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# Empirical singular vectors of baroclinic flows deduced from experimental data

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Instability is related to exponentially growing eigenmodes. Interestingly, when finite time intervals are considered, growth rates of certain initial perturbations can exceed the growth rates of the most unstable modes. Moreover, even when all modes are damped, such particular initial perturbations can grow dramatically during finite time intervals. The perturbations with the largest growth rates are called singular vectors or optimal perturbations. They not only play an important role in atmospheric ensemble predictions, but also for the theory of instability and turbulence. Starting point for the singular vector analysis is a linear dynamical system with a known system matrix. In atmospheric ensemble prediction, linearization is generally done around a nonlinear solution and then the system matrix is time-dependent. In contrast, in turbulence research linearization is done around a mean state. In that case the system matrix is time-independent. We consider the mathematically simpler latter case here. We decompose surface temperature data of a differentially heated rotating annulus experiment into principal oscillation patterns, that are the empirically estimated linear eigenmodes of the system. Using these modes we can estimate the modes of maximal growth, which are thus the empirically estimated singular vectors. In contrast to the traditional approach we deduce these modes from the data alone without using a linear model operator and thus without actually knowing the system matrix (Penland and Sardeshmukh, 1995).

In our study we will address the following questions: What is the appropriate filter technique to remove noise from the data prior to the empirical singular vector analysis? Is there an objective mean to distinguish between noise and signal? How accurate are the empirical singular vectors? To answer the last question we compare the data based results with findings from a numerical model for which the system matrix is known. We want to test the idea that mean flows corresponding with irregular flows have in general larger singular vector growth rates. In contrast to a previous work (Seelig et al., 2012) the present study relies on recent lab experimental data.

References

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