

Seasonal forecast calibration and combination

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Part 2: South American precipitation forecasts

*Targeted Training Activity on “Statistical methods in seasonal prediction”,
ICTP, Trieste, Italy, 2 – 13 August 2010*

Integrated forecasts for South America

Combined and calibrated coupled + empirical forecasts

Coupled model	Country
ECMWF	International
UKMO	U.K.

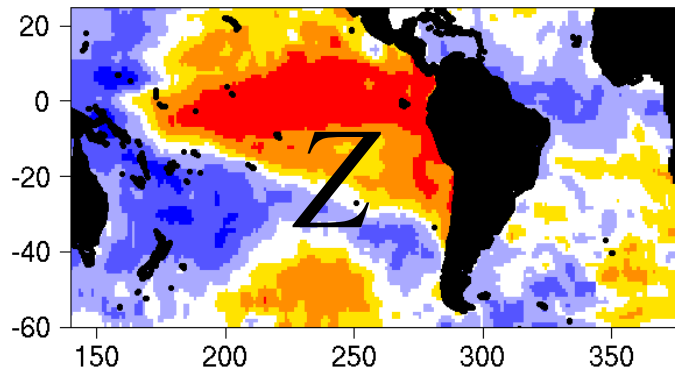
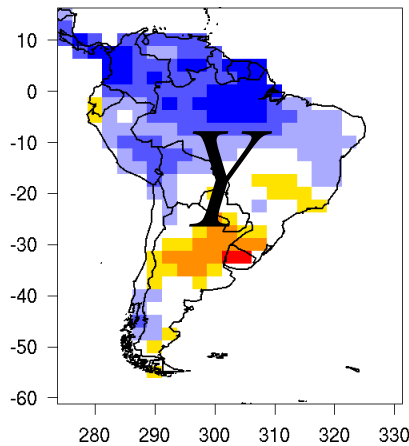
Empirical model
Predictors: Atlantic and Pacific SST
Predictand: Precipitation

*Integrated
forecast*

Hindcast period: 1987-2001

Produced with
Forecast assimilation
(Stephenson et al. 2005)

The empirical model



Data sources:

SST (Reynolds OI v2)

Precipitation (GPCP v2)

1982-2005: 24 years

$$Y|Z \sim N(M(Z - Z_0), T)$$

Y: DJF precipitation

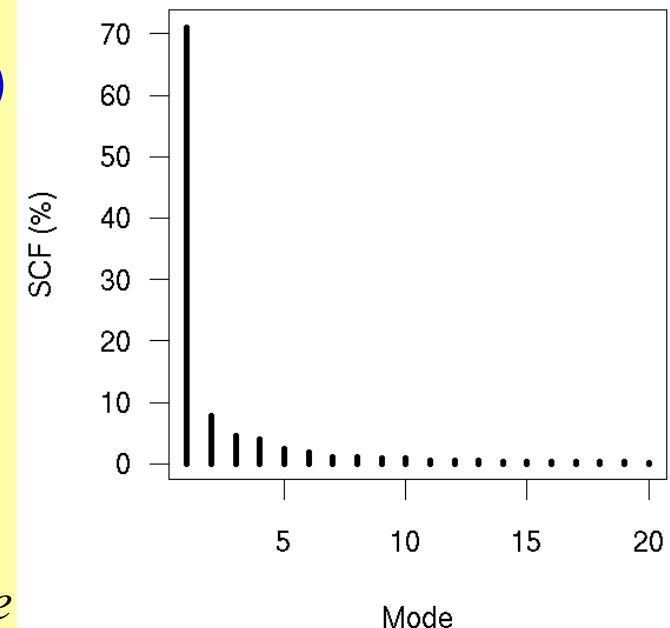
Z: October sea surface temperature (SST)

$$Y : n \times q$$

$$Z : n \times v$$

$$T : q \times q$$

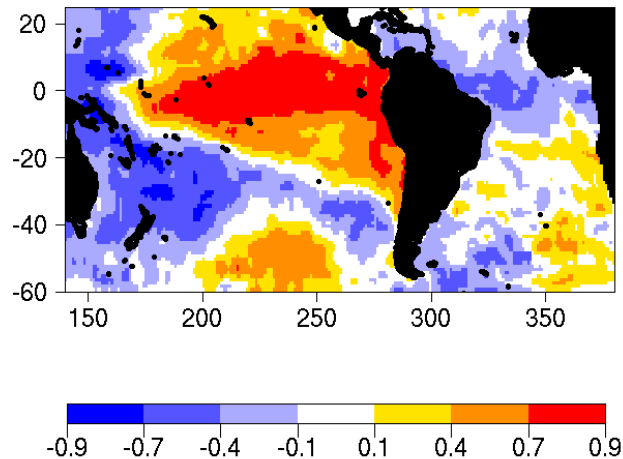
Model uses first three leading Maximum Covariance Analysis (MCA) modes of the matrix $Y^T Z$.



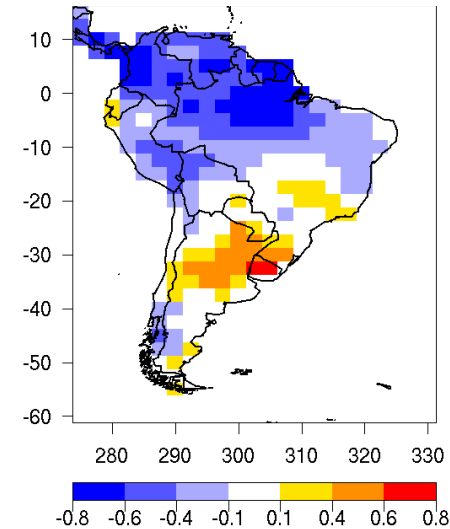
Coelho *et al.* (2006)

Empirical Model (first mode): SCF 71%

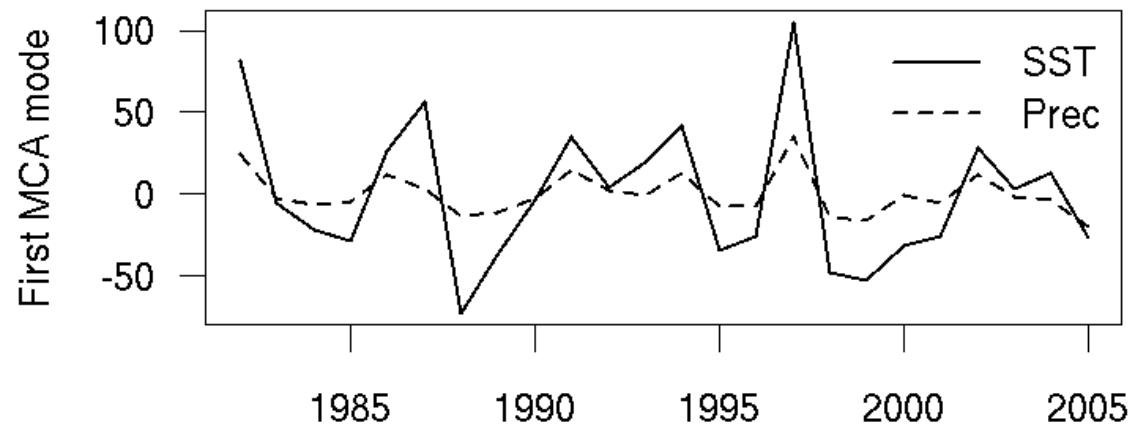
October SST



DJF Precipitation

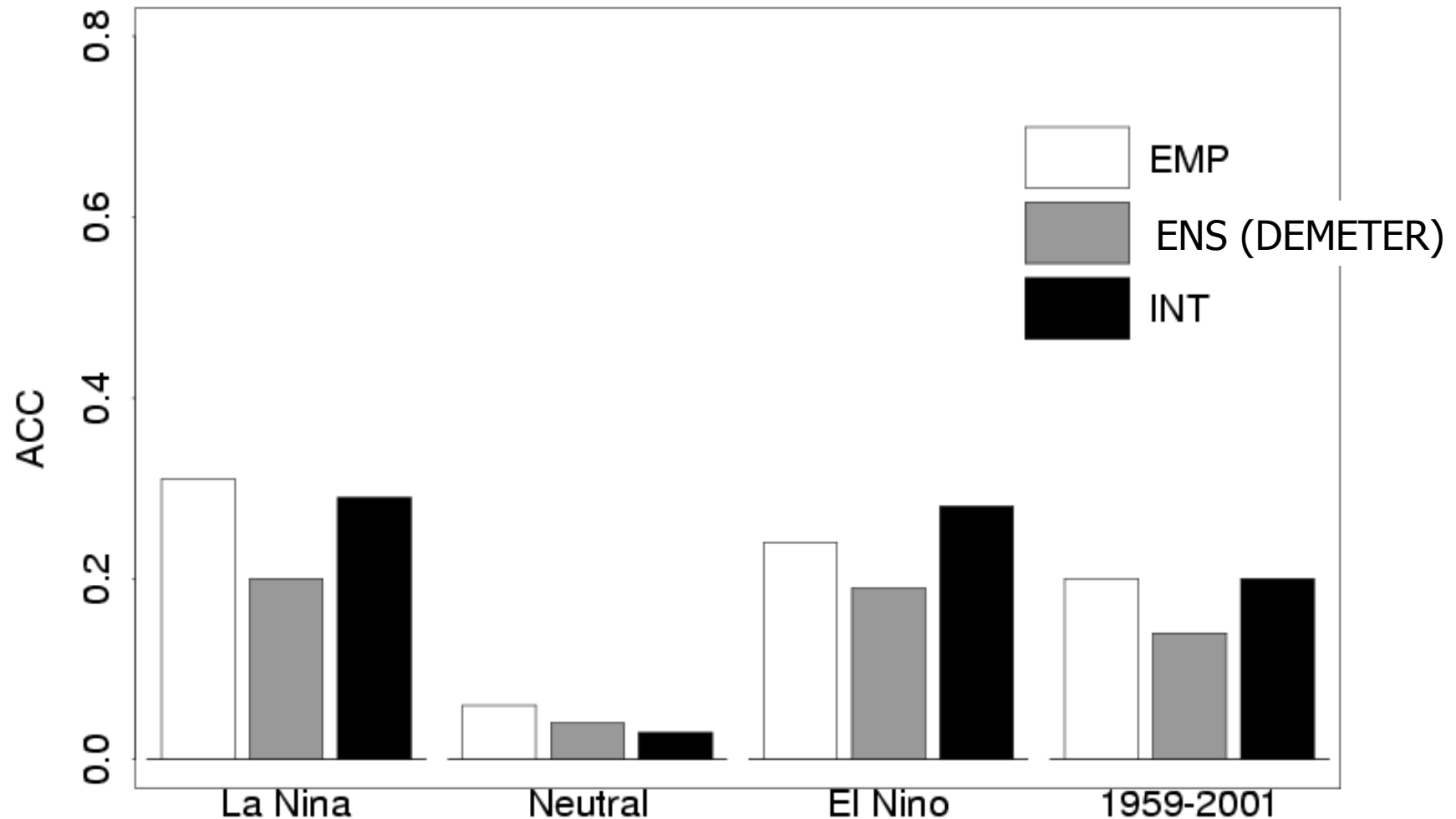


Time series $r = 0.91$



Tropical Pacific (ENSO) and Atlantic: main sources of seasonal predictability in South America

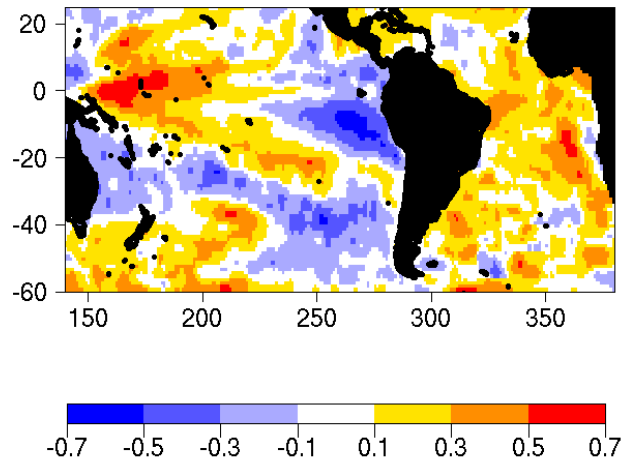
Anomaly Correlation Coefficient (ACC) for South American precipitation forecasts



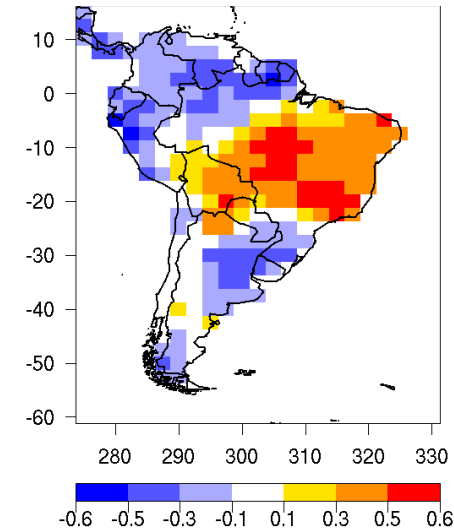
Better (larger) skill during ENSO years compared to neutral years

Empirical Model (second mode): SCF 7.7%

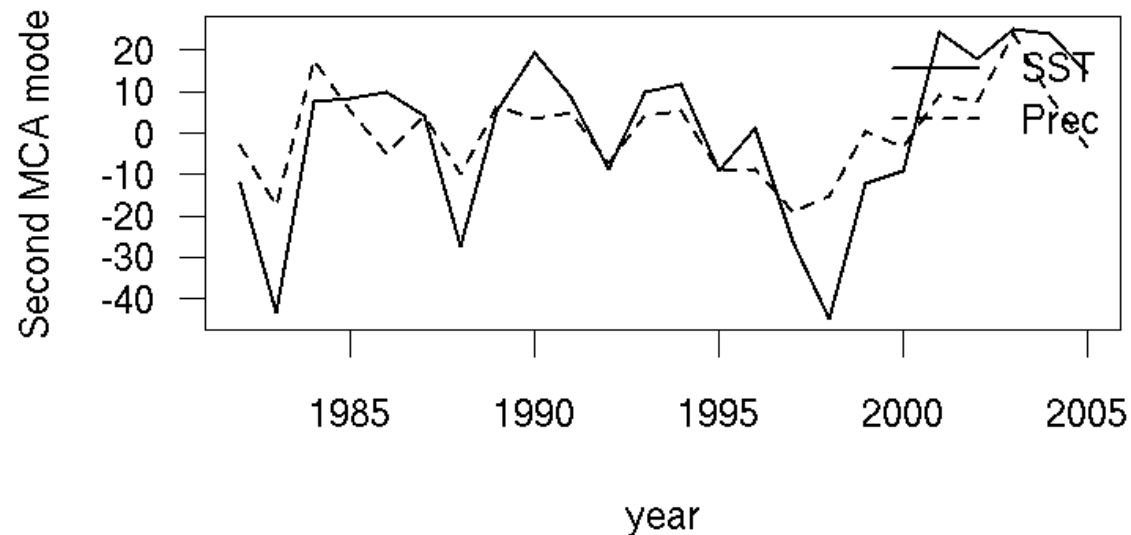
October SST



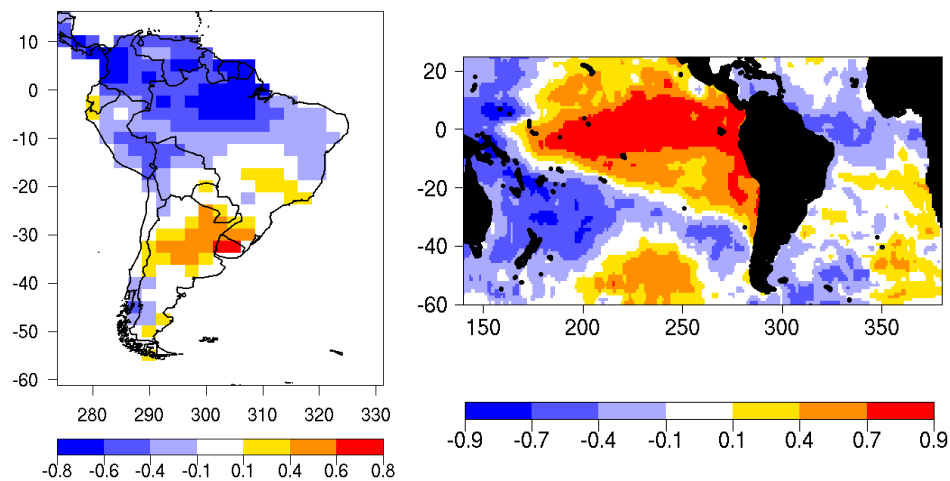
DJF Precipitation



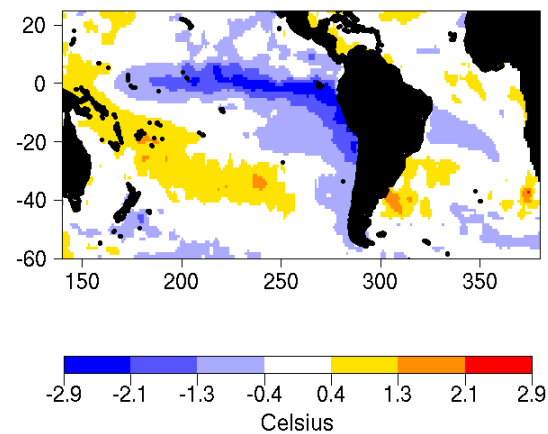
Time series $r = 0.81$



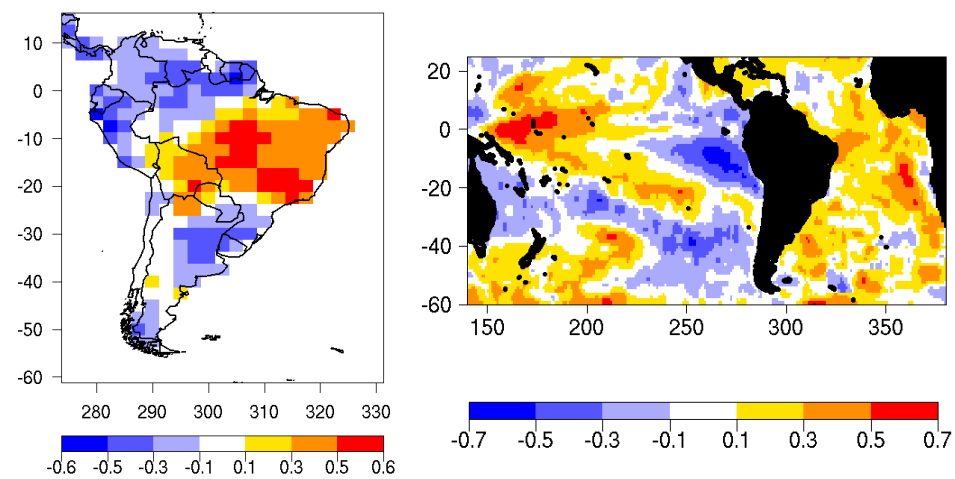
First mode (71%)



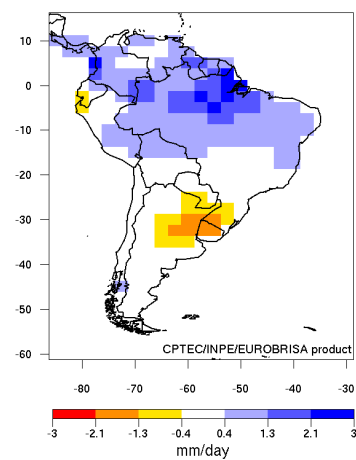
Obs. SST anom. in Oct 2007



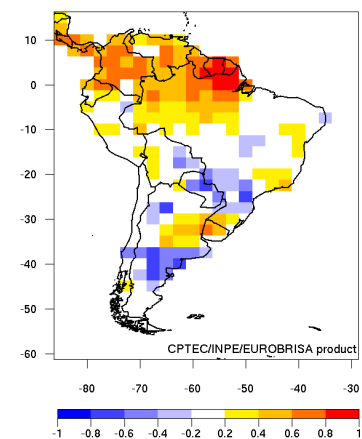
Second mode (7.7%)



Forecast: DJF 2007



Corr. DJF



Bayesian calibration and combination:

Forecast assimilation

$$p(Y | X) = \frac{p(X | Y)p(Y)}{p(X)}$$

Prior:

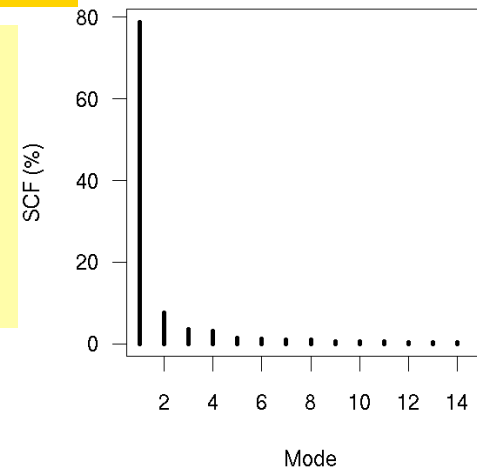
$$Y \sim N(Y_b, C)$$

X: forecasts (coupled + empir.)

Y: DJF precipitation

Likelihood:

$$G = S_{XY} S_{YY}^{-1}$$



Matrices

$$X : n \times p$$

$$Y : n \times q$$

$$Y_b : 1 \times q$$

$$C : q \times q$$

$$S : p \times p$$

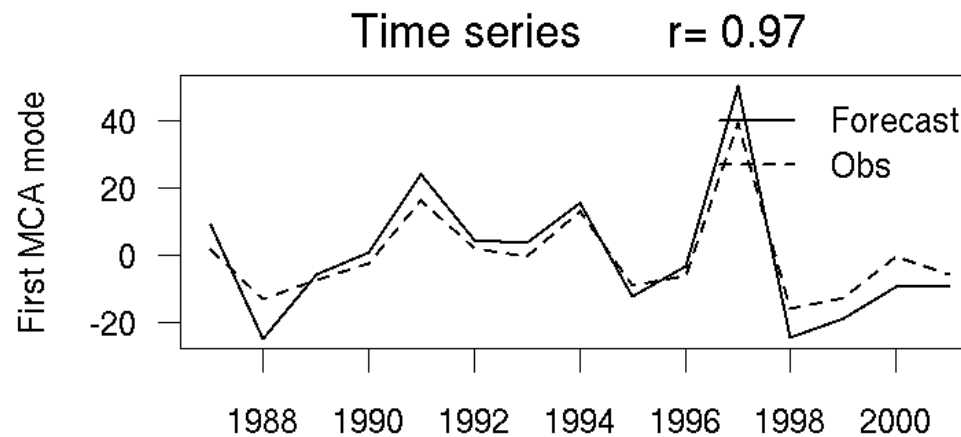
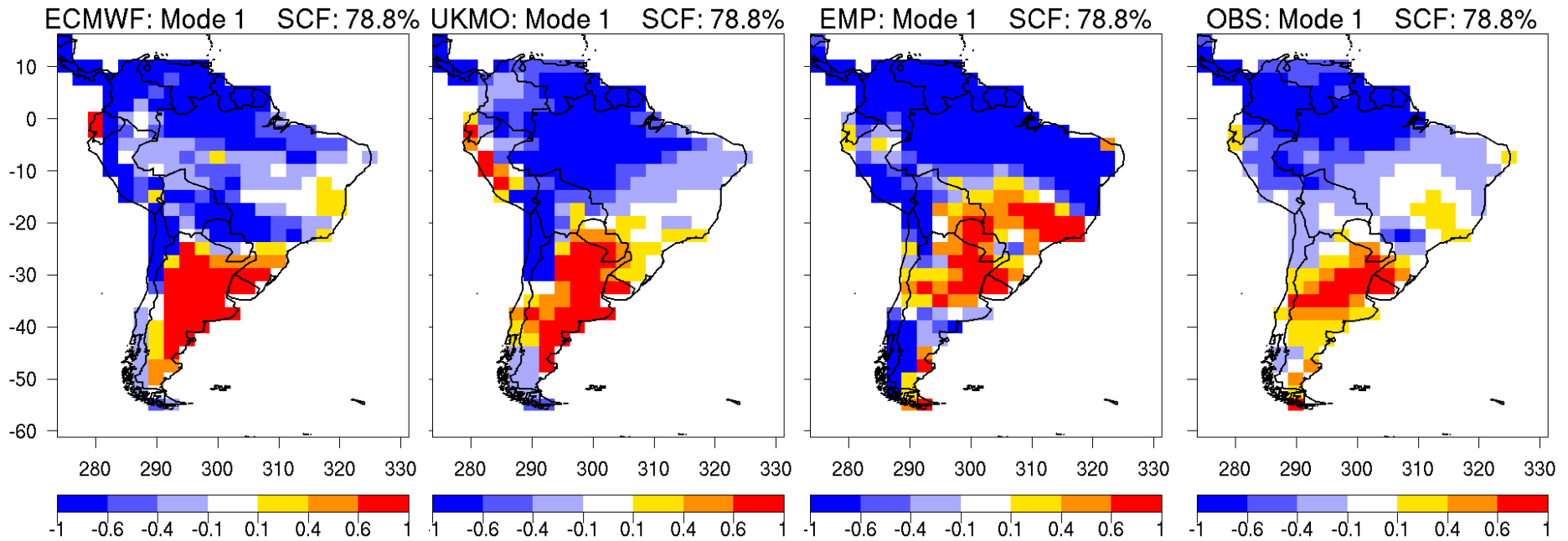
$$Y_a : n \times q$$

$$D : q \times q$$

Posterior:

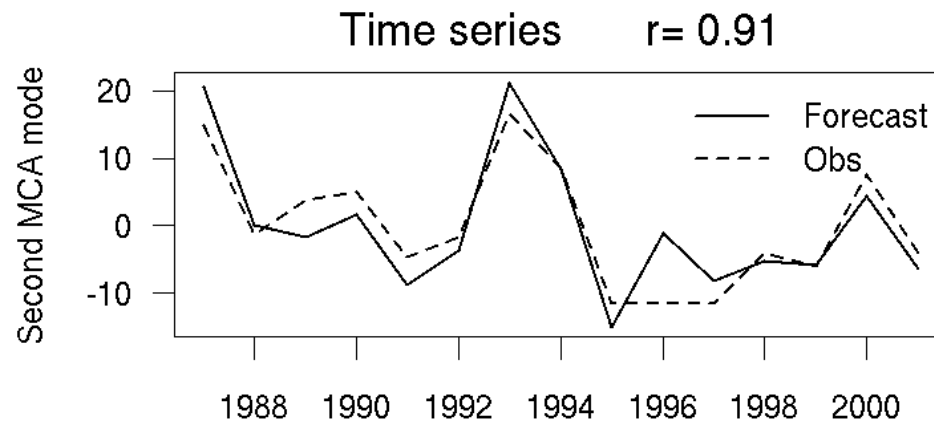
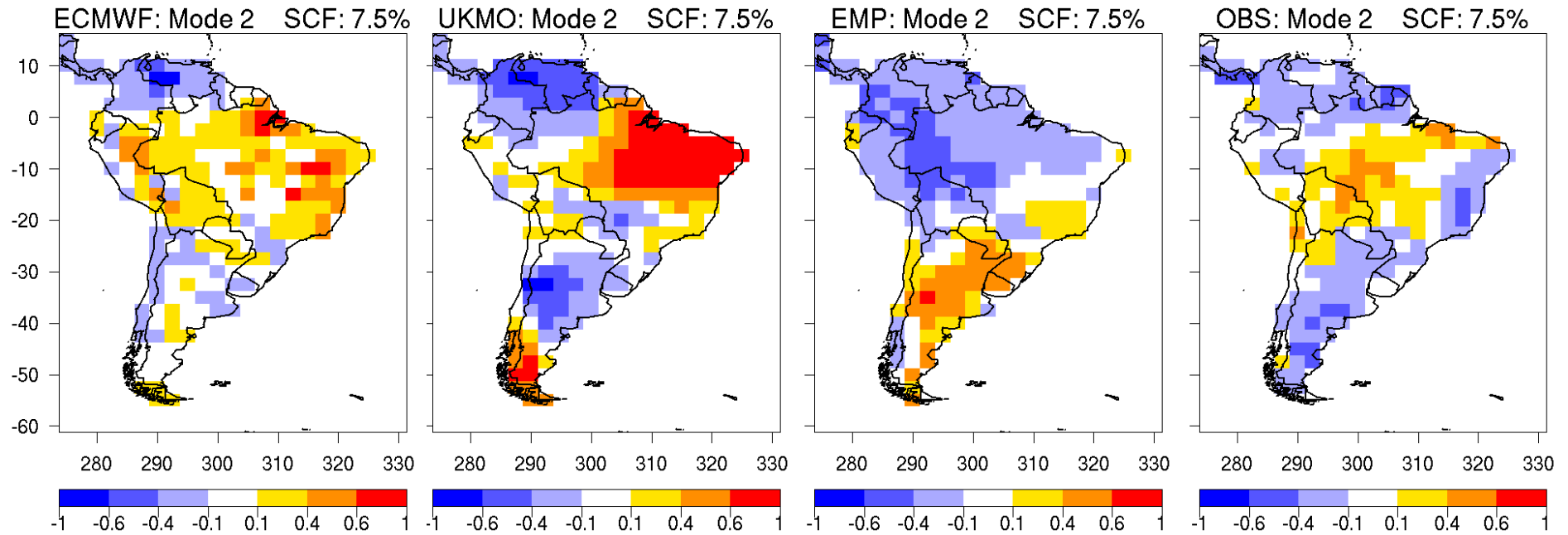
Forecast assimilation uses first three leading MCA modes of the matrix $Y^T X$

Forecast assimilation: first mode (DJF)



Issued: Nov, Valid: DJF

Forecasts assimilation: second mode (DJF)



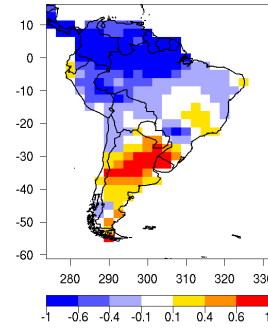
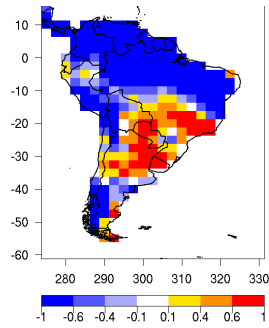
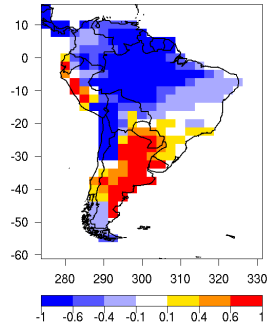
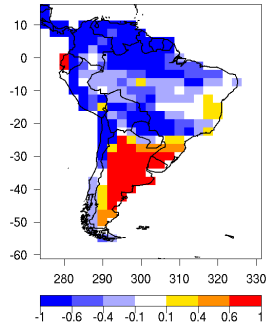
Issued: Nov, Valid: DJF

ECMWF

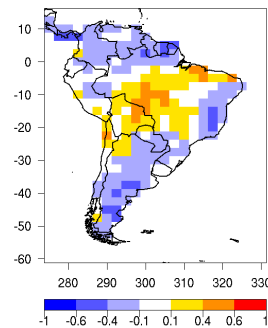
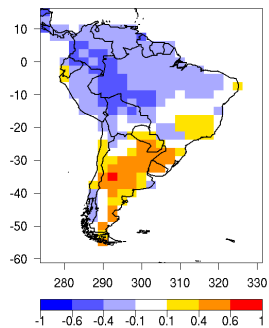
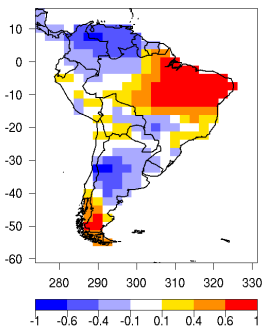
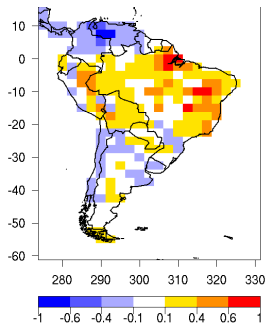
UKMO

EMP

OBS



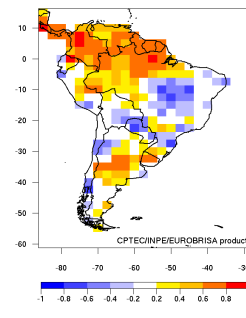
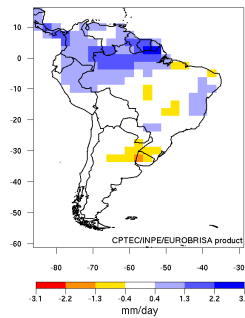
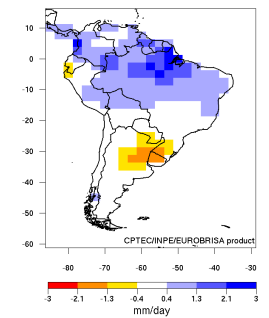
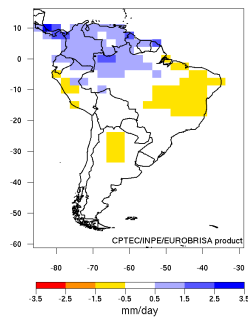
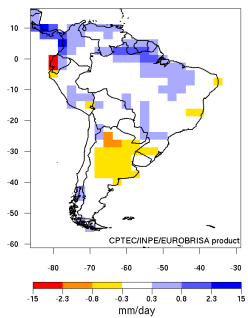
First mode: 78.8%



Second mode: 7.5%

Forecast for DJF 2007

Corr. DJF



ECMWF

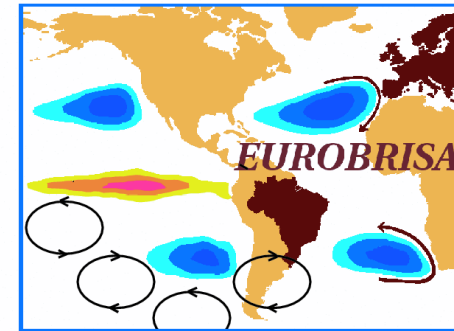
UKMO

EMP

INT

EUROBRISA: A EURO-Brazilian Initiative for improving South American seasonal forecasts

key Idea: To improve seasonal forecasts in S. America: a region where there is seasonal forecast skill and useful value.



<http://eurobrisa.cptec.inpe.br>

Aims

- Strengthen collaboration and promote exchange of expertise and information between European and S. American seasonal forecasters
- Produce improved well-calibrated real-time probabilistic seasonal forecasts for South America (i.e. combine and calibrate coupled and empirical forecasts)
- Develop real-time forecast products for non-profitable governmental use (e.g. reservoir management, hydropower production, agriculture and health)

Involved institutions	Country	Partners
CPTEC	Brazil	Coelho, Costa
ECMWF	EU	Balmaseda, Doblas-Reyes
INMET	Brazil	Moura, Fortes
Met Office	UK	Graham, Colman
Météo France	France	Déqué
UFPR	Brazil	Guetter
Uni. of Exeter	UK	Stephenson
Uni. of São Paulo	Brazil	Ambrizzi, Silva Dias

EUROBRISA activities

Climate prediction research and development

- Produce probabilistic forecasts of precipitation with empirical and dynamical coupled models
- Deliver objectively combined (dynamical + empirical) well-calibrated forecasts
- Compare skill of empirical, dynamical and combined forecasts using deterministic and probabilistic measures

Impacts (collaborative work with users)

- Hydrology: Use of seasonal forecasts for river flow predictions
- Agriculture: Research on the use of seasonal forecasts in agricultural activities; Downscaling of seasonal forecasts for use in crop models
- Health: Use of seasonal forecasts for dengue risk/incidence predictions

EUROBRISA System implemented in 2007

1-month lead precip. forecasts
EUROSIP: ECMWF
UKMO
Meteo-France
Empirical (SST based)
Integrated (Combined: ECMWF, UKMO and empirical)

Real time and verification products

Integrated: Prob. of most likely precip. tercile (%)
Issued: Oct 2007 Valid for NDJ 2007

30/10/2007 08:07:52 | Real time forecasts and verification products are now available (+)

<http://eurobrisa.cptec.inpe.br>

Eurobrisa-CPTEC/INPE - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www6.cptec.inpe.br/eurobrisa/

openSUSE - Getting Started Latest Headlines

CPTEC/INPE/EUROBRISA product

Lower tercile Upper tercile

80-100 70-80 50-70 40-50 40-50 50-70 70-80 80-100

White=central tercile most likely

SUPPORTED BY

Copyright ©INPE/CPTEC 1995 - 2007 - Comments and/or suggestions: Talk to Us | FAQ

→ EUROBRISA project proposal approved by ECMWF council in June 2005: see page 5 of ECMWF newsletter No. 104
 → Leverhulme research network proposal
 → Powerpoint overview

PRESENTATIONS

→ EUROBRISA Integrated System Talk in Portuguese - given at CPTEC and INMET, May 2005
 → Summary and Video talk given at CPTEC
 → EUROBRISA talk given at CPTEC-INMET-IRI workshop, November 2006
 → EUROBRISA poster presented at WCRP workshop on seasonal prediction, Barcelona, 4-7 June 2007

NEWS

30/10/2007 08:07:52 | Real time forecasts and verification products are now available [+]
 30/10/2007 08:06:18 | EUROBRISA web page has been launched [+]
 → More news

USEFUL LINKS

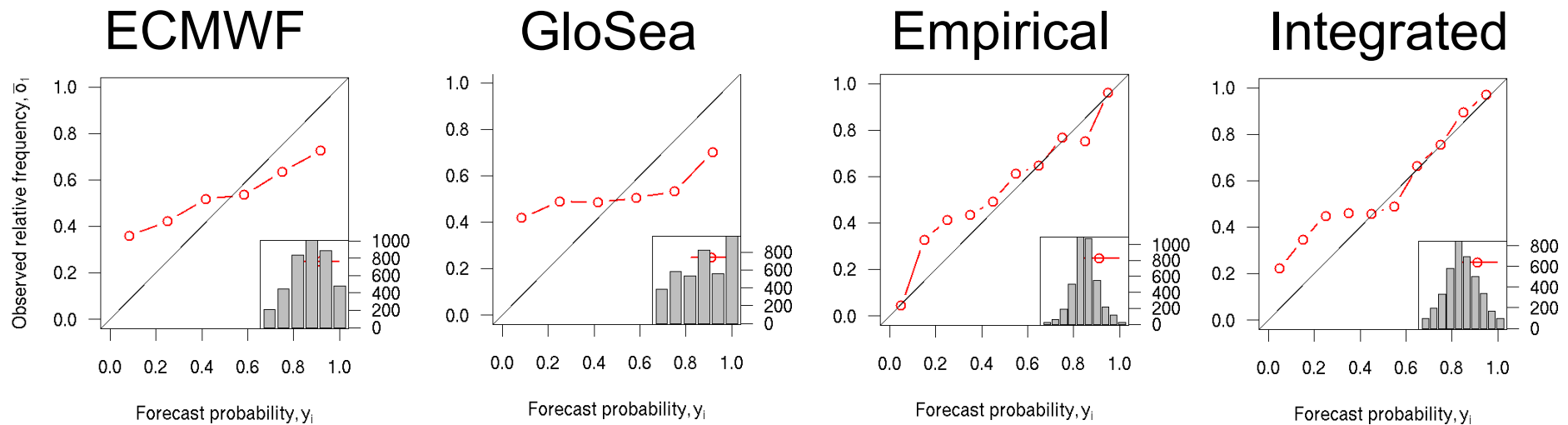
→ South American seasonal forecasts
 → National Meteorological Services
 → CPC Regional Climate Maps

CONTACTS

→ Any comments?
 Please contact either Dr. Caio A. S. Coelho or Prof. David B. Stephenson

Forecast quality JJA

Reliability diagrams for the event positive precipitation anomaly over South America

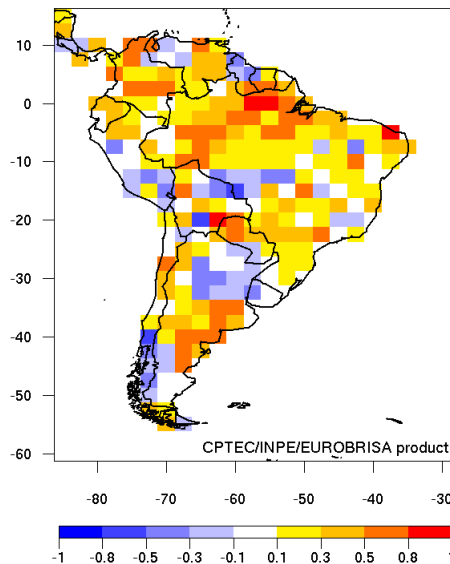


- Hindcast period: 1987-2001
- Start date 1st May (1-month lead for JJA)
- Empirical model uses Apr SST as predictor for JJA precip.
- Integrated forecasts (dynamical & empirical) with forecast assimilation

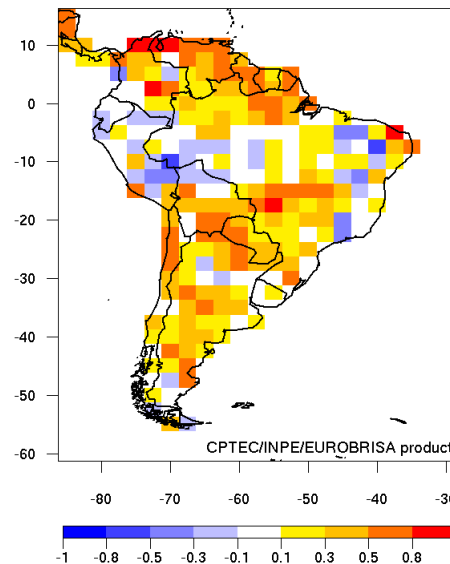
Forecast quality JJA

ROC skill score (2A-1) for the event positive precip. anomaly

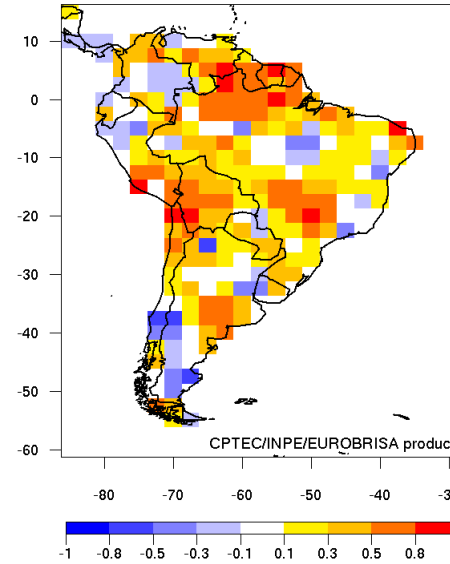
ECMWF



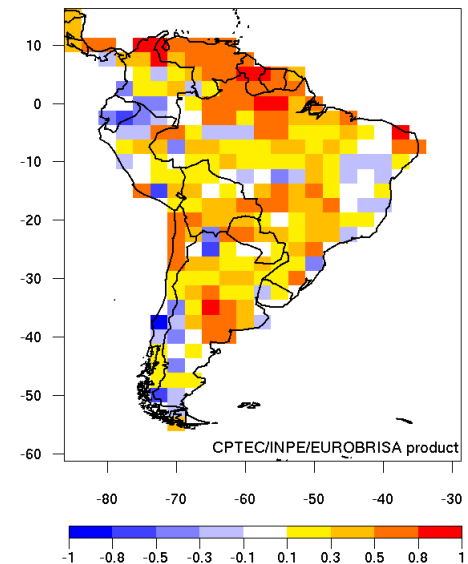
GloSea



Empirical



Integrated



- Hindcast period: 1987-2001
- Start date 1st May (1-month lead for JJA)
- Empirical model uses Apr SST as predictor for JJA precip.
- Integrated forecasts (dynamical & empirical) with forecast assimilation

Forecasts products

Probability of most likely tercile:

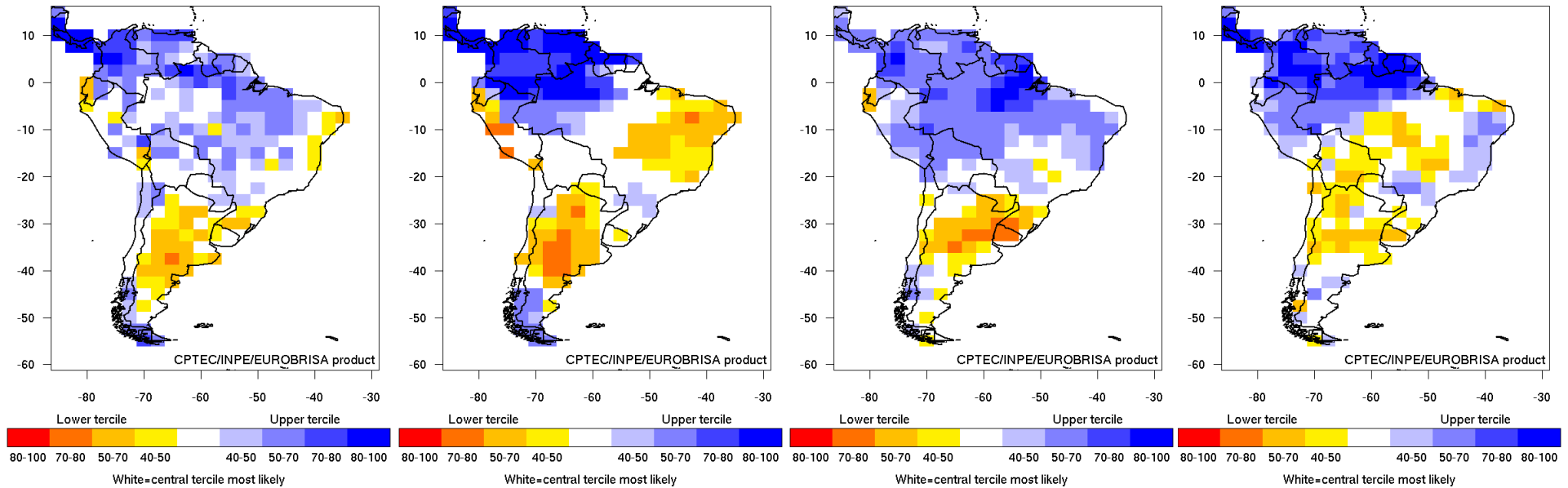
DJF 2007 precipitation

ECMWF

UKMO

Empirical

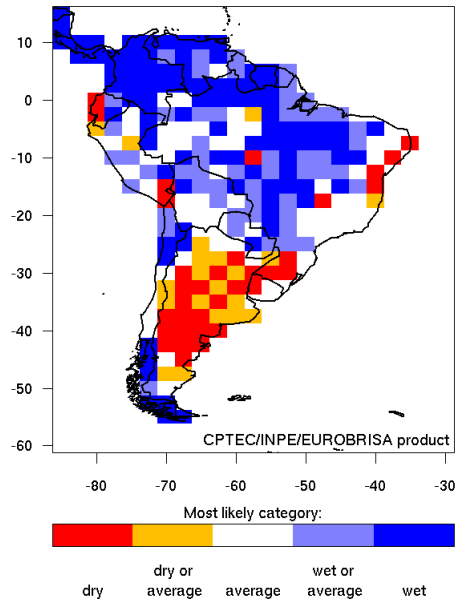
Integrated



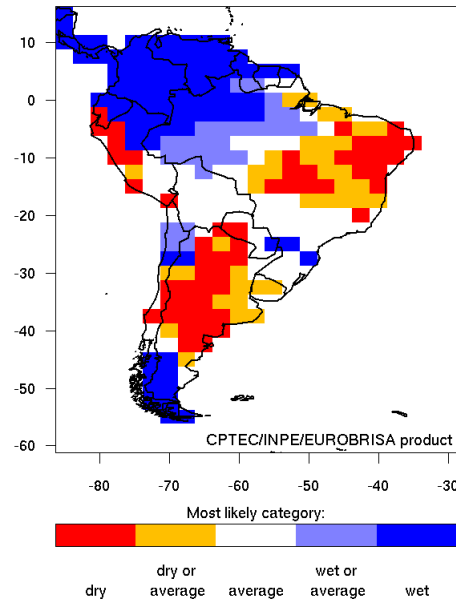
Issued: Nov 2007

Categorical forecasts: DJF 2007 precip.

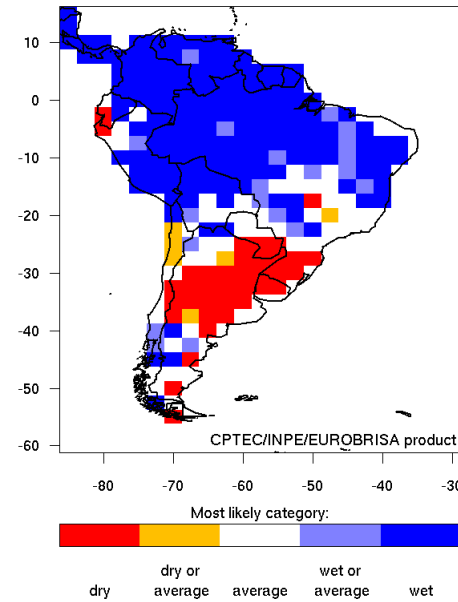
ECMWF



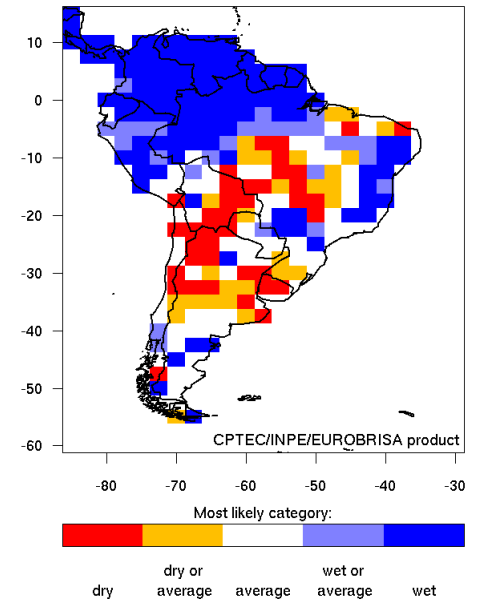
UKMO



Empirical



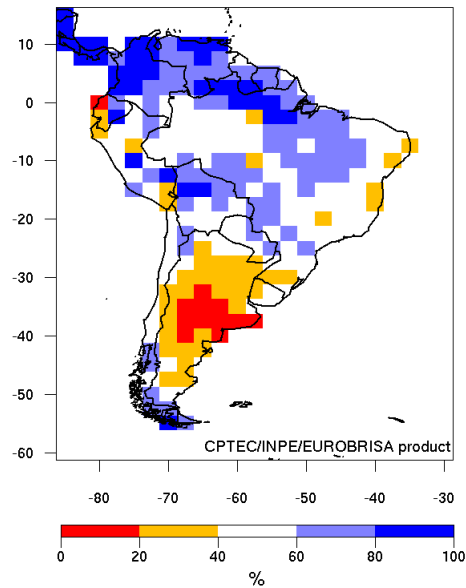
Integrated



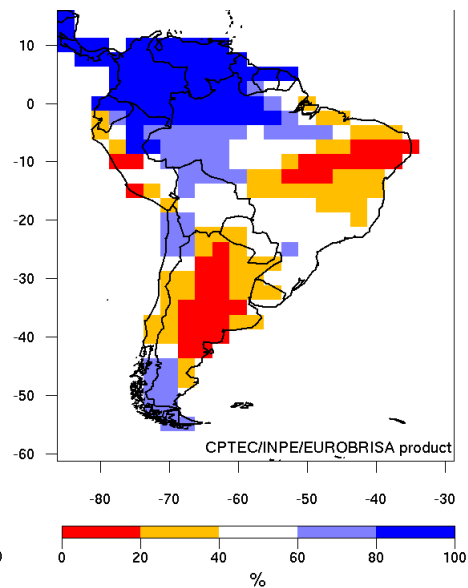
Issued: Nov 2007

Prob of positive anomaly: DJF 2007 precipitation

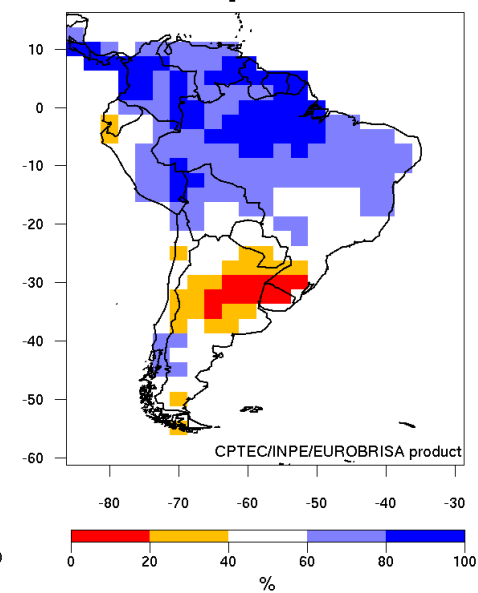
ECMWF



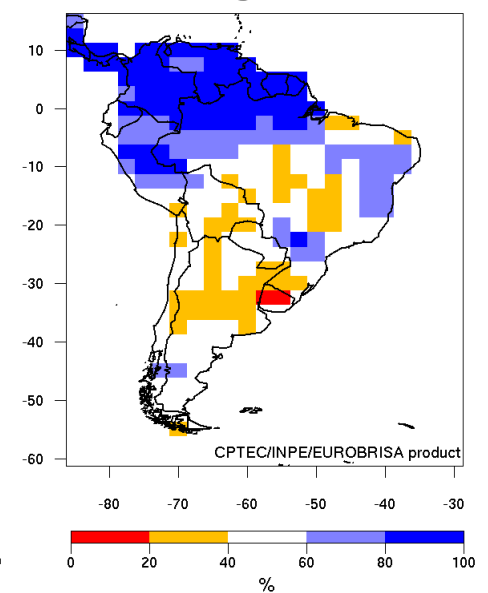
UKMO



Empirical



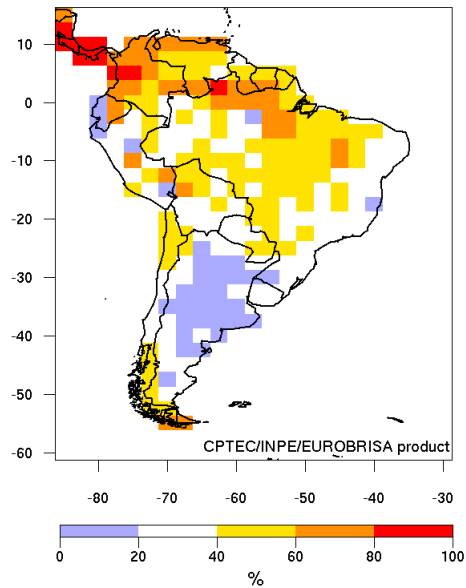
Integrated



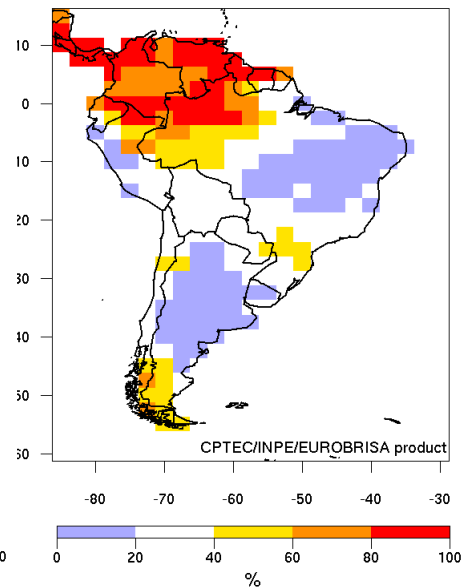
Issued: Nov 2007

Prob of precip. in upper tercile: DJF 2007

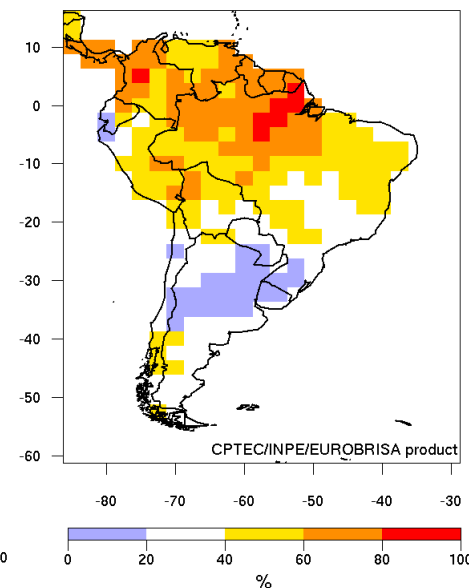
ECMWF



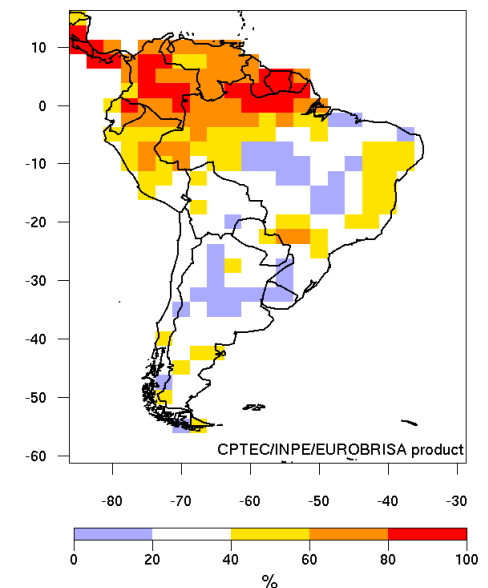
UKMO



Empirical

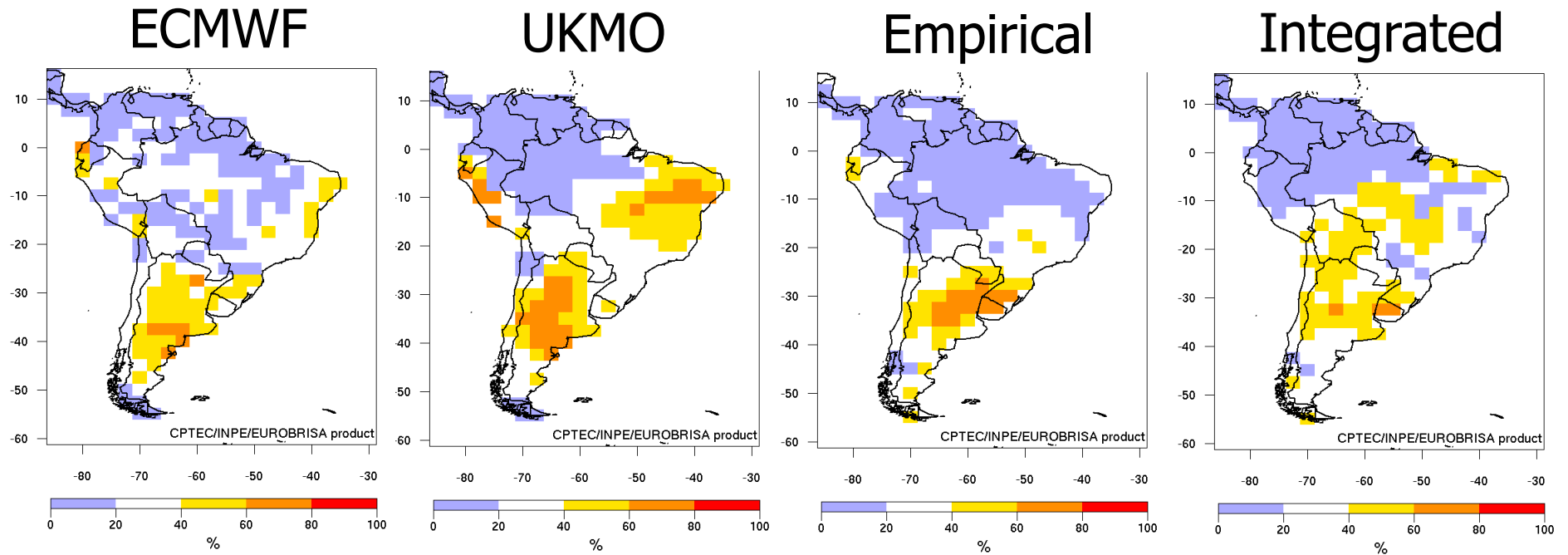


Integrated



Issed: Nov 2007

Prob of precip. in lower tercile: DJF 2007



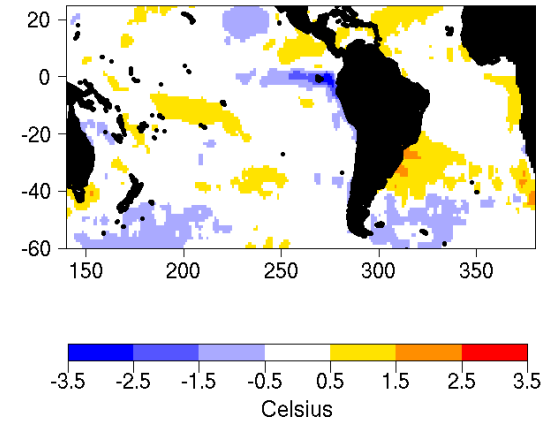
Issued: Nov 2007

**How did EUROBRISA
integrated forecasting system perform
during the 2007/08 La Niña event?**

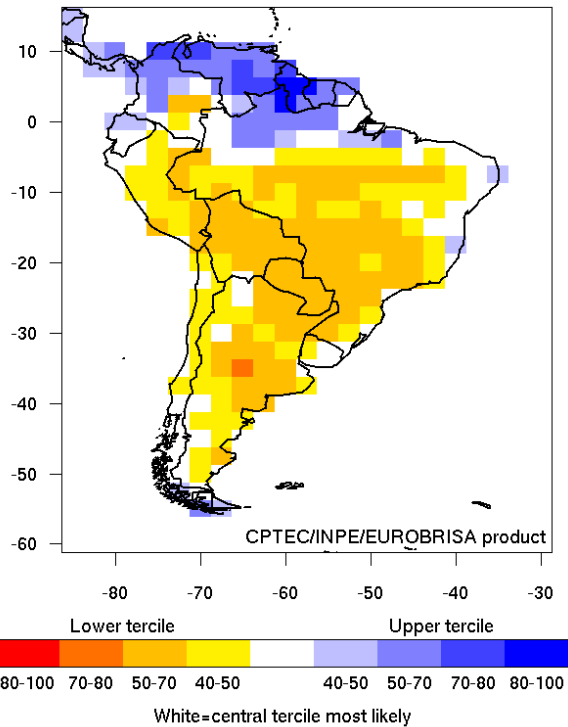
EUROBRISA integrated forecast for JJA 2007

Issued: May 2007

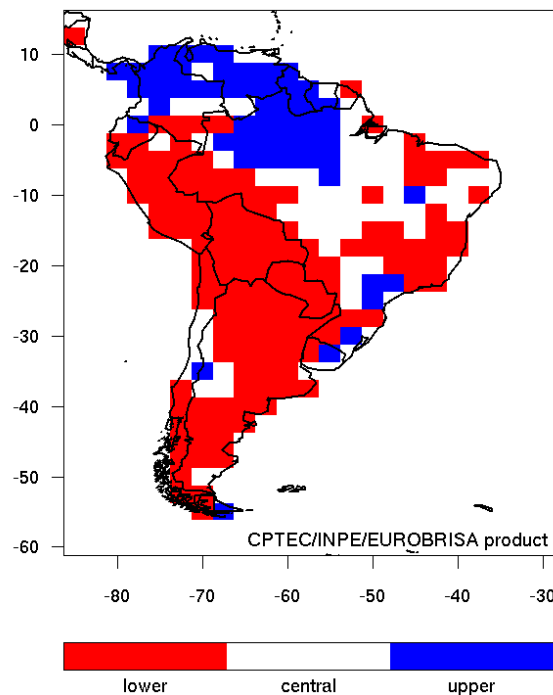
Obs. SST anomaly Apr 2007



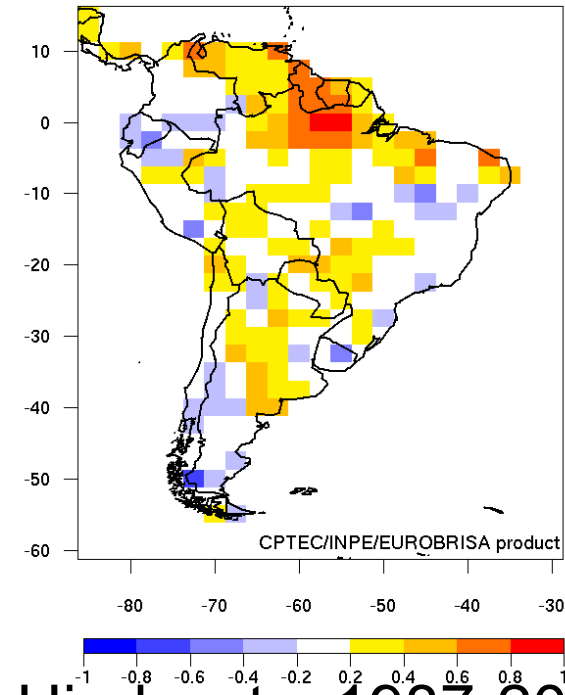
Prob. of most likely precip. tercile (%)



Observed precip. tercile



Gerrity score (tercile categories)

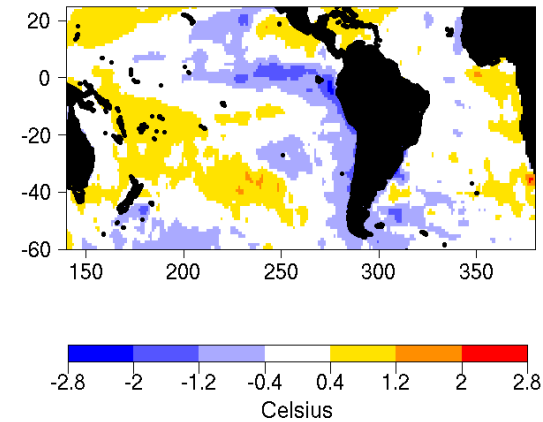


Hindcasts: 1987-2001

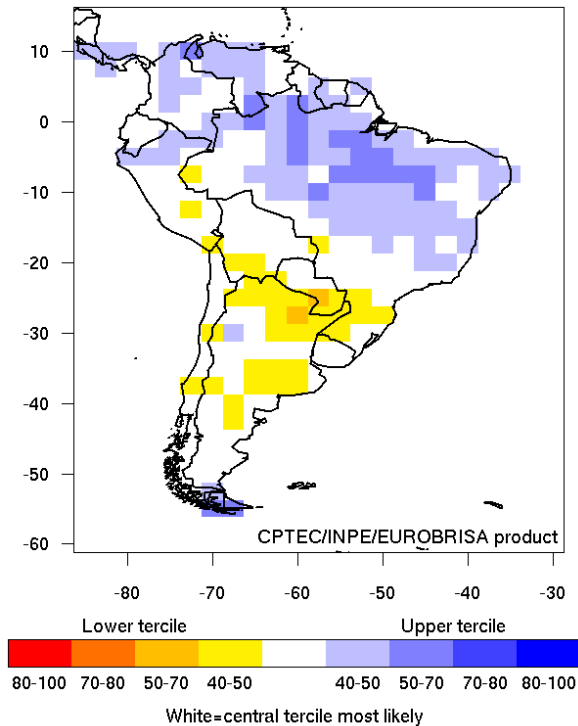
EUROBRISA integrated forecast for SON 2007

Issued: Aug 2007

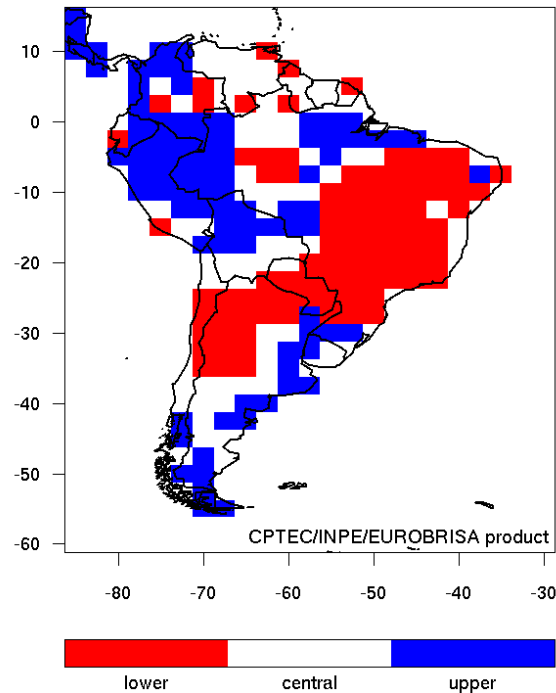
Obs. SST anomaly Jul 2007



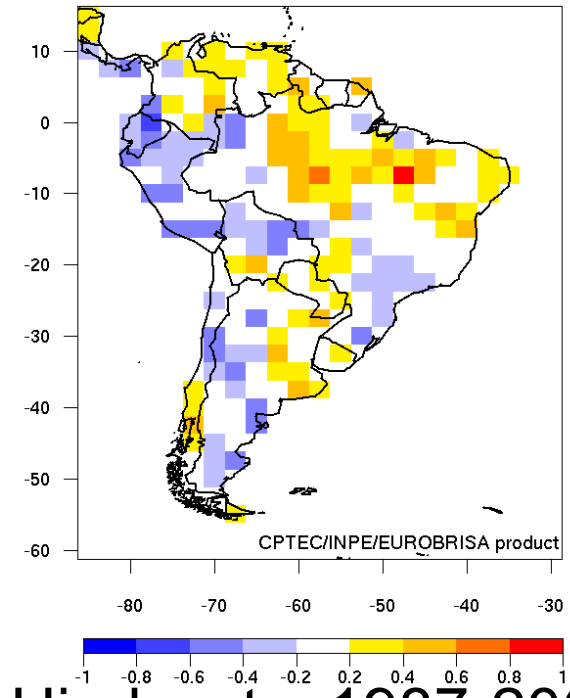
Prob. of most likely precip. tercile (%)



Observed precip. tercile



Gerrity score (tercile categories)

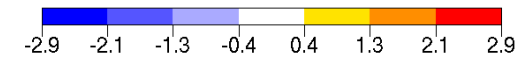
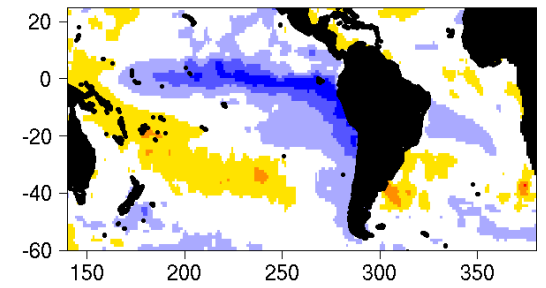


Hindcasts: 1987-2001

EUROBRISA integrated forecast for DJF 2007/08

Issued: Nov 2007

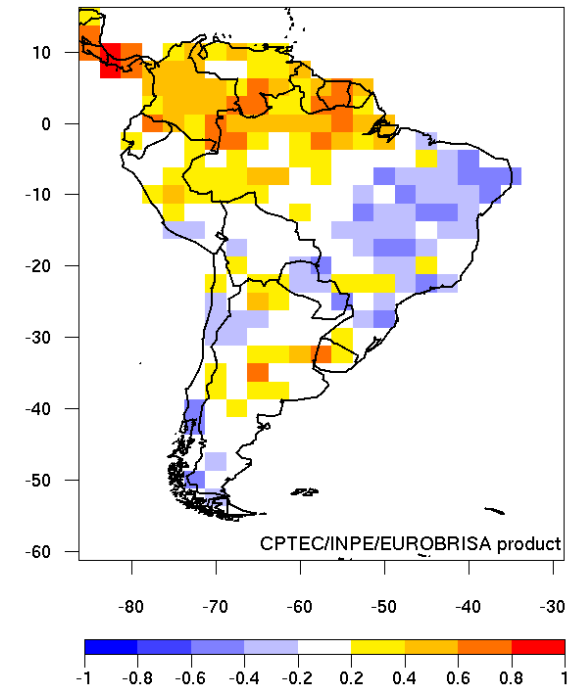
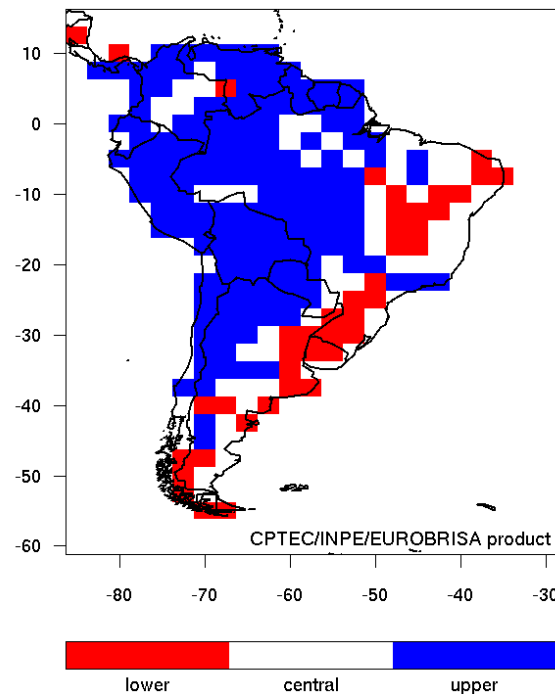
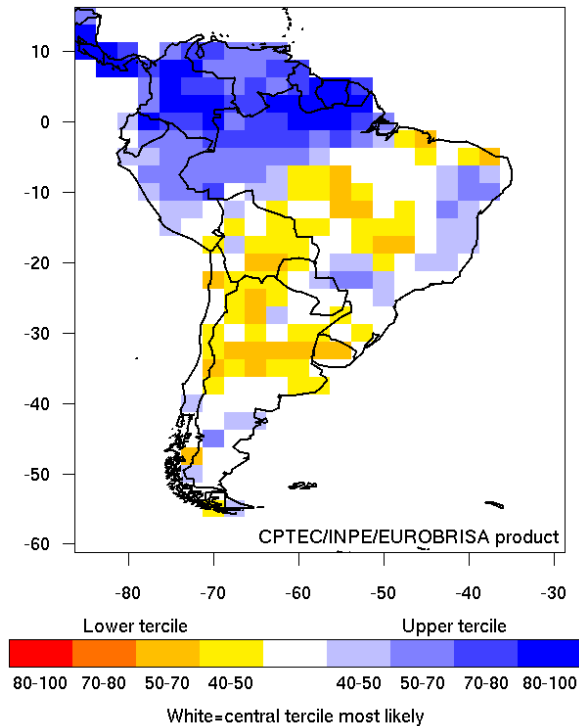
Obs. SST anomaly Oct 2007



Prob. of most likely precip. tercile (%)

Observed precip. tercile

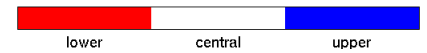
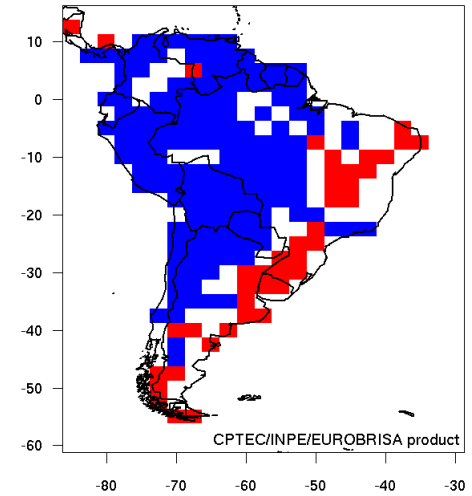
Gerrity score (tercile categories)



What each individual model forecast for DJF 2007/08?

Probability of the most likely precipitation tercile issued in November 2007

Obs. precip. tercile

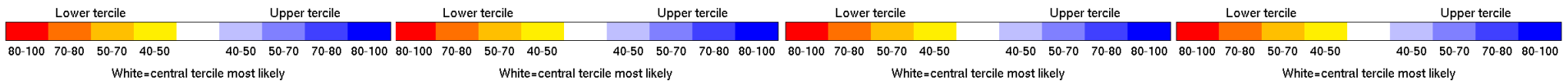
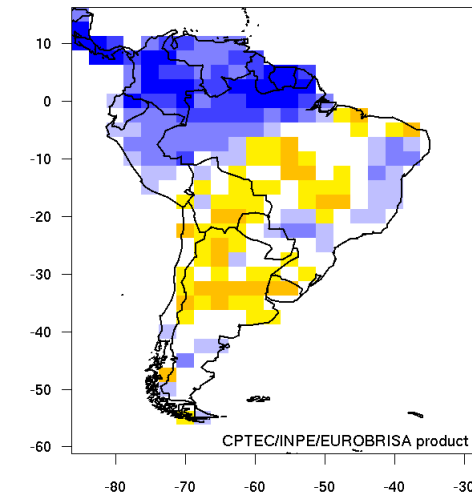
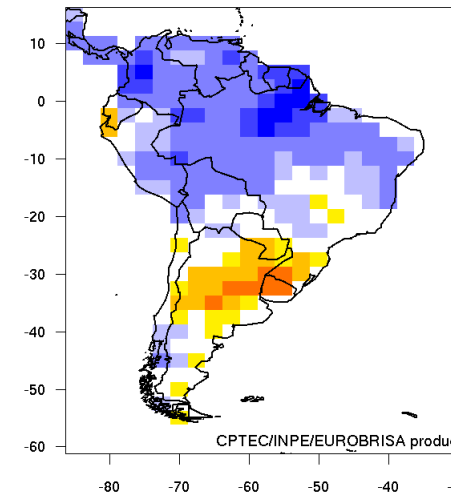
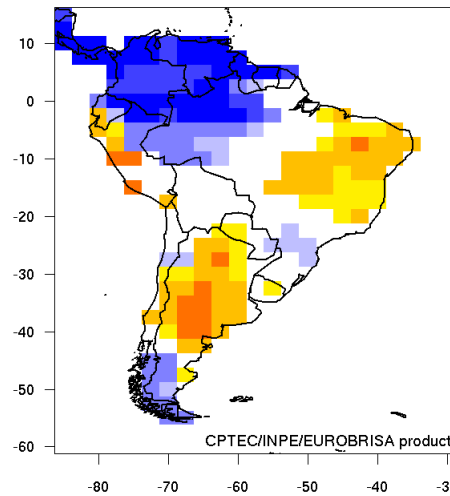
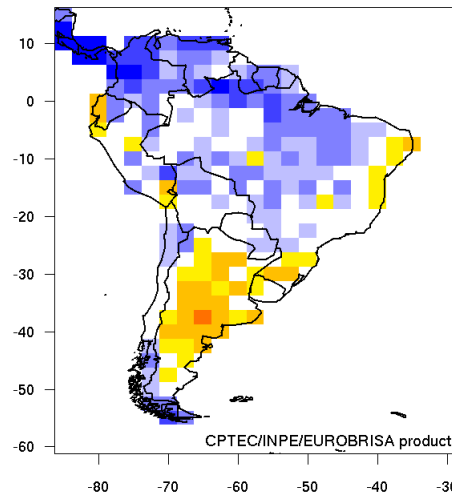


ECMWF

GloSea

Empirical

Integrated



Summary

- Availability of empirical and dynamical model forecasts provides opportunity to produce objectively integrated (i.e. combined and calibrated) forecasts
- S. American seasonal forecasts have best skill in tropical and southeastern regions
- Good performance of EUROBRISA hybrid (empirical-dynamical) system in 2007/08 over regions where forecasts have historically moderate to good skill

Additional information

- **Coelho C.A.S.**, D. B. Stephenson, F. J. Doblas-Reyes, M. Balmaseda, R. Graham 2007: “*Integrated Seasonal Climate Forecasts for South America*”. *CLIVAR Exchanges* No 43, Vol. **12**, No 4, 13-19.
- **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.*, Vol. **19**, 3704-3721.
- **Coelho C.A.S.**, 2005: “*Forecast Calibration and Combination: Bayesian Assimilation of Seasonal Climate Predictions*”. PhD Thesis. University of Reading, 178 pp.
- **Coelho C.A.S.**, D. B. Stephenson, F. J. Doblas-Reyes and M. Balmaseda, 2005: “*From Multi-model Ensemble Predictions to Well-calibrated Probability Forecasts: Seasonal Rainfall Forecasts over South America 1959-2001*”. *CLIVAR Exchanges* No 32, Vol. **10**, No 1, 14-20.
- 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*, Vol. **57**, 253-264.

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