Using time-dependent reference profiles for an instability analysis of an evaporating binary liquid layer

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INTRODUCTION
This work concerns a study about the evaporation of a horizontal binary-liquid layer of an aqueous solution of ethanol in contact with air. The evaporation causes concentration changes of ethanol at the liquid-gas interface accompanied with a cooling. These two phenomena can trigger both solutal and thermal Rayleigh and Marangoni instabilities in the liquid, which are to be studied in this work. For this purpose, the evaporation-induced instability is analysed taking into account horizontally uniform reference profiles. In previous work [1], the instability process, using quasi-stationary reference profiles (no time dependence of the reference profiles), has been studied thoroughly. Making comparisons between the thermal, solutal and Soret Rayleigh and Marangoni effects, it appeared that the solutal Marangoni effect is by far the most important instability mechanism. Extremely small critical liquid layer thicknesses were observed (the liquid layer thickness was used as a control parameter). This means that a liquid layer with a realistic thickness (say, 1 mm) would become unstable almost immediately after its contact with air, much before the transient diffusional boundary layers that develop from the free surface reach the bottom of the liquid. This makes considering a time-dependent reference diffusive solution of much interest for an instability analysis.

RESULTS AND DISCUSSION
• For small H values, the fully transient model does not show any significant differences with respect to the partially transient model
• The difference becomes more pronounced as H increases
• A larger value for H (comparing H =11 and H=101, for instance) means that the gas transfer distance is larger for H=101. This means that the diffusion in the gas phase needs much more time to attain a quasi-stationary state
• The solutal effect being the predominant one, considering the thermal effect gains some importance (though still smaller than the solutal one), due to the larger diffusion time in the gas phase
• Considering a fully transient model (thus also a transient temperature profile next to a transient concentration profile) gives a more unstable system, caused by the thermal diffusion, of which the profile dependence on time was neglected in the partially transient model (quasi-stationary profile for the temperature profiles)

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