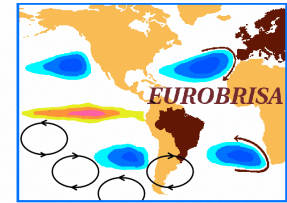# A new hybrid seasonal forecasting system for South America

Caio A. S. Coelho (e-mail: caio.coelho@cptec.inpe.br)

Centro de Previsão de Tempo e Estudos Climáticos (CPTEC)
Instituto Nacional de Pesquisas Espaciais (INPE)

EUROBRISA

http://eurobrisa.cptec.inpe.br

1.   Introduction

Since 2007 CPTEC is producing empirical-dynamical (i.e. hybrid) precipitation seasonal forecasts for South America as part of EUROBRISA: A EURO-BRazilian Initiative for improving South American seasonal forecasts.

The first version of this hybrid forecasting system, was composed by three models; an empirical model that uses Pacific and Atlantic SST as predictor variable for precipitation, and two coupled dynamical models: ECMWF and UKMO.

In December 2009 a new version of the EUROBRISA hybrid forecasting system was implemented, and the system is now composed by five models: the empirical model of the previous system, ECMWF, CPTEC and Meteo-France and the new version of UKMO coupled seasonal forecasting system (known as GloSea 4).

This study illustrates how empirical and dynamical coupled model precipitation seasonal forecasts are being integrated (i.e. combined and calibrated) to produce hybrid forecasts for South America. The skill of one month lead 1981-2005 austral summer (December-January-February, DJF) forecasts is asseesed and compared to the previous system.

2. Calibration and combination procedure for producing hybrid (empirical-dynamical) forecasts

Forecast Assimilation

Y: DJF precipitation
X: 1-month lead precip. forecasts for DJF

$$p(Y \mid X) = \frac{p(X \mid Y)\, p(Y)}{p(X)}$$

Prior: $Y \sim N(Y_b, C)$

Likelihood: $X \mid Y \sim N(G[Y - Y_o], S)$

$$G = S_{XY} S_{YY}^{-1}$$
$$-GY_o = \overline{X} - G\overline{Y}$$
$$S = S_{XX} - G S_{YY} G^T$$

$X : n \times p$
$Y : n \times q$
$Y_b : 1 \times q$
$C : q \times q$
$S : p \times p$
$Y_a : n \times q$
$D : q \times q$

Posterior: $Y \mid X \sim N(Y_a, D)$
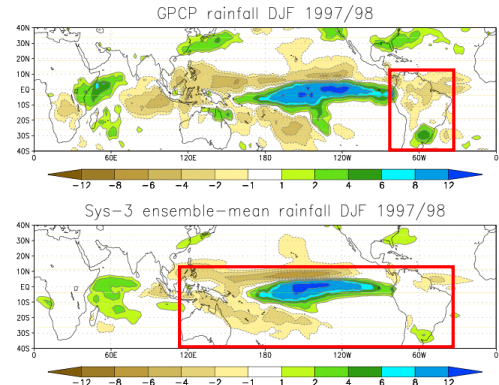
$$Y_a = Y_b + L[X - G(Y_b - Y_o)]$$
$$D = (G^T S^{-1} G + C^{-1})^{-1} = (I - LG)C$$
$$L = CG^T (GCG^T + S)^{-1}$$

GPCP rainfall DJF 1997/98
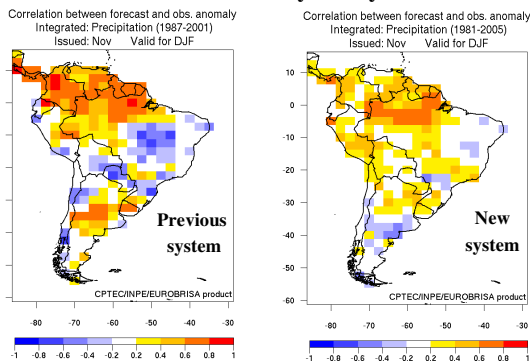
Sys-3 ensemble-mean rainfall DJF 1997/98
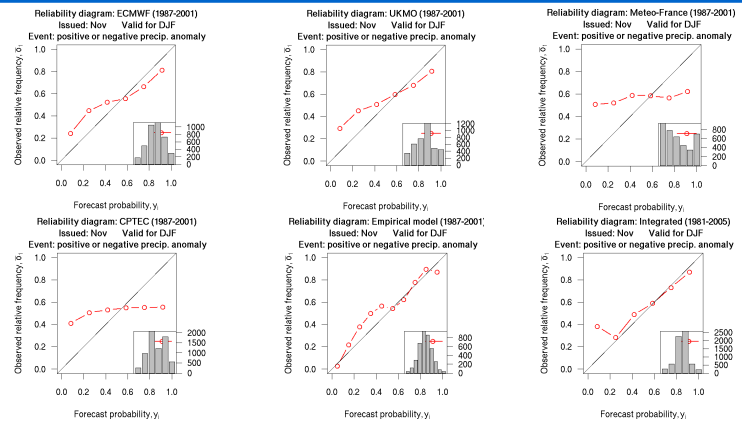
Cortesy: Franco Molteni (ECMWF)

Stephenson et al. (2005), Coelho et al. (2006)

New hybrid system uses precipitation forecasts over land and ocean

Forecast assimilation uses first three leading MCA modes of the matrix $Y^T X$.

3. Skill assessment of the new hydrid system

Correlation between forecast and obs. anomaly
Integrated: Precipitation (1987-2001)
Issued: Nov   Valid for DJF

Previous system

Correlation between forecast and obs. anomaly
Integrated: Precipitation (1981-2005)
Issued: Nov   Valid for DJF

New system

New hybrid system shows improved skill in southeast Brazil and much reduced areas of negative skill compared to the previous system

Reliability diagram: ECMWF (1987-2001)
Reliability diagram: UKMO (1987-2001)
Reliability diagram: Meteo-France (1987-2001)
Reliability diagram: CPTEC (1987-2001)
Reliability diagram: Empirical model (1987-2001)
Reliability diagram: Integrated (1981-2005)

The new hybrid (integrated) forecasts are better calibrated than individual coupled model forecasts

4. Real-time 1-month lead precipitation forecast for DJF 2009/2010
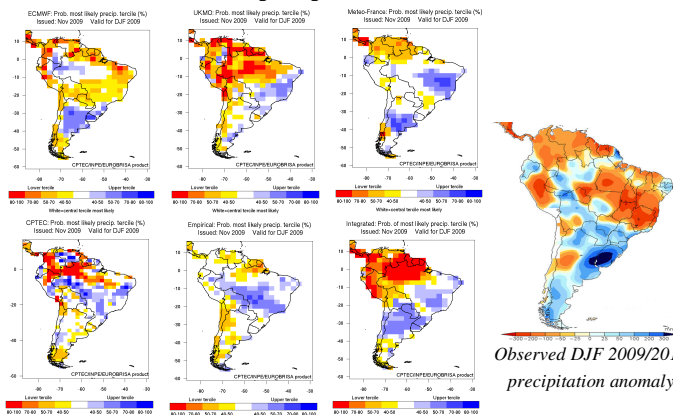
Observed DJF 2009/2010 precipitation anomaly

Hybrid (integrated) forecast shows good correspondence with observations over northern and southeastern South America

5. Conclusions

This new EUROBRISA hybrid system shows improve skill in parts of South America when compared to the previous system. Skill improvement is likely due to:
• inclusion of two additional coupled models (CPTEC and Meteo-France);
• update of UKMO coupled model to a new improved version; and
• use of forecast information over the Pacific ocean in addition to forecasts over South America in the forecast assimilation (calibration and combination) procedure.

The performance of the new hybrid system in forecasting DJF 2009/2010 precipitation has been evaluated subjectively and indicates a reasonably good agreement between the forecast and observed signal over regions where this system has historically moderate to good skill.

References
• Stephenson D. B., C.A.S. Coelho, F. J. Doblas-Reyes and M. Balmaseda, 2005: Forecast Assimilation: A unified framework for the combination of multi-model weather and climate predictions. *Tellus A* . **57**, 253-264.

• Coelho C.A.S., D. B. Stephenson, M. Balmaseda, F. J. Doblas-Reyes and G. J. van Oldenborgh, 2006: Towards an integrated seasonal forecasting system for South America. *J. Climate*. **19**, No. 15, 3704-3721.