

Developing Novel Ozone Parameterizations to Speed Up Climate Change Simulations

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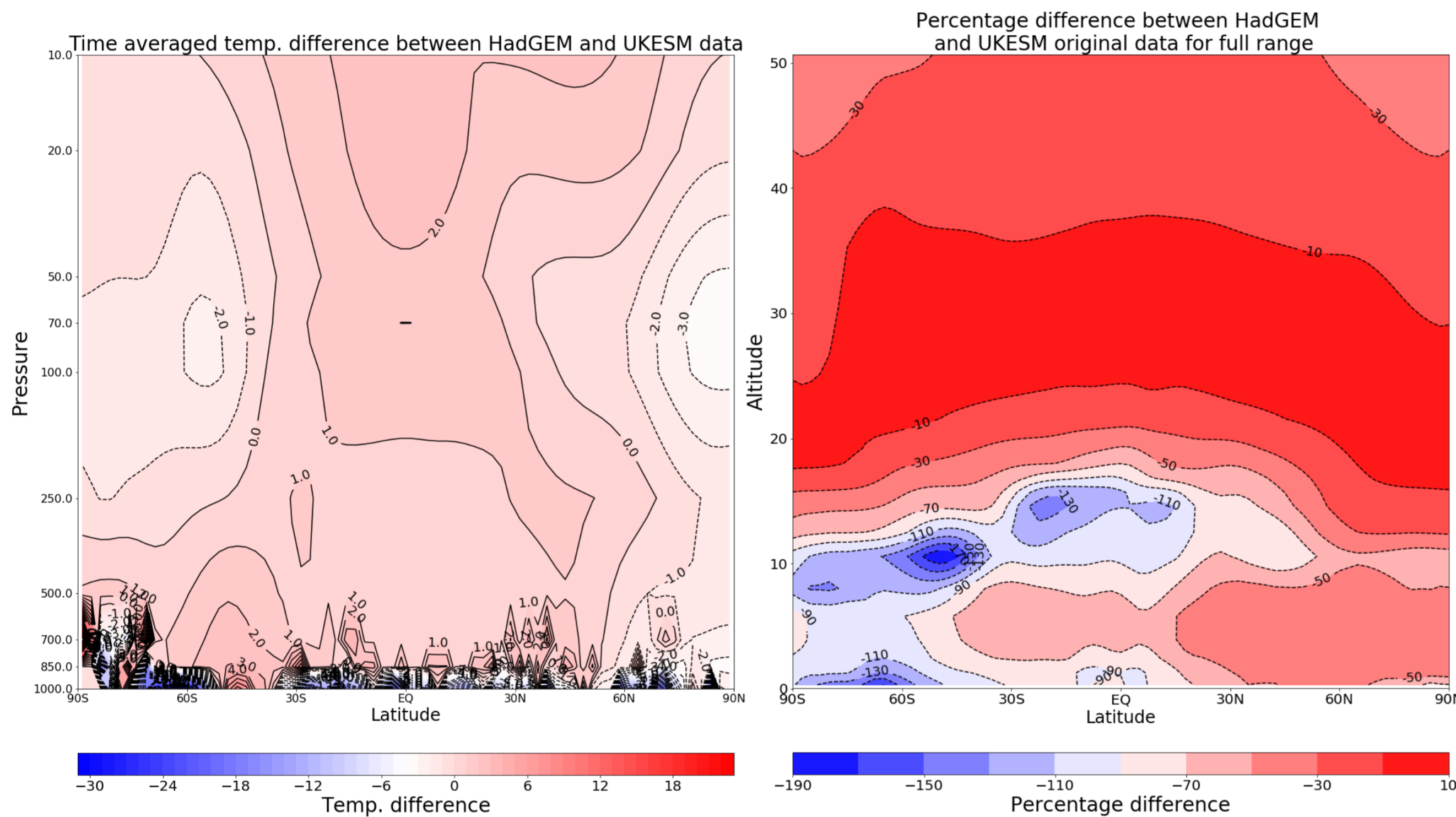
Background Information

- Many studies have shown that changes in ozone ('ozone feedbacks') play an important role in climate change simulations
- Can affect climate sensitivity estimates and atmospheric dynamical responses
- Comprehensive atmospheric chemistry models needed for calculating ozone feedbacks are computationally expensive, tripling the computational time of General Circulation Models

Methodology

- Machine learning regression techniques
- Use input variables that are available in all climate models i.e. temperature field
- Aim to predict daily mean ozone field from temperature field and ensure the regression model's transferability to other climate models
- HadGEM3-AO model by Met Office UK coupled to UKCA chemistry scheme
- UKESM unreleased data used as a test of the transferability – figures on left show the discrepancies between models
- Train model on HadGEM temperature and ozone data and try to predict UKESM ozone data from temperature field
- Ridge regression chosen as it addresses the bias-variance trade-off and minimises the cost function

$$J_k = \sum_{t=1}^N (Y_k^{(t)} - \sum_{j=1}^p c_{kj} X_j^{(t-1)})^2 + \alpha \sum_{j=1}^p c_{kj}^2$$



Results

- Five years of UKESM data needed to scale input/output data
- Few years of data is required to approximate UKESM climatology and offset differences in temperature field
- Regression model trained on HadGEM data can be applied to scaled UKESM data and predicted ozone field performs significantly better than UKESM climatology
- Compare using Error Ratio, ratio of mean squared error between predicted data and actual data, with mean squared error of UKESM climatology and actual data
- Shown that 5 years of data results in a good approximation, by comparing the mean error ratio across all grid cells

Further Work

- Project focused on pre-industrial conditions only, transferability for 4xCO2 case was more difficult and can be further explored
- Further testing on other comprehensive chemistry schemes could confirm the transferability

Figure on right: Time series at three specific grid cells. Error ratio is the ratio of MSE comparing predicted UKESM data with the ozone climatology, an error ratio greater than one means that the prediction performs better than the climatology

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