interactions is well understood but the dynamics can be highly variable depending on topography and local meteorological settings. Due to obvious relevance to wind energy production, most scientific findings relate to the moderate and high energy producing wind speed regimes. Given the variable impact turbines can have on microclimates, particularly temperature, more field observations are needed to quantify the impact of wind farms on the local micrometeorology during weak wind conditions.

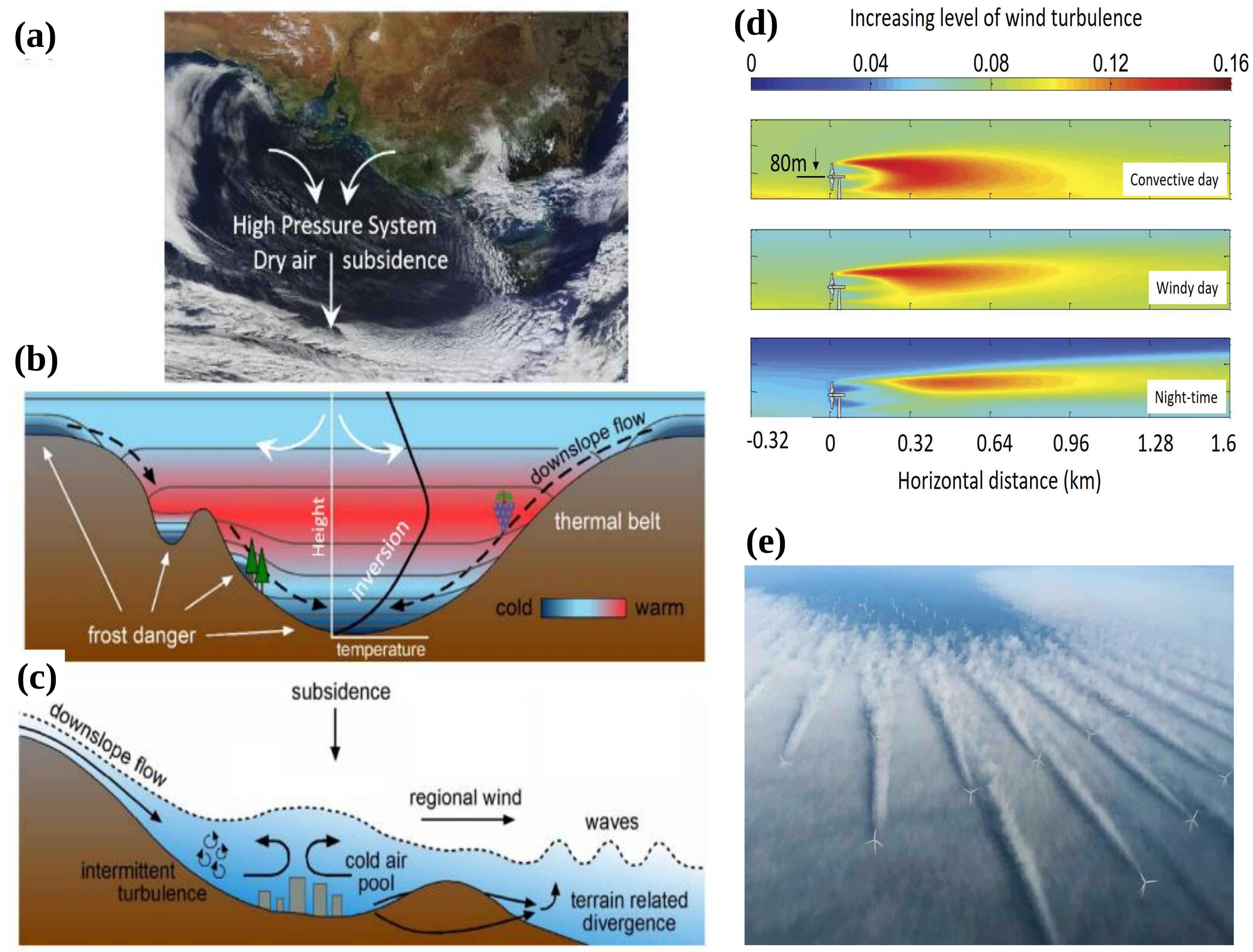

Figure 1. Cold-air pool development and variability in complex terrain. (a) Satellite image of a strong anticyclone south of Australia (Australian Bureau of Meteorology), (b) cross-sections of a valley during cold air drainage, and (c) effects of complex terrain on cold air pool development (adapted from De Wekker et al. 2018). (d) Wind turbine wake visualization from a numerical computer simulation as a function of atmospheric stability and wind conditions for flat terrain conditions (*adapted from Abkar and Porte-Agel 2015). (e)* Aerial photo of wind farm wake near costal Denmark (from Dong Energy/Bel Air Aviation Denmark - Helicopter Services 2017)

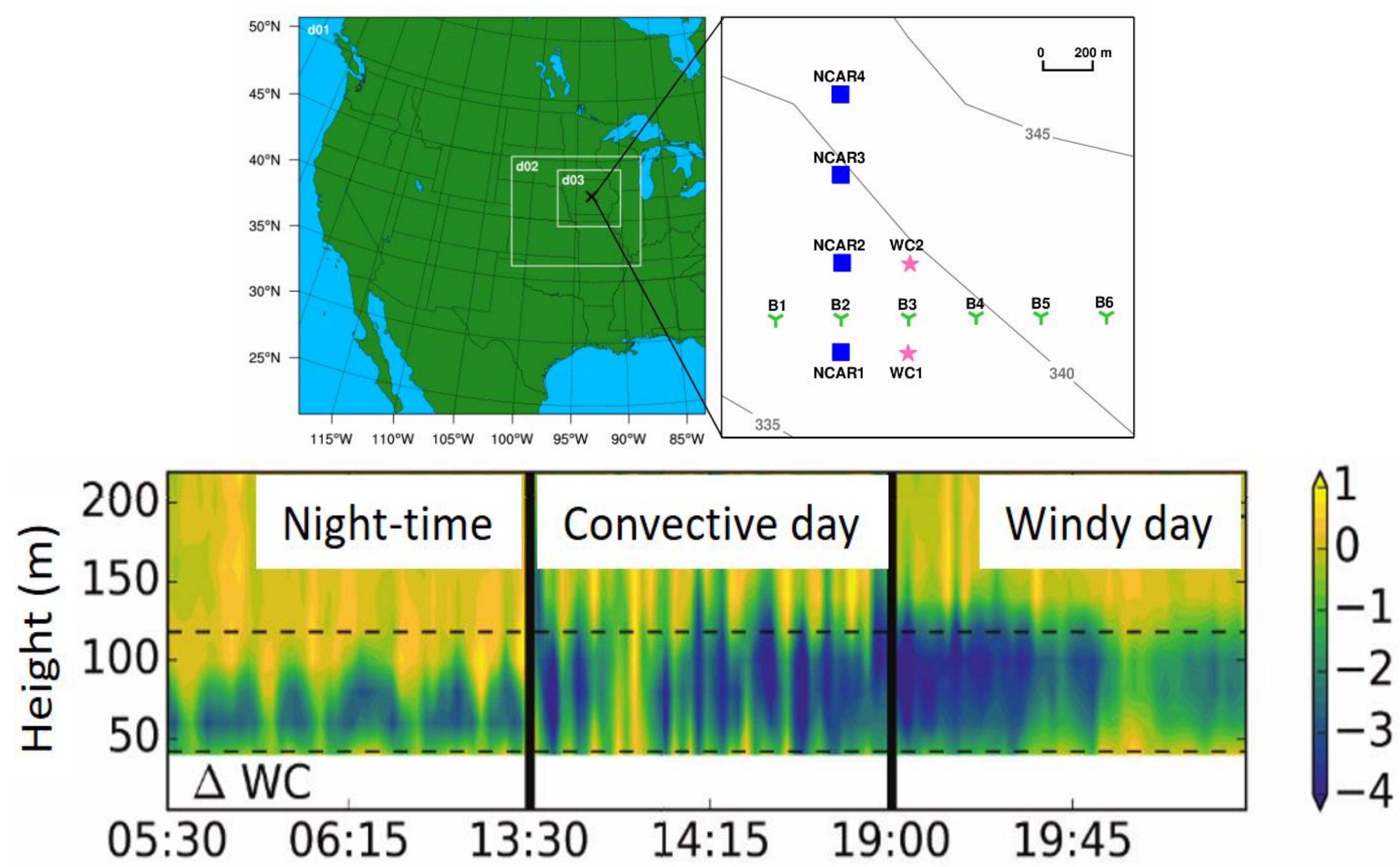

Figure 2. Difference in wind speed against time, height and atmospheric condition between an upwind (WC1) and downwind (WC2) region of a wind farms as measured by a Light Detection and Ranging wind profiler. Negative (blue colours) show periods of wind speed reductions due to the operation of the wind farm *(adapted from Vollmer et al. 2017)*

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