Geophysical Research Abstracts
Vol. 14, EGU2012-5368, 2012
EGU General Assembly 2012

Reconstruction of the 3D flow field in a differentially heated rotating annulus laboratory experiment

U. Harlander (1), G. B. Wright (2), and C. Egbers (1)

(1) Dept. of Aerodynamics and Fluid Mechanics, BTU Cottbus, Germany (haruwe@tu-cottbus.de), (2) Dept. of Mathematics, Boise State University, Boise, USA

In the earth's atmosphere baroclinic instability is responsible for the heat and momentum transport from low to high latitudes. In the fifties, Raymond Hide used a rather simple laboratory experiment to study such vortices in the lab. The experiment is comprised by a cooled inner and heated outer cylinder mounted on a rotating platform, which mimics the heated tropical and cooled polar regions of the earth's atmosphere. The experiment shows rich dynamics that have been studied by varying the radial temperature difference and the rate of annulus revolution. At the Brandenburg University of Technology (BTU) Cottbus the differentially heated rotating annulus is a reference experiment of the DFG priority program 'MetStröm'.

The 3D structure of the annulus flow field has been numerically simulated but, to our knowledge, has not been measured in the laboratory. In the present paper we use novel interpolation techniques to reconstruct the 3D annulus flow field from synchronous Particle Image Velocimetry (PIV) and Infrared Thermography (IRT) measurements.

The PIV system is used to measure the horizontal velocity components at 40, 60, 80, 100, and 120 mm above the bottom. The uppermost level is thus 15 mm below the fluid's surface. The surface temperature is simultaneously measured by an infrared (IR) camera. The PIV and infrared cameras have been mounted above the annulus and they co-rotate with the annulus. From the PIV observations alone a coherent 3D picture of the flow cannot be constructed since the PIV measurements have been taken at different instants of time. Therefore a corresponding IR image has been recorded for each PIV measurement. These IR images can be used to reconstruct the correct phase of the measured velocity fields. Each IR and PIV image for which $t>0$ is rotated back to the position at $t=0$. Then all surface waves have the same phase. In contrast, the PIV velocity fields generally have different phases since they have been taken at different vertical levels. From these rotated fields, a 3D flow field can be reconstructed that is an approximation to the true 3D flow.

The PIV measurements of the horizontal velocity fields do not line up on a nice grid. We therefore use a mesh-free reconstruction method based on radial basis functions (RBFs). Additionally, we employ a filtering strategy for dealing with the noise in the measured velocity fields.