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Fluxes through steady-state chimneys in binary alloy solidification DAVID REES JONES, GRAE WORSTER, DAMTP, University of Cambridge — Solute fluxes from mushy layers in solidifying binary alloys occur predominantly by convection through nearly vertical, straight-sided chimneys. We develop a simple, theoretical study using a patchwork of simplifying approximations that capture the essential physics while rendering the problem analytically tractable. Away from the chimney, the temperature field is horizontally uniform and vertically linear. Near the chimney, a similarity solution with linear vertical structure is found. The lubrication approximation to Stokes flow applies within the chimney itself, and the chimney is proved to be straight-sided. The melt is treated through a boundary-layer parameterization of the heat flux. A linear flux-Rayleigh number relationship is proved analytically in planar geometry, based on a criterion on chimney spacing that optimises the buoyancy flux. In three dimensions, the crucial importance of drainage area is demonstrated, and an approximately linear flux-Rayleigh number relationship is found. This constitutes a simple, physically motivated representation of solute flux, that might be used cheaply in global sea-ice models.

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