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Statistical assessment of predictive modeling uncertainty

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When the results of geophysical models are compared with data, the uncertainties of the model are typically disregarded. We propose a method for defining the uncertainty of a geophysical model based on a numerical procedure that estimates the empirical auto and cross-covariances of model-estimated quantities. These empirical values are then fitted by proper covariance functions and used to compute the covariance matrix associated with the model predictions.
The method is tested using a geophysical finite element model in the Mediterranean region. Using a novel $\chi 2$ analysis in which both data and model uncertainties are taken into account, the model’s estimated tectonic strain pattern due to the Africa-Eurasia convergence in the area that extends from the Calabrian Arc to the Alpine domain is compared with that estimated from GPS velocities while taking into account the model uncertainty through its covariance structure and the covariance of the GPS estimates.
The results indicate that including the estimated model covariance in the testing procedure leads to lower observed $\chi 2$ values that have better statistical significance and might help a sharper identification of the best-fitting geophysical models.