Assessing the Climate Impacts Using Dynamical Downscaling (Regional Climate Model)

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Contents

• Uncertainty in Climate Projections

• Dynamical downscaling with the PRECIS RCM

• A case study of using the PRECIS RCM to make projections of Climate Change impacts on the water resources in the NILE basin
The uncertainty “cascade”

Predicting the impacts of climate change

- **Emissions**
  - Scenarios from population, energy, economics models

- **Concentrations**
  - $CO_2$, methane, sulphates, etc.
  - Carbon cycle and chemistry models

- **Global climate change**
  - Temperature, rainfall, pressure, etc.
  - Coupled global climate models

- **Regional detail**
  - Mountains, coasts, extreme weather, etc.
  - Regional climate models

- **Impacts**
  - Flooding, drought, food supply, etc.
  - Impacts models
Model projections of future global warming with different emissions scenarios (IPCC)
How well do climate models agree?

Change in precipitation (mm day$^{-1}$): average of all IPCC models

White: less than 66% agreement. Colours: 66% or more agreement.
Black dots: 90% or more agreement

2090s relative to present-day, A1B scenario: June-July-August
A1B – 2050
AR4 Ensemble
Precipitation
Global mean temperature rise over 21st century - HadCM3 Ensemble

Atmospheric and some land surface/sea ice uncertainties
“Cause-effect” chain for predicting climate change impacts
- uncertainties at every step

Scenarios from population, energy, economic models

Carbon cycle & chemistry models

Coupled global climate models

Regional climate models

Impacts models
• Climate projections are uncertain

• This uncertainty is not just due to different emission scenarios, but also due to our understanding of model parameterisations.

• We need to understand this uncertainty in the context of climate impacts
Dynamical Downscaling Climate Projections with the PRECIS RCM
From global to local: Modelling pathway

Regional Climate Model

Nested in Global Model

RCM forced by the large scale circulation from GCM

Uncertainties pass from GCM to RCM
What is PRECIS?

Providing REgional Climates for Impact Studies

The RCM uses the same formulation as the GCM.

A Regional Climate Model (RCM) is a tool for downscaling global climate model results to higher spatial resolutions.

Hadley Centre’s regional climate model (RCM) system that can be applied to any area of the globe.

Used to generate detailed projections of future climates from scenarios.

Spatial resolution of 25-50 km
A Regional Climate Model (RCM) is a tool for downscaling global climate model results to higher spatial resolutions.
Winter precipitation over Britain

300km Global Model

(a) 300km GCM: 1979-83

(b) 50km RCM: 1979-83

50km Regional Model

(c) 25km RCM: 1979-83

(d) CRU observations: 1961-90

25km Regional Model

Observed 10km
Uncertainty in regional climate change projections

12 model predictions of summer rainfall
Business as usual emissions scenarios
Components of PRECIS?
Components of PRECIS?

- User interface to set up experiments
- The latest Hadley Centre RCM
- Boundary conditions...
Components of PRECIS 2

- User interface to set up experiments
- The latest Hadley Centre RCM
- Boundary conditions...
- Graphical monitoring of processing

![Graphical Interface](Image)
Components of PRECIS?

- User interface to set up experiments
- The latest Hadley Centre RCM
- Boundary conditions ...
- Graphical monitoring of processing
- Workshop and training materials
- Support and follow up
PRECIS regional workshops & collaborations

- In use following workshop/collaboration
- Workshops planned
• Regional Climate Models can be used to increase regional detail in Climate projections

• Uncertainty is passed to the RCM from the global model.
NILE Case Study
- CC impacts on the flow of the river Nile

Carlo Buontempo
DHI, Egyptian Ministry of Water Resources and Irrigation
The Nile

Large area \((2.9 \times 10^6 \text{ km}^2)\)
which spans several climate regions with significant topographic features

The Nile has a low specific discharge and an high runoff variability

The range projected changes in both precipitation and river runoff tends to be wide

Source: Nile Forecasting System (2002)
Objectives

- To construct climate scenarios for the Nile Basin via regional climate modelling
- To identify possible adaptation strategies to deal with climate change impacts on water resources
- The diversity in GCM projections is partly caused by uncertainties in how to represent the physical processes in the climate system.
- We adopted an *ensemble approach* to inform the assessment of climate change risks.

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NASA is acknowledged for this picture
Boundary condition selection
Members’ selection

Nile Basin Surface T (K)

Nile Basin Precip (mm/day)
Dynamical downscaling

RCM

GCM
Realistic simulation

Assessment of model bias

RCM precipitation JJA 1950-1980

CRU JJA 1969-1979

Unidata IDV was used for the plots
Differences

• The difference in RCM outputs are only driven by differences in the driving conditions.

• This highlight the importance of large scale forcing on local precipitation (ENSO, Monsoon, etc.).

• There is no obvious reason to prefer one ensemble member to another: results from single model simulations can no longer be justified.

~10x
Assessing the impact on the Nile

- The Nile Forecast System – a grid-based hydrological model - will be used to transform the RCM output into possible impact on the river flow along the Nile.

- Delta-change factors will be calculated on a monthly basis for the climatic input variables required for the hydrological model.

- Present-day input time-series will be adjusted based on the calculated delta-change factors and the hydrological model will be re-run with the emission scenario data.

- The procedure will be repeated for each ensemble member to see the range of possible hydrological impact due to climate change.
Assessing the impact on the Nile

• Output from the 5 RCMs is used to drive a hydrological model of the Nile catchment to simulate the impact of Climate on the flow of the Nile

• This is ongoing work
JULES – integrated impacts model
Conclusion

- Results from a single model simulation can no longer be justified for impact studies. The tendency is to move towards a probabilistic assessment of climate impacts.

- This project uses an informative albeit simple approach to include ensemble modelling in an assessment of water resources in a complex multi-national basin such as the Nile.

- The approach described represents an affordable way to inform adaptation decisions using projections which include a consideration of uncertainty in the results.

- RCMs do not improve uncertainty, but add regional detail