In a warming climate, just how predictable are temperature extremes at weather and seasonal time scales?

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Cooling the Warming Debate: Major New Analysis Confirms That Global Warming Is Real
First-order quadratic difference equation

- **Lorenz** illustrated the general problem of predictability by considering the first-order quadratic difference equations:
  \[ Y_{s+1} = aY_s - Y_s^2 \]

- Figure is for \( Y(0) = 1.5; \ a = 3.75 \)
Typical weather forecast skill

Anomaly correlation of 500 hPa height forecasts

- Northern hemisphere
- Southern hemisphere

Year: 1981-2007
- Day 3
- Day 5
- Day 7
- Day 10
ATLAS – Max Temperature climatology for January
NCEP – Raw forecast model data
CC – Climate correction
BC – Bias correction on CC data

Tx - Average Percentage Correct within 2deg - Jan2011
The recent heat wave (1)

Occurrence probability of extreme warm T2m

In South Africa
1) Unified Model
2) NCEP
3) WRF
4) CCAM
The recent heat wave (2)

Tmax: Pretoria (68262): October 2011
The recent heat wave (3)
The recent heat wave (4)

UM 12km horizontal resolution – xaant Run:
Discomfort index (deg C)

12hr Forecast from 12Z 24 OCT 2011 – for 12Z 24 OCT 2011

36hr Forecast from 12Z 24 OCT 2011 – for 12Z 25 OCT 2011
The recent heat wave (5)
24/10/2011
The recent heat wave (6)
Today’s forecast

CCAM 24 hour Rainfall Outlook (mm)
Produced by the Climate Studies, Modelling and Environmental Health Group (CSM&EH) of the CSIR.
Created: 28/10/2011
- Very heavy (> 50 mm)
- Heavy (30–50 mm)
- Moderate (20–35 mm)
- Light to Moderate (10–20 mm)
- Light (1–10 mm)

CCAM Maximum Temperature (°C)
Produced by the Climate Studies, Modelling and Environmental Health Group (CSM&EH) of the CSIR.
Typical weather forecast skill

Anomaly correlation of 500 hPa height forecasts

- Northern hemisphere
- Southern hemisphere

Year: 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07

Correlation: 30% to 100%
How is it possible to predict seasonal climate anomalies?

Predictions of rainfall, frontal passages, etc. for a particular day at a certain location several months ahead has no usable skill. However, there is some skill in predicting anomalies in the seasonal average of the weather. The predictability of seasonal climate anomalies results primarily from the influence of slowly evolving boundary conditions, and most notably SSTs (i.e., El Niño and La Niña), on the atmospheric circulation.
JANUARY NINO3.4 MULTI-MODEL

Temperature Anomaly (°C)


JANUARY

MSE Skill Score (climatology)

Lead-time (months)
In terms of anomalies: 7/10 hits
In terms of “trends”: 8/9 hits

Global Model Hindcasts: End of September for Dec-Jan-Feb

Old Transvaal

Area (averaged):
22°S - 28°S
26°E - 32°E

Corr = 0.7915
Seasonal forecast examples: *Issued Nov 2010*

Mean temperatures

**IRI Multi-Model Probability Forecast for Temperature**
for December-January-February 2011, Issued October 2010

**MULTI-MODEL PROBABILISTIC ENSO FORECASTS (NINO3.4 SST)**
**ISSUED ON: 09-Nov-2010**

**CSIR NRE**
Climate Studies & Modelling

**JANUARY–FEBRUARY–MARCH 2011**

Contribution Agency: International Research Institute for Climate and Society

To find out how ENSO may affect the rainfall over southern Africa during the months ahead, please refer to the forecasts for SADC: http://aave.cesar.africa/themes/climate_template/
Latest seasonal forecasts

IRI Multi-Model Probability Forecast for Temperature for December-January-February 2012, Issued October 2011

Key
- Percentage likelihood of:
  - Above-normal Temperature
  - Near-normal Temperature
  - Below-normal Temperature
- White regions over land have climatological probabilities

Probability (%) of Most Likely Category
- Below-Normal
- Normal
- Above-Normal

MULTI-MODEL PROBABILISTIC ENSO FORECASTS (NINO3.4 SST)
ISSUED ON: 11-Oct-2011

El Nino more likely than usual
- OctNovDec 2011: 3%
- NovDecJan 2012: 2%
- DecJanFeb 2012: 2%
- JanFebMar 2012: 3%
- FebMarApr 2012: 5%

La Nina more likely than usual
- OctNovDec 2011: 55%
- NovDecJan 2012: 60%
- DecJanFeb 2012: 68%
- JanFebMar 2012: 71%
- FebMarApr 2012: 68%

Contributing Agencies:
1) CSIR, NRE
2) International Research Institute for Climate and Society

Access for Climate and Earth System Science

To find out how ENSO may affect the rainfall over southern Africa during the months ahead, please refer to the forecasts for SADC:
http://rava.qeers.net/themes/climate_template/
The multi-model seasonal rainfall and surface temperature forecasting system for SADC under development through ACCESS

Multi-model ensemble of $N_1+N_2+N_3+N_4+N_5+N_6+N_7+N_8+N_9$ members

- **Ensemble 1**: CCAM at CSIR NRE ($N_1$ members)
- **Ensemble 2**: ESM at CPTEC ($N_2$ members)
- **Ensemble 3**: ECHAM4.5 at SAWS ($N_3$ members)
- **Ensemble 4**: HadAM3 at UCT ($N_4$ members)
- **Ensemble 5**: SINTEX-F at JAMSTEC ($N_5$ members)
- **Ensemble 6**: COUPLED models at CSIR NRE ($N_6$ members)
- **Ensemble 7**: Two ECHAM4.5 CGCMs at IRI ($N_7$ members)
- **Ensemble 8**: CFS at NCEP ($N_8$ members)
- **Ensemble 9**: GloSea4 at UK Met Office ($N_9$ members)

**Countries**
- SA (South Africa)
- Brazil*
- USA
- Japan

* IBSA-Ocean

**In use**
**Near future**
**Far future**
Strong anthropogenically forced warming trends have been observed over southern Africa and are projected to continue to rise, consequently justifying the investigation into how the annual update of greenhouse gas (GHG) concentrations in a global model may affect seasonal forecast performance over the region.

Figure 7.17: ECMWF 3-month lead time hindcasts of global 2 m temperature for August–October without (upper panel) and with (lower panel) time-varying anthropogenic greenhouse gases (GHG). In the upper panel the correlation between the ensemble mean and the observations is only 0.29, whereas this increases to 0.68 with variable GHGs, indicating that including variable greenhouse gas concentrations improves the seasonal forecast/hindcast skill of global mean surface air temperature (after Doblas-Reyes et al., 2006).
Summary

• South African modellers have developed the capacity to predict temperatures and their extremes for weather and for seasonal time scales
  – The recent heat wave was captured successfully by forecast models
  – Last summer season’s cool temperatures too

• Seasonal forecasts are only really useful for summer months, while weather forecasts are skilful throughout the year

• More modelling work is required to further improve on forecast performance (including lead-time and skill)