32nd Annual Conference of the South African Society for Atmospheric Sciences

31 October-1 November

Hosts: Climate System Analysis Group (University of Cape Town)

Lagoon Beach Hotel in Milnerton, Cape Town.

ABSTRACT BOOK

Sponsor:

PREFACE

The 32nd annual conference of South African Society for Atmospheric Sciences is being hosted in Cape Town, by the Climate System Analysis Group at UCT. The theme for the conference is "Innovation for Information". It is always a challenging task to know how to translate scientific research/data into useful information. The major aim of the conference is to question, discuss and understand how we traditionally translate research into action and how we could possibly improve on that. We look forward to some interesting and exciting presentations as well as some invigorating discussion after each session.

The continuing practice of asking for extended abstracts was very successful this year with over 30 abstract submitted for review and the proceedings of the conference will be published with an ISBN number. The review process was ably led by Prof Willem Landman and our thanks to him and his hard-working reviewers. The conference proceedings will be available for download from the SASAS and SASAS 2016 web-pages.

There are also over 30 posters on display and we ask that you engage with them and their authors. Rather spend your tea times there, and catch up with friends and colleagues over meals!

On behalf of the SASAS 2016 organising committee, we would like to thank everyone who enthusiastically contributed to the preparation and success of the 32nd Annual SASAS conference. We are also especially grateful to our sponsors from Future Climate from Africa (FCfA). It is our duty to acknowledge their contributions and their financial support of 10 students and some of the contents in your conference bag. Please make a point to visit their stand in the foyer.

We wish you all a successful and memorable conference and welcome you to the fairest Cape in all the world!

Conference Co-Chairs (Climate System Analysis Group, University of Cape Town)

Prof Bruce Hewitson (SARCHI Research Chair in Climate Change)

Dr Peter Johnston (Research officer)

Mrs Kate Kloppers (Senior Scientific Officer)

MESSAGE FROM THE PRESIDENT

Dear Delegates

I welcome you to the 32nd South African Society for Atmospheric Sciences Conference. After the successful 31th Conference held at Lanseria last year, it is a great pleasure to be in Cape Town in such a picturesque location and to be hosted by CSAG. I want to extend a special welcome to overseas delegates from Africa, Europe, USA, South America and Asia. This year, we are, for the second time, awarding the SASAS medal for excellence in science, education and technology. Last year the recipient was Professor Michael Savage. As usual, we will award the Stanley Jackson Award for the best peer reviewed paper in the preceding year. We also have an award for the best poster and oral. I remind you that SASAS aims to stimulate interest and support for all branches of atmospheric sciences, to encourage research and education in the atmospheric sciences and to promote collaboration between organisations and institutions interested in atmospheric science in Southern Africa. This includes meteorology, agro-meteorology, climatology, air quality, ocean-atmosphere interaction, troposphere-stratosphere interaction, physical oceanography, hydroclimatology, numerical modelling, and instrumentation. Proceedings of the conference include all peer reviewed extended abstracts and the document has an ISBN number. This publication qualifies for funding in most institutions (and looks good on your CV). Former conference papers and abstracts are available on the new SASAS web site at http://www.sasas.org.

Ultimately, we compete with one another for grants, for discoveries, for papers, for awards; and we may agree or disagree on how to run things, but SASAS unites us all and the conference is one of the longest running annual conferences in Africa. This is where we uncover the young talent. I encourage everybody to join SASAS by completing the membership form that you will find in on the website.

This year we will be electing a new executive committee during the conference including President and Vice President and results will be announced at the annual assembly at the end of the conference. So, this is my last mandate and we will have a new president by the end of the conference. (I am not leaving SASAS but cannot run for more than three mandates).

Finally, I remind you that we need to grow the society, and therefore welcome any suggestions for improvements. You can voice your idea or concerns at the assembly or ask the executive committee to bring it up. I also remind you that we do have a constitution that can be amended by a vote by the council. This is your opportunity to change things and help the society to progress.

Mathieu Rouault

SASAS President

Professor – Department of Oceanography UCT

COMMITTEES

EVENT ORGANISING COMMITTEE

Conference Co-Chairs -

- Prof Bruce Hewitson (Climate System Analysis Group, University of Cape Town)
- Dr Peter Johnston (Climate System Analysis Group, University of Cape Town)
- Mrs Kate Kloppers (Climate System Analysis Group, University of Cape Town)

Dr Chris Lennard (Climate System Analysis Group, University of Cape Town)

Mrs Melanie Rustin-Nefdt (Climate System Analysis Group, University of Cape Town)

Ms Carla Petersen (Climate System Analysis Group, University of Cape Town)

Ms Tania Williams (Climate System Analysis Group, University of Cape Town)

REVIEW PANEL MEMBERS

Review Convener - Prof Willem Landman (Council for Scientific and Industrial Research, SA)

Dr Babatunde Abiodun (University of Cape Town, SA)

Dr Asmerom Baraki (South African Weather Service, SA)

Dr Mary-Jane Bopape (University of Reading, UK)

Prof Natalie Burls (George Mason University, USA)

Dr Liesl Dyson (University of Pretoria)

Dr Gregor Feig (Council for Scientific and Industrial Research, SA)

Dr Rebecca Garland (Council for Scientific and Industrial Research, SA)

Prof Bruce Hewitson (Climate System Analysis Group, University of Cape Town, SA)

Dr Andries Kruger (South African Weather Service, SA)

Mr Mavhungu Muthige (Council for Scientific and Industrial Research, SA)

Prof Stuart Piketh (School of Geo and Spatial Science, University of North-West, SA)

Prof Mathieu Rouault (University of Cape Town, SA)

Dr Thando Ndarana (Council for Scientific and Industrial Research, SA)

Dr Warren Tennant (Met Office, UK)

Prof Sivakumar Venkataraman (University of KwaZulu-Natal, SA)

Prof Coleen Vogel (University of the Witwatersrand, SA)

Prof Sue Walker (Crops for the Future Research Centre, Malaysia)

Dr Caradee Wright (South African Council for Medical Research, SA)

SASAS MEDAL COMMITTEE

Chairman - Prof Willem Landman (Council for Scientific and Industrial Research, SA)

Dr Babatunde Abiodun (University of Cape Town, SA)

Prof Hassan Bencherif (Universite de La Reunion, Reunion, France)

Dr Simon Mason (International Research Institute for Climate and Society, USA)

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Prof Stuart Piketh (School of Geo and Spatial Science, University of North-West, SA)

Associate Prof, Marcello Vichi (Department of Oceanography, University of Cape Town, SA)

STANLEY JACKSON AWARD REVIEWERS

Prof Natalie Burls (George Mason University, USA)

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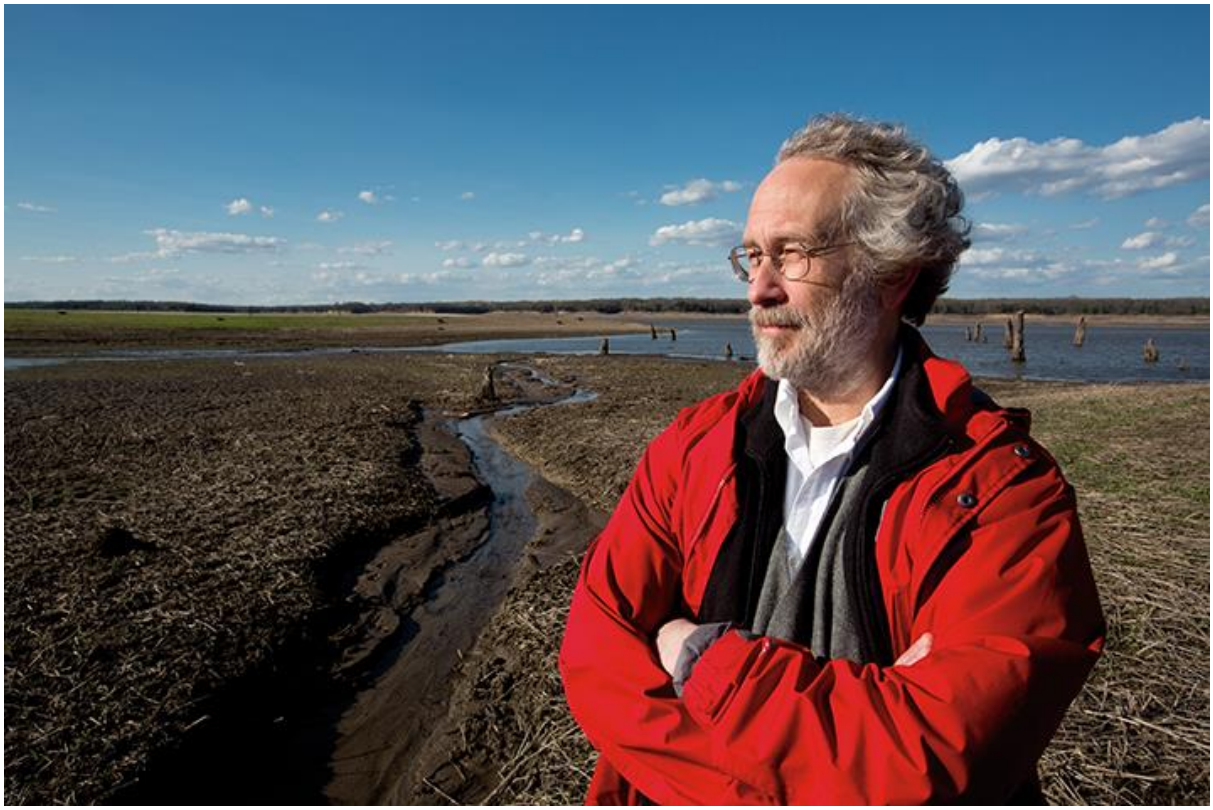
Prof Mike Harrison (Oxford University, UK)

Dr Neil Hart (Oxford University, UK)

Dr Andries Kruger (South African Weather Service, SA)

KEY NOTE SPEAKERS

PROF. WILLIAM J. GUTOWSKI, JR.



Associate Dean for Research and Graduate Education in the College of Liberal Arts and Sciences at Iowa State University

Dr. Gutowski is the Associate Dean for Research and Graduate Education in the College of Liberal Arts and Sciences at Iowa State University. His research concentrates on the role of atmospheric dynamics in climate. Central focuses are the dynamics of the hydrologic cycle, regional climate and weather and climate extremes. Because processes on a wide range of spatial and temporal scales are important for all of these, his research program entails a variety of modeling and data analysis approaches, from which he has authored or co-authored over 100 peer-reviewed publications. His work includes regional modeling of African, Arctic and East Asian (as well as North American) climates, and he has significant collaboration with scientists in these regions. Dr. Gutowski is currently Co-Chair of the Science Advisory Team for the WCRP's Coordinated Regional Downscaling Experiment (CORDEX). Prior to this, he helped lead earlier regional climate programs, most notably the Project to Intercompare Regional Climate Simulations and the North American Regional Climate Change Assessment Program. He has contributed assessment reports of the IPCC (including Lead Author, AR5), the U.S. National Academy of Sciences and the U.S. Climate Change Science Program. He has also served as an Editor for the Journal of Hydrometeorology. In light of his contributions to his field, he was recently elected a Fellow of the American Meteorological Society.

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Water and Climate Change (WACC): Building Community Consensus for a Sustainable Future

William J. Gutowski, Jr.
Iowa State University
Ames, Iowa, USA

Humans have long sought to control water to protect against hydrologic and climatic extremes and improve food and water security. Numerous tensions among users can develop through conflicting needs and values, so water sustainability solutions must be found that lead to outcomes that are both acceptable to stakeholders and scientifically sound. Sustainable water management requires community involvement by social and natural scientists, engineers, water managers and the broader community, that is, all water stakeholders. Changing climate, demographics and economic demand add to the challenge by presenting a moving target for sustainable access to adequate water.

This talk will present efforts to date on a program that combines research with community participation to address comprehensively water sustainability challenges through a three-pronged approach: iterative participatory modeling (IPM), agent-based modeling (ABM) of human decisions and physical modeling of watershed processes. IPM works to elicit community values and interests and provide a basis for co-exploration of relevant data to build a knowledge base that recognizes where confidence and uncertainty are both present in the available information. Agent-based hydrological modeling provides a means of exploring how various community players (agents) interact with each other and with the watershed the face of critical stressors such as changes in climate, demographics and economics. The objective of the three-pronged effort is translational science fostering use-inspired scientific research by engaging members of a watershed community in the exploration of water-management decision options in a modeling environment accessible to participants. The program provides a prototype for coupling natural and human processes in a dynamic, evolving framework that can flexibly address the ever-changing challenges of sustainable water management around the world.

Professor Timothy Carter

Research Professor at the Finnish Environment Institute (SYKE), Helsinki

Timothy Carter is a Research Professor at the Finnish Environment Institute (SYKE), Helsinki with over 35 years of research experience in the field of climate change impacts and adaptation. A geographer, he obtained a B.Sc. from the University of London and Ph.D. from the University of Birmingham, UK. He has worked on climate change and agriculture, methods of impact and adaptation assessment, including scenario development, and climate change adaptation. Based in Austria (International Institute for Applied Systems Analysis), the UK (Birmingham) and since 1990 in Finland, Carter has been a Lead Author for each of the five Intergovernmental Panel on Climate Change (IPCC) Assessment Reports as well as serving on the IPCC Task Group on Data and Scenario Support for Impacts and Climate Analysis (TGICA) since 1996. He has published 3 books and 120 refereed papers and reports.

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Modelling impacts of climate change: what are the information needs?

Timothy R. Carter
Finnish Environment Institute (SYKE), Helsinki, Finland

Conventional approaches to estimating future climate change impacts have placed a high premium on the availability of reliable regional climate projections. This has been one of the justifications for large investments in climate modelling during the past three decades, which have led to demonstrable advances in our understanding of the climate system. This presentation examines some of the consequences of a climate science research emphasis for model-based assessments of future impacts. It suggests that while uncertainties in future impacts attributable to climate are relatively well circumscribed, until recently several other sources of uncertainty have received too little attention. These include the behaviour of the impact models themselves, observations required to calibrate and test models and socioeconomic and environmental assumptions applied in parallel to climate projections. Questions are also posed about the most effective use of climate information to inform impact analysis.

PROGRAMME

DAY 1: 31 OCTOBER

KEY: *STUDENT

0800-0845	**REGISTRATION**
0845-0900	**WELCOME (Dr Peter Johnston) AND HOUSEKEEPING (Mrs Kate Kloppers)**
0900-0930	**KEYNOTE ADDRESS**
	Prof William Gutowski Water and Climate Change (WACC): Building Community Consensus for a Sustainable Future
0930-1000	**INVITED SPEAKER**
	Dr Yushi Morioka Role of Weddell Sea ice variability in southern African climate
1000-1030	**TEA BREAK**

1030-1230 SESSION 1 PARALLEL

1A		**Climate Modelling and Development (Chairperson: Chris Lennard)**	
1	1030-1045	Elelwani Phaduli	Evaluation of the Convective Scale Configurations of the Unified Model
2	1045-1100	Francois A. Engelbrecht	Dynamic core of the Variable-resolution Cubic Ocean Model (VCOM)
3	1100-1115	Magdel Erasmus*	Tropical Temperate Troughs over Southern Africa as Simulated by a Fully Coupled Model
4	1115-1130	Mary-Jane Bopape	Simulating the Convective Boundary Layer with a Dynamic Smagorinsky Model
5	1130-1145	Mavhungu S Muthige*	Impacts of spectral nudging on the simulation of present-day rainfall patterns over southern Africa
6	1145-1200	Rachel James	Representation of Tropical Temperate Troughs over southern Africa in coupled climate models

20 MIN DISCUSSION

1B		**Ocean Dynamics and Atmosphere-Ocean Interactions (Chairperson: Marcello Vichi)**	
1	1030-1045	Mathieu Rouault	Wind changes above warm Agulhas Current eddies
2	1045-1100	Marc de Vos	Towards understanding the impact of assimilating along-track SLA data on simulated eddy characteristics in the Agulhas System
3	1100-1115	Teboho Nchaba	Summer circulation trends over southern Africa and its adjacent oceans
4	1115-1130	Tharone Rapeti	Preliminary investigation into the impacts of assimilating SST and SLA on the surface velocities in a HYCOM of the Agulhas Current

5	1130-1145	Daneeja Mawren*	Variability of tropical cyclone heat potential and barrier layers in the South Indian Ocean
6	1145-1200	Fehmi Dilmahamod*	Investigating the regime of the South-West Indian Ocean Currents through a numerical model.

20 MIN DISCUSSION

1230-1330 LUNCH

1330-1410 POSTER PRESENTATIONS (1 MIN X 30) PLENARY

1410-1550 SESSION 2 PARALLEL

2A		**Climate Modelling and Development (Chairperson: Babatunde Abiodun)**	
1	1410-1425	Stephanie Landman	Predictability of Rain-Bearing Systems over South Africa by Regional and Global Weather Prediction Models
2	1425-1440	Syamala Krishnannair	Comparative study of PCA and wavelet-PCA models for simulating monthly rainfall and temperature for Cape Point station
3	1440-1455	Willem Conradie*	Initial Conditions and Quantifying Model Climates: Does it Matter Where We Come from?
4	1455-1510	Georges-Noel T. Longandjo	How does well ECHAM simulate central Africa rainfall seasonal cycle?
5	1510-1525	Asmerom Beraki	Covariability of remote and local climate forcings and South African winter climate predictability

20 MIN DISCUSSION

2B		**Atmosphere/Ocean Interaction, Aerosols and Atmospheric wave dynamics (Chairperson: Venkataraman Sivakumar)**	
1	1410-1425	Kirodh Boodhraj*	An assessment of the role of vertical mixing schemes in the simulation of Southern Ocean upper dynamics
2	1425-1440	Neil Hart	Upper-level jets and eddies associated with tropical-extratropical cloud bands over southern Africa: The seasonal cycle
3	1440-1455	Xolile Ncipha*	Comparison of summer and spring carbon dioxide vertical and spatial distribution over the Southwest Indian Ocean Islands using TES data
4	1455-1510	Anzel Swart*	An Analysis of the Air Dispersion Potential (ADP) over Uubvlei in Oranjemund, Namibia.
5	1510-1525	Majambo Gamoyo*	Mesoscale dynamics in the Western Indian Ocean (Focus on the Southern Gyre): A numerical investigation using ROMS

20 MIN DISCUSSION

1550-1610 TEA

1610-1730 SESSION 3 PARALLEL

3A		ENSO and seasonal impacts (Chairperson: Asmerom Baraki)	
1	1610-1625	Christien J. Engelbrecht	The 2015/16 Summer vs the Summers of the Last Decade
2	1625-1640	Willem A Landman	Decision-relevant information on seasonal time scales - the case of a farm in northern Namibia
3	1640-1655	Hector Chikoore	Evolution of the 2015/16 El Niño drought: circulation anomalies, heat waves and impacts on southern Africa
4	1655-1710	Takayoshi Ikeda	Linking malaria in Limpopo, South Africa to climate using self-organizing maps

20 MIN DISCUSSION

3B		Atmospheric Air Quality (Chairperson: Nkanyiso Mbatha)	
1	1610-1625	Maluta Pennington Mbedzi*	The potential use of CCAM as a meteorological driver to air quality mode over the Waterberg-Bojanala Priority Area
2	1625-1640	S.K. Sangeetha*	Comparative study of OMI BRD and PCA algorithm retrievals in relation to ground based measurements over a South African Site
3	1640-1655	Sewela Malaka*	Contribution of dairy farming on climate change through direct methane emissions to the atmosphere
4	1655-1710	Lynette V Schalkwyk	Warning South Africa when severe weather unfolds

20 MIN DISCUSSION

1730-1830 POSTER VIEWING (see poster presentation list below)

1730-1830 SASAS BOARD MEETING (by invitation only)

1900 GALA DINNER

DAY 2: 1 NOVEMBER

0830-0900	KEYNOTE ADDRESS
	Prof Tim Carter Modelling impacts of climate change: what are the information needs?
0900-0930	**INVITED SPEAKER**
	Prof Mike Savage Open water evaporation quo vadis?

0930-1030 SESSION 4 PLENARY

4		1.5 Degrees, Climate Services and application (Chairperson: Mark Tadross)	
1	0930-0945	Coleen Vogel	"END of END user!" – Transdisciplinary approaches in climate science.
2	0945-1000	Bruce Hewitson & Katinka Waagsaether	The evolving landscape of Climate Information Websites
3	1000-1015	Piotr Wolski	Improving visualisations of climate projection information

15 MIN DISCUSSION

1030-1100 TEA

1100-1300 SESSION 5 PARALLEL

5A		Applications for water and agriculture (Chairperson: Piotr Wolski)	
1	1100-1115	Harold Weepener	Climate change related impact on avocado production areas in South Africa
2	1115-1130	Johan Malherbe	How would current advice benefit maize farmers with respect to historical associations with El Niño events
3	1130-1145	Shepherd Muchuru	Mitigating vulnerability to drought and enhancing livelihood resilience: A review of Southern Africa region
4	1145-1200	Teboho Masupha*	Temporal evolution of agricultural drought in the Luvuvhu River catchment of South Africa
5	1200-1215	Yao Télesphore Brou	Spatio-temporal variability of rainfall and impacts on vegetation in Reunion Island
6	1215-1230	Lisa van Aardenne	Climate and Tsetse: exploring the effect of climate variability and change on vector biology, population dynamics and distribution in the Zambezi Valley

20 MIN DISCUSSION

5B		Instrumentation and data collection (Chairperson: Mike Savage)	
1	1100-1115	Alexa Brown*	Time, space and vector relationships between historical ship log data and Cape Royal Astronomical Observatory wind data between 1834 and 1854
2	1115-1130	Yerdashin Padayachi	Anthropogenic Heat Flux in South African Cities: Initial estimates from the LUCY model
3	1130-1145	Morné Gijben	Recent improvements to the rapidly developing thunderstorm product - the addition of lightning data into the software

4	1145-1200	Erik Becker	Application of radar data at the South Africa Weather Service
5	1200-1215	Nkanyiso Mbatha	Stratosphere-troposphere exchange climatology over southern Africa using ERA-Interim data set and AIRS/Aqua satellite data
6	1215-1230	Zakhele Shabalala*	Development of a patching tool on recorded daily climate data

20 MIN DISCUSSION

1300-1400 LUNCH

1400-1530 SESSION 6 PARALLEL

6A		**Climate & weather forecasting (Chairperson: Willem Landman)**	
1	1400-1415	Henno Havenga*	High Resolution dBz simulation of some notable hailstorms that occurred in 2013 over the South-African Highveld using WRF
2	1415-1430	Melise du Toit*	The application of support vector regression (SVR) for stream flow prediction on the Amazon basin
3	1430-1445	Kelebogile Mathole	The climatology of the stratospheric zonal wind and its wave driving in the SAWS operation seasonal prediction system
4	1445-1500	Izidine Pinto*	Process-based assessment of two CORDEX climate models projections over southern Africa
5	1500-1515	Elizabeth Webster	Impact-based severe weather warning system

15 MIN DISCUSSION

6B		**Dust - Southern African aerosols, sources pathways and impacts (Chairperson: Frank Eckhardt)**	
1	1400-1415	Johanna von Holdt*	Aeolian dust emission from the Namib Desert: local-scale erodibility controls
2	1415-1430	Rebecca Garland	Representation of aerosol particles and associated transport pathways in regional climate modelling in Africa
3	1430-1445	Priyanka Singh*	Validation and comparison between Aerosol Optical Depth acquired from Sun Photometer and MODIS satellite over Durban
4	1445-1500	Thabo Makgoale*	The sensitivity of simulated temperatures in climate models to aerosols over southern Africa
5	1500-1515	Ruusa Gottlieb*	The contribution of fog to the biogeography of *Arthraerua leubnitziae*in the central Namib desert

15 MIN DISCUSSION

1530-1550 TEA

1550-1600 AWARDS AND CLOSING

1600-1700 AGM

POSTER PRESENTATIONS				
MAIN AUTHOR	**TITLE**	**ABSTRACT PAGE NO.**	**STUDENT**	**BOARD NO.**
Bellinda Monyela	Abnormal climate conditions for summer 2014/2015 over southern Africa	37	*	1
Chris Lennard	Characterizing surface level inversions over Cape Town, South Africa	31		2
Claire Davis	Climate change and extreme weather events in Southern Africa: can countries adapt?	21	*	3
Cobus Olivier	Making seasonal forecasts easier to use	42		4
Eve Wicksteed	Air Pollution and Climate Change in the Greater Cape Town Area	48	*	5
Fabien Desbiolles	Air-Sea interactions over the Angola-Benguela Frontal Zone and their effects on regional atmospheric circulation	22	*	6
Jan Vermeulen	Late plum rain over northeastern South Africa: 1 to 14 March 2014	47		7
Kabelo Mathibela	Testing the applicability of the NAME III dispersion model in predicting air pollutants concentrations over the VTPA	35		8
Kaukurauee Ismael Kangueehi	Trace metal concentration and solubility of aerosols from southern Africa sources transported over the ocean	31	*	9
Kelsey Woor	Assessing the Risk of Failure and Implications to Investment Payback Period for Domestic Rooftop Rainwater Harvesting Systems under Current and Future Climate in the Western Cape	49	*	10
Kwesi Quagraine	Regional climate model based simulations of inter-annual rainfall variability over the Guinean coast of West Africa	43	*	11
Lerato Mpheshea	Predictability of seasonal streamflow in the north-eastern region of South Africa	39	*	12
Mariam Nguvava	The influence of atmospheric teleconnections on drought regimes in Eastern Africa	40	*	13
Mark Jacobson	Topographic effects on the wind field in False Bay	29	*	14
Modathir Abdalla Hassan Zaroug	Are semi-arid regions hotspots of climate change in Africa and South Asia?	50	*	15

Molulaqhooa Maoyi	Simulating the characteristics of Tropical Cyclones over the South West Indian Ocean using an Adaptive Stretched-Grid Global Climate Model	33	*	16
Morwakoma Matabane	Ocean wave forecasting in the southern African region: the use of ECMWF WAM and NCEP Ensemble data	34	*	17
Mthetho Vuyo Sovara	Modeling the impacts of the Indonesian Throughflow on the Indian Ocean using the Parallel Cubic Ocean Model	45	*	18
Mthobisi Nxumalo	Analysis of homogenised extreme temperature trends over South Africa for the period 1931 to 2015	41		19
Neil Hart	The spatial distribution and variability of organised convection over southern Africa as represented by cold cloud duration	25		20
Njabulo Mchunu	Evaluating the Multi-Scale Predictability of a Severe Weather Event Associated with a Cut-off Low over South Africa	36		21
Piotr Wolski	Interannual rainfall variability and SOM-based circulation classification	49		22
Ramapulana Nkoana	Koppen-Geiger climate type maps of the Last Glacial Maximum over south coast	41	*	23
Rodger Duffett	Toward a UAV Sonde: Characterising a Quadcopter for wind speed measurements	23		24
Ruchith Ramakrishnan Devaki	Influence of aerosol-cloud interaction on austral summer precipitation over southern Africa during ENSO events	44		25
Tania Moyikwa	Wind variability along the southern coast of South Africa	39	*	26
Tania Williams	The changing rainfall patterns over Western Cape	48	*	27
Victor Indasi	Climate data in southern Africa: Agreements and contradictions	28	*	28
Zane Dedekind	The effect of prognostic aerosols on simulated stratocumulus over the southeastern Atlantic	21		29

ORAL PRESENTATION AUTHOR INDEX

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ABSTRACTS FROM PEER-REVIEWED CONFERENCE PROCEEDINGS

IN ORDER OF PRESENTATION

Evaluation of the Convective Scale Configurations of the Unified Model

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Abstract

The addition of two convective scale configurations of the Unified Model at the South African Weather Service has led to improvement in both model forecasts and downstream products. Verification statistics of the 1.5 km convective scale model (SA1p5) and 4km convective scale model (SA4) convective scale models has shown that the two models performs better than the 12km model(SA12) . The SA4 configuration performs better than SA1p5 and SA12 when forecasting 2m temperatures. The Contingency Table Statistics shows that the SA4 and SA1p5 configuration has a better skill when forecasting heavy precipitation events compared to SA12. The Gilbert Skill Score shows that SA12 has less or no skill at all for higher precipitation amounts.

Keywords: Verification, Numerical Weather Prediction, Unified Model, Spatial Verification

Dynamic core of the Variable-resolution Cubic Ocean Model (VCOM)

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Abstract

A new global ocean model is currently under development at the CSIR in South Africa, to serve as the ocean component of the Variable-resolution Earth System Model (VRESM). A novel aspect of VRESM is that both its ocean and atmospheric components employ the equi-angular gnomonic-cubic grid. A key computational advantage of this grid system is that it offers quasi-uniform resolution globally, even more so than in the case of the more widely used conformal-cubic grid, and significantly more so than in the case of the latitude-longitude grid. However, use of the equi-angular gnomonic-cubic projection results in a coordinate system that is non-orthoganal, which in turn implies that the primitive equations assume a more complicated form that in the case of orthogonal (e.g. conformal-cubic and latitude-longitude) coordinate systems. In this paper we derive the form that the hyrostatic primitive equations assume on the equi-angular gnomonic-cubic grid for an ocean that satisfies the Boussinesq assumption, thereby obtaining the dynamic core of the new ocean model. Given that the equi-angular gnomonic-cubic grid offers flexible options for high-resolution stretched-grid modelling through the Schmidt transformation, the new ocean model is termed the "Variable-resolution Cubic Ocean Model (VCOM)".

Keywords: Ocean model, Equi-angular gnomonic-cubic-projection, Quasi-uniform resolution, Primitive equations, VCOM.

Tropical Temperate Troughs over Southern Africa as Simulated by a Fully Coupled Model

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Abstract

The formation and development of tropical temperate troughs across southern Africa are investigated to determine the skill of a fully coupled model to simulate these tropical-temperate interactions. Hindcast outgoing long wave radiation data from the Global Seasonal Forecast System version 5 of the UK Met Office is compared to observed data for the months of November to February for the period 1996/1997 to 2009/2010. Overall, model data showed a smaller number of tropical temperate troughs than the observed data. The root mean square error revealed that on a monthly basis the model performs better at shorter lead times than at longer lead times. The monthly performance is also better than the overall seasonal performance.

Keywords: Cloud bands, GloSea5, Heavy rainfall, Metbot, Tropical-extratropical interactions

Simulating the Convective Boundary Layer with a Dynamic Smagorinsky Model

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Abstract

A convective boundary layer is simulated with the Smagorinsky model with different variations of the dynamic Smagorinsky model using different grid spacings. One variation of the dynamic model is scale dependent and is thought to be suitable for the grey zones where large eddies and the grid spacing are of similar size. Shortcomings in the Smagorinsky model at lower resolutions are found in all variations of the dynamic model, while at higher resolution all simulations are similar. The results suggest that the choice of the subgrid model is not important when simulating a convective boundary layer because large eddies dominate the flow.

Keywords: Grey zone, Dynamic model, Atmospheric boundary layer, Large eddy model

Impacts of spectral nudging on the simulation of present-day rainfall patterns over southern Africa

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Abstract

Regional climate models (RCMs) provide finer-scale simulations than those of Global climate models (GCMs), whilst being forced by the output of the host GCMs. In this study, we examine the influence of various strengths of spectral nudging on the simulation rainfall patterns in Southern Africa. We use the Conformal-Cubic Atmospheric Model (CCAM) as RCM to downscale ERA-interim reanalysis data to a resolution of 50 km in the horizontal over the globe. A scale-selective filter (spectral nudging technique) is used for nudging the CCAM simulations. The filter is applied at length scales of 9000 km, and 4500 km. The model simulations of rainfall are compared against CRUTS3.2. Both the experiments realistically simulate the present day rainfall patterns.

Keywords: Regional climate models, Rainfall, Spectral nudging

Wind changes above warm Agulhas Current eddies

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Abstract

Sea-surface temperature (SST), altimetry derived sea-level anomalies (SLA) and surface current are used south of the Agulhas Current to identify warm core mesoscale ocean eddies presenting a distinct SST perturbation superior to 1°C to the surrounding ocean. The analysis of 960 twice daily instantaneous charts of equivalent stability neutral wind speed estimates from the SeaWinds scatterometer onboard the QuikScat satellite collocated with SST during the lifespan of six warm eddies show stronger wind speed above those warm eddies than surrounding water for half of the cases. For cases where the wind is stronger above warm eddies, there is no relationship between the increase in surface wind speed and the SST perturbation. Mean wind increase is about 15 % at 1.8 $m.s^{-1}$. Wind speed increase of 4 to 7 $m.s^{-1}$ above warm eddies is not uncommon. Average eddy radius is 100 km and SST perturbations range from 1°C to 6°C

Towards understanding the impact of assimilating along-track SLA data on simulated eddy characteristics in the Agulhas System

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Nansen Environmental and Remote Center, Norway[4]

Abstract

The impact of assimilating along-track sea level anomaly (SLA) data into a regional Hybrid Coordinate Ocean Model (HYCOM) is investigated with regard to the simulation of mesoscale eddy characteristics in the Agulhas System. Eddy characteristics from an assimilated (*Assim*) and an unassimilated (*Free*) simulation experiment in HYCOM are compared with each other, using satellite altimetry derived eddy characteristics as a basis to evaluate accuracy. Overall, *Assim* yields improvements over *Free* in eddy density distribution and dynamics. South of Madagascar, the number of eddies simulated by both HYCOM experiments is too low, although *Assim* offers some improvements in this regard.

Keywords: Along-track SLA, HYCOM, Mesoscale eddies, Agulhas System, Data assimilation, Satellite altimetry

Summer circulation trends over southern Africa and its adjacent oceans.

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Abstract

The study detects and determines wind speed trends and their drivers between 1980 and 2015 at 10-m and 850 hPa. Trends are detected in the CFSR, MERRA and ERA-Interim data using Theil-Sen and Mann-Kendall methods. Circulation types and their occurrence frequencies are determined using self organising maps. Negative trends dominate in space and magnitude and average -0.19 and -0.36 m s^{-1}/ decade at 10-m and 850 hPa respectively. The trends are moderately linearly associated with the Antarctic and southern oscillation indices and linked to reduced subsidence at 500 hPa and a poleward migration of the subtropical south Atlantic anticyclone.

Keywords: Subtropical Anticyclone, Southern Annular Mode, Intertropical Convergence Zone, Wind speed trends, Angolan low

Preliminary investigation into the impacts of assimilating SST and SLA on the surface velocities in a HYCOM of the Agulhas Current

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Abstract

Data assimilative ocean models play crucial roles in furthering the understanding, and providing forecasts of the Agulhas Current system. This study investigates the impact that assimilating sea surface temperatures (SST) combined with sea level anomalies (SLA) has on the simulated surface velocities of the Agulhas Current in a Hybrid Coordinate Ocean Model. A preliminary comparison of a free running simulation (FREE) and two assimilation experiments, (1) SLA only assimilation ($ASSIM_{SLA}$) and (2) combined SLA and SST assimilation ($ASSIM_{combined}$), indicates that the impact is sensitive to the observed/simulated velocity magnitude in the Agulhas Current, while the mean velocities are overestimated compared to drifter observations.

Keywords: Forecasts, Agulhas Current, Data assimilation, SST, SLA, Surface velocities

Predictability of Rain-Bearing Systems over South Africa by Regional and Global Weather Prediction Models

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Abstract

Five different numerical model forecasts were used to predict daily rainfall totals, with lead times of day 1 and day 2 for the period of January 2011 to March 2015. Corresponding ERA-Int daily 12 UTC 850 hPa circulation and African Rainfall Climatology observed rainfall fields were used to cluster the days into 35 nodes, each assigned to one of 9 rain-bearing systems. Results showed that for all rain-bearing systems and all lead-times the ensemble mean outperformed the individual model forecasts. It was also shown that the forecasts overall had more skill in prediction daily rainfall totals associated with ridging highs and Tropical Temperate Troughs.

Keywords: Rainfall Predictability, Rain-bearing systems, Numerical Weather Prediction, Ensemble Forecasts, SOM, African Rainfall Climatology, ERA-Int

Comparative study of PCA and wavelet-PCA models for simulating monthly rainfall and temperature at Cape Point

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Abstract

31 years of long-term time series analysis of rainfall and temperature data are used for simulating or re-constructing temperature variations and the estimation of rainfall for a weather station at Cape Point. This paper aims at studying the relationship among climatic variables using multivariate techniques such as principal component analysis (PCA) and wavelet-PCA. In this study, we have tested the simulations by dividing the data into two parts, the first 21 years of data were used to train/simulate the model and the rest of 10 years for comparison purpose to test the performance of the simulation. Model performance was evaluated using Correlation Coefficient (R), Root mean square error (RMSE) and Accuracy and Prediction error (PE). The results show that the wavelet-PCA model is comparable with the PCA model which may be attributed to the regularity in the seasonal patterns.

Keywords: Rainfall predictions, Temperature variations, Wavelet analysis, Multivariate methods

Initial Conditions and Quantifying Model Climates: Does it Matter Where We Come from?

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UK Met Office

Abstract

There is no agreed-upon procedure to quantify model climates from their output. Here, we explore differences in characterisations of regional variable climatologies (expressed using probability distributions) that arise when three different climate quantification approaches are applied to the output of an initial condition (IC) ensemble experiment, using a climate system model. We find that that ensemble member trajectories, distinguished in set-up only by the round-off order differences in initial atmospheric temperature, can – over certain regional domains and for particular system ICs – give significantly ([Equation]) different variable probability distributions. Further, using different quantification approaches to capture what might be presumed to be the same "climatic state" – which itself may be influenced by the initial climate system state – can yield significantly different distributions. We conclude that a multivariate distribution, sampled over both time and multiple ensemble members, together with measures of autocorrelation, may serve as a useful quantification approach for model climates.

How does well ECHAM simulate central Africa rainfall seasonal cycle?

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Abstract

Due to poor meteorological observations network over central Africa, water resources are not well evaluated yet. In this paper, we used a state-of-art atmospheric climate model forced by SST (ECHAM version 5.3) to figure out what are mechanisms and how central Africa rainfall are represented in observations in term of spatial distribution, seasonality and intensity. So ECHAM5.3 does well capture the westward (eastward) migration of central Africa rainfall annual cycle as well as its spatial distribution, but it fails to simulate its intensity. However, the seasonal variation of ITCZ location of the thermally-driven central Africa rainfall is controlled either by local and remote latent heat or by low level convergence during strong rainy and dry seasons respectively.

Keywords: Bias; Guinea Gulf; ITCZ location; Latent heat; Moist Static Energy

An assessment of the role of the k-ε vertical mixing scheme in the simulation of Southern Ocean upper dynamics

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Abstract

Following the work done by Reffrey, Calone and Bourdalle-Badie (2015) we implemented a one dimensional(1D) ocean physical model in the sub-Antarctic Southern Ocean using the Nucleus for the European Modelling of the Ocean(NEMO) model. The 1D model is a first attempt at studying sub-grid scale parameterizations in the region. It was used to test the effects of the k-ε turbulence closure scheme on the simulation of vertical mixing in the water column structure in the North Pacific and Southern Ocean, using the available scattered data as comparison. This analysis also gives indications for the choice of the grid's vertical levels.

Keywords: NEMO, Sub-mesoscale Parameterizations, Turbulence Closure Model, Vertical Mixing, Southern Ocean

Comparison of summer and spring carbon dioxide vertical and spatial distribution over the Southwest Indian Ocean Islands using TES data

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Abstract

Southwest Indian Ocean (SWIO) Islands States are vulnerable to environmental hazards, caused by pressure on the environment to satisfy the socio-economic needs of growing human population. The forests of these tropical islands are rich in biodiversity and they are large carbon sinks. Rapid population growth in these islands is identified as one of the main factors responsible for deforestation, which in turn is the main source of carbon dioxide (CO_2) emissions. This study is born from the Agence Universitaire de la Francophonie (AUF) programme called *observation des Risques naturels en Milieux Insulaires (RAMI)*. In this study we contrast the CO_2 3-dimensional atmospheric loading between the wet austral summer and dry spring seasons, and compare the relative CO_2 loading over the Comoros, Madagascar, Reunion and Mauritius islands. We found there is a general shift to higher concentrations from summer to spring season and the CO_2 concentration is highest at the southern part of Madagascar in both seasons. This study also illustrates the influence of source strength and meteorology.

Keywords: Tropical forest deforestation, Carbon dioxide

An Analysis of the Air Dispersion Potential over Uubvlei, Oranjemund, Namibia.

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Abstract

The 800 MW Kudu power project in south-west Namibia is a Combined Cycle Gas Turbine (CCGT) that will use natural gas from the Kudu gas field located in the Atlantic Ocean, 170km off-shore. The Kudu Project aims to respond to the increased power demand in the southern African region and to limit Namibia's importation of energy from South Africa. The proposed site for the CCGT power plant is located at Uubvlei (~25 km north of Oranjemund town). The proximity of the ocean to the proposed site means that it will significantly influence the meteorological factors that have an effect on pollution dispersion in the atmosphere. The overall aim of this paper is to analyse the air pollution characteristics of the study region on the basis of an integral Air Dispersion Potential (ADP) index. This index combines the parameters responsible for the spreading of pollutants in the atmosphere and indicates if the conditions are unfavourable, moderate or favourable for the dispersion of pollutants. The period with the most favourable ADP values is summer during daytime and the most unfavourable conditions for pollution dispersion are found in winter during the night. It was found that overall,

the biggest contributor to favourable dispersion of air pollution in the region is the Monin-Obukhov Length. Wind speed mostly contributes moderately to ADP while mixing height is predominantly unfavourable.

Keywords: Air Quality, Wind Velocity, Monin-Obukhov Length, Atmospheric Stability

The 2015/16 Summer vs the Summers of the last decade

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Abstract

Maximum temperature, minimum temperature and rainfall data of 248 weather stations across South Africa are used to assess the magnitude and spatial distribution of temperature and rainfall anomalies during the 2015/16 summer season relative to the previous 9 summer seasons. The 2015/2016 summer season was characterized by the presence of a very strong El Niño. The months of October and December were especially hot and dry, with 40% of the stations during December associated with maximum temperature anomalies exceeding 4˚C. Rainfall conditions improved during the late summer, with exceptional rainfall anomalies over the western interior during January. Despite the improved rainfall conditions, January and February still experienced anomalously warm conditions over almost the entire country.

Keywords: South Africa, Temperature anomalies, Rainfall anomalies, El Niño

Decision-relevant information on seasonal time scales – the case of a farm in northern Namibia

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Abstract

The potential advantage for a farmer to use seasonal forecasts from models is demonstrated in this case study. The farm is located in the northern regions of Namibia near Grootfontein, where El Niño and La Niña events have in the past been associated with respectively drought and wet seasons. Two forecasting approaches are evaluated: The use of climatological rainfall data collected at the farm over 50 years to provide insight into what a coming summer rainfall season might be like, and the use of robust seasonal forecasting models of varying complexity (statistical and dynamical) to predict seasonal rainfall totals. For both approaches, skill is assessed for three categories that represent the 25th and 75th percentile of the climatological records, i.e. extreme rainfall seasons. Forecasts of the most recent 5 years for the 4-month season of December to March are compared through the use of the Ranked Probability Skill Score (RPSS). It is shown that both the forecast models outscore the use of estimates based on the climatological data of the farm as well as forecasts of climatology, and hence we propose that the farmer may derive greater benefit from using forecasts from models.

Keywords: ENSO, Seasonal climate modelling, Skill

The potential use of CCAM as a meteorological driver to air quality models over the Waterberg-Bojanala Priority Area

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Abstract

This study seeks to assess the ability of the Conformal-Cubic Atmospheric Model (CCAM) in predicting meteorological parameters relevant to air quality studies. CCAM is evaluated against observations from a variety of sources at eight locations in the study area. The variables of interest include temperature, wind speed and rainfall. The CCAM simulations have been performed at a resolution of 8 km. The results show that the model realistically simulated the diurnal cycle in temperature and the onset of stronger winds at most of the locations. The model also realistically portray the seasonal cycle in rainfall over the Waterberg-Bojanala region, although rainfall amounts are overestimated.

Keywords: Meteorological models, Air quality models, Rainfall, Temperature, Wind speed.

Comparative study of OMI BRD and PCA algorithm retrievals in relation to ground based measurements over a South African Site

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Abstract

The Ozone Monitoring Instrument (OMI) on board the National Aeronautics and Space Administration's (NASA) Aura satellite plays a vital role in observing global emissions of ozone and other trace gases since its launch in 2004. Here, a comparative study of two OMI planetary boundary layer (PBL) sulphur dioxide (SO_2) products with Band Residual Difference (BRD) and Principal Component Analysis (PCA) techniques have been studied by estimating their monthly and seasonal variations in relation to their corresponding ground-based (GB) instrument variations located at Sharpeville (27.86 ^{0}E; 26.68 ^{0}S), Gauteng Province, South Africa during the time period from 2007 to 2013. The results showed that PCA retrievals followed similar trend and

overestimated GB SO_2 values, whereas BRD retrievals underestimated them throughout the entire period. The SO_2 overall monthly variations measured by the GB instrument showed maximum values during winter. The daily, monthly regression analysis and seasonal correlation studies have also indicated that PCA technique performed better than BRD algorithm.

Keywords: SO_2 measurements, Satellite, Ground based, Climatology and Comparison

Open water evaporation – quo vadis?

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Abstract

Evaporation estimation is still a challenge for the atmospheric, agricultural and environmental sciences, particularly in the face of climate change. How can evaporation, an important component of the water balance, be measured or estimated routinely with reliable accuracy and precision? Different methods for measuring or estimating evaporation are reviewed. Remote sensing modelling methods have good spatial but poor temporal resolution compared to most other methods that have poor spatial but good temporal resolution. The Monin-Obukhov Similarity Theory (MOST) is applied to open water evaporation and the impact of climate change for differing scenarios is presented using a long-term dataset.

Keywords: Climate change, Eddy covariance, Monin-Obukhov similarity theory, Open water evaporation, Penman-Monteith.

The evolving landscape of Climate Information Websites

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Abstract

Climate Information Websites (CIWs), online platforms providing a variety of climate data and information, have seen a rapid and organic growth, yet with variable content and quality, while unfettered by any code of practice. This builds and ethical-epistemic dilemma (value choices predicated on understanding how we know something) that warrants assessment, since the presence of CIWs contribute to real-world consequences and commitment. We consider the context of CIW growth, and review a representative sample of CIWs to draw out key issues for consideration in CIW development. The net conclusion is that few CIWs approach the standards of robust information, many present substantial hurdles to the user, and in some cases there are clear examples of indefensible and inappropriate practices.

Key words: Climate change, Next-users, Climate services, Climate portals and Value judgements

Improving visualizations of climate projection information

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Abstract

In the complex landscape of climate projections creating meaningful graphical presentations of data is not a trivial task. In the RSA context, the presentations in the most of high profile documents focused on presenting aspects of spatial heterogeneity of the signal, at the expense of the nuanced information on its uncertainty and significance. Here, we present an alternative way of visualizing climate projections that stresses multi-model ensemble agreement and the magnitude of projected change, offers ability to capture the time of emergence, and maintains the ability to discern regional differences in signal.

Keywords: Climate change, visualization, communication, uncertainty

Climate change related impact on avocado production areas in South Africa

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Abstract

Potential changes in avocado production areas over South Africa under future climate change are investigated using six high-resolution projections of a regional climate model. Apart from the climate, the soil also determines whether an area can be suitable for crop production. Here, the national land type database, developed and hosted at the Agricultural Research Council, is employed to complement the climate criteria in delineating avocado production areas under climate change. Southward shifts along the eastern coastal board of the country as well as towards the eastern higher lying areas are projected to be the new areas suitable for avocado production.

Keywords: Climate projections; Crop suitability; GIS; *Persea americana* MILLS

How would current advice benefit maize farmers with respect to historical associations with El Niño events?

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Abstract

We evaluate the potential effect of a range of management decisions that can be taken by maize farmers in the western maize production region of South Africa in response to forecasts of dry conditions founded on the ENSO signal. Recommendations are based on crop simulation results for the period 1953 – 2016. Current typical advice, such as early planting and conservative practices, are evaluated focusing on El Niño years relative to the rest. Findings will contribute to the advice given during fora such as the National Agrometeorological Committee Meetings, aimed at informing best practices before and during growing seasons.

Key words: El Niño, Maize production, South Africa, Seasonal forecast, Crop modelling

Time, space and vector relationships between historical ship log data and Cape Royal Astronomical Observatory wind data between 1834 and 1854.

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Abstract

This project assesses the extent to which Climatological Database for the World's Oceans (CLIWOC) data reflect recently digitized historical wind data from the Royal Astronomical Observatory in Cape Town, South Africa (1834 – 1854). This follows the precipitation reconstructions done by Hannaford *et al.* (2015) using CLIWOC ship log data. Temporal, spatial and vector relationships are established for each season using scatter plot graphs and Pearson correlation. No significant correlation or signal is evident over time, or with a difference in distance. However, seasonality is represented consistently in wind vector distribution. Thus, historical wind data used here are accurate but have no correlation over time and space. This project highlights the major inconsistencies and limitations in the CLIWOC data compared to land based historical data. Researchers in the future should use CLIWOC, or land based data, appropriately to suit the research question.

Anthropogenic Heat Flux in South African Cities: Initial Estimates from the LUCY model

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Abstract

The anthropogenic heat fluxes (AHF) from buildings, transport and people are an essential component of the urban climate within cities. Presently limited information on the AHF in South African cities exists. This study quantifies the AHF in South African cities using the LUCY (Large scale Urban Consumption of energy) model. This initial work provides an important baseline to support developing an improved characterisation of urban heat islands under a changing climate in South African cities.

Key words: Urban Climate; Cities; Urban Heat Island; Climate Change

Recent improvements to the Rapidly Developing Thunderstorm product – the addition of lightning data

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Abstract

The Rapidly Developing Thunderstorms (RDT) product has been operational at the South African Weather Service since 2014, and has proved to be a very useful tool for nowcasting purposes, especially where radar systems are not available or operational. The aim of this work was to test the effect of including lightning data as auxiliary data into the RDT product and to verify this against radar reflectivity over South Africa. The results of 25 cases over South Africa show that the inclusion of lightning data on average improves the POD by 6.6%, the HSS by 4.6% and the FAR by 0.1%.

Keywords: nowcasting, satellite, numerical weather prediction, lightning, data sparse regions

Evaluating WRF's dBZ diagnostic feature on the 28 November 2013 hailstorm over the South-African Highveld

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Abstract

The Weather research and Forecasting model (WRF) is used to simulate a severe storm that occurred in 2013 over the Highveld region, a particular storm on 28 November resulted in over ZAR1,6 billon insurance loss, the most expensive catastrophe in South-Africa to date. A WRF domain of 4km and a nested domain of 1.3km is set-up over the Highveld. ERA-Interim (0.75ºx0.75º) is used to initialize the model. WRF radar reflectivity diagnostic (dBZ) was used as the main evaluation tool of WRF's ability to simulate the occurrence the severe storm. The model was successful in simulating the spatial and temporal presence of high dBZ value for the case study. WRF also simulated to larger scale formation of the storm reasonably well when compared with satellite imagery.

Keywords: Numerical Weather Prediction, dBZ, Hailstorms, Highveld

The application of support vector regression (SVR) for stream flow prediction on the Amazon basin

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Abstract

Long-term forecasting of river runoff is important for climate scientists and hydrologists. By analysing the processes of a river basin characterized by measurable variables, an empirical data-driven model can be constructed. The support vector regression technique is used in this study to analyse historical stream flow occurrences and predict stream flow values for the Amazon basin. Up to twelve month predictions are made and the coefficient of determination and root-mean-square error are used for accuracy assessment. Compared to previous studies, satisfactory results are obtained. Inclusion of environmental aspects such as precipitation and evaporation are suggested for more accurate predictions.

Keywords: Support vector machine, Support vector regression, Amazon basin, Stream flow prediction

The climatology of the stratospheric zonal wind and its wave driving in the SAWS operation seasonal prediction system

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Abstract

Stratospheric circulation during winter and spring is mostly determined by wave activity forcing which propagates from the troposphere to the stratosphere. Eddy-heat fluxes, which contributes to wave activity forcing are to some extent proxy for coupling the troposphere and the stratosphere. This process occurs as heat fluxes propagates from the upper troposphere up into the stratosphere and interact with the stratospheric mean flow. Using eddy diagnostic method, the study reveals that wave forcing is an important mechanism for defining the proper stratosphere and the dynamical coupling thereof. However, this mechanism seems to be absent in the South African Weather Service - SAWS-ECHAM4.5-MOM coupled model. The result shown by the model's wave forcing suggests inconsistencies with regards to the Charney-Drazin wave propagation theory. This shortcoming also affects important stratospheric circulation and dynamics of the model during winter and spring.

Keywords: wave activity, eddy-heat flux, stratosphere, dynamical mechanism

Representation of aerosol particles and associated transport pathways in regional climate modelling in Africa

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Abstract

Aerosol particles can have large impacts on air quality and on the climate system. Regional climate models for Africa have not been well-tested and validated for their representation and simulation of aerosol particles. This study aimed to validate the current representation of aerosol particles in the Conformal Cubic Atmospheric Model (CCAM), using the CMIP5 historical emissions inventory, to monitored data over Africa. In this study, CCAM was used to produce historical regional climate model simulations at 50 km horizontal resolution, globally, through the dynamical downscaling of ERA Interim reanalysis data. CCAM has a prognostic aerosol scheme for organic carbon, black carbon, sulphate, and dust, and non-prognostic sea salt. The aerosol optical depth (AOD) at 550nm from CCAM was compared to the AOD values (observed at 440nm and adjusted to 550nm using the Ångström exponent) from AERONET stations across Africa for 1999-2012. For this validation with AERONET, sites that are strongly impacted by aerosols from natural sources were prioritized. In general, the model captures well the monthly trends of the AERONET data. In addition, a climatology of simulated

aerosol transport during the southern African biomass burning season was developed using self-organizing maps. This presentation will provide, through comparisons to monitored data, a basis for understanding how well aerosol particles are represented over Africa in regional climate modelling using the emissions inventory from the latest Intergovernmental Panel on Climate Change assessment report.

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Keywords*:* Aerosol optical depth, CMIP5 emissions, CCAM, AERONET

Comparison between Aerosol Optical Depth acquired from Sun Photometer and MODIS satellite over Durban

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Abstract

Due to the ubiquitous and inconsistent nature of aerosol loads, multiple instrumentation are required to measure their loads. Long-term, detailed measurements from satellites, ground-based instruments and weather data are required to adequately measure aerosols for a given area. This study uses the preliminary results from the ground-based Durban sun photometer (part of the AERONET federated group) to compare aerosol optical depth at 550 nm (AOD) to the satellite Moderate Resolution Imaging Spectroradiometer (MODIS) for the Aqua, Terra plus Aqua and Terra combined (average of both) datasets for the dark target (DT) and deep blue (DB) retrieval algorithms to validate satellite retrievals. The results show moderate correlations between MODIS Terra and AERONET for both DB (R^2 = 0.70) and DT (R^2 = 0.60), and between MODIS Aqua and AERONET for DB (0.68). Good correlations were noted for MODIS Terra and Aqua merged for both DB (0.79) and DT (0.74). It was concluded that for certain seasons MODIS predicted AOD better than other seasons and that usage of MODIS sensors and recommendations are quite complicated and specific to certain regions.

Key Words: Aerosols, Aerosol Optical Depth, AERONET, MODIS radiometry, dark target, deep blue

SHORT ABSTRACTS

IN ALPHABETICAL ORDER

Application of Radar Data at the South Africa Weather Service

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Abstract

Over the past few years the South African Weather Service (SAWS) has invested a lot of time and money into the improvement of radar based applications. The SAWS radar network was upgraded with 10 Gematronik Meteor 600S S-band radars during 2010-2012, bringing the network total to 14 radars. Currently, two international projects opened the doors for various collaborations with international partners, which significantly improved how radar data can be used. The first project, Rain for Africa (R4A), is funded by the Dutch government and aims to reach smallholding farmers in rural Africa and provide them with the necessary information to improve their crop yield. The second project is the World Meteorological Organization's Aviation Research and Development Project (AvRDP), which was initiated in an effort to improve nowcasting for aviation applications. Oliver Tambo International Airport (ORTIA) in Johannesburg, South Africa, was selected as one of the participating airports in this project.

One of the deliverables of the R4A project is to establish a high quality Quantitative Precipitation Estimation (QPE) product using radar data. Collaboration with the Dutch Weather Service, KNMI, has resulted in the implementation of calibration monitoring software to monitor antenna alignment and radar performance. SCOUT radar processing software (developed by Hydro&Meteo in Germany) is used to handle Quality Control (QC) processes on the raw radar data. The existing QPE algorithm was updated to include precipitation classification with dual Z-R relationships, and the use of Optical Flow vectors to smooth temporal biases within accumulations.
The AvRDP project will investigate improvements of convective rainfall nowcasting cases over ORTIA. With the help of the Hong Kong Observatory (HKO), the community version of SWIRLS (Short-range Warning of Intense Rainstorms in Localized Systems), or com-SWIRLS are being tested over the ORTIA domain. In this presentation the advances with SAWS radar data will be demonstrated together with verified results. It is hoped the successful implementation of the QPE algorithm and com-SWIRLS will pave the way forward for improved nowcasting tools using radar data.

Covariability of remote and local climate forcings and South African winter climate predictability

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Abstract

Observational and numerical studies noted the importance of midlatitude atmospheric variability notably in connection of the Southern Annular Mode (SAM) on South African austral winter variability. However, understanding the interaction and covariability of various relevant climate forcings, the role they play in modulating local climate variability and their potential predictability, are not extensively studied in manner that conclusively overcome the challenges operational or research institutions like the SAWS (South African Weather Service) are facing to confidently inform climate sensitive sectors of the economy to make informed

decisions. It is a common knowledge that climate models' ability to offer useful information on the likelihood of austral inter climate in South Africa is substantially crippled due to lack of plausible teleconnection physics in climate models. This circumstance presents the flavour of test how the next generation of Earth System Models (ESM) address the drawback.

This ongoing study is primarily aimed at investigating the interaction of modes of climate variability and their associations with dominant dynamical synoptic structures in space-time continuum. With this in mind, we extensively examined the covariability behaviour of the SAM, ENSO, sub-tropical jet meriodioanal, position and rainfall using pairwise wavelet analysis. In addition, the southern hemisphere observed (330K isentropic level) potential vorticity (PV; by placing more emphasis on the south Atlantic basin) was subjected to self-organizing maps (SOM) analysis to investigate the dynamical behaviour of midlatitude storm tracts and identify dominant synoptic patterns that may associate to these slowly evolving models of climate variability.

The preliminary results suggest that the SAM and winter rainfall region of South African rainfall exhibit noticeable covariabilty in 4-6yrs cycle with fairly reasonable positive correlation. In the 6-12 months period, however, they tend to show invers association. The result further suggests that at the sub-seasonal to seasonal timescales, not tangible coherence is traceable though they manifest some periodicity characteristics independently. The other aspect worth emphasizing is that the SAM underwent a shift from 4-6yrs to 1-2yrs period of significant power in early 2000s and 2010s. In addition, the SOM analysis identified different distinctive synoptic features.

In conclusion, the study has provided useful insight into the coupling of the SAM and austral winter rainfall at various timescales. It is shown that the SAM is found to influence the rainfall variability at two distinct spectral bands. Various synoptic dynamical atmospheric features have also been identified that suggest how and when the vortices may be confined within the polar region or penetrates deep into the sub-continent. The notion has been applied at the SAWS for the last couple of years to contemplate the most probable expectation of winter season at reasonable lead-time with a promising outcome. Similar analysis on other modes of climate variability such as ENSO and their teleconnection is underway.

Key words: SAM, ENSO, Austral winter, South Africa, Teleconnection, Storm tracks

Spatio-temporal variability of rainfall and impacts on vegetation in Reunion Island

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Abstract

Reunion Island is located in the southwest Indian Ocean with a diverse climatological context weakened by the consequences of global warming. The rugged terrain and the exposure to the east-west trade winds explain the abundance of microclimates on the island.

The first objective of this study was to attempt to characterize the spatiotemporal variability of rainfall in La Reunion. The results of the identification of discontinuities in rainfall data series and drought indices highlight two different geographic situations. On the west, leeward coast, discontinuity in the rainfall series occurred between 1980 and 1989. It shows a significant decline in annual rainfall amounts (between 14 and 32%). On the east, windward coast, the discontinuities dates are variables (mainly between 1968 and 1972). There is only a small decrease or even an increase in the annual rainfall amounts. By observing the length of the rainy season, the imbalance between the windward coast's climate and the leeward coast's is extended. It is very short on the

west coast since 2006 whereas the rainy season is difficult to separate from the dry season on the east coast because of the very important rainfall amounts throughout the year.

As the areas of forest and grassland are falling steadily, a study of the impact of the rainfall spatiotemporal variability has to be done. Consequently, the second objective of this study was to measure of the co-variation between “rain” and “NDVI”. We used remote sensing methods using MODIS low-resolution images from 2000 to 2013. Results show that vegetative sets on the west of the island, which are often affected the water stress, respond well to rainfall changes. However, those on the east coast are less sensitive to a decrease or an increase in rainfall amounts. Nevertheless, the correlation coefficient has medium intensity with a maximum value ranging from 0,3 to 0,4. Yet, a multivariate analysis shows that the value of these coefficients is mainly due to the heterogeneous landscape of La Reunion.

Key words: Climate variability, rainfall, microclimates, NDVI, Reunion Island, MODIS.

Evolution of the 2015/16 El Niño drought: circulation anomalies, heat waves and impacts in southern Africa

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Abstract

Whilst the 2015/16 El Niño was virtually tied to the 1997/98 event, its evolution and impacts in southern Africa are not comparable. We analyze the temperature, rainfall and circulation anomalies that characterized the 2015/16 drought season using station and reanalysis data. Composite analysis is used to analyze the drought impacts at monthly, sub-seasonal and seasonal timescales. Positive SST anomalies (>2°C) spread toward the eastern equatorial Pacific between June and September 2015 reaching a peak (>3°C) during December. Repeated heat wave conditions characterized much of the subcontinent with land surface temperature anomalies >10°C. Anticyclonic wind anomalies, an absent Angola Low and the failure of surface ridging anticyclones over the southeast coast resulted in westerly wind anomalies and a reduced moisture flux from the SW Indian Ocean. The prevailing surface winds were therefore continental, dry and warm. It is argued that whilst the mid-tropospheric Botswana High was intense and persistent, the main synoptic drivers of drought were at the surface as the thermodynamic fields were not favorable for uplift and cloud development. Large areas of the summer rainfall region (south of 12°S) experienced below average rainfall with fewer rainy days and longer dry spells. As typical with an El Niño season, tropical cyclone activity was subdued with no landfall or cyclogenesis in the Mozambique Channel. The land under cultivation was significantly reduced and most of the early crops wilted. Whilst the 2015/16 drought had greater impact than the 1997/98 season, the 1991/92 event remains the most severe drought to have affected the region. Results of this study contribute to understanding El Niño induced droughts and how affected communities may build resilience and adapt to a changing climate.

Keywords: Drought, Heat waves, Ridging highs, El Niño, Southern Africa

Climate change and extreme weather events in Southern Africa: can countries adapt?

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Abstract

Globally, the frequency, extent and severity of climate-related disasters have increased notably over the last several years and account for upwards of 80% of the reported natural disasters worldwide. In southern Africa weather related events account for the largest percentage (67%) of natural disaster deaths with the most common events being floods, storm surges, droughts, and wildfires. Based on data from the Centre for Research on the Epidemiology of Disasters (CRED)/Emergency Events Database (EM-DAT), this report estimates that over the past four decades (1980-2015) weather-related disasters in SADC have resulted in damages in the region of 10 billion USD and have left 2.47 million people homeless and affected an estimated 140 million people[1]. Climate change is projected to increase the frequency and magnitude of extreme weather events [Field], which, without reductions in vulnerability, will increase the risk of disasters. Southern Africa is widely recognised as one of the most vulnerable regions, because of low levels of adaptive capacity, particularly among rural communities. Investments into developing countries in SADC have in the past been more focused on the reactive recovery from a disaster and on crisis management rather than on the improvement of adaptive capacity. It is being increasingly argued that climate change adaptation (CCA) and disaster risk management (DRM) need to be integrated in order to build the resilience of affected communities. Both approaches aim to mitigate climate-related risks by reducing and modifying environmental and human factors in order to support sustainable economic and social development. Climate finance mechanisms provide an opportunity for the investment in to proactive disaster risk management (DRM) measures, which are aligned with climate change adaptation programs. Addressing the preparedness, readiness and response to disasters, while adapting to climate change, is essential and needs to be a priority area for planning and policy development in SADC.

Keywords: Drought, Floods, Wildfire, Storm surges, Disaster risk management, Climate finance

The effect of prognostic aerosols on simulated stratocumulus over the south-eastern Atlantic

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Abstract

The largest contributions of uncertainty in Earth's changing energy budget originate in the form of aerosols and clouds. Large amounts of solar radiation are reflected back into space by stratus and stratocumulus clouds. Due to a large amount aerosols being transported into the vicinity of the stratocumulus cloud deck, off the coast of Namibia, it is unclear of how the aerosols indirectly affects cloud development. The direct effects of aerosols to the radiation budget are much better understood. The sensitivity of the Conformal Cubic Atmospheric Model (CCAM) is tested to study the response of simulated stratocumulus, during the southern African biomass burning season from July to October, with and without prognostic aerosols using the CMIP5 historical emissions inventory. CCAM has a prognostic aerosol scheme for organic carbon, black carbon, sulphate, and dust, and non-prognostic sea salt. ERA Interim reanalysis data was used to dynamically downscale CCAM to a resolution of 50 km in the horizontal. CCAM was nudged every 6 hours to specifically address indirect effects of aerosols on clouds. The stratus climatology simulations from 1979 to 2012 with and without aerosols are

highly correlated. There are some minor differences seen in the south-eastern Atlantic close to Angola. The no aerosol simulation shows an increase in stratocumulus cloud, but since these differences are so small between simulations it is negligible. Self-Organising Maps were used to investigate the finer scales differences in the simulations.
Keywords: Namibia, CCAM, Simulations, Low-cloud

Air-Sea interactions over the Angola-Benguela Frontal Zone and their effects on regional atmospheric circulation.

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Abstract

The Angola-Benguela frontal zone (ABZF) has been identified as a key region for Southern Africa climate variability. It has been shown that both oceanic and atmospheric variability of this area controlled local and remote key aspects of the climate. In particular, atmospheric convection and moisture fluxes drive rainfall variability over the Southern African continent [Reason et al., 2002]. Since the past decade, several studies have shown the importance of mesoscale air-sea interactions for local convection, cloud formation and wind adjustments [Xie, 2004 ; O'Neill et al., 2003 ; 2016]. In particular, Sea Surface Temperature (SST) changes lead to deep convection, which in turn exites the dynamics response of first baroclinic mode structure with strong surface wind signals [Xie, 2004]. Businger and Shaw [1984, see the schematic diagram in their Fig. 10] earlier sketched several interactions of eddy SST imprints with the atmospheric boundary layer, and numerous studies have clearly evidenced air-sea couplings over oceanic mesoscale coherent structures. Small-scale SST features are of primary importance on the air-sea fluxes, impacting the overlying marine atmospheric boundary layer (MABL) with possible consequences on the regional atmospheric circulation [O'Neill et al., 2003]. The thermal feedback to the atmosphere has been recently studied [e.g., Spall, 2007, Perlin et al., 2007 ; 2011 ; Minobe et al., 2008] : SST gradients induce gradients in lower-atmospheric stratification; hence, gradients in vertical momentum flux in the atmospheric boundary layer and gradients in the surface wind. Chelton et al. [2004 ; 2007], using satellite observations, show approximately linear relationships between the surface stress curl (divergence) and the crosswind (downwind) components of the local SST gradient. Recent studies also highlight how mesoscale SST front may have an impact up to the troposphere [Minobe et al., 2008]. To our knowledge, the effects of mesoscale SST dynamics on the surface wind speed has not been yet studied in the ABZF region. The present study outlines two of the main coupling mechanisms (see Small et al. [2008] for details), (i) changes in the near-surface stability and surface wind, and (ii) secondary circulations associated with perturbations in the surface atmospheric pressure over the SST fronts. Coupling processes are investigated with satellite data. This study employs wind retrievals from the SeaWinds scatterometer on board QuikSCAT and covers the period from 2000 to 2009. The temperature dataset used is the Reynolds SST [Reynolds et al., 2007], which is a reconstruction by optimal interpolation of daily SST fields derived from two high-resolution datatsets : Advanced Very High Resolution Radiometer (AVHRR) and Advanced Microwave Scanning Radiometer (AMSR). Turbulent heat fluxes from Bentamy et al. [2013] are also used. We notably show that the wind over ABZF is mainly impacted by the secondary circulation associated with surface atmospheric pressure perturbations due to SST front. An atmospheric model is then used (WRF, Skamarock et al., 2008) to assess the sensitivity of the regional atmospheric circulation to ocean dynamics. We show that the frontal zone could impact the moisture fluxes that reach the continent and the water vapor content of the Angola-Low pressure system. This latter is an important features for tropical-extra-tropical interactions and rainfall variability over the Southern Africa.

KEYWORDS : Air-Sea interactions, Mesoscale dynamics, Convection, Moisture Fluxes, Rainfall Variability.

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Investigating the regime of the South-West Indian Ocean Currents and through a numerical model.

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Abstract

The South-West Indian Ocean (SWIO) is a complex system consisting with a particular interest because it includes one of the three major source regions of the Agulhas Current, the East Madagascar Current (EMC). Variability in the EMC is known to influence the timing of ring formation at the Agulhas Retroflection, and ultimately the strength and stability of the Atlantic overturning circulation due to the leakage of water from the Indian Ocean into the Atlantic Ocean. The termination regime of the EMC, after passing the southern tip of Madagascar has not been completely resolved. Whether or not a possible non-persistent retroflection exists, it is however known that nearly symmetric dipolar vortex pairs joins the Agulhas Current from the southern tip. Its variability can also be impacted by the high eddy kinetic energy (EKE) band observed at 25°S, from Australia to Madagascar. Also occurring in this region is the shallow eastward flow known as the South Indian Ocean Countercurrent (SICC) and one of the largest dendroid phytoplankton blooms in the world, the Southeast Madagascar bloom.

This unique system, where variability of the termination regime of the EMC, associated with complex mechanisms of the SICC and mesoscale eddies, will be investigated using a high resolution regional model.

We will discuss the eddy characteristics of the mesoscale eddies in the high EKE band, with a section on its seasonality, as well as the eddy-current interaction which influence largely the variability of the EMC. In doing so, the fate of the termination regime of the EMC could be resolved. We will also analyse how eddies could influence the onset of the South-east Madagascar Phytoplankton bloom. These plankton cells, which bloom at the surface or which are upwelled from the deep chlorophyll maximum, have been shown from a cruise data to be nitrogen-fixers. This study will explore the possibility of nutrient being advected in the bloom area, and the complex mechanisms which cause the phytoplankton cells to use these nutrients, hence triggering the bloom at various spots simultaneously.

Keywords: Eddy characteristics, Eddy-current Interaction, Lagrangian study, Upwelling, Chlorophyll bloom

Toward a UAV Sonde: Characterising a Quadcopter for wind speed measurements.

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Christo Le Roux, Intermet International
Bruce Hewitson, Climate Systems Analysis Group, University of Cape Town
Chris Jack, Climate Systems Analysis Group, University of Cape Town

Abstract

Measurements from boundary layer atmospheric conditions are an important input in climate and weather modelling. The use of balloon based systems does not provide sufficient resolution within the boundary layer. Unmanned Aerial Vehicle [UAV] based systems are of interest in providing higher resolution measurements with greater temporal and spatial control. The UAV can carry instrumentation to measure diverse parameters including temperature, humidity and pressure. This is easily extended to include more specialised sensors for pollutant or gas composition measurement. However, wind speed and direction remain elusive. This poster will present work in progress deriving wind speed measurements from a quadcopter's inertial measurement unit

[IMU]. The IMU provides accelerometer and gyrometer measurements that are used to control the copter's flight. The lean angle of the copter is proportional to the air speed of the copter. This lean angle is used to derive a unit vector proportional to the air speed of the copter. The air speed, ground speed and wind speed may be related to each other via vector summation. Since the ground speed and direction may be obtained from GPS output in the copter logs the wind speed can be derived if the the air speed is known. A method for calibrating the copter to allow the unit vector for the air speed to be scaled to represent air speed is presented here.

Mesoscale dynamics in the Western Indian Ocean (Focus on the Southern Gyre): A numerical investigation using ROMS

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Abstract

The Southern Gyre (SG) is a persistent cyclonic mesoscale eddy that is observed seasonally in the western Indian Ocean during the summer monsoon (June–July–August) at a quasi-steady location near the equator. Its dynamics remain unclear despite playing a role in transporting water masses and other properties northwards across the equator. Here, the Regional Ocean Modeling System (ROMS) is applied to investigate characterist ics of the Southern Gyre which is not well resolved by sparse available in -situ measurements in the region. The circulation indicative of the Southern Gyre is found to appear on average in May about one month before the start of the summer (SW) monsoon and is consistent with arrival of the annual Rossby waves at the western boundary near 4°S. Westerly winds during the March-May season over the central and eastern equatorial Indian Ocean force successive planetary waves westward at speeds of 0.15 m. s^{-1}. The Southern Gyre peaks throughout July and August, while moving northward but it is not deep reaching with maximu m velocities of about 0.5 m. s^{-1}. The present investigation identifies the development of positive vorticity bursts which are identified as poten tial actors in the weakening and dissipation of the Southern Gyre.

Keywords: Southern Gyre, Northwest Indian Ocean, Monsoon, Regional Ocean Modeling System

The contribution of fog to the biogeography of *Arthraerua Leubnitziae* in the Central Namib Desert.

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Abstract

Fog is a key service provider to the diverse coastal Namib Desert biota delivering five times more moisture than rain. Apart from the importance of fog as a source of water for plants, it is also associated with particulates that may contain essential nutrients for plants. Furthermore, dry deposition can be an important input of nutrients to many ecosystems, but without water dust deposited on leaves or on soil is inaccessible for plant uptake. In other studies of coastal ecosystems (Strandveld) it has been found that this combined deposition of nutrients represents a major source of nutrients to terrestrial ecosystems. In this case, the plants decreased inland, with the range of the species being limited to those areas where fog occurs.

Meteorological data from the SASSCAL funded FogNet array of stations based at Gobabeb were used. The stations are located in perpendicular transects, seven from near the coast to 100 km inland at 1000 m elevation and four from Gobabeb northward at 400-500 m elevation. FogNet aims at contributing to these knowledge gaps

by observing fog precipitation (FP) within a network of 10 meteorological stations arranged in a west-east and a north-south transect in the Central Namib. So-called Juvik cylinders are used as fog collectors mounted above rain gauges to measure FP. Further measurements include wind speed and wind direction, net and global radiation, air temperature and relative humidity, precipitation, soil moisture and soil temperature, and a leaf wetness sensor
This study investigated the plant morphological and physiological attributes of *A. leubnitziae* (Amarenthaceae) to determine whether these contribute to fog interception and the uptake of water and nutrients. Some of the other attributes of the plants investigated include canopy properties (leaf area per stem area), stem properties, the ability to take up foliar applied deuterium-labeled water, tissue elemental concentrations and tissue water, C and N isotopes. Elemental and isotopic composition of the soils along the transect were also measured. *Arthraerua leubnitziae* was found to use fog water and nutrients therein. Future research plans are aimed at quantifying fog water use.

Keywords: Fog water, vegetation, elemental composition, Isotopes, SASSCAL

The spatial distribution and variability of organised convection over southern Africa as represented by cold cloud duration

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Abstract

Organised convection, such as mesoscale convective systems and complexes are common to the meteorology of the tropics and to a lesser extent the subtropics. Intense and widespread rainfall associated with these systems is important for wet seasons totals, and often associated with local flooding. Convective-permitting numerical weather prediction and climate simulation development is proceeding rapidly and starting to offer the potential to predict and quantify the present and future climate of mesoscale convection for regions of interest. However, this model development will require credible observations with which to confront the numerical solutions. In regions as vast as southern Africa, station data is sparse and radar coverage too low, hence the need for satellite-derived observations.

Cold cloud duration (CCD), as computed from geostationary satellite-derived brightness temperature, provides a useful indication of the intensity and duration of strongly convective cloud. CCD is used routinely in algorithms that estimate rainfall over Africa, such as provided by the TAMSAT* research group (Grimes et al 1999). This study uses daily CCD computed on a 4km grid from 1983-present. In order to consider organised convection a convective coverage metric is introduced which computes the area of a 1° radius spherical cap which contains a convective cloud with a temperature below a cold cloud threshold, for a predetermined duration. The metric expresses the ratio between this area and the total area of the spherical cap. This convective coverage metric is computed across Africa, providing a measure of large-scale organised convective activity.

The climatology of convective coverage is computed across southern Africa and the monthly progression is presented for austral summer. Standard deviation of convective coverage in each month provides an indication of the local variability in widespread convective activity. As may be expected, the areas on margins of the core convective regions exhibit the most variability. This is particularly pronounced in the core summer months in an east-west band across northern Namibia and into Malawi, Mozambique and southern Tanzania. The composite response in El-Niño years has spatial and temporal heterogeneity. Nevertheless, during December a clear signal emerges of reduced convective coverage across Zambia and Zimbabwe with enhanced wide-spread convection across Tanzania.

In conclusion, this study presents the development of an organised convection climatology with which to confront convective-permitting climate simulations, and research into the variability of convective activity across southern Africa.

*Tropical Applications of Meteorology using Satellite data and ground-based observations (TAMSAT)

Keywords: Model evaluation, tropical convection, satellite data, organised convection

Upper-level jets and eddies associated with tropical-extratropical cloud bands over southern Africa: The seasonal cycle

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Abstract

The seasonal cycle of rainfall over southern Africa is well described. As summer develops, the region of frequent tropical convection moves south until much of tropical southern Africa receives regular convective rainfall. In the subtropics large northwest to southeast bands of rainfall occur regularly, contributing much of the annual rainfall to large swaths of semi-arid regions. Known locally as tropical temperate troughs (TTTs), these cloud bands contribute a substantial proportion of rainfall, especially in the more arid regions of southern Africa. Heavy rainfall and local flooding is often associated with the deep convection embedded in these cloud bands. Dynamically, these systems are a class of tropical-extratropical interaction and previous literature has established that troughs in the upper-level westerly flow are necessary for their development however, not sufficient.

Variation in the occurrence of these weather systems has been linked to regional rainfall variability. This variability can be thought of in terms of different evolutions of individual seasons. Recent work has shown that there is an asymmetric distribution in the climatological frequency of TTTs, with peak occurrence in early summer over the subcontinent and mid- to late summer over the southwest Indian Ocean. The dynamics underlying this seasonal cycle remain poorly explored and thus there is limited context within which to assess natural variations or forced perturbations of the TTT climatology. This study provides a fuller diagnosis of one aspect of the seasonal cycle over southern Africa, the upper-level westerly flow.

Upper-level flow is one of the key synoptic controls on the timing and location of subtropical precipitation, and in turn is influenced by this precipitation and the associated heating. In this work, particular attention is given to the way eddies interact with the seasonally evolving mean state, and how this relates to TTT formation during summer months. To this end the flow is separated into fast (eddy) and slowly-varying components. The slowly-varying mean state is diagnosed by the monthly distribution of subtropical and eddy-driven jet axes and the zonally asymmetric 200hPa flow field. Eddies associated with TTT formation are consider by compositing for events flagged using an objective TTT identification methodology. Furthermore, we quantify the eddy kinetic energy of these events and the strength of the mean state flow within which each event develops.

The above analysis is computed for seasons with neutral El-Niño Southern Oscillation (ENSO) conditions. Perturbations to this seasonal cycle are considered for positive and negative phase ENSO seasons. Finally, we discuss implications for the diagnosis of climate model simulations.

Keywords
Tropical-extratropical interaction, rainfall variability, seasonal cycle, dynamical processes

Aeolian dust emission from the Namib Desert: local-scale erodibility controls

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Abstract

Satellite imagery has been used extensively in the study of dust from the late 1990s with important contributions being made in terms of sources, transport pathways and deposition areas. However, modelling of mineral dust emissions remains a challenge given the coarse spatial and temporal resolution of the data on which these models are based. The Namib Desert has been identified as one of the largest sources of dust in the southern hemisphere with the aid of MODIS imagery, with emissions from the ephemeral river valleys caused by the erosive Bergwind playing a pivotal role during morning hours. The opening of the Landsat archive, and its morning overpass, presents the opportunity to investigate these events at a higher spatial resolution (up to 15 X 15 m) than previously possible. Landsat identified 37 major dust episodes over the last 25 years that originated primarily from the ephemeral valleys. Examination of the imagery enabled the identification of local-scale source points to direct ground based testing of the surfaces responsible for dust emission. Emissivity tests were undertaken using a Pi-Swerl portable wind tunnel both on erodible and control surfaces in order to determine the micro-scale surface characteristics that control erodibility. The dust frequency record for this region using MODIS was extended to 2015 to provide an 11-year record. Era-interim and SASSCAL data for the corresponding period was used to determine some of the environmental variables that play a role in dust emission. Combining the high spatial resolution remote sensing data from Landsat, with high temporal resolution data from MODIS and climate data obtained from Era-interim and SASSCAL, with Pi-Swerl measurements and surface erodibility variables, provided the opportunity to explore interrelationships between variables controlling emissivity. Based on the Era-interim 10m wind data, dust was detected with remote sensing for only 15.8 % of the wind events of sufficient magnitude to produce dust. This is in part due to the temporal, spatial and spectral characteristics of the satellite sensors used to detect dust. However the environmental conditions and characteristics of desert surfaces that control dust emission also play a vital role. A boosted regression tree (BRT) analysis found that some of the most influential surface variables that control emission are the presence of a supply source of sediments with a platykurtic particle size distribution, gravel cover, moisture content and the presence of sand for saltation. The analysis of SASSCAL data reveal that these surface characteristics combined with high magnitude, low humidity wind events of sufficient duration result in the emission of dust.

In addition, the local-scale source points covering a 25-year period made it possible to study the evolution of dust emission from these systems, with modification of the hydrological systems playing a significant role. Our findings suggest that surface disruption by humans plays a major role in the dust emission dynamics of the region. Some field areas have been heavily impacted by human activity especially with regard to their hydrological regime, and our data confirm the significant influence this has on dust emission potential. We also find that disruption of the stable gravel plain stone pavements as a result of development and tourism has a demonstrative impact on dust emissions and this presents a significant challenge for future land management of the region. These results will provide an important contribution towards attempts to model dust and determine the impacts and significance of dust from this region. Further field campaigns to measure and sample dust will provide important contributions to our understanding of dust emission.

Keywords: Landsat, MODIS, Remote sensing, Climate data, Pi-Swerl

Linking malaria in Limpopo, South Africa to climate using self-organizing maps

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Abstract

Global malaria cases have drastically dropped in recent years, however there is still high incidence in northeastern provinces of South Africa (Limpopo province) with seasonal transmission of malaria. Past studies have reported various relationships between malaria and climatic factors. The aim of this study is to investigate patterns in malaria incidence in Limpopo and explore the seasonal and spatial association to climate variables. Self-organizing maps were used to find patterns in malaria incidence based on case data. Composite analysis showed different climate patterns that associated to high and low incidence events. Precipitation was a key factor for high malaria incidence in all seasons, especially in neighboring countries such as Mozambique at two- to three-months lag, in addition to strong easterly winds over Mozambique Channel at two-month lag. However, the association of malaria incidence to temperature was different depending on the season. Composite maps of sea surface temperature anomaly showed La Niña patterns associating to high malaria incidence in Sep-Nov, and Indian Ocean Subtropical Dipole patterns in Dec-Feb. Links of malaria incidence to lagged climate factors suggest the importance of local climate as well as that of neighbouring countries, implying that there is a need for strengthening cross-border malaria control management to minimize the spread of malaria.

Keywords: Composite analysis, Spatio-seasonal analysis, La Niña, Indian Ocean Subtropical Dipole

Climate data in Southern Africa: agreements and contradictions

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Abstract

Climate affects all sectors of the economy across the world, with varying degrees of sensitivity and vulnerability, yet our understanding of the climate systems is often hindered by the availability of high quality data. Although several station-based datasets collected and archived by various local weather agencies exist, there has been a decline in the number of these station datasets that are publicly available, mainly due in insufficient resources, as well as a tendency by country meteorological services to restrict free access to the data. The implications on climate science and climate-impact studies are hard to quantify but almost certainly significant. This study presents long-term climate statistics and trends from eighteen freely available datasets and discusses the agreements and contradictions in trends. These findings forms part of the ongoing research activities within the FCFA FRACTAL project on climate change and urban resilience.

Key words: Climate data, Agreements and Contradictions.

Topographic effects on the wind field in False Bay

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Abstract

The wind in False Bay, South Africa, is governed by the interactions of large scale weather systems and rugged coastal topography – Table Mountain and the Cape Peninsula to the west of the bay and the Hottentots Holland and Kogelberg mountain ranges to the east. An understanding of the dynamical mechanisms of topographic forcing, which produce considerable temporal and spatial complexity in the wind field, is relevant to a number of applications – including regional weather forecasting, assessments of wind energy potential, wildfire modelling, and numerical modelling of the sea state and circulation within the bay. The present study uses the Weather Research and Forecasting (WRF) atmospheric model to investigate the interactions of mesoscale flows with local topography under two different, but common, synoptic events – the passage of a cold front associated with a low pressure system giving rise to strong NW wind conditions, and an anticyclone ridging to the south of the continent producing strong SE winds. The research relates model predictions to those of a number of idealised studies of flow over mountains, which have explored orographic effects such as mountain waves, downslope winds, and flow splitting and blocking. The model results show that the strength of the blocking effect of Table Mountain in the case of NW – and Kogelberg in the case of SE – winds is related to the nondimensional mountain height given by the Froude number [Equation], where [Equation] is the Brunt-Väisälä frequency, [Equation] the mountain height, and [Equation] the flow speed. In particular, higher Froude numbers (due to lower wind speeds) are associated with upstream flow splitting and more pronounced blocking. Under NW flow – in which wind speeds increase with altitude – Table Mountain additionally acts to produce mountain waves that propagate across False Bay. In contrast, SE flow – which is shallow (with wind speed maxima between 500m and 1000m) under the given synoptic conditions – interacts with the topography in a more complicated way. Severe downslope windstorms occur in the lee of two peaks in the Kogelberg range, producing two characteristic lobes of high surface wind speed pointing in a WNW direction across False Bay. These high winds, however, are largely blocked by the combined effect of the Cape Peninsula mountains and mesoscale flow that accelerates around Cape Hangklip and veers northwards along the western edge of the bay. In summary, the research demonstrates the importance of a variety of topographic forcing mechanisms in determining well-known characteristic features of the wind field in False Bay under two commonly occurring synoptic regimes.
Keywords: WRF, Numerical modelling, Froude number

Representation of Tropical Temperate Troughs over southern Africa in coupled climate models

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Abstract

Climate model projections are increasingly being used for adaptation planning, in spite of large biases in their mean climate, and divergence between models in terms of future change. If climate scientists are to support decision making, it is important to better understand how climate models behave over regions of interest. Analysis of important processes in each region has the potential to inform model development and confidence assessments (James et al. 2016).

In the case of southern Africa, Tropical Temperate Troughs (TTTs) are a good target for evaluation, since they play an important role in generating precipitation over southern Africa, particularly heavy precipitation events. TTTs might also be a good indicator of the credibility of modelled regional dynamics: the location of tropical convection, storm tracks, subtropical highs, and the Angola low all influence the formation of Tropical-Temperate Cloud Bands (TTCBs). Previous work has suggested that climate models simulate TTT-like variability using principal component or cluster analysis. Here we directly identify TTCBs from daily OLR data, enabling analysis of their frequency, spatial distribution, annual cycle, and associated weather phenomena.

The analysis is based on an automated cloud band identification algorithm, developed by Hart et al. (2012) to flag and track TTT systems. Contiguous regions of low OLR which have sufficient latitudinal extent and positive tilt (NW-SE orientation) are flagged as TTCBs, and then data from the preceding and subsequent days are analysed to characterise the life cycle of the TTT event. TTTs are identified in satellite-derived OLR data and data from coupled climate models, with a particular focus on the Met Office Unified Model, as part of a four year effort to improve its ability to simulate African climate (the IMPALA project, www.futureclimateafrica.org).

The models exhibit important differences in terms of the number of TTTs simulated, and their seasonal cycle. The Unified Model (HadGEM3-GC2) generates TTTs with a similar spatial signature as in satellite data, but with almost double the number of events: over 3000 in 35 years. The model also produces too much rainfall associated with TTTs and this may partly explain its wet bias over southern Africa. The number of TTTs is especially large over Madagascar and the Indian Ocean, where the model is known to have a particularly large wet bias and exaggerated convection. Over the continent of southern Africa there is a marked difference in the seasonal cycle of events between the model and satellite data. In the satellite data, TTTs are summer phenomenon, peaking with the onset of the rainfall season in November. In contrast, HadGEM3-GC2 produces TTTs throughout the year, including during winter, implying differences in terms of the mechanisms for rainy season onset.

These results imply that TTTs might be an important determinant of model performance over southern Africa. Further analysis will seek to identify how TTTs are generated in models and, depending on how this compares with our observed understanding of TTTs, the extent to which models can reliably simulate TTT-related variability, and changes in TTTs in future (the UMFULA project, www.futureclimateafrica.org). In the meantime, the distinction between HadGEM3-GC2 and satellite data in terms of the onset of the rainfall season would imply caution in application of future projections: many models suggest that climate change will lead to drying in November, and a delay in the onset of summer rainfall. Further work to understand the processes associated with this change is important before this can be considered a reliable projection.

Keywords: Model evaluation, Tropical-extratropical interaction, General Circulation Models, Outgoing Longwave Radiation

Trace metal concentration and solubility of aerosols from southern African sources transported over the Oceans.

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Abstract

The Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT) was used to create seasonal climatologies (2005-2008) of air parcel trajectories from southern Africa's dust sources, namely Etosha Pan, Kuiseb and Omaruru River in Namibia and Makgadikgadi Pans in Botswana. Air trajectories from these sources were modelled for 10 days forward when dust plumes occurred. Density maps were created using ArcMap for different seasons from the different dust sources. Most of the modelled trajectories from the Etosha, Kuiseb and Omaruru River travelled along the Namibian coastline extending as far as north western African region, thus possibly providing essential nutrients to the Benguela Current ecosystem. In contrast, Makgadikgadi Pan air masses travelled predominantly towards the south eastern regions (as far as Australia) with only a small fraction moving towards the north western part of the Atlantic Ocean (Benguela Current**)**. This showed that air parcels from southern Africa affect regions thousands of kilometers over a relatively short time period. During winter, autumn and spring, air masses predominantly travel along the Namibia coastline towards the north-western region while during summer months, air masses travel more towards the Indian Ocean.

Surface sediment samples were collected from four known dust plume source locations in order to determine their physical characteristics and trace elemental composition. Particle size analysis showed that Etosha, Kuiseb and Omaruru samples were fine grained (< 5 µm to 20 µm), while Makgadikgadi Pans being coarser averaging 145 µm. Trace elemental chemistry revealed that Kuiseb and Omaruru River dust sources are more enriched in Ti, Al, Fe, Cu and Zn which are important micronutrients to phytoplankton, although Cu can be toxic in high concentrations. Etosha, in contrast, was more enriched in Mg and Ca. The two ephemeral rivers in Namibia are important source of micronutrients to the Benguela Ecosystem and the southern oceans especially during the winter, spring and autumn seasons but less in summer.

Keywords: Dust Sources, Southern Africa, Trace Elemental Biogeochemistry, HYSPLIT Modelling.

Characterizing surface level inversions over Cape Town, South Africa

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Abstract

The link between large-scale synoptic forcing and surface level inversions is examined in Cape Town, South Africa. The most common type of surface level inversions (SLI) is a radiation inversion and usually occurs during still, cloudless nights as the surface of the earth cools as a result of radiant energy loss and cools air immediately above it. Surface level inversions are often associated with heavy pollution events as they trap pollutants originating from industry, fires and morning traffic in a thin vertical layer above the ground surface.

Vertical sounding data spanning the period 1985 – 2015 was obtained from the University of Wyoming and is used to investigate the seasonal, annual and interannual characteristics of SLIs. A trend assessment is carried out at the annual and monthly scales. Inversion events are then associated with archetypal synoptic conditions to identify the synoptic drivers of inversions throughout the year.

Results indicate SLIs are prevalent all year round with a maximum during the winter season, however, a large number of SLI's can occur in the core summer months of December and January (up to 20 days of the month). Annual trends in the frequency of occurrence of SLIs between 1985 – 2015 are negative, however this trend is not statistically significant. On a monthly scale this is reflected in all months with highest trend values in June and July. Synoptic states most associated with SLI's are (1) anticyclone conditions caused by a weak South Atlantic High Pressure system (SAHP) and (2) a trough over the west coast of the country that is associated with

dry berg winds. The SAHP is associated with descending air, calm conditions and radiative cooling whereas the west coast trough with dry, continental air that is advected into the region.

Global-scale projected changes suggest a shift to a more EL Nino like state of the Equatorial Pacific, which is associated with lower wind speeds over Cape Town in summer. Furthermore, an expanding Hadley circulation is projected to shift mid-latitude cyclones southwards which facilitates more dry days during winter. This would suggest a higher frequency of SLIs in future, which is opposite to the observed trend. As both of these global-scale drivers affect synoptic-scale systems, the synoptic typing approach adopted here is a useful methodology to investigate projected future changes in the frequency of SLIs as a result of global warming.

Keywords: Soundings, Vertical stability, Historical trends

The sensitivity of simulated temperatures in climate models to aerosols over southern Africa

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Abstract

Atmospheric aerosols can impact climate directly, through interacting with solar radiation, as well as indirectly by modifying clouds. The Intergovernmental Panel on Climate Change (IPCC)‘s fifth Assessment Report (AR5) stated that the level of scientific understanding of aerosols radiative forcing is medium to low. Southern Africa has high levels of aerosol loading, especially during the biomass burning season, However few climate modelling studies focus on this region. An understanding of the impact of aerosols on southern Africa surface temperature will provide an important baseline for regional climate patterns and variability. The current study focuses on using Goddard Institute for Space Studies Global Climate Model (GISS-GCM) that uses the CMIP5 emissions and spatial resolution of 2 × 2.5° for 1979-2012. Two scenarios where ran, one with aerosols scheme on and one without aerosols to investigate the sensitivity of the simulated surface temperature on the presence of southern Africa aerosols. As the first step, the study evaluated GISS-GCM by comparing the simulated surface temperature to Climate Research Unit (CRU) observations over the southern African region about 10° N to 50° S and 0° W to 60° E. The model captured the temporal and spatial pattern of surface temperature reasonably well. A warm bias of 0.8 °C is pronounced over the western part of southern Africa during JJA and SON season. The sensitivity study is achieved through comparing surface temperature from model runs with and without aerosols. In general, the “aerosol on” scenario, surface temperatures are cooler in many parts of study domain compared to the “aerosol off” run. The purpose of the presentation is to show the simulated climatology of surface temperatures as compared to CRU observations and monthly and seasonal average sensitivity of surface temperatures to aerosols across full period.

Keywords –Aerosol particles, Climate, Surface temperature

Contribution of dairy farming on climate change through direct methane emissions to the atmosphere

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Abstract

There is a scientific consensus that climate change is due to the increased anthropogenic greenhouse gas emissions from various sectors including agriculture. The largest quantity of methane emissions in dairy production is produced from entTeric fermentation. The objective of this study was to estimate methane emissions from enteric fermentation by dairy cattle. Data was collected from one (1) farm using a questionnaire for the period of five (5) years, 2010 to 2014. Agricultural Land Use (ALU) software version 4.0.0 was used to estimate enteric methane emissions. The methane emission factors were ranging from 45 to 96 Kg CH4/head/year and this was the same for all years. Dairy cattle in 2010, 2011, 2012, 2013, and 2014 contributed 71589, 87255, 113421, 283332 and 266364 Kg CO2eq respectively. Emissions increased since 2010 to 2013, however, from 2013 to 2014 emissions decreased from 283332 to 266364 Kg CO2eq. Enteric methane emissions were directly related to annual number of animals, emissions increased and decreased with dairy population size on-farm. However, this was due to higher feed intake energy required by higher population number of dairy cattle to produce milk. This implies that emissions are dependent on animal characteristics, the type and quality of feed and the feed intake. Therefore, there is a need for evaluation of dairy feeding systems which will reduce dairy enteric methane emissions to the atmosphere.

Keywords: Greenhouse gas, Climate change, Dairy farming, Enteric fermentation, Feeding systems, Feed intake energy

Simulating the characteristics of Tropical Cyclones over the South West Indian Ocean using an Adaptive Stretched-Grid Global Climate Model

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Abstract

Tropical Cyclones (TCs) are one of the most devastating natural phenomena. This study examines the capability of a GCM with adaptive grid stretching (CAM-EULAG, hereafter CEU) in simulating the characteristics of TCs over the South West Indian Ocean (SWIO). In the study, CEU is applied with a variable increment global grid that has a fine horizontal grid resolution (0.5°x0.5°) over the SWIO and coarser resolution (1°x1° – 2°x2.25°) over the rest of the globe. The simulation is performed for 11 years (1999-2010) and validated against the Joint Typhoon Warning Centre (JTWC) best track observation, Global Precipitation Climatology Project (GPCP) satellite data, and ERA-Interim (ERAINT) reanalysis. The results of this study show that CEU gives a realistic simulation of the SWIO. However, there are discrepancies in the climatic features over the Mozambique Channel (MC). These include a substantial cyclonic feature over the MC that produces a high TC count bias in the model simulation. Despite this, CEU shows some skill in simulating the spatial distribution of TC genesis locations and tracks over much of the basin. The dynamical structure and intensities of the CEU TCs compare well with observation, though the model struggles to produce TCs with a deeper pressure centre. The reanalysis has the same problem. The monthly variation of TC occurrence is well produced by the model but struggles to reproduce the interannual variation. This study has an application in improving and adopting CEU for seasonal forecasting over the SWIO.

Temporal evolution of agricultural drought in the Luvuvhu River catchment of South Africa

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Abstract

Recurrent droughts and increasing water demands in most semi-arid areas of Limpopo Province, South Africa, result in vulnerable small-scale farmers being faced with challenges such as poor crop development and low yields. For this reason, the Water Requirement Satisfaction Index (WRSI) was used to quantify drought affecting rain-fed maize production in the Luvuvhu River catchment. Analysis was conducted using seven weather stations with rainfall and temperature data which adequately represent the catchment. Computation of WRSI was performed using a crop water balance model in Instat+ software and the index was formulated using dekadal rainfall, dekadal evapotranspiration, soil water-holding capacity and crop coefficients as inputs. A 120-day maturing maize crop was considered and the model was run based on the average start of the rainy season in the area. Temporal variations of the drought severity from 1974 to 2015 were analyzed and trends were determined using the non-parametric Spearman's Rank Correlation test. Results showed noticeable seasons subjected to drought conditions, corresponding to an average frequency of once every two to three seasons. However, there was a high variability of drought severity across the area, with extreme drought episodes (WRSI<50) commonly identified in the northern parts (which receive <600 mm of annual precipitation) as compared to the lower catchment. This implies high risk of crop failure, making the upper regions unsuitable for rain-fed maize production. Furthermore, drought trends analysis indicated no significant trends, with ρ values close to 0 over the study period at all stations. Therefore, such findings on the frequency and severity of drought derived from historical climate, soil and crop data can provide valuable information on how to plan for crops and develop plans for mitigating the possible impacts of drought in a given area.

Keywords: Crop water requirements, Drought index, Maize growing period, Trends

Ocean wave forecasting in the southern African region: the use of ECMWF WAM and NCEP Ensemble data

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Abstract

On the 12th May 2016 the South African Weather Service (SAWS) effected the ocean wave forecasting system in their internal/local computing portal. The system employs wave and swell fields to forecast the daily wave state in the surrounding oceans, namely, the Atlantic and the Indian oceans. The system also generates meteograms for East London, FA Platform, Cape Point, and Saldanha Bay using significant wave height, mean wave height, and mean direction of wind waves as forecasting fields. The forecasts are generated with NCEP 22 member ensemble and ECMWF WAM data; the NCEP data have 1X1 degree horizontal spatial resolution with a 6 hourly time stepping, and the ECMWF data have 0.25x0.25 degree horizontal spatial resolution with a 3 hourly time stepping. The simulations of each wave/swell field are done for a forecast window of 6 days. In this study 2 cases are examined in the southern African winter period – the passage of the cold frontal system in the period 09-12 June 2016, and cut-off low event in the period 25-26 July 2016 which resulted in heavy rainfall along most of the South African eastern coastal areas. The studies' focus on the spatial extent and timing of the wave/swell events in the Agulhas current region. The forecasts are validated with IFREMER Jason-2/Cryosat-2,

ASCAT Metop-A/Metop-B data, SAWS marine shipping data, and EUMETSAT VIS/IR spectral satellite data. In the studies it was found that both events were accurately forecasted by ECMWF WAM and NCEP data.

Testing the applicability of the NAME III dispersion model in predicting air pollutants concentrations over the VTPA

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Abstract

The South African Weather Service (SAWS) air quality modeling has a long term goal to develop a system capable of generating atmospheric air quality forecast for a range of primary and secondary pollutants in order to advise and warn the public on possible high levels pollutant concentration in the air and also provide support to the relevant policy development. A pilot Numerical Atmospheric Dispersion Modelling Environment (NAME III) air quality modeling system has been developed and underwent evaluation for its capability in simulating air quality over the Vaal Triangle Priority Area. The modeling system aims to fulfill the following two objectives: to produce national air quality forecast and to conduct air quality modeling studies to assist in relevant policy development. This study presents the description of the modeling system and the discussion of the results from the evaluation. The model was run for twelve months from March 2010 to February 2011. Only two pollutants were considered for this particular study, namely; Ozone (O3) and Sulphur Dioxide (SO2). The NAME III-global data air quality modeling system was tested against monthly averaged concentrations of SO2 and O3 from the VTPA air quality monitoring network. The Bias, NMB, RMSE statistical measures were used to assess the model's performance. The preliminary results demonstrate that the modeling system perform fairly well relative to the measured data although it under predict SO2 and Ozone concesntrations. The model-measured ozone concentration comparison shows little difference with an overall difference of less than 50%. In most cases, the modeled concentrations of SO2 and O3 are in the same magnitude with the measured data except for only two incidences of very low modeled SO2 concentrations in Sebokeng. The NRMSE values are below the value of one and very close to zero in some cases. These results indicate that the modeling system could be a very important tool for use in air quality modeling studies as well as providing real time air quality forecasts.

Keywords: Air Quality, modeling, Emissions, NAME III, Ozone, Sulphur Dioxide

Variability of Tropical Cyclone Heat Potential and Barrier Layers in the South Indian Ocean

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Abstract

Track and intensity are key aspects of tropical cyclone behaviour. Intensity is related to tropical cyclone heat potential (TCHP) and barrier layer thickness (BLT). Here, the variability of TCHP and BLT in the South West Indian Ocean and their relationships with tropical cyclones is investigated. It is shown that cyclone intensification is influenced by large TCHP values, deep barrier layers and the presence of anticyclonic eddies in the upper ocean.

TCHP and BLT time series across the Seychelles-Chagos thermocline ridge (SCTR) are correlated with ENSO, r = 0.57 (4 month lag) and 0.53 (2 month lag) respectively. Large BLT fluctuations overlay with large positive TCHP values during the summer (r = 0.78, November-March) and are modulated by westward propagating Rossby waves. In particular, TCHP is enhanced along the Rossby wave path which may lead to positive rainfall anomalies across the SCTR. After the 1997-1998 El Nino, a warming trend in the TCHP was observed over most of the basin, except across the SCTR which may be associated with changes in the regional atmospheric circulation. Increasing SST and frequency of Category-5 tropical cyclones also occurred.

An analysis of the ocean response to Category 5 Tropical Cyclone Bansi that developed over and east of Madagascar during January 2015 is performed. Its unusual track was found to be linked with the strengthening of the monsoonal north westerlies while its rapid intensification from Category-2 to Category-4 was linked to a high-TCHP region, associated with a warm core eddy and large BLT.

Keywords: Rossby waves, Tropical cyclone heat potential, Barrier layer thickness, Anticyclonic eddies, Seychelles-Chagos thermocline ridge, South Indian Ocean variability

Stratosphere-troposphere exchange climatology over Southern Africa using ERA-Interim data set and AIRS/Aqua satellite data

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Abstract

South AfricaStratosphere–troposphere exchange (STE) plays an especial role on atmospheric chemistry as it changes the oxidative capacity of the troposphere and potentially also affects the climate system because ozone and water vapour are potent greenhouse gases. Moreover, the exchange of particles between the stratosphere and the troposphere could lead to an increase of "bad" ozone (tropospheric ozone) and a decrease of "good" ozone (stratospheric ozone). In this study, we use the ERA-Interim reanalysis data set from the European Centre for Medium-Range Weather Forecasts (ECMWF) and a refined version of a previously developed Lagrangian methodology investigate and explain the stratosphere–troposphere exchange (STE) over Southern Africa. The Lagrangian method was used to calculate mass and ozone fluxes across the tropopause, pressure surfaces in the middle and lower troposphere (500, 600, 700, and 800 hPa) and the top of the PBL. Also, data measured by Atmospheric Infrared Sounder (AIRS) instrument, one of the six instruments aboard the Aqua satellite was used to investigate ozone concentrations at different pressure levels in the troposphere and the lower stratosphere. This is essential as it helps to explain even a deep exchange event, a process where particles of stratodpheric origin can penetrate to pressure levels above 700 hPa, and even reach planetary boundary layer (PBL). This study also reports the seasonality of the STE in the Southern Africa region in conjunction with a seasonal cycle of ozone concentration at the tropopause, as well as the trends of the occurrence of the STE events over the years.
Keywords: STE, Climatology, Ozone, stratosphere, troposphere

Evaluating the Multi-Scale Predictability of a Severe Weather Event Associated with a Cut-off Low over South Africa.

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Abstract

Cut-off low is a cold low (depression) in mid-latitudes (occasionally almost in subtropical latitudes) where air of polar origin is cut off from the main sub polar belt of low pressure and cold air, the normal track of depressions. Such slow-moving low are associated with unsettled weather and, and can be associated with thunderstorms. The severity of thunderstorms can rise to an extent where supercell thunderstorm is formed resulting in violent weather.

Tornadoes are violently rotating columns of air that extend from a supercell thunderstorm storm cloud to the ground. These violent, convective occurrence primarily develop within supercell thunderstorms, but also form in thunderstorms along squall lines, near the ends of thunderstorm bow echoes, and within landfall hurricane. One

of the recent Tornadic events was the one produced by thunderstorm associated with an intense cut-off low system over Tembisa area, Ekurhuleni district of Gauteng at around 15:30 local time, on the 26th July 2016.

Tornado is more of mesoscale event and is difficult to predict using NWP models, especially of lower resolution. In this study we investigated how well the medium-range models predicted the cut-off low 10-days in advance. Subsequently we also looked at how well the short-range, high resolution models predicted the severity of the Tornado event over Ekurhuleni on the 20 July 2016.

The investigation was undertaken by using 2 medium range models namely, NCEP GEFS and ECMWF and 4 short-range models; Weather Research and Forecasting (WRF) model, Unified Model (UM) with 12 km, 4 km and 1.5 km respectively. Subjective analysis from each model was used to analyse the geopotential height at the surface and 5h00hpa, by examining the dominating weather system over the country. To verify short range models for severity of Tornado, we used the Irene Radar Quantitative Precipitation Estimation fields with a resolution of 1 km.

Abnormal climate conditions for summer 2014/2015 over Southern Africa

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Abstract

During summer 2014/2015, anomalous climate over Southern Africa led to severe droughts over the subcontinent. In the meantime, the Pacific Ocean was warmer than normal and oceanic condition almost qualified as El Nino. Lack of rainfall during January and February 2015 caused the drought, which was the strongest in Southern Africa since 1995. The main aim of the study was to investigate the atmospheric and oceanic conditions that prevailed during the drought of summer 2014/2015 and compare them to canonical El Niño patterns. GPCP rainfall and Reynolds SST data are used to document SST and rainfall anomalies during the 2014/2015 season and are compared with conditions that generally occur during El Niño in summer. Futhermore, NCEP Reanalysis data was used to plot the composite mean and anomalies of large-scale circulations at monthly and seasonal scale. Analyses of the atmospheric and oceanic patterns associated with the drought over Southern Africa of the summer 2014/2015 suggest that the patterns were characteristic of a typical El Niño event. The higher than normal pressures over the subcontinent during January 2015 and March 2015 could have suppressed rainfall therefore causing droughts over Southern Africa during the summer 2014/2015. However, there are differences in oceanic and meteorological conditions from canonical El Nino pattern in some of the months (December 2014 and March 2015). Seasonal cooling over the Mozambique Channel in all the months of the summer seasons and warming of the South Pacific Ocean during January 2015 are different from typical El Niño pattern.

Keywords: Summer rainfall, Canonical El Niño , Southern Africa

Role of Weddell Sea ice variability in southern African climate

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Abstract

Southern Africa receives most of its annual rainfall during austral summer when the South Indian Convergence Zone (SICZ) develops in the northwest-southeast direction. The interannual rainfall variability during austral summer has been extensively studied in association with ocean-rooted climate phenomena (El Niño/Southern Oscillation, Subtropical Dipole, etc). However, a role of Antarctic sea-ice variability in the summer rainfall is poorly understood. Considering a significant seasonal variation of sea-ice extent, the interannual sea-ice variability in the Weddell Sea may have some impact on the rainfall variability through the atmospheric teleconnection. Therefore, this study aims at identifying a possible link between the Weddell Sea ice and the southern African rainfall variability during austral summer.

To describe the association between the Weddell Sea ice and southern African rainfall variability, lead-lag correlation and composite analyses are made for historical datasets after 1982 when the satellite data becomes available. For further examination of the observed association, a series of coupled general circulation model (CGCM) experiments is performed by using SINTEX-F2 model. In the control (CTR) experiment, the atmosphere and ocean are freely interacted and integrated over 180 years. Then, monthly output of the last 150 years is analyzed. Similarly, the five sensitivity experiments, called TP, TALL, SAO, TMD, and CLM, are conducted, where the interannual variability of sea surface temperature (SST) in the tropical Pacific, the tropics, the South Atlantic, the tropics-midlatitudes, and the global oceans are suppressed by the monthly climatology of the SST in the CTR experiment, respectively.

The lead-lag correlation analysis shows that the sea ice concentration (SIC) in the Weddell Sea is highly correlated (-0.61) with the southern African rainfall during early austral summer. The composite analysis during the low Weddell SIC years also shows that the low SIC anomaly is associated with anticyclonic atmospheric circulation anomalies over the South Atlantic and southern Indian Ocean, which facilitates more moisture advection from the southern Indian Ocean. This low SIC anomaly is found to cause warmer skin temperature and reduce the meridional temperature gradient to the north. This is a favoring condition for sustaining the anticyclonic circulation anomaly over the South Atlantic by enhancing the near-surface atmospheric stability.

This intriguing association between the Weddell SIC and atmospheric circulation anomalies is well simulated in a series of CGCM experiments except the CLM experiment. In this experiment, a zonally elongated high pressure anomaly dominates over the Antarctica during the low Weddell SIC years. The distinct difference between the TMD and CLM experiments further indicates that in the absence of the high-latitude SST variability, the atmospheric internal variability, called the Southern Annular Mode, dominates in the Southern Hemisphere. Thus, the CGCM results suggest that the SST variability in the high latitudes plays an important role in the Weddell Sea ice variability and the associated air-sea-ice interaction in the Weddell Sea may have some impact on the overlying atmosphere in the South Atlantic, which is important for the southern African climate.

Keywords: Weddell Sea, Southern African rainfall, Air-sea-ice interaction, Interannual variability

Wind variability along the southern coast of South Africa

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Abstract

A study conducted by Schumann (1992) revealed an abrupt change in wind speed and direction in the south coast of South Africa after one of the strongest El Ninos in 1982/83. He carried out a wind analysis over a 38 year period (1950-1988), with the change identified being represented in the last five years of the timeseries. This study seeks to see if the change discovered by Schumann was permanent or not by reconstructing the timeseries and extending it to 2014. Changes in wind speed and direction from a station in Cape Town, provided by the South African Weather Service, are analyzed from 1960 -2014. The wind direction analysis shows a statistical significant positive trend while the wind speed analysis shows a relatively weaker positive trend. There is a great deal of variability associated with both wind variables. This variation is partly explained by the direct or indirect effect of El Niño Southern Oscillation (ENSO) events and another mode of atmospheric variability, Southern Annular Modes (SAM). It is observed that in most strong El Nino events, the wind decreases in magnitude and changes in direction. The opposite is true for La Nina events. The understanding of the tendency of winds to move towards or away from the equator during the various phases of SAM appears to be significantly responsible for the modification of winds in this area. However, it also be taken into consideration that over this period, changes in the location of the station and instruments used to measure winds occurred. These changes were reflected in the data and need to be considered during the analysis. The significance of this field of research is that changes in winds over this area have an impact in the Benguela upwelling system as well as local pollution dispersion. Also Understanding the winds over South Africa is vital to be able to improve forecasts, disentangle the complex nature of global change impacts on wind and clarify human error in order to grasp long term trend.

Key words: Interannual varaibility, Winds, ENSO, SAM

Predictability of seasonal streamflow in the north-eastern region of South Africa

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Abstract

Flood events can cause infrastructural damage and may lead to loss of life, particularly if flood waters are deep and fast flowing. The accurate and skillful prediction of flood events at short-range time scales, and the anticipation of seasons with a high probability of flood events to occur at lead-times of a month or longer, is useful to facilitate effective water management, whilst properties and valuables can be moved or protected and people evacuated from areas prone to flooding. Deterministic forecasts of flood-events to occur at a specific location at a specific point in time are only skillful a few days ahead. However, state-of-the-art seasonal forecast systems are known to be skillful in predicting seasonal rainfall anomalies at lead-times of a few months in certain parts of the world, including the summer rainfall region of southern Africa. Therefore, for the case where a seasonal forecast system is predicting an excessively wet season, risk managers can use this information to put themselves in a ready mode by preparing contingency plans for reducing the impacts of flooding. As the predicted wet season commences managers can then begin monitor daily medium-range forecast to identify high risk areas and subsequently alert the relevant communities to the possibility of flooding. This study harnesses the seasonal predictability of weather to statistically downscale streamflow in the north-eastern region of South Africa. The Conformal-Cubic Atmospheric model (CCAM) is used to generate hindcasts of the low level atmospheric fields (850 hPa geopotential heights). Hindcasts are then downscaled to streamflow over the north-

eastern region of South Africa. CCAM's capability to forecasts seasonal streamflow is verified against naturalized flow time series produced by the Water Resources 2012 project.

Keywords: CCAM, Statistical downscaling, Streamflow, Seasonal forecasting

Mitigating vulnerability to drought and enhancing livelihood resilience: A review of Southern Africa region

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Abstract

Southern Africa's economies and agriculture are highly sensitive to climatic variability. In various parts of the region, drought is one of the natural phenomenon contributing to famine and acute malnutrition. The consequences of drought and the ability of the region to adapt or recover from the resulting economic, environmental and social effects depend on many factors. The social and environmental effects of drought are huge with damages and associated costs often undermining and threatening development gains and economic prosperity of the region. It is imperative to reduce countries' vulnerability to climate variability and to the adverse impacts posed by the changing climate. This paper highlights the challenges posed by drought in southern Africa and reviews the current drought risk management approaches, especially the effective use of predicting anomalously wet summer seasons in mitigating drought risks and protect livelihoods. The study suggests the possibilities of making best use of anomalously wet seasonal forecast and its significance in selecting appropriate drought risk management strategies in southern Africa. Such forecast could potentially be better able to mitigate drought risks owing to their higher reliability. However, their effectiveness also depends on socio-economic and agro-climatic conditions. Wet seasonal forecasting should inform effective drought risk management strategies in managing impacts of drought particularly to the vulnerable regions and households. An integrated approach that combines seasonal forecasts of a promising season and adaptations measures to manage drought risks within vulnerable communities is considered here to be the appropriate intervention for managing climate variability and drought.

Keywords: Climate variability, Drought, Drought risk management, Seasonal forecasting, Southern Africa

The influence of atmospheric teleconnections on drought regimes in Eastern Africa

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Abstract

Drought remains a threat to many socio-economic activities in eastern Africa, yet the drivers of mega-droughts (i.e. drought regimes) over this region remain unknown. This study presents the spatial and temporal structure of drought regimes in Eastern Africa and examines the influence some atmospheric teleconnections have on the drought regimes. Gridded observation data for 75 years (1940 – 2014) were analyzed for the study. The Standardized Precipitation-Evapotranspiration Index, which is based on climate water balance, was used to characterize the drought at 3- and 12-month scales, while the Principal Component Analysis (PCA) was used to identify the drought regions. We used wavelet analysis to study the temporal variability of the drought regimes and used wavelet coherence analysis to quantify the coupling between the drought regimes and various atmospheric teleconnections. The results of the study show that four drought regimes, which account for more than 50% of SPEI variance over Eastern Africa, have their core areas over different parts of the region. However, most drought modes show significant variability at 2- to 8-year cycles. Three of the drought regimes have a strong correlation with El Nino Southern Oscillation and the India Ocean Dipole while the fourth one has a strong correlation with the Western Equatorial Pacific SSTs which corresponds to La Niña events. The results

of the study may provide valuable insights on how to improve drought early warning systems and disaster risk managements in Eastern Africa.

Keywords: Drought, Climate Indices, SPEI

Koppen-Geiger climate type maps of the Last Glacial Maximum over south coast

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Abstract

The cyclic nature of climate at Milankovitch time-scales, and in particular the waxing and waning of the ice ages, drove shifts in species distributions globally. To understand the prehistoric southern African landscape, and also the present-day biome distribution of the region, it is critical to understand the effects of these dramatic shifts on climate vegetation across the southern Africa. Climate classifications are helpful tools to better identify and understand certain patterns in climate data. Koppen-Geiger (K-G) is one of the most widely used climate classifications, and is based on regional temperature and precipitation patterns. Here we present K-G type maps corresponding to the Last Glacial Maximum (LGM) climate over southern Africa. The maps were constructed using climate model simulations performed over southern Africa for the LGM. An ensemble of global climate model (GCM) simulations of the Coupled Model Intercomparison Project Phase Five (CMIP5), obtained for the LGM, were downscaled for this purpose. The regional model used is the Comformal-Cubic Atmospheric Model (CCAM), a variable-resolution global atmospheric model of the CSIRO, applied by the CSIR on the XSEDE super computer in the United States. The results are insightful in terms of providing an indication of how climate regimes and vegetation biomes over southern Africa may have looked like during the LGM.

Keywords: Koppen-Geiger climate type, Last Glacial Maximum, climatic change

Analysis of homogenized extreme temperature trends over South Africa for the period 1931 to 2015

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Abstract

Previous analysis of the historical climatology of temperatures in South Africa revealed generally warming trends of average and extreme temperatures over recent decades. These results conform to the widely published increasing global surface temperature trends. The extreme temperature indices are of particular importance due to the potential role they play in different natural phenomena and in various socio-economic sectors. It is worth noting that previous studies made use of datasets which only dated back to about the year 1961 due to various factors which influence data availability and quality. This study intended to serve as an update of the state of South African trends of daily maximum and minimum temperatures as well as their extremes. The use of homogenized data in this study made it possible to extend the analysis period up to 85 years, beginning from the year 1931 up to 2015, while maintaining the critical spatial density of stations. Datasets for 36 stations were quality controlled to ensure that erroneous data values did not influence results of the homogenization procedure. The homogenisation procedure enabled the detection of variability that could not be attributed to climatic factors in the time series. The homogenisation was done using the RHtestsV4 software which is

endorsed by the World Meteorological Organization-Expert Team on Climate Change Detection and Indices (WMO-ETCCDI), with daily maximum and minimum temperature datasets as inputs. The WMO-ETCCDI climate index calculation software RClimDex was subsequently used to identify trends and the statistical significance thereof of a set of relevant extreme temperature indices. Results from this study were mostly consistent with those of previous studies as they indicated countywide increases in extreme warm events along with decreasing trends evident for extreme cold events. Warming trends are notably stronger in the western and eastern parts of the country compared to the central interior. However, cooling trends in the central interior identified by previous studies were not confirmed in this study. While previous studies showed that the general warming was greatest in autumn, this study found the austral summer to be the season with the strongest warming trend. The magnitudes of seasonal temperature trends varied considerably between regions. Annual mean temperature trends were significantly positive for most of the analyzed stations across the country. Night time temperatures showed negative trends for most stations while positive trends were observed for warm night time events. There was a general decrease in cool days and a generally increase in hot days observed across the country. All stations showed negative trends in the duration of cold spells while most stations displayed positive trends in warm spell duration. While some stations indicated negative trends in diurnal temperature ranges, others showed positive trends. Significantly negative trends in diurnal temperature trends dominate much of the eastern and southern parts of the country while significantly positive trends were found to be more abundant over the western half of the country. The study concluded that historical climate trends are influenced by the period of record available for the analysis. The latter is most evident in the case where previous (shorter period based) studies revealed negative warming trends in the central interior while this study could not identify such trends. It is worth noting that during the analysis process, there were cases where strong trends were evident in the original data. In addition, there were cases in the analysis where stations in close proximity would have different results which implies that factors apart from the climate change and variability might have influenced them. Nevertheless, the instrumental record confirms the impact of general global warming in South Africa and confirms both spatial and temporal variations, all which serves as important information to be used in various areas such as climate model validation and development of climate change adaptation scenarios.

Key words: Indices; Climate variability detection

Making Seasonal Forecasts Easier to Use

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Abstract

Seasonal forecasts are currently exceptionally difficult to interpret for users outside of the atmospheric sciences community. The biggest problem with interpreting seasonal forecasts as it is presented currently is the shear amount of information that needs to be understood and combined in order to correctly interpret what the next season's climate conditions will be. For example, a user must understand the categories for which the forecasts are made, the terciles that divide these categories, the probabilities forecasted for each of the categories and then still needs to evaluate them separately with the forecasting system's skill scores. The general user is then overwhelmed by information which they generally do not understand and is unable to correctly use the information in their important decision making strategies.

In this study a new seasonal forecast product is proposed that attempts to remove most of the complexity that users must follow to get to the final product. Currently seasonal forecasts from the South African Weather Service is produced using a statistical downscaling system that incorporates multiple global model forecasts and hindcasts as well as historical data for rainfall and temperature. The end product from this system is probabilities for the occurrence of three equally probable categories called above-normal, near-normal and below-normal. However this is not the only useful information from the system, it can also produce information on how good the system is in predicting each of those categories given the historical data of the observations and models. In this particular case the probabilities and the two-alternative first choice (2AFC) skill scores will be used to produce a product that will be easier to interpret by the general user that may not have the technical background necessary to effectively use the current seasonal products.

The proposed methodology is to rather represent the relative odds (probabilities) between the two outer categories from the forecast, and then apply a mask using the 2AFC score to exclude areas that is known to be prone to bad forecasts. As most users are mostly concerned with whether a season would be wetter (colder) or drier (warmer), the near normal category is not visually considered however it still has an impact to determine whether the relative odds are significant in size. The new proposed product would then essentially combine four information maps into one, and only highlight areas of importance for users.

The maps presented as an example of the product are for one of the seasonal forecasts made in Aug 2016. These new maps then clearly indicate the areas where potential negative or positive impacts are more likely as well as areas where there is not sufficient skill to make any informed decisions. The proposed product is still in development and may change depending on feedback from users, however the principle of such a product will remain the same to reduce the complexity in interpreting seasonal forecasts.

Keywords: Climate, Prediction, Interpretability, User

Process-based assessment of two CORDEX climate models projections over southern Africa

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Abstract

Changes in precipitation are projected by many global climate models as a response to greenhouse gas increases, and such changes will have significant environmental and social impacts. These impacts are a function of exposure and vulnerability. Hence there is critical need to understand the nature of the climate and how it might change. Results from an ensemble of regional climate models from the Coordinated Regional Downscaling Experiment (CORDEX) project are used to investigate projected changes in circulation patterns associated with changes in precipitation. The physical drivers of the projected change are evaluated by examining the models ability to simulate circulation patterns over the regions with the aid of Self-Organizing Maps (SOM). Regional climate models projections indicate that annual total precipitation will decrease. And these decreases in annual total precipitation are primarily associated with increases in the frequency of high-pressure systems over the region and decreases in the occurrence of mid-latitude cyclones. Circulation changes include an increase in the occurrence of the oceanic high-pressure systems, a more dominant high-pressure circulation poleward of the continent and a decreased occurrence of patterns of continental lows and mid-latitude lows.

Regional climate model based simulations of inter-annual rainfall variability over the Guinean Coast of West Africa

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Abstract

Using the RCA4-SMHI regional climate model driven by ten individual General Circulation Models (GCMs) from CORDEX, the inter-annual rainfall variability of the peak monsoon over the Guinean Coast is investigated. The RCA4-SMHI simulations showed improved performance over the GCMs in depicting the rainfall variability over the Guinean Coast. Some simulations from the RCA4-SMHI as compared with observations show over-estimation over the Guinea mountains. Generally, regional climate models performed well when simulated over

the Guinean coast and they do give a good representation of the inter-annual rainfall variability across the sub-region.

Keywords: regional climate models, rainfall variability, monsoon, Guinea Coast

Influence of aerosol-cloud interaction on austral summer precipitation over Southern Africa during ENSO events

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Abstract

In the present study, we are investigating the role of aerosols-and clouds in modulating the austral summer precipitation (December-February) during ENSO events over southern Africa region for the period from 2002 to-2012 by using satellite and complimentary data sets. El-Nino and La-Nina years were selected based on the Oceanic Nino Index (ONI). Based on this years 2002 and 2009 were selected as El-Nino years and 2007 and 2010 were selected as the La-Nina years. Aerosol radiative forcing (ARF) and Cloud radiative forcing (CRF) shows distinct patterns for El-Nina and La-Nina years. Further analysis were carried out by selecting the four Southern Africa regions where the precipitation shows remarkable difference during El- Nino and La-Nina years. These regions are R1 (33 °S-24 °S, 18 °E-30 °E), R2 (17 °S-10 °S, 24 °E-32 °E), R3 (19 °S-9 °S, 33 °E-41 °E) and R4 (7 °S-0 °, 27 °E-36 °E). Aerosol Optical depth (AOD) shows considerable differences during these events.. In region R1, R2 and R3 AOD shows more abundance in El-Nino years as compared to La-Nina years where as in R4 the AOD shows more abundance in La-Nina years. Cloud Droplet Effective radius (CDER) shows higher values during La-Nina years over R1,R2 and R3 regions but in R4 region CDER shows higher values in El-Nino years. Aerosol indirect effect (AIE) is estimated both for fixed cloud liquid water path (CLWP) and for fixed cloud ice path (CIP) bins, ranging from 1-300 gm^{-2} at 25gm^{-2} interval over all the selected regions for El-Nino and La-Nina years. The results indicate more influence of positive indirect effect (Twommey effect) over R1 and R3 region during El-Nino years as compared to La-Nina years where as in R4 region, negative indirect effect(Anti-Twommey effect) are found to have a substantial influence during El-Nino years and is found to be less influenced during La-Nina years. This analysis reveals the important role of aerosol on cloud-precipitation interaction mechanism illustrating the interlinkage between dynamics, thermodynamics and microphysics during austral summer season over southern Africa.

Key words: Aerosols, Aerosol radiative forcing, Aerosol Indirect Effect

Development of a patching tool on recorded daily climate data

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Abstract

Complete and reliable climate data is required by various users to improve climate services, applications and research. However, this important task is commonly affected by missing long term climate data records, caused by significant number of reasons. Thus, we conducted a study which aims at developing a stand-alone patching tool for filling the missing observations in climate data. The different climatic variables that can be estimated include daily minimum and maximum temperature, rainfall, radiation, water vapour pressure and wind speed. The tool has a functionality of determining an appropriate patching method as well as to patch climate data, using the closest or best correlated neighbouring weather stations. The patching techniques that can be applied to fill the climatological gaps are: Arithmetic averaging (AA); Normal ratio (NR); Inverse distance weighted

(IDW); Correlation coefficient (CC); Multiple regression (MR) and UK-Traditional method (UK). For each of these techniques, the tool also enables the user to select the number of neighbouring stations to be used. Thereafter, the best method of estimating the daily data is tested using the following statistical criteria: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and Correlation coefficient (r).

Keywords: Missing climate data, Patching techniques, Weather station

Modelling the impacts of the Indonesian Throughflow on the Indian Ocean using the Parallel Cubic Ocean Model.

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Abstract

Over the past two-decades the Indian Ocean has experienced an anomalous warming due to the enhancement of heat transport by the Indonesian Throughflow (ITF) in response to intensified trade winds in the equatorial Pacific. Anthropogenic climate change simulations predict a weakening of the Walker Circulation in response to a warming world. It is commonly assumed that this would consequently result in a decrease in the total ITF transport into the Indian Ocean. It is for this reason that this study aims to investigate the effect of ITF variability on the Southern Indian Ocean gyre on annual to climate timescales, and the link between Indian Ocean "hotspots", the regions in the Indian Ocean where ocean warming is fastest under climate change, and the ITF. An equi-angular gnomonic cubic grid ocean general circulation model run at approximately 1.9^0 (000 km) horizontal resolution with 32 vertical z-coordinate layers is employed. The simulation, forced by a monthly mean atmospheric climatology, will be integrated for 3000 years, the longest ever simulation period in the domain, since the aim is to uncover and analyse the internal variability and its links with the southern Indian Ocean. Preliminary results show that the model appropriately reproduces observed global and regional data fields and vertical profiles respectively.

Keywords: Indonesian Throughflow, Indian Ocean variability, Cubic Grid Ocean General Circulation Model. South Indian Ocean Gyre, Indian Ocean Marine Hotspots.

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Climate and Tsetse: exploring the effect of climate variability and change on vector biology, population dynamics and distribution in the Zambezi Valley

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Abstract

The vector of African trypanosomiasis is the tsetse fly (*Glossina spp*). There is strong evidence that temperature influences key aspects of the biology and population dynamics of the tsetse fly, such as the rates of larval production, pupal development, abortion and mortality among young and mature adults. The Rekomitjie research station in the Zambezi Valley, Zimbabwe has recorded data on past changes in tsetse abundance along with daily weather values over the last 50 years. These two datasets provide evidence on how gradually increasing temperatures influence the tsetse fly population size, and highlights the role extreme seasons or weather events play in causing the tsetse fly population to crash. These datasets, along with climate change information, also makes it possible to move towards the development of models that suggest how tsetse distribution and abundance might be affected under various climate change scenarios.

Warning South Africa when severe weather unfolds

Lynette Van Schalkwyk and Annette Venter

Abstract

During July 2016 an intense Cut-off Low (COL) developed over Southern Africa. This COL caused havoc over a period of four days leading to heavy rain in the Free State and Kwazulu Natal, disruptive snowfalls, gale force winds and severe thunderstorms that resulted in hail and a tornado near Tembisa. The eNCA Weather department disseminated warnings and advisories as issued by the South African Weather Service (SAWS) during the course of the event and provided additional information and advice to the public as the system unfolded. Using this event as an example, we provide feedback regarding the effectiveness of the Severe Weather Warning System (SWWS) that was implemented by the SAWS in 2010. We also investigate the role and use of social media during the coverage of severe weather events and identify areas for future improvement.

Late plum rain over northeastern South Africa: 1 to 14 March 2014

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Abstract

The continuous rainfall from 1 to 14 March 2014 over northeastern provinces of Republic of South Africa that was caused by one slow moving upper air trough system from the 3rd to 7th and another two upper air troughs from 9th to 11th and 12th to 13th March respectively resulted in many rainfall records being broken, for example: 31 year highest daily rainfall of 132 mm the 4th for March at Mbombela (Nelspruit) in Mpumalanga.

Highest daily rainfalls were 161 mm the 13th at Pilanesberg (NE Northwest) and 160 mm the 4th at Komatidraai in Lowveld of Mpumalanga. The event resulted in 306 mm the first 10 days of month at Steenbokfontein near Vaalwater in SW Limpopo. Consequently the Mokolo River flooded and there were also dam brakes at Bela Bela that caused flash flooding at the Klein-Kariba resort with live lost and infrastructure damage.

Impacts from this severe weather event were dam brakes, flash floods, river floods, lives lost, extensive damage to infrastructure and power failures due to coal becoming wet. Advantages from plum rain event were dams filled at end of rainfall season.

"END of END user!" – Transdisciplinary approaches in climate science.

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Abstract

The production and provision of various types of climate information, such as forecasts, outlooks, and advisories are usually *directed to decision makers* usually referred to as END (*sic*) users in a range of climate-sensitive sectors, such as agriculture, natural resources, infrastructure, health, and emergency response. These so called 'others' or END users include rural actors, intermediaries (e.g. extension agents, development workers, agri-business, the media, etc.), institutional stakeholders (e.g. early warning systems, NGOs, etc.), and also policy makers. Climate science is still largely conceptualized and driven by a strong positivist approach, whereby science is viewed as a 'hard science' endeavor that is external to social spaces, for example, rural actors who are usually viewed as the intended *beneficiaries of climate services.* In this paper, this approach is challenged as the predominant form of "co-production" in climate services. Examples of drought practices, both past and current, are used to challenge the nature of mode 1 knowledge production to address such wicked climate challenges. Calls for more reflexive thinking including Mode 2 and other approaches, e.g. transdisciplinary approaches, are called for.

Impact-Based Severe Weather Warning System

Elizabeth Webster
South African Weather Service

Abstract

Weather disasters occur every year across the world, adversely impacting communities and thus people in general. Up to now, warnings have been issued to the general public and relevant Disaster Management Centres based on thresholds of the severe weather conditions expected and not according to the impact certain weather conditions could have. This poster addresses a case study where warnings were issued using an Impact-Based Severe Weather Warning System that is in the process of being developed at the South African Weather Service.

Air Pollution and Climate Change in the Greater Cape Town Area
Projecting the change in frequency of high pollution days in winter

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Abstract

High air pollution commonly occurs in Cape Town and is dangerous to human health. Previous research links air pollution and atmospheric conditions. Under the threat of climate change and thus a changing atmosphere, air pollution is likely to be affected. We look at the possible impact that a changing climate will have on the frequency of high pollution days in Cape Town. We use self-organising maps (SOMs) and ERA-Interim reanalysis sea-level pressure data to determine the frequency of common atmospheric states over Cape Town in winter. We then map high pollution days (determined from City of Cape Town air quality data) to certain atmospheric states in the SOM. Results show that high pollution days correlate to weak synoptic forcing and high-pressure systems over South Africa. Using the regional climate model (RCM) RCA4 to downscale 8 global climate models (GCMs), we project the change in frequency of atmospheric states corresponding to high pollution days under RCP8.5. These downscaled GCM results show an increase in the frequency of these atmospheric states; however, model validation shows that the RCM tends to over-simulate the weak synoptic forcing associated with high pollution days. However, the change in frequency between individual downscaled GCMs of these synoptic types can be strongly positive (most evidently in the far future) or strongly negative (the near future) so the GCM boundary conditions likely dominate the signal. We conclude that the signal is mixed and that both direction and magnitude of change in the frequency of synoptic states associated with high pollution days is uncertain. However, it is still important to implement mitigation measures and to prepare for and adapt to the possible increase in air pollution.

Keywords: Air pollution, Climate change, Self-organising map, Global climate model, Cape Town

Changes in the Spatial Pattern of Western Cape Rainfall.

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Abstract

This study analyses the changing spatial nature of rainfall patterns over the Western Cape. The region is subject to winter rainfall and is strongly influenced by topography and orographic rainfall. The current South African Weather Service (SAWS) observational network is sparsely spaced and located in low altitude areas. In this study multiple data sources are integrated to improve the representation of the weather station network over Western Cape. The integrated set of rainfall data is used to build a set of representative rainfall patterns over the Western Cape using Self Organizing Maps (SOMs). The SOM is trained with two datasets, the first is an integrated two-year (2014 and 2015) dataset which includes high altitude weather stations from Agricultural Research Council (ARC) and the Fynbos Fire Weather Stations (FFWS) as well as weather station data from SAWS. The second training is done with a 36-year (1980 to 2015) dataset taken from the SAWS weather network only. This study analyzes historical trends for the frequency of occurrence and seasonal timing of these rainfall states represented by SOM. As expected the high rainfall states occur predominantly during winter months while the low rainfall states occur throughout the year. The two SOM nodes associated with the extreme rainfall states, both high and low rainfall states, show maximum frequencies throughout the 36 years while intermediate states show fairly evenly distributed frequencies during the time period. The frequency analysis suggests that the total frequency of high (low) rainfall states have decreased (increased) over the last 36 years. The trend analysis does however show that the intensity of high rainfall events has increased.

Keywords: Rainfall, Self-Organizing Maps, Western Cape, Nodes.

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Interannual rainfall variability and SOM-based circulation classification

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Abstract

Self-Organizing Maps (SOM) based classification of synoptic circulation patterns is increasingly used in interpretation of large-scale drivers of local climate variability, and in the process of statistical downscaling. These applications rely on the basic premise of synoptic climatology, i.e. that local weather is conditioned by the large-scale circulation. While it is clear that this relationship holds in principle, the implications of its implementation through SOM-based classification, particularly at interannual and longer time scales, are not well recognized. Here we use a SOM to understand the interannual synoptic drivers of climate variability at two locations in the winter and summer rainfall regimes of South Africa. We quantify the portion of variance in seasonal rainfall totals that is explained by year to year differences in the synoptic circulation, as schematized by a SOM. We furthermore test how different spatial-domain sizes and synoptic variables affect the ability of the SOM to capture the dominant synoptic drivers of interannual rainfall variability. Additionally, we identify systematic synoptic forcing of local rainfall that is not captured by SOM classification. The results indicate that frequency of synoptic states as schematized by a relatively disaggregated SOM (7x9) of prognostic atmospheric variables, including specific humidity, air temperature and geostrophic winds, captures only 20-50% of interannual variability of local rainfall, and that the residual variance contains a strong systematic component. Utilizing synoptic types frequencies within a multivariate linear regression framework demonstrates that this residual variance can largely be explained using synoptic variables over a particular location; even though they are used in the development of the SOM; their influence, however, diminishes with the size of the SOM spatial-domain. The influence of the SOM domain size, the choice of SOM atmospheric variables and grid-point explanatory variables on the levels of explained variance is consistent with the general understanding of the dominant processes and atmospheric variables that affect rainfall variability at the analysed locations.

Keywords: SOM, rainfall variability

Assessing the Risk of Failure and Implications to Investment Payback Period for Domestic Rooftop Rainwater Harvesting Systems under Current and Future Climate in the Western Cape.

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Abstract

South Africa is a water scarce country with a variable climate. Anthropogenic climate change is expected to increase the variability of South Africa's climate as well as cause changes in rainfall patterns and increase evaporation rates countrywide. This may place significant pressure on water resources and supply in South Africa. One of possible ways to partially alleviate water supply problems is to implement domestic rainwater harvesting systems. However, due to climate change the reliability of these systems may change in the future. In this research project, the feasibility of rainwater harvesting systems was assessed, under current and future climate, in typical low and high cost housing in four climate zones of the Western Cape. The performance of the water harvesting system was assessed through two indices; one expressing a risk of failure (reliability) of the system and another expressing a payback time on the investment. These indices were chosen in order to assess the current reliability of the system in comparison to the expected future reliability and to assess the feasibility of the system based on the time the initial investment takes to pay back, based on monetary savings per month. Under moderate future change scenario, the reliability of the water harvesting system shows an increase in majority of locations in the Western Cape. The investment payback time varies strongly between low/high income households and climate regions. Overall, the domestic rainwater harvesting system is a viable and feasible option only for supplementing household water supply in the current and future climate for the Western Cape.

Keywords: Climate Change; Rainwater Harvesting; Feasibility; Risk.

Are semi-arid regions hotspots of climate change in Africa and South Asia?

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Targeted journal: Journal of Arid Environments.

Abstract

Semi-arid regions, such as the African Sahel, are typically located in the boundary between arid and sub-humid subtropical (much wetter) climate zones. These transitional climatic regions are relatively highly populated, with population's livelihoods strongly dependent on climate-controlled natural (ecosystem) resources of often marginal utility. The understanding of factors underlying vulnerability of ecosystems and human populations to climate change in semi-arid regions is, therefore, critical. This paper compares aggregated and spatially explicit trends in climate variables (temperature and rainfall) in semi-arid regions of Southern Africa, West Africa, East Africa and India, with trends in the surrounding, non-semi arid regions. It provides insights into a notion of semi-arid regions as hotspots of climate change, and informs concerns about vulnerability of these regions to climate change. The latest evidence and understanding of climate-related trends, in the semi-arid regions of Africa and India are presented. Temperature trends in semi arid regions in Southern and West Africa are stronger than in the surrounding non semi-arid regions over the last half century. In West Africa, although the rainfall over both the semi-arid regions and the surrounding non semi-arid regions were decreasing, declines outside the semi-arid regions were stronger. In Southern Africa, rainfall was observed to increase within the semi-arid region and decline outside that region. Significant year-to-year and longer-term variability in rainfall patterns means that any attribution of rainfall trends to anthropogenic climate change is complicated. Ultimately the impacts of climate change on human and biophysical systems will manifest themselves through the combined effect of changes in temperature, rainfall, humidity and other climate-related variables. Moreover, it is only by understanding specific system sensitivities and adaptive capacities that useful information can be derived to support adaptation research and practice. This paper provides information about historical climate and is aimed at informing policy makers, practitioners and researchers working in these regions.


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