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Key Points:
- Overall atmospheric winds significantly damp ocean eddies
- The large-scale wind stress curl systematically strengthens or weakens ocean eddies
- There is a linear relationship between the wind stress curl and wind work on eddies

Supporting Information:
- Supporting Information S1

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Work done by atmospheric winds on mesoscale ocean eddies

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Abstract Mesoscale eddies are ubiquitous in the ocean and dominate the ocean's kinetic energy. However, physical processes influencing ocean eddy energy remain poorly understood. Mesoscale ocean eddy-wind interaction potentially provides an energy flux into or out of the eddy field, but its effect on ocean eddies has not yet been determined. Here we examine work done by atmospheric winds on more than 1,200,000 mesoscale eddies identified from satellite altimetry data and show that atmospheric winds significantly damp mesoscale ocean eddies, particularly in the energetic western boundary current regions and the Southern Ocean. Furthermore, the large-scale wind stress curl is found to on average systematically inject kinetic energy into anticyclonic (cyclonic) eddies in the subtropical (subpolar) gyres while mechanically damps anticyclonic (cyclonic) eddies in the subpolar (subtropical) gyres.

1. Introduction

Eddies play a vital role in shaping the large-scale ocean circulation and in transporting mass, heat, and other climatically important tracers in the ocean [e.g., *Gill et al.*, 1974; *Hecht and Smith*, 2008]. Although progress has been made in recent years [e.g., *Wunsch*, 1998; *Zhai et al.*, 2010; *Nikurashin et al.*, 2012], our understanding of physical processes governing eddy energy in the ocean remains rather limited. One of the physical processes that may have a significant impact on ocean eddies and the energy they carry, but yet to be quantified, is mesoscale eddy-wind interaction, i.e., direct work done by the wind on ocean eddies.

It has been recognized [e.g., *Dewar and Flierl*, 1987; *Duhaut and Straub*, 2006; *Dawe and Thompson*, 2006; *Zhai and Greatbatch*, 2007; *Hughes and Wilson*, 2008; *Scott and Xu*, 2009; *Zhai et al.*, 2012] that atmospheric winds can systematically damp the ocean currents if the relative motion between the atmosphere and underlying surface ocean is taken into account in the surface stress calculation (so-called "relative wind stress effect"). Because the eddies dominate kinetic energy at the ocean surface, simple scaling analysis suggests that damping by the relative wind stress should primarily operate on mesoscale eddies [*Duhaut and Straub*, 2006; *Hughes and Wilson*, 2008]. Reduction in wind power input to the ocean when the relative wind stress is used in the power calculation is therefore generally attributed to the negative wind work on ocean eddies [*Hughes and Wilson*, 2008; *Zhai et al.*, 2012]. However, to our knowledge, there have been no direct observational studies yet that clearly demonstrate and quantify the damping effect of ocean eddies by the relative wind stress, particularly on a global scale.

Since atmospheric winds tend to vary on much greater spatial scales than mesoscale ocean eddies, interpretation of eddy-wind interaction often assumes that the background wind field is spatially uniform over the lateral extent of the eddies and therefore generally emphasizes the vortex structure of ocean eddies and its role in generating the anomalous relative wind stress curl on the scale of the eddies [*Duhaut and Straub*, 2006; *Zhai and Greatbatch*, 2007; *Zhai et al.*, 2012]. On the other hand, it is well known that the surface wind stress exhibits large spatial variations characterized by anticyclonic wind stress curl in the subtropical ocean and cyclonic wind stress curl in the subpolar ocean (see Text S1 in the supporting information). Little is known about the impact of the large-scale wind stress curl on power input to mesoscale ocean eddies. Here we use satellite observations to quantify for the first time the work done by atmospheric winds on mesoscale eddies in the global ocean.