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Understanding the earth system with machine learning

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The Earth is a complex dynamic networked system. Machine learning, i.e. derivation of computational models from data, has already made important contributions to predict and understand components of the Earth system, specifically in climate, remote sensing and environmental sciences. For instance, classifications of land cover types, prediction of land-atmosphere and ocean-atmosphere exchange, or detection of extreme events have greatly benefited from these approaches. Such data-driven information has already changed how Earth System models are evaluated and further developed. However, many studies have not yet sufficiently addressed and exploited dynamic aspects of systems, such as memory effects for prediction and effects of spatial context, e.g. for classification and change detection. In particular new developments in deep learning offer great potential to overcome these limitations. Most promising near-future applications include nowcasting and short-term forecasting applications, as well as anomaly detection and classification based on spatial and temporal context information. A longer-term vision includes data-driven seasonal forecasting, modeling of long-range spatial connections across multiple time-scales, modeling dynamics where spatial context plays an important role (e.g. fires), and for uncovering yet unknown (tele)connections between variables. One key challenge and opportunity will be to integrate physical modeling approaches with machine learning into hybrid modeling approaches, which will combine physical consistency and machine learning versatility.

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