Bright and broadband coherent mid-IR radiation is important for exciting and probing molecular vibrations. Using cascaded nonlinearities in conventional quadratic nonlinear crystals like lithium niobate, self-defocusing near-IR solitons have been demonstrated that led to very broadband supercontinuum generation in the visible, near-IR, and short-wavelength mid-IR. Here we conduct an experiment where a mid-IR crystal is pumped in the mid-IR. The crystal is cut for noncritical interaction, so the three-wave mixing of a single mid-IR femtosecond pump source leads to highly phase-mismatched second-harmonic generation. This self-acting cascaded process leads to the formation of a self-defocusing soliton at the mid-IR pump wavelength and after the self-compression point multiple octave-spanning supercontinua are observed. The results were recorded in a commercially available crystal LiInS2 pumped in the 3-4 µm range with 85 fs 50 µJ pulse energy, with the broadest supercontinuum covering 1.6-7.0 µm. We measured up 30 µJ energy in the supercontinuum, and the energy promises to scale favorably with an increased pump energy. Other mid-IR crystals can readily be used as well to cover other pump wavelengths and target other supercontinuum wavelength ranges.