Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

Skin friction field and thermal plume formation in turbulent convection[1] JOERG SCHUMACHER, VINODH BANDARU, ANASTASIYA KOLCHINSKAYA, TU Ilmenau, JANET SCHEEL, Occidental College Los Angeles, KATHRIN PADBERG-GEHLE, TU Dresden — The dynamics in the thin boundary layers of temperature and velocity is the key to a deeper understanding of turbulent transport of heat and momentum in thermal convection. The velocity gradient right at the heated plate of a Rayleigh-Bénard convection cell forms the two-dimensional skin friction field and is related to the formation of thermal plumes in the boundary layer right above the plate. Our analysis is based on a direct numerical simulation of Rayleigh-Bénard convection in a closed cylindrical cell of aspect ratio $\Gamma = 1$ and focused on the critical points of the skin friction field. We identify triplets of critical points, which are composed of two unstable nodes and a saddle between them, as the characteristic building block of the skin friction field. Isolated triplets as well as networks of triplets are detected. The majority of the ridges of line-like thermal plumes coincide with the unstable manifolds of the saddles. From a dynamical Lagrangian perspective, thermal plumes are formed together with an attractive hyperbolic Lagrangian Coherent Structure of the skin friction field. We discuss the differences from the skin friction field in turbulent channel flows from the perspective of the Poincaré-Hopf index theorem for two-dimensional vector field.

[1]This work is supported by the Deutsche Forschungsgemeinschaft.

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Date submitted: 17 Jul 2015 Electronic form version 1.4