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Offshore wind farms in complex terrain

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Offshore wind energy is poised for explosive growth in India following the mandate of the new National Offshore Wind Energy Policy. Two regions that have been identified with the most offshore wind power potential are both along coastlines with complex topography. The first region is in the Arabian Sea along the west coast of the Indian peninsula. The Western Ghat mountain range runs parallel to this coast separated from the sea by a very narrow (10-25 km wide) coastal plain. The second region is in the Palk Strait which is a 50-80 km wide channel between the southern tip of India and Sri Lanka. This study explores how the complex topography of the two regions affects wind resources and wind farm wakes using observed data and numerical simulations for a hypothetical wind farm conducted with the WRF model equipped with a sub-grid wind turbine parameterization scheme.
The flow for the Arabian Sea region is primarily south-westerly and driven by large-scale processes. Apart from occasional weak land-breezes topography does not seem to be a major contributor to wind resources there. The Palk Strait is different where the topography shapes the strong, consistent north-easterly or south-westerly flow that is further supplemented by land breezes from both sides. Energy extraction by wind farms causes a localized momentum deficit that triggers horizontal convergence which tends to partially offset the deficit. Numerical simulations show that this horizontal convergence is affected by the complex terrain. This phenomenon is particularly strong for the Arabian Sea wind farms due to the blocking effect of the Western Ghats on the wake vortices.
This study advances our understanding of wind farm wakes in complex terrain in general and can play a meaningful role in wind farm siting in these two regions.