Geophysical Research Abstracts
Vol. 12, EGU2010-12236, 2010
EGU General Assembly 2010

Comparison of velocity and temperature time series data analysis in experiments on the thermally driven rotating annulus

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The model of the differentially heated, rotating cylindrical gap filled with a fluid is since more than four decades extensively used for laboratory experiments of baroclinic wave interactions, and a number of data acquisition techniques are applied e.g. to unhide regular waves of different zonal wave number, to better understand the transition to the quasi-chaotic regime, and to reveal the underlying dynamical processes of complex wave flows.

In our experiments presented here, we make use of non-intrusive measurement techniques of a quite different nature. While the high accurate Laser-Doppler-Velocimetry (LDV) is used for measurements of the radial velocity component at equidistant azimuthal positions, a high sensitive thermographic camera, which resolution allows for resolving fine scale structures, measures the surface temperature field.

Both sets of time series data are analyzed by using multivariate statistical techniques. While the LDV data sets are studied by applying the Multi-Channel Singular Spectrum Analysis ($M-SSA$), the temperature data sets are analyzed by applying the Empirical Orthogonal Functions (EOF).

In addition, the temperature data are processed in a way to become comparable to the LDV data, i.e. reducing the size of the data set in such a manner that the temperature measurements would imaginary be performed at equidistant azimuthal positions only. This approach initially results in a great loss of information. But applying the $M-SSA$ to the reduced temperature data sets enable us not only to compare the data analysis methods but also to reclassify the results yielded with the LDV data analysis.

The measurements are performed at particular parameter points, where our former studies show that kinds of complex wave patterns occur [1, 2]. For example, we found a dominant and a weak mode in the 3-4 wave transition region. This finding confirms earlier ideas on wave dispersion in transition regions between regular waves. Increasing the annulus' rotation leads to a growth of the weak mode until this mode becomes the dominant one.

[1] Th. von Larcher and C. Egbers, *Experiments on transitions of baroclinic waves in a differentially heated rotating annulus*, Nonlinear Processes in Geophysics, 2005, 12, 1033-1041, NPG Print: ISSN 1023-5809, NPG Online: ISSN 1607-7946

[2] U. Harlander, Th. von Larcher, Y. Wang and C. Egbers, *PIV- and LDV-measurements of baroclinic wave interactions in a thermally driven rotating annulus*, Experiments in Fluids, 2009, DOI: 10.1007/s00348-009-0792-5