From Five Metres to One Kilometre: How Does The W-Layer Shape The Stratocumulus-Topped Boundary Layer?

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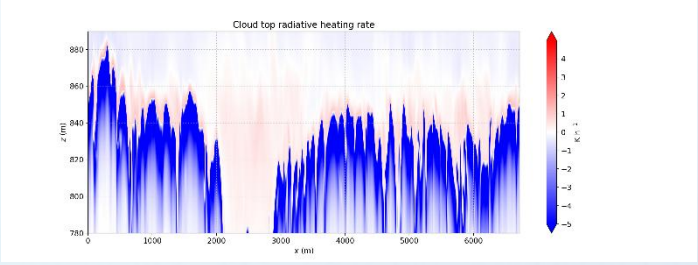
We discover a 5-metre thick, warming “W-Layer” in the capping inversion direct above the stratocumulus cloud top. The W-Layer establishes through clear-sky radiative effects. Water vapour and CO_2 absorb heat from higher altitudes but emit less because of the temperature inversion, resulting in a net warming in the W-Layer. The W-Layer was previously unresolved in numerical models and field measurements, either because of insufficient vertical resolution or the lack of an appropriate radiation model which represents the clear-sky effects.

To study the impact of the W-Layer on the stratocumulus-topped boundary layer, we introduce a “band” radiation model to direct numerical simulations (DNSs) which resolve metre-scale features. The band model partly retains the spectral dependence of the clear-sky absorption by partitioning the longwave spectrum into two water vapour absorption bands, one CO_2 absorption band and a window region. The band model is computationally efficient and can reproduce the warming characteristics in the W-Layer.

We run a set of DNSs at Reynolds number Re = 5000, which corresponds to a vertical resolution of 2.2 m at the cloud top. We find that the W-Layer suppresses entrainment by enhancing the buoyancy jump across the capping inversion. Correspondingly, the cloud top remains moister and the cloud top temperature variability reduces.



Warm colour indicates the W-Layer, which sits directly above the strongly cooling stratocumulus cloud top.

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Zoom Link (Mixed-mode)

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