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Neural Supermodeling

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Deep learning is a modeling approach that has shown impressive results in image processing and is arguably a promising tool for dealing with spatially extended complex systems such earth atmosphere with its visually interpretable patterns. A disadvantage of the neural network approach is that it typically requires an enormous amount of training data.

Another recently proposed modeling approach is supermodeling. In supermodeling it is assumed that a dynamical system – the truth – is modelled by a set of good but imperfect models. The idea is to improve model performance by dynamically combining imperfect models during the simulation. The resulting combination of models is called the supermodel. The combination strength has to be learned from data. However, since supermodels do not start from scratch, but make use of existing domain knowledge, they may learn from less data.

One of the ways to combine models is to define the tendencies of the supermodel as linear (weighted) combinations of the imperfect model tendencies. Several methods including linear regression have been proposed to optimize the weights. However, the combination method might also be nonlinear. In this work we propose and explore a novel combination of deep learning and supermodeling, in which convolutional neural networks are used as tool to combine the predictions of the imperfect models. The different supermodeling strategies are applied in simulations in a controlled environment with a three-level, quasi-geostrophic spectral model that serves as ground truth and perturbed models that serve as the imperfect models.