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Chaotic dynamics of large-scale double-diffusive convection in a porous medium

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Abstract

We have studied the chaotic dynamics of the large-scale double-diffusive convection of a viscoelastic fluid in a porous medium from the viewpoint of dynamical systems theory. A fifth-order nonlinear dynamical system modeling the double-diffusive convection is theoretically obtained by incorporating the Darcy-Brinkman equation into transport equations through a physical dimensionless parameter representing porosity. We clearly show that the chaotic convective motion becomes much more complicated with increasing porosity. The degree of dynamic instability during chaotic convective motion is quantified by two important measures: the network entropy of the degree distribution in the horizontal visibility graph and the Kaplan-Yorke dimension in terms of Lyapunov exponents. We also present an interesting on-off intermittent phenomenon in the probability distribution of time intervals exhibiting nearly complete synchronization.

Keywords: chaos, dynamical system, double-diffusive convection

1. Introduction

Simultaneous changes in the vertical temperature and concentration gradients in a horizontal fluid layer induce complex fluid motion known as double-diffusive convection [1–3]. Double-diffusive convection in a porous medium ap-

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