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An analysis of the formation, propagation and fate of North Brazil Current rings

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Near the western boundary of the tropical North Atlantic, where the North Brazil Current (NBC) retroflects into the North Equatorial Countercurrent, large anticyclonic rings are shed. After separating from the retroflection region, the so-called NBC rings travel northwestward along the Brazilian coast, until they reach the island chain of the Lesser Antilles and disintegrate. These rings contribute substantially to the upper limb return flow of the Atlantic Meridional Overturning Circulation (AMOC) by carrying South Atlantic Water into the northern subtropical gyre. Their relevance for the northward transport of South Atlantic Water depends on the frequency of their generation as well as on their horizontal and vertical structure. Different types of rings are produced: they can be either confined to the surface layers or deep reaching, as well as only subsurface intensified with no surface signature. The ring shedding and propagation and the complex interaction of the rings with the Lesser Antilles are investigated in the 1/12° FLAME model. The ring properties simulated in FLAME reach the upper limit of the observed rings in diameter and agree with recent observations on seasonal variability, which indicates a maximum shedding during the first half of the year. When the rings reach the shallow topography of the Lesser Antilles, they are trapped by the island triangle of St. Lucia, Barbados and Tobago and interact with the island chain. The model provides a resolution which is capable of resolving the complex topographic conditions at the islands and illuminates various possible fates for the water contained in the rings. It also reproduces laboratory experiments, which indicate that both cyclones and anticyclones are formed after a ring passes through a topographic gap. Trajectories of artificial floats, which were inserted into the modeled velocity field, are used to investigate the pathways of the ring cores and their fate after they encounter the Lesser Antilles. The majority of the floats entered the Caribbean, while the northward, Atlantic pathway was found to be of minor importance. No prominent pathway was found east of Barbados, where a ring could avoid the interaction with the islands and migrate towards the northern Lesser Antilles undisturbed.
We present our results obtained with FLAME, provide a comparison with results from Garaffo et al. (2003), who used the isopycnic MICOM model and discuss the differences to available observations. While the high resolution models reproduce many aspects of the complex ring life, some important propagation pathways indicated in observations remain unresolved.