The long-standing problem of understanding the evolution of the global magnetic fields that drive solar activity through different temporal scales is becoming more tractable because, in addition to 400 years of sunspot records, we now have almost 4 solar cycles of magnetic field observations. These observations allow us to discern physical connections between dynamo model variables and observations using data assimilation analysis. In particular, the Ensemble Kalman Filter approach takes into account uncertainties in both observations and modeling and allows us to make reliable forecasts of solar cycle activity by using a relatively simple non-linear dynamical model of the solar dynamo. To expand this approach for more complex 2D and 3D dynamo modeling, it is necessary to decompose the observed synoptic magnetograms into poloidal and toroidal field components. In this presentation I will present initial results on magnetogram decomposition and assimilation of magnetogram data into dynamo modeling.

The large-scale magnetic helicity shows significantly better correlation with future sunspot numbers; in particular, the magnetic helicity substantially decreases prior to weak sunspot cycles. The strong correlation of the solar magnetic field with future sunspot numbers has been found in our comparison of best estimates of the sunspot number variations according to the annual sunspot numbers and model parameters. We have developed a relatively simple non-linear mean-field dynamo model, which nevertheless can describe essential general properties of the cycles and the observed sunspot number series (such as Waldmeier’s rule). Combined with the data assimilation approach, this model provides reasonable predictions of future solar activity in a time range from 7 – 8 years up to a whole solar cycle. However, our attempts to make predictions for a period longer than one cycle often fell due to accumulation of errors.