Weather and Climate Project in support of the implementation of the SADC Cyber-Infrastructure Framework

SADC Cyber-Infrastructure(CI) Framework

SADC STI response to Climate Change Framework

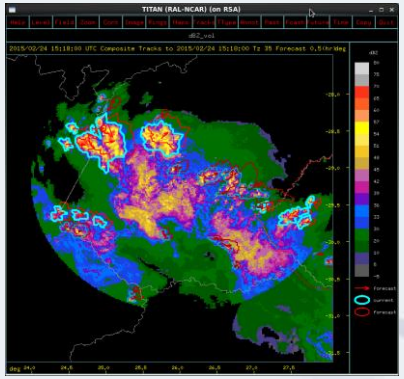
Improving weather and climate early warnings in Southern Africa

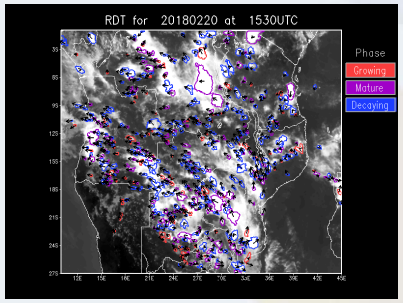
African School of Physics seminar
08 September 2020

South African Weather Service

Weather and Climate Early Warnings

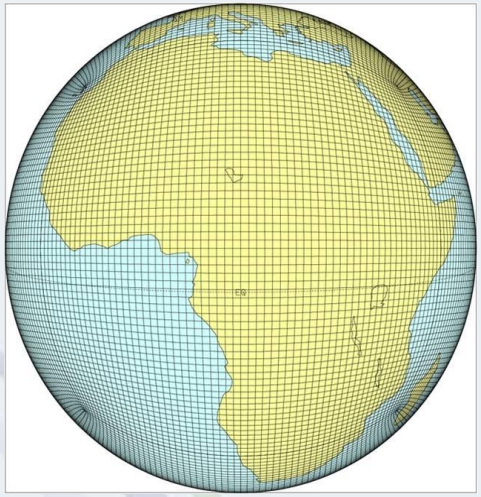
Observations





No observations

Models



$$\frac{Du}{Dt} - fv + \frac{\partial \varphi}{\partial x} - \sigma \frac{\partial \varphi}{\partial \sigma}\frac{\partial \ln p_s}{\partial x} = 0$$

$$\frac{Dv}{Dt} + fu + \frac{\partial \varphi}{\partial y} - \sigma \frac{\partial \varphi}{\partial \sigma}\frac{\partial \ln p_s}{\partial y} = 0$$

$$\frac{R}{g}\frac{D}{Dt}\left(\frac{\omega T}{p}\right) + g + \frac{p}{p_s}\frac{g}{RT}\frac{\partial \varphi}{\partial \sigma} = 0$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \dot{\sigma}}{\partial \sigma} + \frac{D \ln p_s}{Dt} = 0$$

$$\frac{DT}{Dt} - \kappa \frac{\omega T}{p} = 0$$

Models missing events

POSTPROCESSING

Forecasters

Miss events

Applications

Agriculture
Health
Energy
Water
Disaster Risk Reduction

DISSEMINATION

Warnings not reaching the communities

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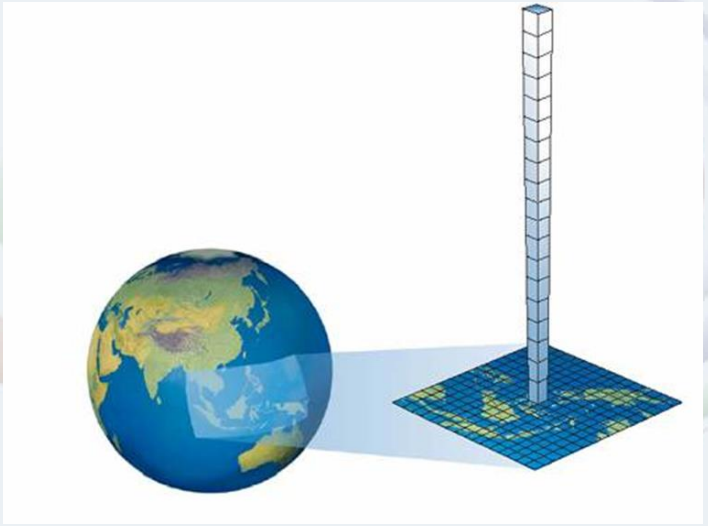
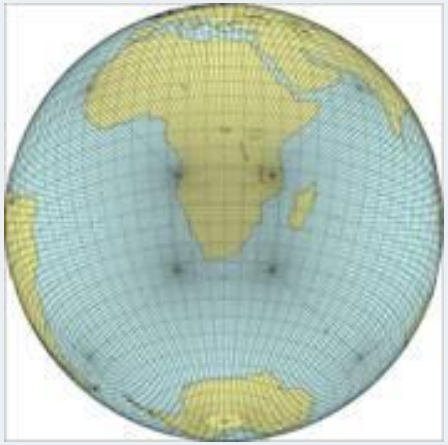
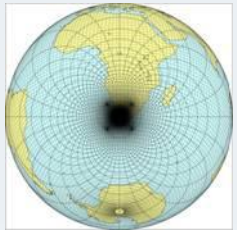
Modelling

- High resolution over area of interest
- Traditional limited area modelling – time dependent lateral boundary conditions
- Stretched grid – resolution gets coarser as one moves away from area of interest
- Procedure used for Numerical Weather Prediction, and climate change projections – less for seasonal forecasting





Courtesy of Prof Engelbrecht



$$\frac{DV}{Dt} = -\frac{1}{\rho}\nabla p - fk \times V - gk + F$$

$$\frac{D\rho}{Dt} = -\rho \nabla . V$$

$$c_p \frac{DT}{Dt} - \alpha \frac{Dp}{Dt} = 0$$

$$\frac{\mathrm{D}}{\mathrm{D}t} \equiv \frac{\partial}{\partial t} + \mathbf{v} \cdot \nabla$$

South African Weather Service

Questionnaires

- Angola – Meteorological Service
- Botswana – University, Meteorological Service
- Eswatini – Meteorological Service
- Mauritius – Meteorological Service
- Namibia – University, Meteorological Service, government
- South Africa – Meteorological Service
- Tanzania – Meteorological Service
- Zambia- Meteorological Service

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HPC Infrastructure

- Five of the countries have HPC infrastructure
  - ❖3 – Meteorological Services
  - ❖5 – through HPC ecosystems, 1 – national initiative
  - ❖Only 2 Met services aware of HPC ecosystems project
- Models running
  - ❖WRF – 4 countries
  - ❖UM – 1 country
  - ❖COSMO – 4 countries
  - ❖ocean-atmosphere coupled model- 1 country
  - ❖Climate Predictability Tool- statistical
- Resolutions
  - ❖NWP - Three countries running with grid spacing less than 10km

DATA SCIENCE JOURNAL

Bopape, M-JM, et al. 2019. A Regional Project in Support of the SADC Cyber-Infrastructure Framework Implementation: Weather and Climate. *Data Science Journal,* 18: 34, pp. 1–10. DOI: https://doi.org/10.5334/dsj-2019-034

PRACTICE PAPER

A Regional Project in Support of the SADC Cyber-Infrastructure Framework Implementation: Weather and Climate

Mary-Jane Morongwa Bopape[1], Happy Marumo Sithole[2], Tshiamo Motshegwa[3],

Areas of research

- Area 1 : Simulations: Weather and climate
- Area 2: Postprocessing: verification, ensembles combinations, process studies, merging of observations with simulations
- Area 3: Applications: Disaster Risk Reduction, Agriculture, Hydrology, Health, Energy
- Area 4: Human Capital Development: training workshops and postgraduate studies

- Replying to calls for proposals scope informed by duration and budget of the call

South African Weather Service

Climate Research for Development Fellowship

- Funder: United Kingdom of Great Britain and Northern Ireland's (UK) Department for International Development (DFID)
- WISER programme supports Africa-led research through CR4D in Africa initiative
- Research grant manager is the African Academy of Sciences

- Title: "Improving Weather and Climate early warning systems over Southern Africa"
- Pilot project to include: Botswana, Mozambique, Namibia, South Africa, Tanzania, Zambia
- Collaborators: NASA, UK Met Office, University of Reading

Aim

- The aim of this project is to improve weather and climate early warning systems within Southern Africa.
  - ❖Study atmospheric processes using different sources of data
  - ❖Evaluate and verify current Numerical Weather Prediction models using a number of observation sources.
  - ❖Test different model configurations to determine the most efficient choices.
  - ❖Improve simulations through modification of the model physics (i.e. boundary layer and microphysics).
- Develop sector specific products: Disaster risk reduction, agriculture, hydrology, energy and health

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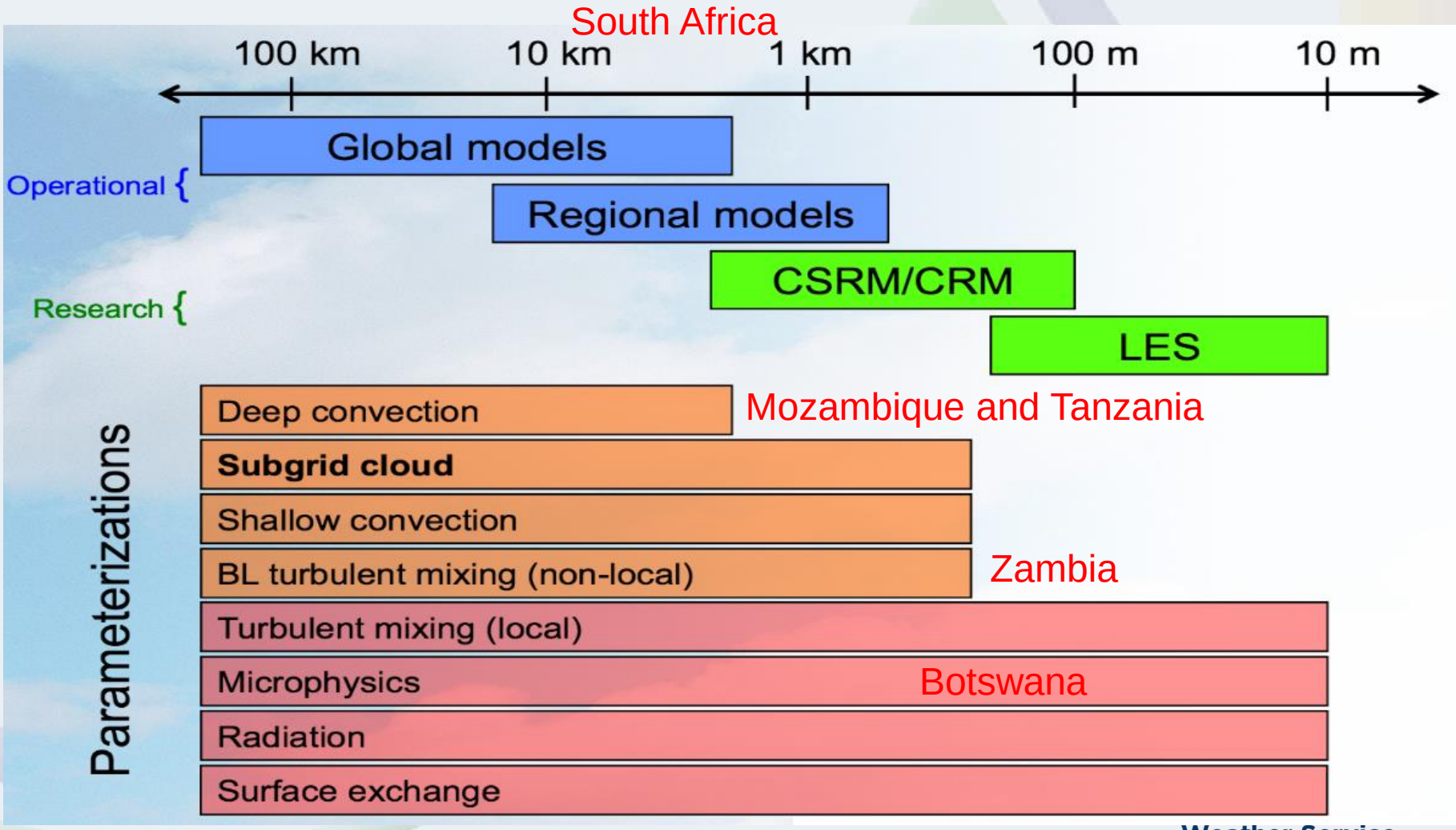
Spatial Scales in Atmospheric Modelling



Courtesy of Dr Bouyssel

Work done

- Three workshops ran successfully – had NASA and University of Reading model developers attending & presenting – now co-authoring papers.
- Got HPC hosts and Met Services in different countries to meet and work together
- WRF implemented in Botswana, Namibia, & Zambia as a direct consequence of this project, Mozambique and Tanzania ran on Met Service servers
  - Zambia now even testing upto medium range
- Take home messages from simulations so far
  - Configuration – important to know the correct setting – wrong setting no benefit from high resolution
  - Turbulence – Capturing of storm simulation impacted heavily by vertical mixing
  - Microphysics – simulations look more like each than with observations
  - Convection – all overestimate rainfall
  - Observations – different from each other

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Lessons learnt and Way forward

RESEARCH ARTICLE

Sensitivity of Botswana Ex-Tropical Cyclone Dineo rainfall simulations to cloud microphysics scheme [version 1; peer review: awaiting peer review]

Charles Molongwane [1], Mary-Jane M. Bopape [2], Ann Fridlind [3], Tshiamo Motshegwa [4], Toshihisa Matsui[5], Elelwani Phaduli[2], Bigani Sehurutshi[4], Robert Maisha[2]

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[2]South African Weather Service, Pretoria, South Africa
[3]Goddard Institute for Space Studies, National Aeronautics and Space Administration, New York, New York, NY 10025, USA
[4]Department of Computer Science, University of Botswana, Gaborone, Botswana
[5]Mesoscale Dynamics and precipitation lab, NASA Global Space Flight Center, Greenbelt, Maryland, MD 20771, USA

Article

Convection parametrization and multi-nesting dependence of a heavy rainfall event over Namibia with Weather Research and Forecasting (WRF) model

Sieglinde Somses [1]*, Mary-Jane M. Bopape [2], Thando Ndarana [3], Ann Fridlind [4], Toshihisa Matsui [5], Elelwani Phaduli [2], Anton Limbo [6], Shaka Maikhudumu [6], Robert Maisha [2] and Edward Rakate [7]

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7 Centre for High Performance Computing, Council for Scientific and Industrial Research, Pretoria, South

- Finalise other papers
- Mobilise for more funding – longer term better
- Limited modelling literature
- Met Service personnel multi-hatted – need to work with Universities to do more research

South African Weather Service

Model Development Framework

- Engagements in South Africa so far
- Models used currently developed outside the African continent
- Aim to contribute towards the development of models
- Become an independent user of models to operational and policy needs
- First five years: build capacity by using available models
- Focus on the Conformal Cubic Atmospheric Model (CCAM)

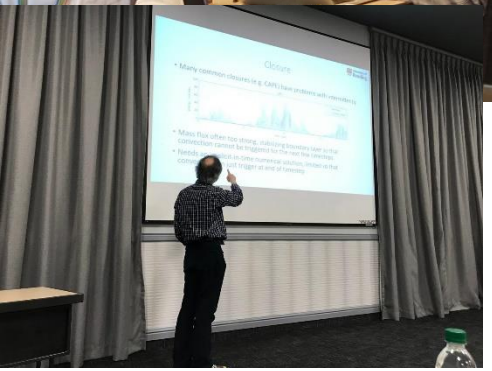
South African Weather Service


Climate Research for Development Fellowships
• Funder: United Kingdom of Great Britain and Northern Ireland's (UK) Department for International Development (DFID)
• WISER programme supports Africa-led research through CR4D in Africa initiative
• Research grant manager is the African Academy of Sciences
• 21 projects funded across the continent
• Launch on 3 June 2019 in Nairobi, Kenya


NASA high-end computing


UMERICAL WEATHER PREDICTION (NWP)
TRAINING WORKSHOP

Thank you


Closure