Observed and Projected Ocean Wind Speed Trends and Marine Boundary Layer Clouds

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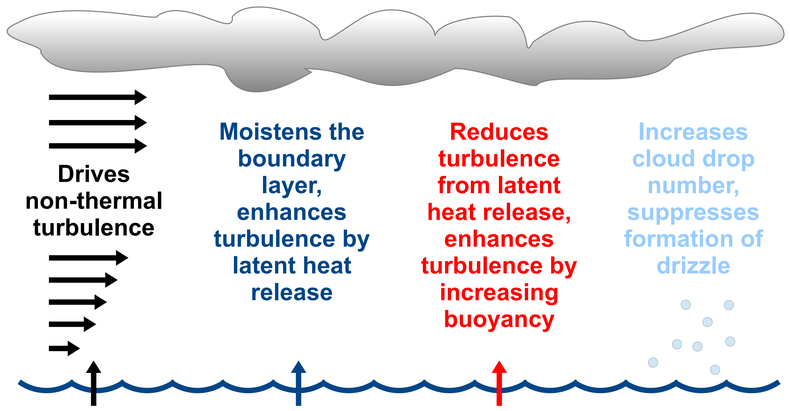
- Satellite observations show increasing ocean surface wind speeds 1991-2008
- Climate models predict ocean surface wind speed trends for the 21st century
- How do marine boundary layer clouds respond to changes in wind speed?
- What is the resulting change in radiative forcing?



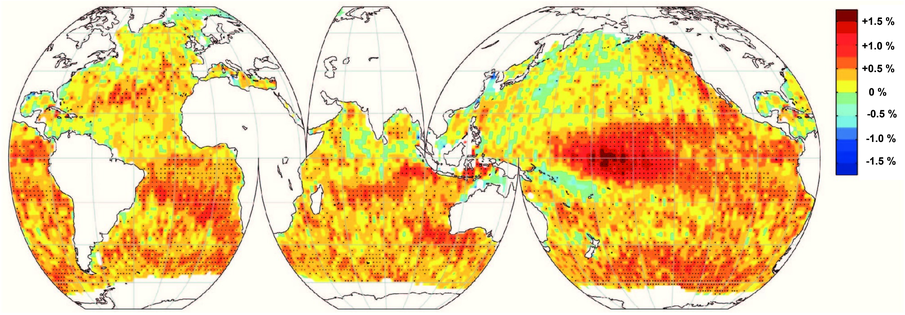
Higher wind speed drives surface fluxes:

- Horizontal momentum (shear)
- Latent heat (moisture)
- Sensible heat
- Sea spray aerosol

Here we attempt to isolate the effect of the surface horizontal momentum flux, which can lead to shear at the inversion, and potentially increase entrainment resulting in decoupling, from the effect of the surface sensible and latent heat fluxes.

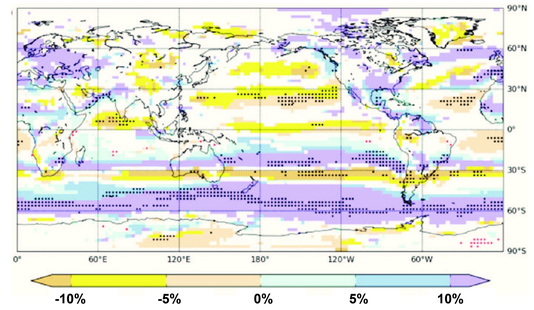
Time-averaged response of net down-welling radiation to geostrophic wind speed change	All surface fluxes respond to wind speed	Only horizontal momentum flux from the surface responds to wind speed
+ 25%	4.8 W m^{-2}	0.6 W m^{-2}
- 25%	-5.8 W m^{-2}	4.3 W m^{-2}

Annual mean 10 m wind speed trend 1991 - 2008



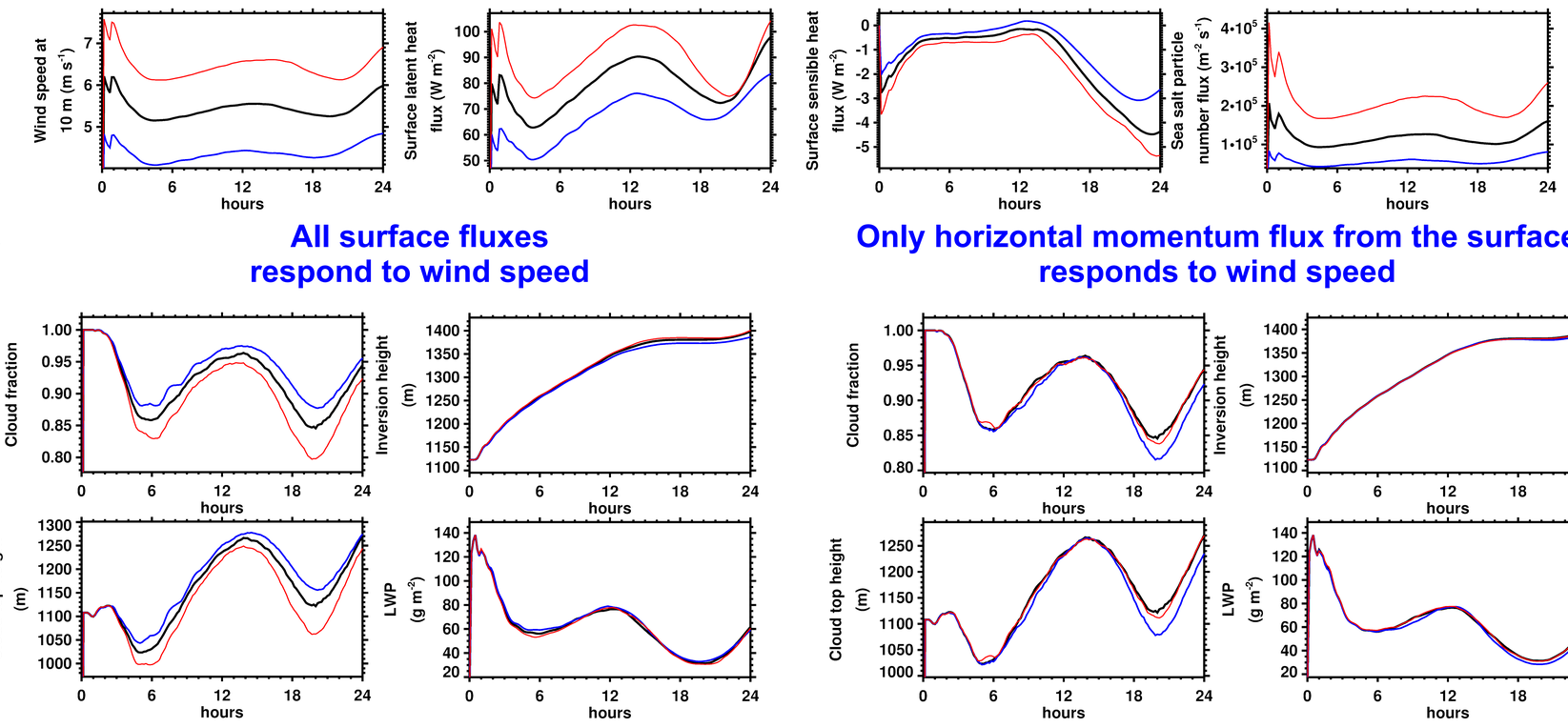
Satellite altimeter, Young et al. (Nature, 2011)

JJA 10 m wind speed 2081–2100 relative to 1981–2000



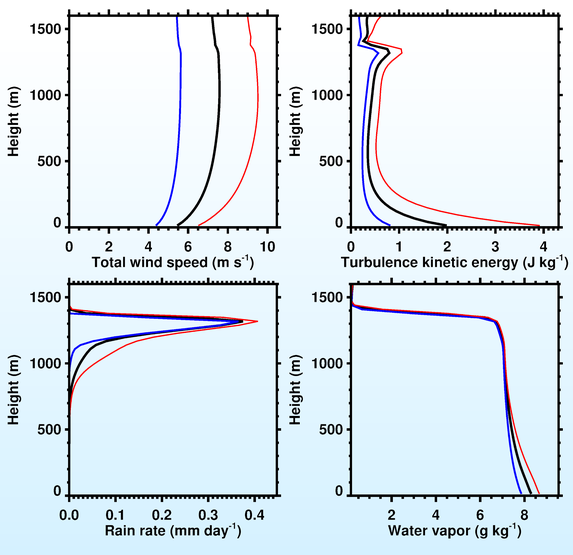
Mean of 19 climate models, McInnes et al. (Atm. Sci. Lett., 2011)

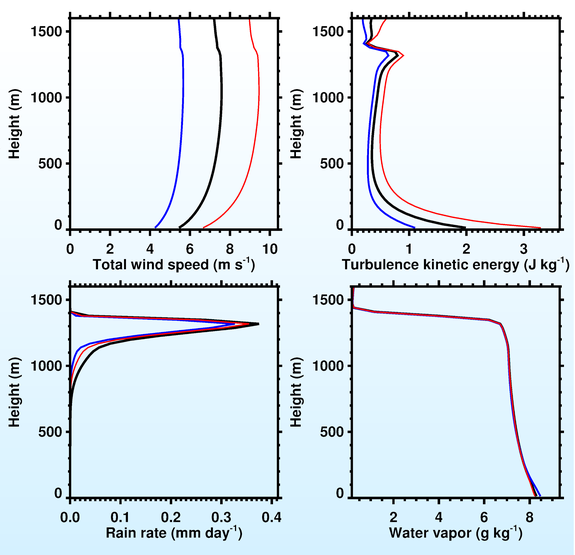
WRF (VOCALS Rex RF14) simulation with geostrophic wind speed ± 25 %



All surface fluxes respond to wind speed

Only horizontal momentum flux from the surface responds to wind speed





- ***Higher wind speed reduces cloud radiative forcing*** in the present simulations because of a reduction in cloud fraction
- Response of surface ***heat fluxes*** to ***higher wind speed*** leads to ***stronger decoupling*** → Hypothesis: Decoupling is caused by humidification of the sub-cloud layer (not shear-driven entrainment)
- Response of surface shear to wind speed ***opposes*** response of surface heat fluxes to wind speed
- Next steps:

→ Higher resolution simulations

→ Analysis of observations