Numerical weather prediction (NWP) model output is typically used to drive atmospheric transport and dispersion (AT&D) models. To assess the meteorological uncertainty, ensembles of NWP models are often used; the spread in the ensemble predictions is correlated to forecast uncertainty. To obtain appropriate spread in concentration predictions from AT&D models, the NWP ensemble should represent “good” spread in low-level wind direction and atmospheric boundary layer (ABL) depth. To adequately sample the probability distribution function of the forecast atmospheric state, it is necessary to account for several sources of uncertainty, including the initial conditions, lateral boundary conditions, and model physics parameterizations. Limited computational resources typically constrain the size of ensembles, so choices must be made about which members to include when configuring an ensemble. This study examines an NWP ensemble that varies physics parameterizations for 18 randomly selected forecast periods in June-July-August 2009. Statistical guidance methods are employed to verify the ensemble forecasts and to down-select a small number of physics configurations to be used in a future ensemble that will also incorporate initial condition and lateral boundary condition variability. Verification is focused on meteorological parameters at the surface and in the ABL that are the most relevant to AT&D modeling.