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Variability of the Mistral and Seasonal Atmospheric Forcing on Deep Convection in the Gulf of Lion

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The vertical stability of the ocean in the Gulf of Lion responds to the atmospheric forcing on both the seasonal and anomaly timescale, with the latter predominantly driven by the Mistral winds. The inter-annual variability of the atmospheric forcing on both timescales determines the occurrence of deep convection in the gulf. Deep convection is the major process in the Western Mediterranean Basin leading to dense water formation, which assists with the general circulation of the Mediterranean Sea, and also leads to years of phytoplankton blooming, due to increasing the oxygen and nutrient content along the water column.

Yearly NEMO ocean simulations were run over the span of 20 years, from 1993 to 2013, through the RegIPSL regional climate model and forced by atmospheric outputs from a coupled WRF/ORCHIDEE simulation, also produced through the RegIPSL model. Two ocean simulations per year were run, a control and a seasonal run, with the latter forced by a filtered atmospheric forcing, to separate the ocean's response at the seasonal and anomaly timescales.

These simulations revealed the importance of the magnitude and variability of the seasonal atmospheric forcing regarding the vertical stability, or stratification, of the Gulf of Lion. On average, roughly 50% of the relative destratification over the course of the preconditioning period (the period leading up to a potential deep convection event) came from the seasonal change in stratification. Years with deep convection not only had a less than average yearly maximum stratification, but also had a greater than average (greater than 50%) seasonal contribution to the preconditioning destratification. The anomaly timescale contribution typically only provided, on average, about 27% of the destratification required for deep convection to occur, with its contribution during deep convection years hovering slightly above, at around 30%. The necessary additional 70% required came from the above average seasonal contribution mentioned beforehand, demonstrating the importance of the seasonal contribution and its variability.

The increased seasonal contribution was explained by the use of a simple model that relates the seasonal atmospheric heat flux components to the stratification index, a diagnostic for the vertical stability. The seasonal forcing varied greatly over the 20-year span, and years with larger upward latent and sensible heat fluxes and lower downward shortwave radiation fluxes were more likely to be deep convection years. The anomaly forcing also showed variability, and years with more

frequent and stronger Mistral events were also more likely to be deep convection years.

If future years shift towards having larger downward shortwave radiation fluxes, such as years with less cloud cover, and/or weaker upward latent/sensible heat fluxes, such as years with warmer advected air masses, then deep convection may occur less often. This could then lead to a shift in the Mediterranean Sea circulation and alter biological processes in the region.