Integration of statistical and dynamical methods in seasonal forecasting: an example for Kenya

OBJECTIVE

To investigate improvements to forecast performance that can be obtained by combining both statistical and dynamical forecasts.

The dynamical systems used are

- **UK Met Office Glosea4 (G4)**
- **European Centre for Medium Range Weather Forecast system3 (ECMWF)**
- **NOAA NCEP Climate Prediction Centre CFS1 and CFS2 systems (CFS1,CFS2)**
- **Meteo France Arpege (MF)**
- **Japan Meteorological Agency (JMA)**

METHODOLOGY

Indices of dynamical forecasts are employed as additional predictors to the precursor SST and atmosphere indices used in the KMS statistical forecasts in a linear regression model predicting seasonal precipitation for 12 climatic zones in Kenya. Dynamical forecasts include direct model predictions of precipitation for a rectangular region approximately covering Kenya and EOF indices of model precipitation and 850 mb wind vector output for an extended domain covering most of Africa, tropical Atlantic and Indian Ocean and therefore representing large scale atmospheric patterns which are thought to be associated with precipitation in Kenya.

SKILL SCORE USED

$$SS = \frac{ROC_{stats+dyn}}{ROC_{dyn}} - 1$$

SKILL (SS) FOR BELOW AND ABOVE NORMAL FROM SEPARATE MODELS (ECMWF AND MF)

OND		ECMWF		MF			ECMWF		MF		
		A	B	A	B		A	B	A	B	
ZONE 1						ZONE 7					
	ss-ppn	0.03	0.13	0.04	0.07	ss-ppn	0.01	0	0	0.03	
	ss-uv	0.01	0.09	0.03	0.03	ss-uv	+0.1	+0.1	0.09	+0.05	
	ss+ew	0.01	0.04	0.06	0.01	ss+ew	+0.05	+0.03	+0.02	+0.02	
ZONE 2						ZONE 8					
	ss-ppn	0.16	0.16	0.16	0.12	ss-ppn	0.03	0.03	0.01	+0.04	
	ss-uv	0.12	0.12	0.16	0.1	ss-uv	0.06	+0.01	0.02	+0.03	
	ss+ew	0.01	0.07	0.09	0.07	ss+ew	+0.03	+0.02	0.01	+0.03	
ZONE 3						ZONE 9					
	ss-ppn	0.03	+0.02	0.02	+0.03	ss-ppn	+0.04	0.08	+0.09	0.08	
	ss-uv	+0.01	+0.04	+0.01	+0.04	ss-uv	+0.12	0.06	+0.03	0.09	
	ss+ew	+0.01	0	0.03	0.02	ss+ew	+0.02	0.05	+0.02	+0.09	
ZONE 4						ZONE 10					
	ss-ppn	0.06	+0.02	0.08	+0.04	ss-ppn	+0.01	+0.03	+0.02	0.05	
	ss-uv	0	0	0.05	+0.02	ss-uv	+0.04	+0.03	+0.08	0.03	
	ss+ew	+0.02	+0.01	0.01	0	ss+ew	+0.02	+0.01	+0.04	0.05	
ZONE 5						ZONE 11					
	ss-ppn	+0.01	+0.05	0	+0.04	ss-ppn	0	+0.02	+0.02	0	
	ss-uv	+0.03	+0.08	+0.02	+0.08	ss-uv	+0.02	0	+0.02	+0.06	
	ss+ew	+0.03	+0.04	+0.01	+0.01	ss+ew	+0.01	+0.02	0	0	
ZONE 6						ZONE 12					
	ss-ppn	0.19	0.11	0.2	0.12	ss-ppn	0.02	0.04	0.05	0.05	
	ss-uv	0.12	0.14	0.15	0.11	ss-uv	+0.02	0.03	0	+0.01	
	ss+ew	+0.01	0.01	+0.01	0.01	ss+ew	+0.03	+0.01	0.03	+0.02	

MAM		ECMWF		MF				ECMWF		MF	
		A	B	A	B			A	B	A	B
ZONE 1	ss-ppn	0.11	0.02	-0.21	-0.02	ZONE7	ss-ppn	0.26	0.05	0.02	-0.08
	ss-uv	0	0.05	-0.29	-0.26		ss-uv	0.18	-0.01	-0.11	-0.11
ZONE 2	ss-ppn	-0.1	0	0.08	0	ZONE8	ss-ppn	-0.05	0.13	-0.19	0.03
	ss-uv	0.11	0.12	-0.03	-0.21		ss-uv	0.17	0.01	-0.06	-0.04
ZONE3	ss-ppn	0.1	0.06	-0.2	0.03	ZONE9	ss-ppn	-0.09	-0.05	-0.16	-0.07
	ss-uv	-0.09	-0.05	-0.18	-0.04		ss-uv	-0.08	-0.06	-0.34	-0.35
ZONE4	ss-ppn	0.06	0.03	-0.06	-0.13	ZONE10	ss-ppn	0.04	-0.16	-0.07	-0.1
	ss-uv	-0.05	-0.02	0.09	-0.01		ss-uv	0.1	-0.05	-0.14	-0.08
ZONE5	ss-ppn	0.01	0.12	-0.16	-0.34	ZONE11	ss-ppn	0.05	-0.03	-0.21	-0.3
	ss-uv	-0.01	-0.05	-0.33	-0.36		ss-uv	0	-0.01	-0.15	-0.15
ZONE6	ss-ppn	0.01	-0.11	-0.2	-0.36	ZONE12	ss-ppn	-0.06	-0.07	0.04	-0.04
	ss-uv	0.1	-0.03	-0.35	-0.35		ss-uv	0.01	-0.02	0.09	-0.14

NOTE: G4, CFS and JMA had ZERO SS

The Skill Score (SS) was also calculated for the following combinations of models

- MME: Multi-Model Ensemble average mean of direct model precipitation predictions for a rectangular box approximately covering Kenya from 4 models (ECMWF, MF, Glosea4 and CFS2) assessed over 1989-2005
  MME2 as MME but for ECMWF and MF only
- GRAND: MME + EOF indices of EC and MF precipitation and 850mb wind vectors assessed over 1989-2005.
- (Note: Only EOF indices from the ECMWF and MF systems were found to improve the skill of the statistical methods (see tables) therefore other EOFs indices for other models not used in GRAND).
- GRAND2 : MME2 + EOF indices of EC and MF precipitation and 850mb wind vectors assessed over 1989-2005

SS FOR ABOVE NORMAL AND BELOW NORMAL CATEGORIES FROM COMBINED MODELS

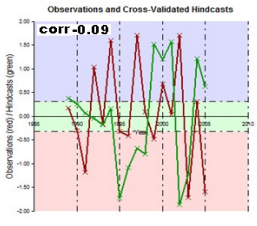
MAM

	MME	GRAND	MF+EC		MME	GRAND	GRAND2
ZONE1				ZONE7			
A	0.05	-0.65	-0.12	A	-0.12	1.5	-0.1
B	0.05	-0.23	-0.37	B	0.08	0.36	-0.23
ZONE2				ZONE8			
A	-0.19	-0.44	-0.05	A	-0.15	0.18	-0.01
B	0.06	-0.07	-0.22	B	0.28	0.33	-0.01
ZONE3				ZONE9			
A	0.11	-0.22	-0.04	A	-0.23	-0.57	-0.38
B	0.09	-0.28	0.07	B	-0.05	-0.6	-0.27
ZONE4				ZONE10			
A	0.38	0.31	-0.11	A	0.07	-0.29	-0.3
B	-0.19	0.36	-0.14	B	-0.11	-0.38	-0.4
ZONE5				ZONE11			
A	-0.06	0.22	-0.13	A	0.03	0.23	-0.14
B	0	0.18	-0.3	B	0.15	0.29	-0.26
ZONE6				ZONE12			
A	0.07	0	-0.39	A	-0.06	-0.4	-0.14
B	0.22	0.43	-0.49	B	0.07	-0.66	-0.28

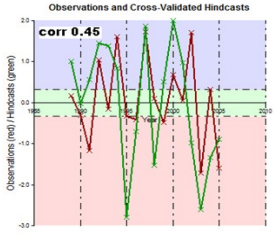
OND

	MME	GRAND	MF+EC		MME	GRAND	GRAND2
ZONE 1				ZONE 7			
A	-0.06	-0.25	0.04	A	0.08	-0.15	0.03
B	-0.14	-0.17	0.16	B	0.11	0.15	-0.09
ZONE 2				ZONE 8			
A	-0.05	0.43	0.13	A	-0.07	-0.15	0.04
B	-0.53	-0.28	0.14	B	0.05	0.1	-0.07
ZONE 3				ZONE 9			
A	0.03	-0.1	-0.04	A	-0.04	0.09	-0.08
B	-0.08	-0.07	-0.05	B	-0.1	-0.17	0.05
ZONE 4				ZONE 10			
A	0.46	1.04	0.01	A	-0.16	0.16	-0.01
B	0.04	0.74	-0.03	B	-0.06	-0.14	0.06
ZONE 5				ZONE 11			
A	0.07	-0.09	-0.01	A	0.21	-0.44	-0.07
B	0.05	-0.27	-0.02	B	-0.16	0.06	-0.06
ZONE 6				ZONE 12			
A	0.23	0.18	0.27	A	0.58	1	0
B	0.15	0.46	0.19	B	0.41	0.11	0.02

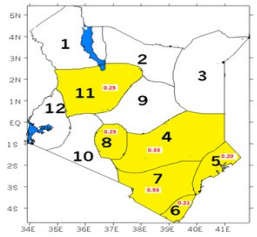
PCR for Zone 4 for statistical predictors (OND)



PCR for Zone 4 for GRAND (OND)



SS AVERAGE -MAM -GRAND



SS AVERAGE OND GRAND