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Scales and properties of cold filaments in the southern Benguela upwelling system

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The Benguela upwelling system is one of the four most active upwelling systems in the world. Meso-scale and submeso-scale structures like eddies and filaments are build up, due to instabilities at the front between the cold upwelled water and the warm surface water offshore. The heat exchange across the front is carried out mainly by such structures, especially filaments due to their offshore extent. Therefore cold upwelling filaments play an important role in the heat budget of the south-east Atlantic. This study is focussed on the southern part of the Benguela upwelling system, especially on the upwelling cell off Lüderitz.

We combine satellite data and ship-borne measurements to investigate the appearance of such filaments and their properties (vertical and horizontal extent, mean temperature anomaly, mean velocity etc.). We use infra-red measurements of the MODIS satellite from 2011 to 2014. Two cruises in the region of interest were carried out in August 2013 and February 2014 and provide highly resolved surface data of temperature and salinity as well as vertical information on temperature, salinity and velocity.

The spatial and temporal distribution of the filaments including the meridional and longitudinal extent is determined using a frequency analysis (wavelet analysis) of our data sets. Most filaments occurred between 25°S and 27°S, corresponding to the position of the Lüderitz cell. The observed filaments have a meridional extent between 5km and 44km and propagate more than 20km offshore. The lifetime of a filament is between 2 and 12 days. The time series of satellite data provides information on the seasonal and year-to-year variability in the appearance of filaments. Additionally the variability of the forcing winds is analysed and results are connected to the appearance of filaments. The filament activity is highest in southern summer, corresponding to the main upwelling season. The ship-borne measurements allow a highly resolved analysis of the horizontal and vertical structures of the filaments. The vertical extent of the filaments is between 80m and 140m. Further we obtain from this analysis characteristic features in the distinct parts of a filament, e.g. centre and boundary region. The centre of a filament is characterised by a westward current, while the flow is eastward in the boundary region.
In contrast to most previous studies, which are often case studies of one or two filaments, we are able to look at more than 150 filaments per year due to the combination of ship-borne and satellite measurements.