SEASONAL PREDICTION FOR SOUTHERN AFRICA: MAXIMISING THE SKILL FROM FORECAST SYSTEMS

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The evolution of the science of seasonal forecasting in southern Africa

- Model/system development started in early 1990s – SAWS, UCT, UP, Wits (statistical forecast systems)
- South African Long-Lead Forecast Forum
- SARCOF started in 1997 – consensus through discussions
- Late 1990s – started to use AGCMs and post-processing
  - At SAWS (COLA T30, then ECHAM4.5)
  - At UCT (HadAM3P)
  - At UP (CSIRO-II/III, then CCAM)
  - At CSIR (CCAM – since 2009)
- Global Forecasting Centre for Southern Africa – 2003
- Objective multi-model forecast systems – 2008
- Coupled model considerations – 2010 onwards
Deterministic statistical model (antecedent SST as predictor):
DJF 2005/06 forecast made early December

The MOS-PP-ECHAM4.5 system was successful in predicting enhanced probabilities of above-normal over the central-western parts and enhanced probabilities in below-normal over the south-western parts, but predicted only small probabilities of above-normal over the north-eastern parts.
First ever operational regional climate model forecast for southern Africa

**ECHAM4.5-RegCM3**

DJF forecasts using RCM
Figure 12. Correlation differences between the (a) ECHAM4.5-RegCM3 system and the ECHAM4.5-MOS system (24-member mean), the (b) ECHAM4.5-RegCM3 system and the baseline model (using SSTs to simulate rainfall), the (c) ECHAM4.5-MOS and the raw ECHAM4.5 systems (24-member mean), and the (d) ECHAM4.5-MOS (24-member mean) and the baseline system (using SSTs to simulate rainfall) over the 10-year test period. Negative values are masked out.
Operational Forecast Skill
From CONSENSUS discussions

Verification over 7 years of consensus forecast production
New objective multi-model forecast

Assessment of Rainfall for April to June 2008

Old subjective consensus forecast

Expected Total Rainfall for the period April-May-June 2008
Figure 3. ROC scores, averaged over the southern African domain, for the above-normal and below-normal rainfall categories. Scores for the single models and for the two multi-models are shown.

Figure 6. As in Figure 5, but for the two multi-models.

Figure 7. ROC scores, averaged over the southern African domain, for the above-normal and below-normal rainfall categories during El Niño, La Niña and neutral seasons. Scores for the MMcca multi-model are shown.
The multi-model seasonal rainfall and surface temperature forecasting system for SADC under development in South Africa

**Multi-model ensemble of** $N_1+N_2+N_3+N_4+N_5+N_6+N_7+N_8+N_9$ **members**
Some MM Combination Schemes

- Bayesian optimal weighting (B1)
- Bayesian sequential optimal weighting (B2)
- Canonical variate analysis
  - using members (C1)
  - using PCs (C2)
  - using moments (C3)
- Equal weighting (E1)
- Generalized linear model
  - using members (G1)
  - using PCs (G2)
  - using moments (G3)
- Multiple linear regression
  - using members (M1)
  - using PCs (M2)
  - using moments (M3)
- Stepwise regression
  - using members (S1)
  - using PCs (S2)
  - using moments (S3)

1. Models recalibrated and combined at the same time
2. Each model recalibrated, then averaged
ToR 1: To facilitate cooperation between the centres within southern Africa that run an operational global scale long-range forecasting (LRF - from 30 days up to 2 years) system

ToR 2: To produce global forecasts from dynamical forecasting systems

ToR 3: To establish a web based environment for non-commercial product dissemination

ToR 4: The consortium will be managed by a committee

ToR 5: To compile archived hindcasts

ToR 6: To apply standard verification tools

ToR 7: To assist in training and capacity building for LRF

ToR 8: To actively pursue the development and improvement of global scale LRF techniques

UCT: HadAM3P
SAWS: ECHAM4.5 (AGCM and CGCM)
CSIR: CCAM, VCM, UTCM

“ToshioGeorge”
(multi-node machine)
ROC Scores: Coupled vs. 2-tiered systems
ROC differences
New operational approach

Atmospheric Initial Conditions

Model Output Statistics

SST Boundary Conditions

Resolution ~100km

Conformal-Cubic Atmospheric Model
Cross-validation: DJF (Nov) (3-year-out)

Kendalls tau: MOS 850 hPa

Differences: Raw - MOS 850

Kendalls tau: MOS Precip

Differences: Raw - MOS Precip

Kendalls tau: Raw Precip

HadGEM3 CV Verification

DJF  IC: nov

Kendalls tau: MOS 850 hPa

Differences: Raw - MOS 850

Kendalls tau: MOS Precip

Differences: Raw - MOS Precip

Kendalls tau: Raw Precip

HadGEM3 Retro Verification

DJF IC: nov
DJF reliability (retro-active)
SOM
(HadGEM3 daily data, IC: Aug, 1 member)

Christien Engelbrecht
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).
Applications Modelling

Simulated crop production for growing season

LSM 1

LSM 2

Observations (red) / Hindcasts (green)
Applications Modelling

DJF 1999/2000 flooding; ECHAM4.5-MOM3-DC2 fully coupled model forecast late October 1999
To summarize

- From empirical to physical
- MOS > RCM
- Objective combination > subjective consensus
- CGCMs have great potential
- AGCMs should continue to be optimized
- Downscaling and verification important components of forecast system
- System improvement still continuing, including applications model development
- South African modellers need international partners such as the UK Met Office!