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The use of potential vorticity building blocks to understand rapid development from complex initial conditions

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The short-time rapid development, often occurring in initial-value experiments simulating the atmosphere at mid-latitudes, is with a few exceptions highly different from the linear evolution of the growing normal mode (GNM). A particularly delicate topic is the fact that while the GNM amplifies at the same exponential rate in all norms, the growth from more complex initial conditions (among which the optimal perturbations, disturbances which amplify maximally in a specific time-interval and according to a certain norm) is generally norm-dependent and structurally changes play an important role.

We present and discuss a new set of dynamical tools, which are based on the partitioning of the flow in so-called potential vorticity building blocks, which are vertically localized, zonally wavelike anomalies of potential vorticity. These tools allow for an unambiguous investigation of the mechanisms behind the growth and the propagation occurring in initial-value experiments of quasi-geostrophic models (and optimal perturbations in particular). As an example the techniques are used to study optimal perturbation evolution in the Charney model for baroclinic instability.