Second International Workshop

Development of near-term climate scenarios (2020-2035) for vulnerable watersheds to climatic variability at the interanual, decadal and climate change time scales

18th-21th August, Cartagena, Colombia

Final Meeting Report

Access to the webpage

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1. Introduction

A workshop was held during August 18-21 in Cartagena, Colombia, to provide professionals with training in the application of probabilistic near-term climate scenarios to assess water resources vulnerabilities in pilot watershed in Latin America.

1.1. Word of Welcome

Jeroen Cooreman, Belgian ambassador in Colombia, opened the workshop on Tuesday. In the 'World Economic Forum' in Davos, the water topic was represented as one of the most urgent global challenges. This is one of the numerous examples showing the increasing global importance of good management and practice of water resources. Belgium wants to cooperate at international level to find adequate solutions for problems of common water sources. In this way the Flemish government funds already 15 years the IHP- programme of UNESCO, covering this MWAR-LAC project as well. Therefore, the participants were invited to contribute to this bigger global challenge.

Mercedes Flórez, Director of the Centro de Formación de la Cooperación Española (AECID), welcomed all participants to the Centre and to the City of Cartagena, and gave a brief overview of the 'Programa Iberoamericano de Formación Técnica Especializada' (PIFTE- España) and the activities organized by the Centro de Formación as part of this and other AECID supported programmes. She also introduced the participants to the functioning of the centre and the logistical aspects of the course.

Koen Verbist, UNESCO Programme Specialist, welcomed all participants to the meeting, as part of the UNESCO-IHP project funded by Flanders (FUST) with strong support from the Spanish Cooperation Agency (AECID). He indicated that this meeting is part of the Water Security approach of the VIIIth phase of UNESCO-IHP, in which aspects of Water Scarcity and Extreme Events are key topics. This workshop is part of a method to develop robust methodologies that can provide further insight in the impact of climate change on water resources, and has the objective to provide a 'proof of concept' and to identify the challenges still encountered taking into account the diversity of climates and climatic variability encountered in the Region of Latin America. By inviting 7 different countries with diverse climatic conditions, the methodology can be effectively applied and tested on a range of different water resources challenges. And finally, the workshop and the project also have the objective to strengthen regional collaboration and integration with respect to Integrated Water Resources Management across the Region.

1.2. MWAR-LAC Project – Koen Verbist

The MWAR–LAC project is funded by the Flanders-UNESCO Science Trust Fund (FUST) and is implemented by the UNESCO International Hydrological Programme (IHP) in collaboration with the

Water Center for Arid and Semi-Arid Zones in Latin America and the Caribbean (CAZALAC), which belongs to the network of Category II centres under the auspices of UNESCO.

The objective of the MWAR-LAC project is to strengthen the capacity to manage the water resources of arid and semiarid areas in LAC through networking and facilitating international and regional cooperation. This will be achieved by developing pilot experiences and participating in regional projects together with relevant partners in Latin America.

The project has three main thematic priorities:

- improved water governance as a basis to attain integrated water resources management
- use of modern techniques and methodologies to asses and improve water use efficiency
- hydro-climatic risk management including decision making

The overall goal of the project is to contribute to improving the quality of life and alleviating the poverty of local communities in arid and semiarid environments in Latin America and the Caribbean (LAC), through a reduction in the vulnerability of water resources systems to global changes based on sound scientific knowledge.

1.3. Objectives of the Workshop – Koen Verbist

The project has the aim to develop probabilistic scenarios for short term climatic conditions for vulnerable catchments in Latin America. For the support of decision making these scenarios can give more information on the future vulnerability of the water supply in the environment of these water bodies. The following specific objectives are defined for this workshop:

- The creation of a new tool to decompose climatic variability and project this variability for future climatic conditions
- The use of available water management models and calibration in pilot basins
- The creation of available probabilistic climate series on short term (2020-2050) at a level of monitoring stations in pilot basins
- The creation of future projections of water resources at the level of available monitoring stations

1.4. Theoretical framework and methodology – Koen Verbist & Gabriel Rodriguez

To understand climatic variability it is important to separate between sub-annual, interannual, decadal variability and long-term trends, caused by climate change. To avoid incorrect identification of trends in observed data series, it is recommended to use sufficiently long time series to identify tendencies. In a time series both red and white noise can occur, which respectively are and are not auto-correlated. This is an expression of the randomness of a climatic system. Temperature time series, for example, shows a larger autocorrelation in comparison with precipitation. Global Climate Models provide insight in projected trends, but are also characterized by significant uncertainty, both due to the scenarios selected as the inherent model uncertainty. For decision making traditionally a top-down 'downscaling' methodology of several of these models is used and the the results are then used to provide guidance for decision making. The SimGen model, on the other hand, is compatible with the bottom-up approach termed 'Decision Scaling', where the risk is calculated by summing the different products of impact with their probabilities of occurrence. SimGen counts both with deterministic components (e.g. long term trends caused by anthropogenic influence, decadal natural variability and interannual variability like ENSO), as with randomness of events (e.g. atmospheric noise with an auto-correlated character that interacts with the ocean). Sources for this model come from large-scale GCMs, observations that characterize local and decadal variability.

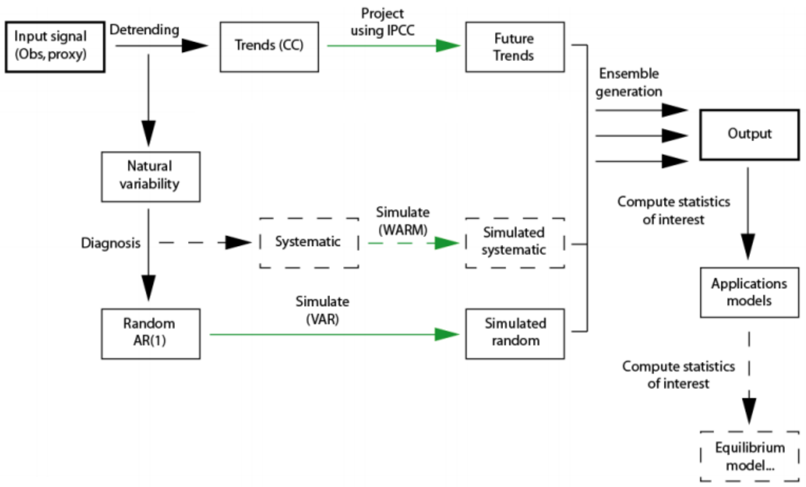


Fig. 1 Conceptual methodology of SimGen (Green et al., 2012a)

2. Generation of climate scenarios and linkage with the VIC model in Central Chile - Deniz Bozkurt & Maisa Rojas

In this presentation climate scenarios are generated and trends in precipitation and temperature are deduced. These observations are linked with the land surface model VIC (Variable Infiltration Capacity) to predict runoff in Central Chile. The RCP 8.5 scenario of the CMIP5 simulations, with the raw data of the GCMs, show an elevated trend (3-4°C) for temperatures in central Chile in the near future and a reduction of 20-25% of precipitation, at the end of the century. These temperature and precipitation data for the basins of Rapel, Mataquito, Maule and Itata are adjusted, through a transfer function, using daily station-based data. The results are imported in the hydrological VIC model to evaluate future changes in runoff. The model is calibrated with snow cover above 1000m asl, of MODIS images, and shows a very good correlation. The results (Fig 2.) indicate a reduction of sub- and superficial water for the four basins, together with a displacement of total annual runoff of 3-5 weeks.

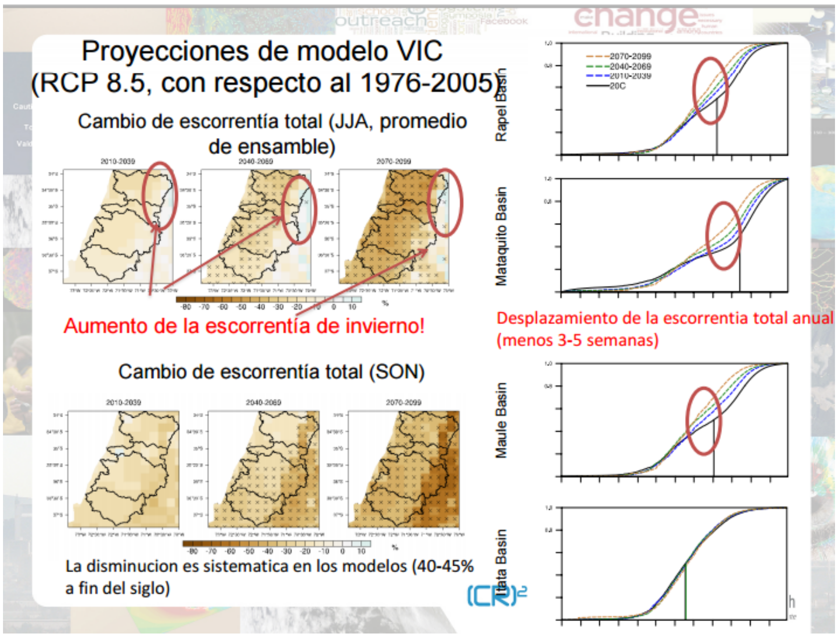


Fig. 2 Results of the VIC model to evaluate future projections of runoff in several basins in central Chile, based on the RCP 8.5 climate change scenario.

The regional climate change signals can exacerbate the consequences of future droughts in the central region of Chile. Finally projections of extreme events are analyzed: Most probably, an increase of inundations in the Cordilleran regions caused by thawing and the augmentation of winterly runoff can be expected.

3. Case Study Using the SimGen model in Argentina and Uruguay – Gabriel Rodriguez

This case study deals with the use of SImgen for application in Argentina and Uruguay, where climate change impacts are combined with impacts from changes in ozone concentration in the atmosphere. The preliminary steps of the modelling are performed in R or RStudio; i.e. assembling the structure of the data directories and the input data preparation. The latter includes conversion to the right data format, calculation of the regional mean and decomposition of the climatic variability.

The stochastic decadal component is used to build the VAR-model. To adjust this model in R, the package 'DSE' is recommended and the data is required as time series. The model is verified by comparing the correlation between the variables in a simulated sequence with the observed series. If the model is acceptable it is used to generate a large amount of simulations. The stochastic decadal simulation is generated in Python. The output function and its variables are given in Fig. 4. From the simulations that were generated using the VAR-model, a specific decade is selected falling into a predefined percentile. In Fig. 3 the decades are indicated that fall into the 10% driest decades of the simulation.

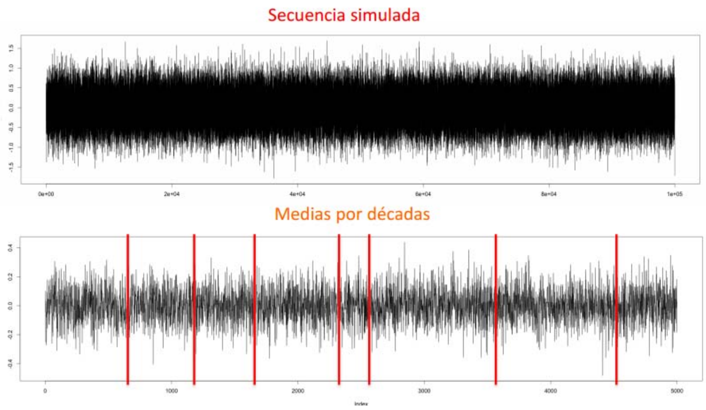
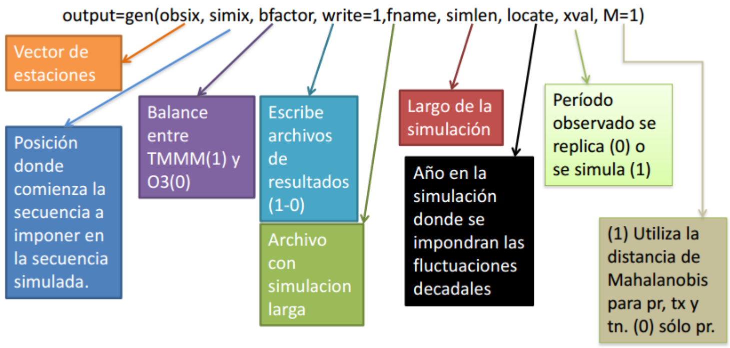


Fig. 3 Simulated sequences of the VAR model and the 10% driest decades (red lines)

In this case study the projections are based on the interaction between global warming and the ozone concentration, defined by the 'bfactor'. In other locations, this factor is replaced by a distribution of expected climatic trends as identified by 43 Global Circulation Models.



output=gen([2000,2001], 2955, 0.5, write=1,fname='sim_100kyr.dat', simlen=60, locate=2041, xval=0, M=1)

Fig. 4 The output function of the SimGen function, with the explanation of each variable

Finally, the generated stochastic simulation, together with the deterministic decadal variation and global trend, future projections for the chosen variables can be represented. Resulting graphs show the future projections for precipitation, minimum and maximum temperatures; for this specific case study the graphs in Fig. 5 are obtained.

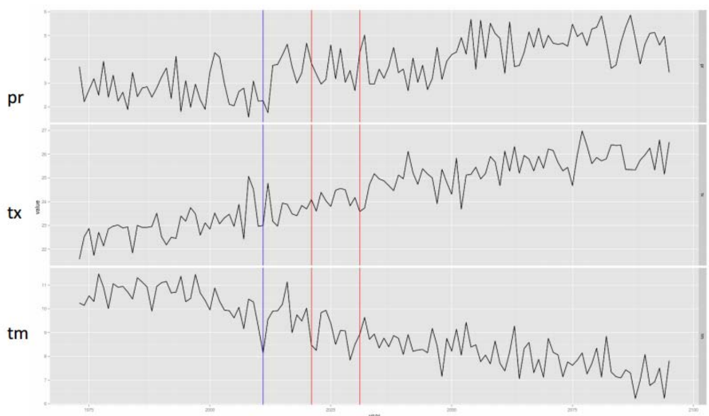


Fig. 5 Resulting future projections of the SimGen model for respectively precipitation, minimum and maximum temperature while evaluating ozone and climate change influence in Argentina and Uruguay.

4. Application of the SimGen model in the Huasco basin - Koen Verbist, Hector Maureira & Pablo Rojas

The Huasco basin, represented in Fig. 6, is situated in in the south of the Atacama region. 12.000 ha of the 985.000 ha basin is cultivated. Beside potable water, the most important water consuming activities are agriculture (mainly grapes, citrus, olives), mining- and hydropower industry. The basin counts with three reservoirs.

The input data for the SimGen model is obtained from the Chilean Climate Data Library, originating from two meteorological stations in the catchment (Conay and Santa Juana). However, the time series are not complete so both statistical data completing as well as synthetic data are used to fill these gaps. In this specific case study the synthetic time series are obtained from historical GCM data, adjusted and scaled with the observations from the meteorological stations in the basin itself (courtesy Universidad de Chile). Validation with the historical application of several climate change models shows a poor correlation of the data from the statistical method, in comparison with the synthetic data. Another important discussion point is the quality of the datasets and thus the number of stations to be included; e.g. the meteorological station Conay accounts for a large enough dataset, but there exists a strong correlation between minimum and maximum measured temperatures, making the quality of its time series rather doubtful. Both results in SimGen, with synthetic station data, as well as the poor quality data from the Conay station, are represented in Fig. 7.

Fig. 6 representation of the Huasco basin, central Chile

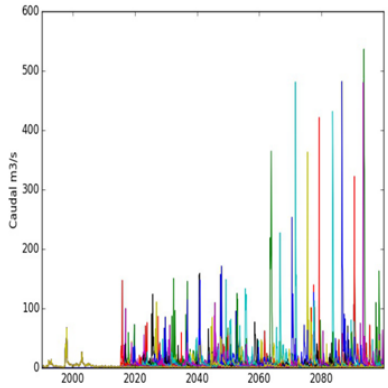
Salida de Estación sintética

Salida estación CONAY, en donde se aprecia que el tener malos datos y/o datos mal rellenados se obtienen malas simulaciones

Fig. 7 SimGen results for temperature in the Huasco basin, using respectively synthetic data and time series from the Conay station.

In this case study 15 climate change models are used and the mean and standard deviation for the Huasco basin are determined to import in the SimGen model. A 50% quantile is selected for the future projection, using the mean trend from the models used. Depending on the purpose of the results other quantiles can be chosen as well.

The results of the SimGen model are used as input for the hydrological Water Evaluation And Planning (WEAP) model, to project discharges at certain locations in the basin for future water allocation between different water users. The results of several discharge projections are represented in Fig. 8.



Modelo	Promedio [m^3/s]	Modelo	Promedio [m^3/s]
Reach	7.8	Reach13	9.8
Reach1	7.9	Reach14	4.8
Reach2	3.0	Reach15	7.4
Reach3	1.9	Reach16	7.4
Reach4	2.6	Reach17	9.6
Reach5	2.7	Reach18	4.5
Reach6	2.7	Reach19	11.2
Reach7	3.6	Reach20	5.0
Reach8	4.3	Reach21	2.2
Reach9	2.3	Reach22	6.3
Reach10	4.4	Reach23	3.7
Reach11	4.9	Reach24	1.8
Reach12	5.2		

Descripción	Series
Total de Series	25
Aumento de Caudal promedio	8
Disminución de Caudal promedio	17
Aumento de Máximo caudal promedio Histórico	25
Disminución de Máximo caudal promedio Histórico	0

Fig. 8 the results of several discharge projections in the Huasco basin, using the WEAP model, based on SimGen predictions.

The step by step performance of the SimGen model on the Huasco basin case study is carried out in the [presentation] of Koen Verbist, Hector Maureira and Pablo Rojas.

5. Pilot country results

The practical part of the workshop consisted of applying the SimGen model on data of relevant basins in the countries of each of the participants. A similar elaboration and presentation, to the Huasco basin, was targeted. The following regions and basins were included:

Perú - Cuenca Chancay (Luis Metzger & Martin Leyva)

Bolivia - Cuenca del rio Keto (Katherine Rojas)

Bolivia - Cuenca del Rio Desaguadero Medio (Juana Mejia)

Colombia - Cuenca del Río Bogotá (Claudia Romero, Giraldo Mendez & Lizeth Llanos)

Costa Rica - Cuenca del Río Toro (Jose Cantillano)

Honduras - Cuenca del Río Choluteca (Jose Ayala)

Argentina - Cuenca del Aroyo Itacaruaré (Gabriel Rodriguez & María Feler)

6. Conclusions and future challenges

The participants were trained to generate medium-term climate scenarios, taking the historical information of each country into account, allowing to identify the projected trends for their pilot basins. The SimGen model was used for this exercise and the first results of each country were discussed. The demand for this tool was confirmed for each present country; e.g. long term planning of water supply for irrigation or hydroelectric power applications, identification of threats to water security, incorporation of this methodology in university course material and identification of water availability on government level to accept irrigation projects.

The SimGen model provides a tool to decompose climate variability in different components, to provide a realistic representation of future projections of climatic conditions in vulnerable basins of Latin America. During the workshop some comments on and recommendations of the methodology and implementation of the model were discussed. There was agreement on the poor results of the statistical method to complete datasets. A weather generator, making use of external data, was suggested to tackle this problem. The creation of synthetic series could also work, however an adjustment and validation of the script to the specific region is necessary. As it is in some cases realistic that locally the performance of a certain climate model is already approved or rejected. Therefore, it could be necessary to implement an option to choose a certain (locally validated) CMIP5 model, or even a regional climate model (RCM), prior to the application of SimGen. Subsequently the suggestion was brought up to run the SimGen model for every pixel and create distribution maps for entire Latin America in order to save time when this information has to be consulted. A major disadvantage is that in this way the choice of climate model is omitted. Furthermore the identification of homogeneous zones, previously to the delineation of a case study, was proposed. This is beneficial, for example, to select which meteorological stations can be combined for a specific area in one simgen model run. This could be integrated in the scripts as well.

In the further development and implementation of this workshop a manual and tutorial is foreseen, with detailed instructions of SimGen, to make the model and its application more user friendly and to improve its understanding. In this manual several comprehensive elaborated case studies in pilot basins will be represented, with projections for several climate change scenarios and various stochastic simulations.

To finalize, two long term critical remarks of the functioning of the model are raised. Firstly, the model does not include an evaluation on projections and changes in precipitation duration and intensity in decadal components. Both are crucial variables that are highly likely subjected to climate change. Secondly, the model could be used or adapted to follow a bottom up process (first outlining the circumstances and natural characteristics of a basin, its strengths and weaknesses, and thereafter adding the climate change component), such as the recently defined 'decision scaling' approach. A further and profound exploration of this methodology for the chosen pilot basins is planned in the beginning of next year. Finally a manual of the SimGen methodology is foreseen to ensure incorporation of climate scenarios in a framework for decision-making and national policies.

7. List of Participants

	Name	Institution	Country	e-mail
1	Katherine Rojas	UMSA	Bolivia	katherinerojasmurillo@gmail.com
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16	Lizeth Llanos	CIAT-CIP	Colombia	l.llanos@cgiar.org
17	Koen Verbist	UNESCO	Chile	k.verbist@unesco.org

8. Programme of the workshop

Programme

Time	Activity	Instructor
09:00-09:30	***Inauguration*** Director of Centro de Formación en Cartagena de Indias - Colombia Embassador Jeroen Cooreman of the Belgian Embassy in Colombia Dr. Koen Verbist, Program Specialist of UNESCO	
09:30-09:45	Presentation of the participants	
09:45-10:00	Presentation of the general framework of Water Resources Management in vulnerable zones of Latin America – Koen Verbist, UNESCO	Koen Verbist
10:00-10:30	Coffee	
10:30-11:00	Introduction to the general framwork of decadal variability simulations for water resources management[1]	Koen Verbist
11:00-12:30	Presentation of the Software SimGen[2]	Gabriel Rodriguez
12.30:-13:30	Lunch	
13:30.-14:00	Generation of climate scenarios and the linkage with the Model VIC	Deniz Bozkurt
14:00.-15:30	Installation of Virtual Machines with Python and R	Gabriel Rodriguez
15:30-15:45	Coffee	

15:45-17:00	Installation of Virtual Machines with Python and R	Gabriel Rodriguez

Day 2: Training of the use of methodologies, using case studies

Time	Activity	Instructor
08:30-09:30	A Casestudy in Argentina and Uruguay, using SimGen	Gabriel Rodriguez
09:30-10:30	Practical Exercise : Application of SimGen in Argentina and Uruguay	Gabriel Rodriguez
10:30-11:00	Coffee	
11:00-13:00	Practical Exercise : Application of SimGen in Argentina and Uruguay	Gabriel Rodriguez
13:00-14:00	Lunch	
14:00.-15:30	Application of SimGen in the pilot watershed Huasco, using the hydrological model WEAP	Hector Maureira/ Sergio Gutierrez/Koen Verbist
15:30-15:45	Coffee	
15:45-17:00	Practical Exercise: Application of SimGen for the application of WEAP-Huasco	Koen Verbist/Hector Maureira/ Sergio Gutierrez/ Gabriel Rodriguez

Day 3: Individual work of the participants´ national databases with supervision of the instructors

Time	Activity	Instructor
08:30-10:30	Application of SimGen for case studies in ALC. Step 1: Entering the data and decomposing time series	Hector Maureira/Gabriel Rodriguez/Koen Verbist
10:30-11:00	Coffee	
10:11-13:00	Step 2: Decomposing the annual and decadal variation on a regional level	Gabriel Rodriguez/ Koen Verbist
13:00-14:00	Lunch	
14:00.-15:30	Step 3: Decomposing the sub-anual variation	Gabriel Rodriguez/

		Koen Verbist
15:30-15:45	Coffee	
15:45-17:00	Step 3: Decomposing the sub-anual variation	Gabriel Rodriguez/ Koen Verbist

Day 4: Individual work of the participants´ national databases with supervision of the instructors

Time	Activity	Instructor
8:30 - 9:00	Evaluation by CF	CF
09:00-10:30	Step 4: Identification of the regional tendency to climate change	Gabriel Rodriguez/ Koen Verbist
10:30-11:00	Coffee	
11:00-12:00	Step 5 : Simulation and evaluation of models	Gabriel Rodriguez/ Koen Verbist
12:00-12:30	Conclusions and roadmap for future activities	
12:30-13:00	***Closure*** Director of Centro de Formación en Cartagena de Indias - Colombia Koen Verbist, Program Specialist of UNESCO	
13:00-14:00	Lunch	

References

(1) Greene, A.M., M. Hellmuth, and J.W. Hansen. 2012a. A framework for the simulation of regional decadal variability for agricultural and other applications. CCAFS Report. International Research Institute for Climate and Society.

(2) Greene, A.M. 2012. The SimGen software package: User guide and notes. International Research Institute for Climate and Society.

(3) Greene, A.M., M. Hellmuth, and T. Lumsden. 2012b. Stochastic decadal climate simulations for the Berg and Breede Water Management Areas, Western Cape province, South Africa. Water Resour Res 48:W06504.