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Detailed projections of future climate change over Africa: the Variable Resolution Earth System Model and supercomputing on the CHPC Lengau cluster

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Global Climate Models (GCMs) have become the main tools to project future climate change. GCMs that are capable of also simulating the global carbon cycle are referred to as Earth System Models (ESMs). Currently, about 30 GCMs exist globally, but only one of these (developed by the CSIRO in Australia) had its origin in the southern hemisphere. Moreover, Africa is the only continent for which GCM projections have not improved moving from Assessment Report Four to Assessment Report Five (AR5) of the Intergovernmental Panel on Climate Change (IPCC), indicating a lack of focus on African climate issues in GCM development. Against this background, a new coupled climate model, the Variable-resolution Earth System Model (VrESM) is currently under development through collaborative research between the Council for Industrial Research (CSIR) in South Africa and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) In Australia. The model employs ocean, atmosphere and land-surface models all cast on a cube-based grid and can be applied at quasi-uniform horizontal resolution to function as a global climate model, or in stretched-grid mode to function as a high-resolution regional climate model. The atmospheric model component is the Variable-cubic Atmospheric Model (VCAM) of CSIRO, which has evolved from the widely used Conformal-cubic Atmospheric Model (CCAM). The CSIRO Atmosphere Biosphere Land Exchange model (CABLE) provides VrESM with a dynamic land-surface, whilst the ocean is simulated by the newly developed Variable-cubic Ocean Model (VCOM) of the CSIR. VRESM development is taking place with the immediate objective of generating African-based projections of future global climate change as a contribution to CMIP6, whilst the stretched-grid version of the model and its component models (e.g. CCAM) is to be used to generate simulations of the coupled southern African climate system as part of the second phase of the Coordinated Regional Downscaling Experiment (CORDEX).

Here we present an overview of the numerical architecture and the main component models of VrESM. We proceed to showcase the most detailed projections of future climate change ever obtained for the southern African region. These simulations were performed at a resolution of about 8 km in the horizontal for the period 1961-2100 under both low and high mitigation scenarios. For each scenario, six GCMs that contributed to AR5 of the IPCC were first downscaled to 50 km resolution globally using CCAM - as a contribution to CORDEX, and subsequently to 8 km resolution over Cape Town. The projections are analysed with a focus on the current drought in the Cape Town region - insights are provided on whether this drought can be attributed to climate change and on whether more such droughts can be expected under climate change. All VrESM development, and the application of VrESM and its component models, are taking place on the Lengau cluster of the CHPC. The talk thus also provides insights into the computational requirements of performing the high-resolution simulations described above, including the characteristics of the code in terms of scaling on Lengau.

HPC content

Included in abstract

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