DYNAMIC TIPPING NEAR RESONANCE IN THE STOMMEL MODEL OF THE MAOC

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We study the behaviour of (resonant) dynamic B-tipping in a forced two-dimensional non-autonomous system close to a non-smooth saddle-focus (NSF) bifurcation. The NSF arises when a saddle-point and a focus meet at a border collision bifurcation. The emphasis is on the Stommel 2-box model, which is a piecewise-smooth continuous dynamical system, modelling thermohaline circulation. This model exhibits a NSF as parameters vary. By using techniques from the theory of non-smooth dynamical systems we are able to provide precise estimates for the general tipping behaviour close to the NSF as parameters vary. In particular we consider the combination of both slow drift and also periodic changes in the parameters, corresponding, for example, to the effects of climate change and seasonal variations. The results are significantly different from the usual B-tipping point estimates close to a saddle-node bifurcation. In particular we see a more rapid rate of tipping in the slow drift case, and an advancing of the tipping point under periodic changes. The latter is made much more pronounced when the periodic variation resonates with the natural frequency of the focus, leading both to much more complicated behaviour close to tipping, and also significantly advanced tipping in this case.