The importance of solar polar magnetic fields for the dynamo and for solar cycle forecasting has become increasingly clear in recent years. Polar fields are observed to be built up from active region trailing polarities by meridional flow advection and turbulent diffusion. The surface flux transport (SFT) models describing this process involve a number of free parameters and optional choices such as turbulent diffusivity, meridional flow amplitude or choice of meridional flow profile. In the past these choices were usually optimized to best reproduce the overall time-latitude pattern (butterfly diagram) of the magnetic field distribution. In this approach, mid-latitude features (plumes) are given great weight, while the smaller polar areas, observed less well due to perspective problems, have little influence. As a result, models optimized in this way often show significant disagreements with observations of the polar field, esp. regarding the timing of polar field reversals and maxima or latitudinal extent of the polar field concentration. Here we take the alternative approach of constraining SFT model parameters and assumptions by reducing the allowed parameter space to the domain where the phase of polar field variations and the latitudinal extent of the polar magnetic cap agree with observational constraints. Results are presented for various assumed meridional flow profiles and for different measures of the polar field (e.g. WSO mean longitudinal field in the polar aperture or dipole moment). These optimizations can further be used in the study of polar field variations in SFT models involving data assimilation.