This talk will review recent progress in the numerical modelling of magnetic flux emerging from the solar convection zone into the overlying atmosphere. The first part of the talk will focus on how radiative magnetohydrodynamics simulations of emerging flux are enabling us to explore how active regions form. Emphasis will be placed on the physical mechanisms responsible for much of the observed photospheric properties of active regions, including the appearance of anomalous granulation, mixed polarity field at the granulation scale, as well as the formation of pores, spots and light bridges.

The second part of the talk will focus on simulations that use magnetograms from SDO/HMI as bottom boundary data. Such data-driven simulations enable us to explore how photospheric changes drive evolution in the corona. Applications to specific active regions and comparisons with SDO/AIA observations of the corona will be presented.