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Daily to Decadal Sea Surface Temperature Variability Driven by State-Dependent Stochastic Heat Fluxes

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The classic Frankignoul-Hasselmann hypothesis for sea surface temperature (SST) variability of an oceanic mixed layer assumes that the surface heat flux can be simply parameterized as noise induced by atmospheric variability plus a linear temperature relaxation rate. It is suggested here, however, that rapid fluctuations in this rate, as might be expected for example due to gustiness of the sea surface winds, are large enough that they cannot be ignored. Such fluctuations cannot be fully modeled by noise that is independent of the state of the SST anomaly itself. Rather, they require the inclusion of a state-dependent (that is, multiplicative) noise term, which can be expected to impact both persistence and the relative occurrence of high amplitude anomalies.

As a test of this hypothesis, daily observations at several Ocean Weather Stations (OWS) are examined. Significant skewness and kurtosis of the distributions of SST anomalies is found, which is shown to be consistent with a multiplicative noise model. The observed wintertime SST distribution at OWS P is reproduced using a single column variable depth mixed layer model; the resulting non-Gaussianity is found to be largely due to the state-dependence of rapidly-varying (effectively stochastic) sensible and latent heat flux anomalies.

Our model for the non-Gaussianity of anomalous SST variability (counterintuitively) implies that the multiplicative noise increases the persistence, predictability, and variance of midlatitude SST anomalies. The effect is strongest on annual and longer timescales and may, therefore, be important to understand and model interannual and interdecadal SST and related climate variability.