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Accounting for multi-model ensemble dependence and the Ensemble Dependence Transformation: an application to climate projection

We introduce the “replicate Earth” ensemble interpretation framework, based on theoretically derived statistical relationships between ensembles of perfect models (replicate Earths) and observations. We transform an ensemble of (imperfect) climate projections into an ensemble whose mean and variance have the same statistical relationship to observations as an ensemble of replicate Earths. We use a ‘perfect model’ approach to test whether this Ensemble Dependence Transformation (EDT) approach can improve 21st century CMIP projections. In these tests, where 21st century model simulations are used as out-of-sample ‘observations’, the mean square difference between the transformed ensemble mean and ‘observations’ is on average 30% less than for the untransformed ensemble mean. In addition, the variance of the transformed ensemble matches the variance of the ensemble mean about the ‘observations’ much better than in the untransformed ensemble. Results show that the EDT has a significant effect on 21st century projections of both surface air temperature and precipitation. It changes projected global average temperature increases by as much as 16% (0.2C for B1), regional average temperatures by as much as 2.6C (RCP85) and regional average annual rainfall by as much as 410mm (RCP60). In some regions, however, the effect is minimal.

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Track Classification: Workshop on Predictability, dynamics and applications research using the TIGGE and S2S ensembles