Compressible Kelvin-Helmholtz instability at the terrestrial magnetopause
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The compressible magnetohydrodynamic Kelvin-Helmholtz instability occurs in two varieties, one that can be called incompressible as it exists in the limit of vanishing compressibility (primary instability), while the other exists only when compressibility is included in the model (secondary instability). In previous work we developed techniques to investigate the stability of a surface of discontinuity between two different uniform flows. Our treatment includes arbitrary jumps of the velocity and magnetic fields as well as of density and temperature, with no restriction on the wave vector of the modes. Then it allows stability analyses of complex configurations not previously studied in detail. Here we apply our methods to investigate the stability of various typical situations occurring at different regions of the front side, and the near flanks of the magnetopause. The physical conditions of the vector and scalar fields that characterize the equilibrium interface at the positions considered are obtained both from experimental data and from results of simulation codes of the magnetosheath available in the literature. We give particular attention to the compressible modes in configurations in which the incompressible modes are stabilized by the magnetic shear. For configurations of the front of the magnetopause, which have small relative velocities, we find that the incompressible MHD model gives reliable estimates of their stability, and compressibility effects do not introduce significant changes. However, at the flanks of the magnetopause the occurrence of the secondary instability and the shift of the boundary of the primary instability play an important role. Consequently, configurations that are stable if compressibility is neglected turn out to be unstable when it is considered and the stability properties are quite sensitive on the values of the parameters. Then compressibility should be taken into account when assessing the stability properties of these configurations, since the estimates based on incompressible MHD may be misleading. A careful analysis is required in each case, since no simple rule of thumb can be given.