An Operational Multi-model Seasonal Forecast System for South America: the EUROBRISA Project

Francisco J. Doblas-Reyes (ECMWF)
on behalf of the EUROBRISA consortium

EUROBRISA is financially supported by The Leverhulme Trust FAPESP

PLAN OF TALK

1. Introduction to EUROBRISA
2. EUROBRISA integrated forecasting system
3. Forecasts for 2007-2008
4. Forecast quality
5. Summary

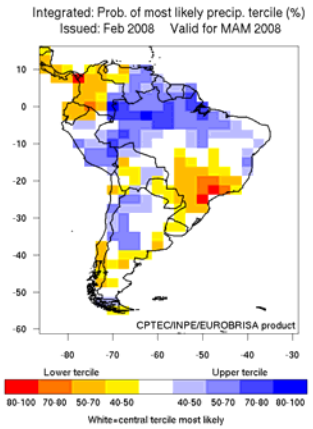
ECMWF Forecast Users Meeting, Reading 12 June 2008

EUROBRISA aims

1. Strengthen collaboration and promote exchange of expertise and information between European and South American climate scientists;

2. Produce improved seasonal climate forecasts for South America using recent scientific advances in both coupled ocean-atmosphere modelling and statistical calibration and combination of multi-model ensemble forecasts;

3. Develop forecast products for non-profitable governmental use in South America (reservoir management, hydropower production, and agriculture).



A GREAT OPPORTUNITY
TO DO SOMETHING REALLY USEFUL!

EUROBRISA partners

University of Exeter (UE), U.K.
David Stephenson, Rachel Lowe … + Trevor Bailey

Centre for Weather Prediction and Climate Studies (CPTEC), Brazil
Caio Coelho, Maria Assunçao Dias, Simone Costa

European Centre for Medium-range Weather Forecasts (ECMWF), UK
Francisco Doblas-Reyes, **Magdalena Balmaseda**

U.K. Met Office (UKMO), Exeter, UK
Alberto Arribas, Richard Graham

Météo-France (MF), Toulouse, France
Michel Déqué, Jean-Philippe Piédelièvre

Federal University of Paraná (UFPR), Brazil
Alexandre Guetter

Brazilian National Institute of Meteorology (INMET), Brazil
Antonio Moura, Lauro Fortes and Yumiko Marina T. da Anunciação

University of São Paulo (USP), São Paulo, Brazil
Tercio Ambrizzi

EUROBRISA achievements so far

1. Strengthen collaboration between European and South American climate scientists

- 1st EUROBRISA workshop (Mar 2008)
- EUROBRISA web site launched (Oct 2007)

  http://**www6.cptec.inpe.br/eurobrisa**
- Network facilitator appointed in Exeter (Oct 2007)

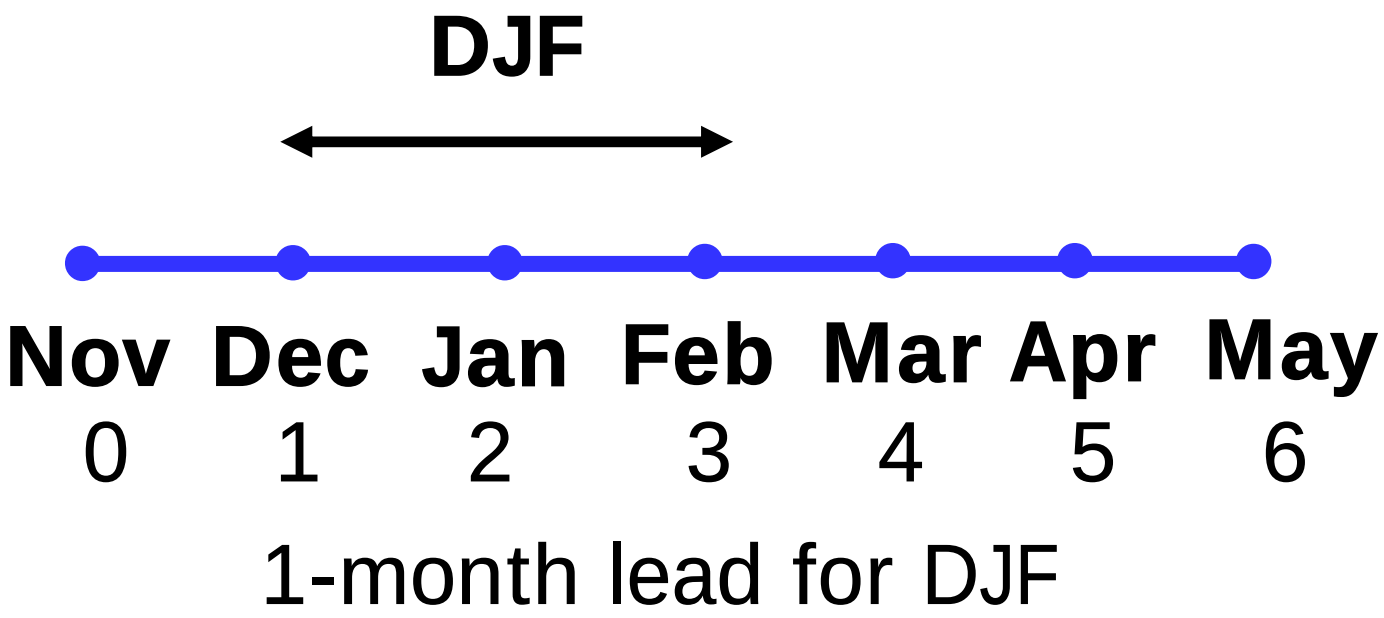
2. Produce improved seasonal climate forecasts for South America

- Consideration of La Niña 2008 as a case study
- New visualisation approaches for seasonal forecasts
- Project summary published in CLIVAR Exchanges (Oct 2007)
- Forecasts and verification products made available online (Oct 2007)
- Forecasting system set up at CPTEC (Jul-Oct 2007)

3. Develop forecast products for non-profitable governmental use in South America

- First examples of crop applications (maize)
- Entrainment of new application areas (e.g. health)

Seasonal climate forecasts



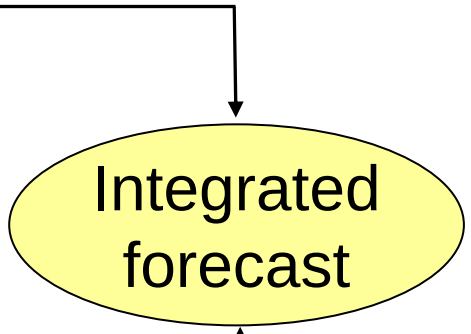
Current forecast approaches

- Empirical/statistical models
- Dynamical atmospheric models
- Dynamical coupled (ocean-atmosphere) models

EUROBRISA forecasting system

- Combined and calibrated coupled + empirical precip. forecasts
- Hybrid multi-model probabilistic system

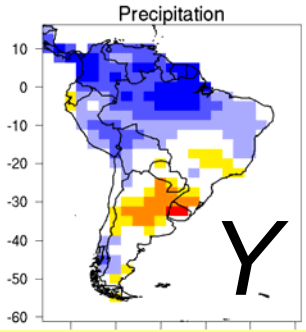
Coupled model	Country
ECMWF System 3	International
GloSea System 3	UK

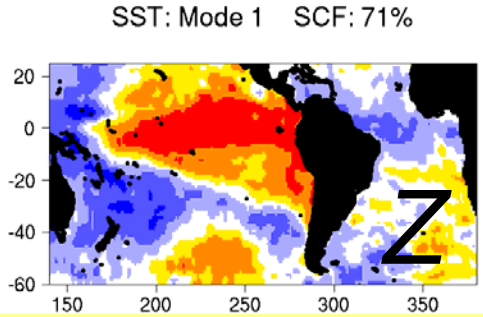


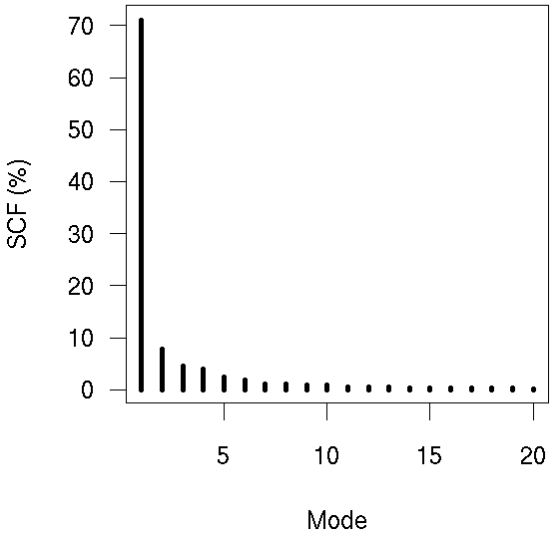
Empirical model
Predictors: Atlantic and Pacific SST
Predictand: Precipitation

Hindcast period: 1987-2001

The empirical model







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

Y: DJF precipitation Z: October SST

$$M = S_{YZ} S_{ZZ}^{-1} \qquad Y : n \times q$$

$$-M Z_o = \bar{Y} - \bar{Z} M \qquad Z : n \times v$$

$$T = S_{YY} - S_{YZ} S_{ZZ}^{-1} S_{YZ}^{T} \qquad T : q \times q$$

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

Data sources:

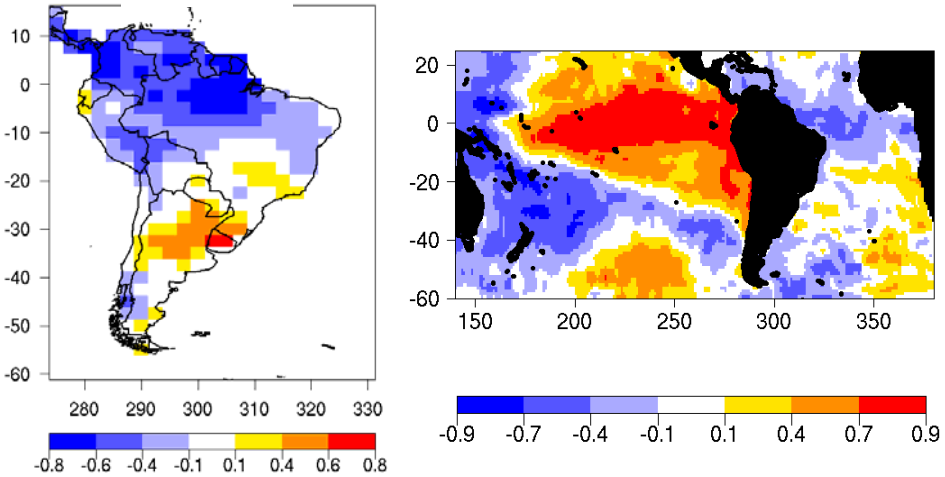
- SST: Reynolds OI v2
- Precipitation: GPCP v2

Coelho *et al.* (J. Climate, 19, 3704-3721, 2006)

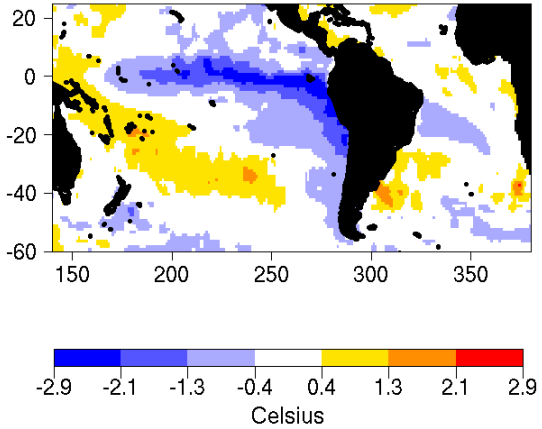
Empirical forecast DJF 2007/08

Issued November 2007

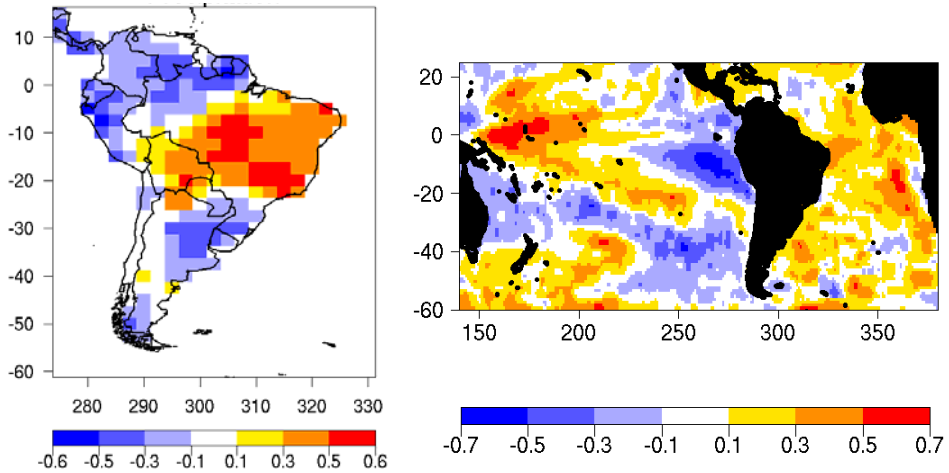
First MCA mode (71%)



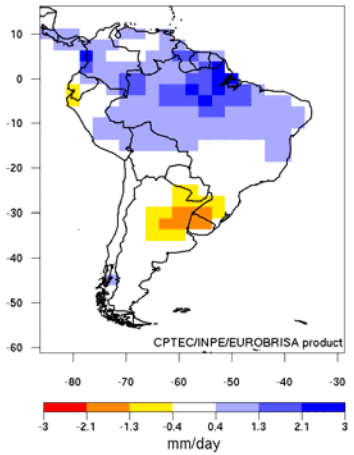
Observed SST Oct 2007



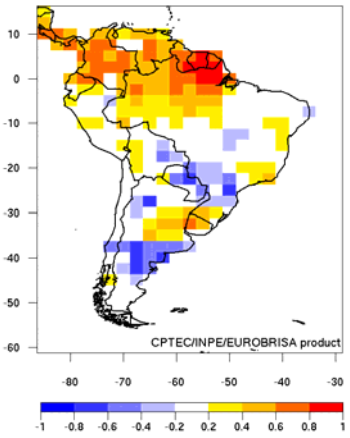
Second MCA mode (7.7%)



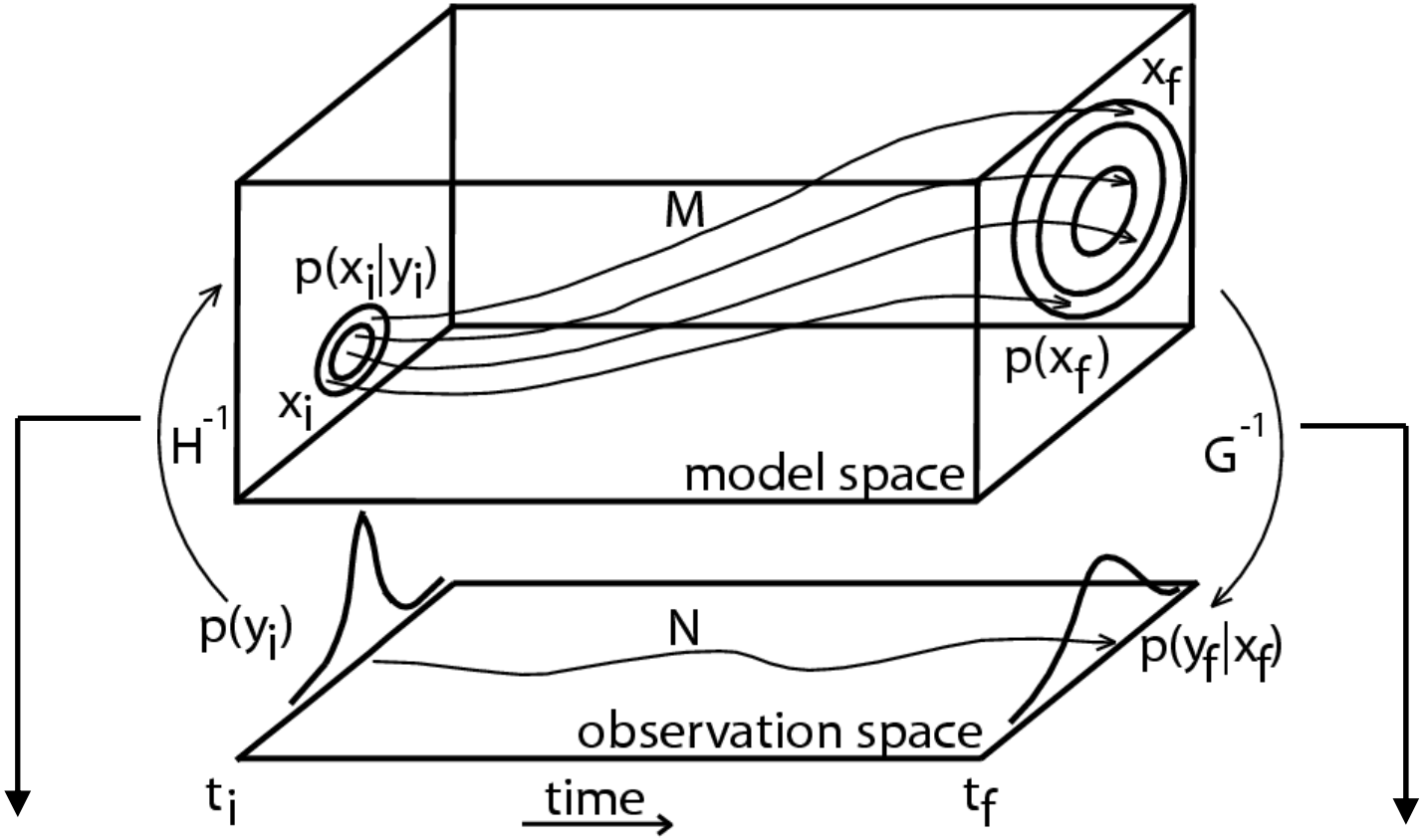
Forecast DJF 07/08



Corr. DJF



Forecast assimilation



Data Assimilation

$$p(x_i \mid y_i) = \frac{p(y_i \mid x_i)p(x_i)}{p(y_i)}$$

"Forecast Assimilation"

$$p(y_f \mid x_f) = \frac{p(x_f \mid y_f)p(y_f)}{p(x_f)}$$

Stephenson *et al.* (Tellus A, 57, 253-264, 2005)

Forecast assimilation

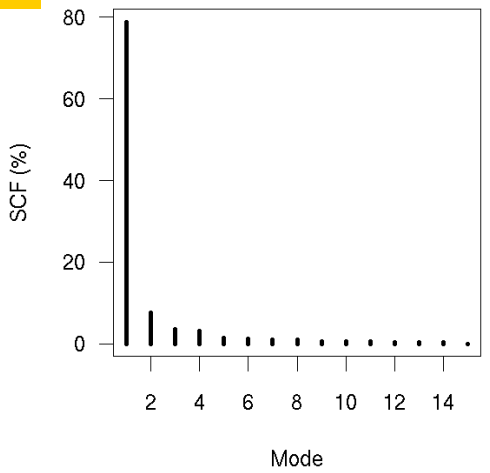
$$p(Y \mid X) = \frac{p(X \mid Y)\,p(Y)}{p(X)}$$

X: forecasts (dynam. & empir.)
Y: DJF precipitation

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

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

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



Posterior: $Y \mid X \sim N(Y_a, D)$

$$Y_a = Y_b + L(X - G(Y_b - Y_o))$$
$$D = (G^T S^{-1} G + C^{-1})^{-1} = (I - LG)C$$
$$L = CG^T (GCG^T + S)^{-1}$$

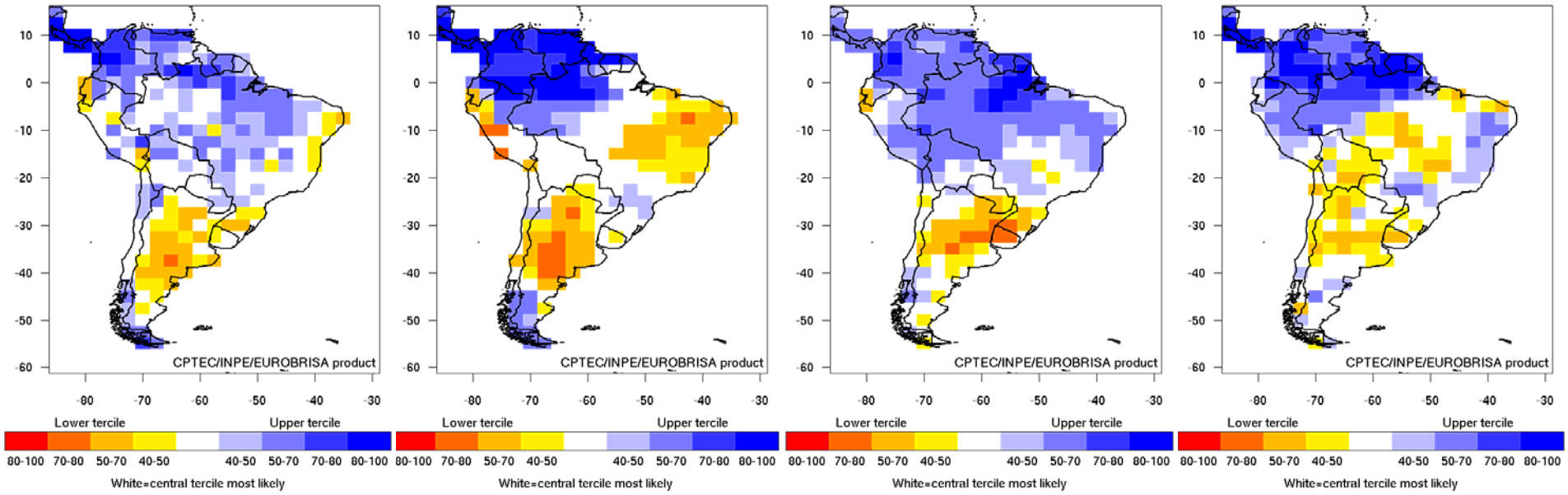
Matrices

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

Forecasts DJF 2007/08

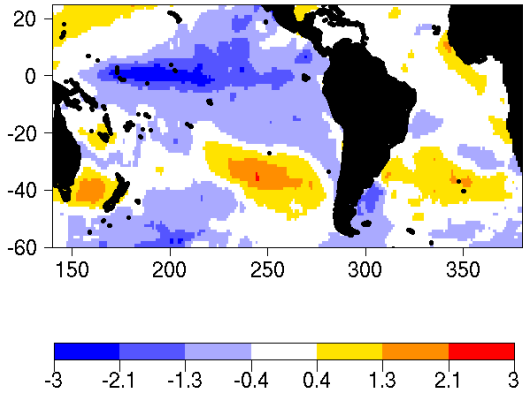
Probability of the most likely precipitation tercile issued in November 2007.

ECMWF GloSea Empirical Integrated



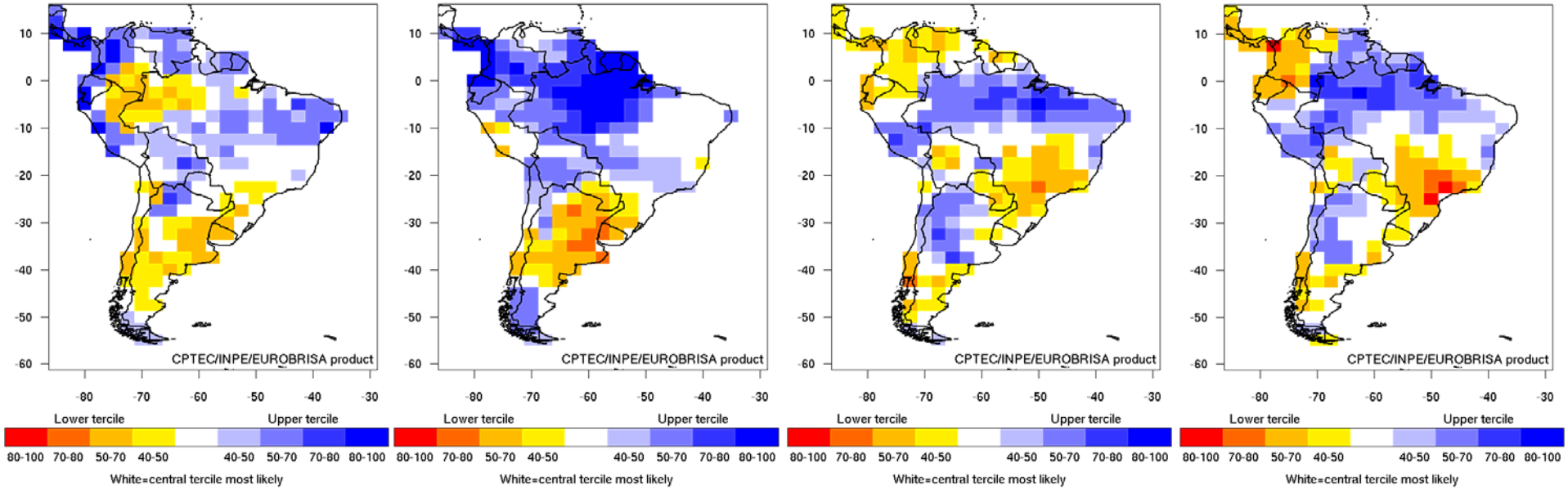
Forecasts MAM 2008

Obs. SST anomaly Jan 2008



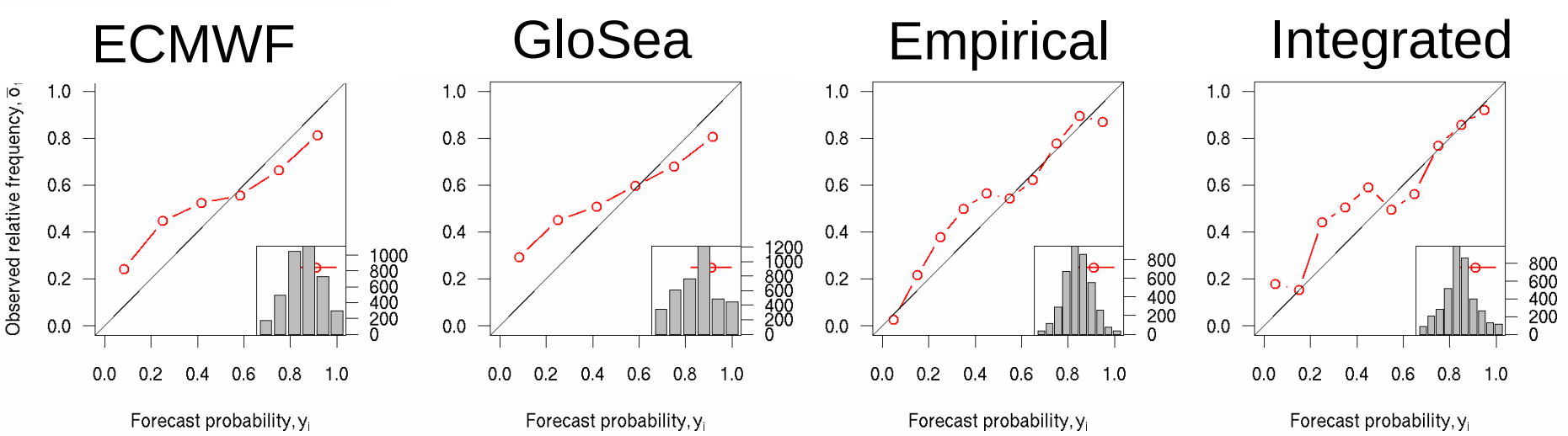
Probability of the most likely precipitation tercile issued in February 2008.

ECMWF GloSea Empirical Integrated



Forecast quality DJF

Attributes diagrams for positive anomalies of DJF precipitation over South America

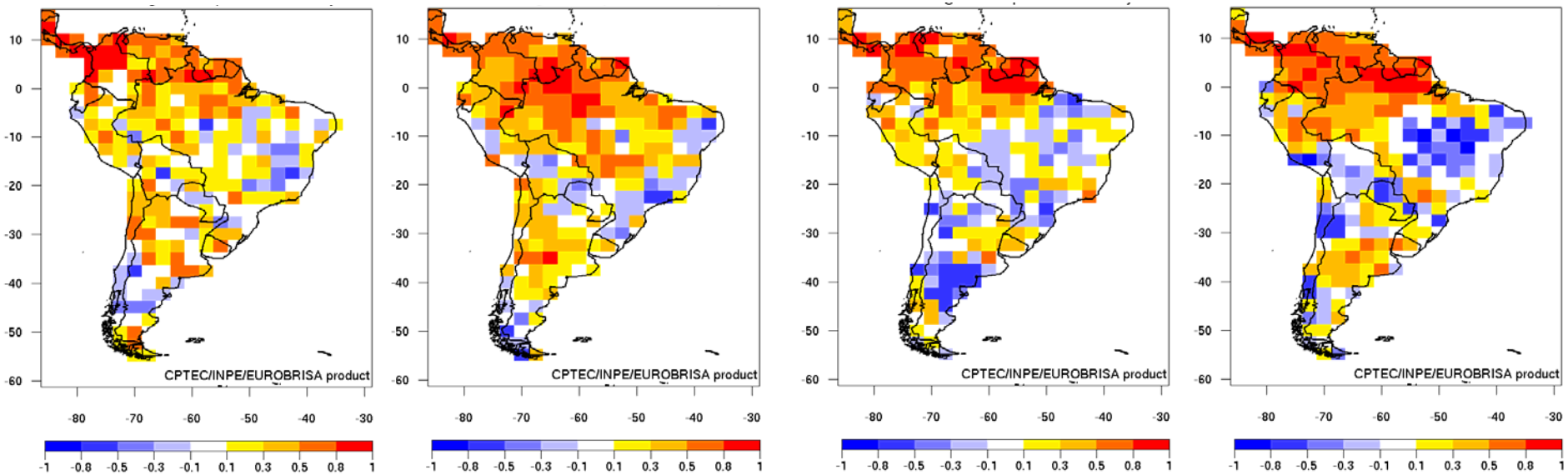


- Hindcast period: 1987-2001
- Start date 1st Nov (1-month lead for DJF)
- Empirical model uses Oct SST as predictor for DJF precip.
- Integrated forecasts (dynamical & empirical) with forecast assimilation

Forecast quality DJF

ROC skill score (2A-1) for positive anomalies of DJF precipitation over South America

ECMWF GloSea Empirical Integrated



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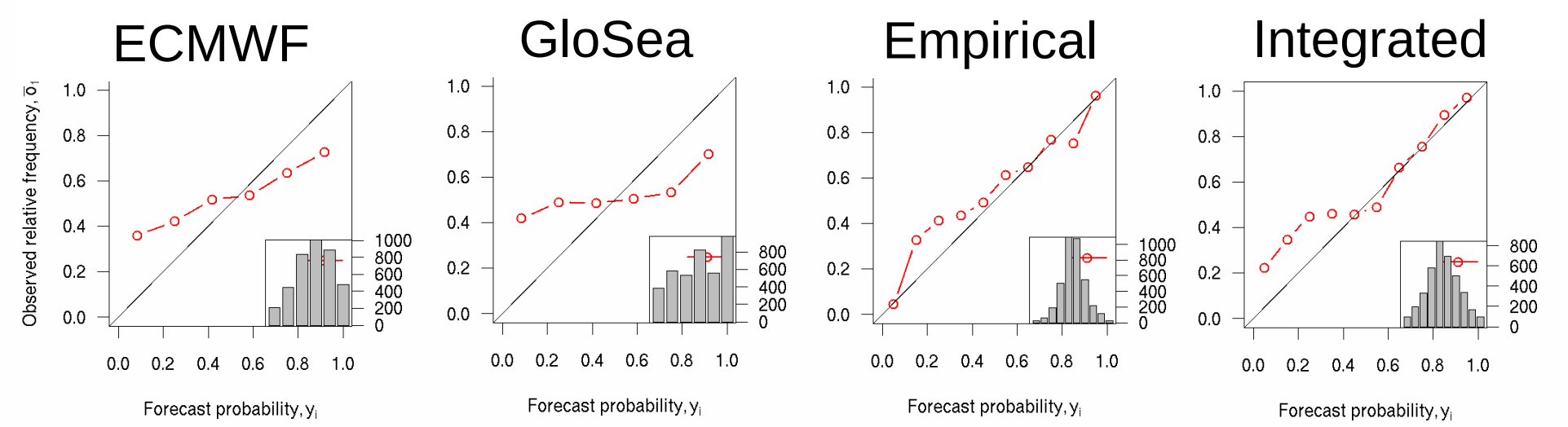
Forecast quality JJA

Attributes diagrams for positive anomalies of JJA precipitation over South America

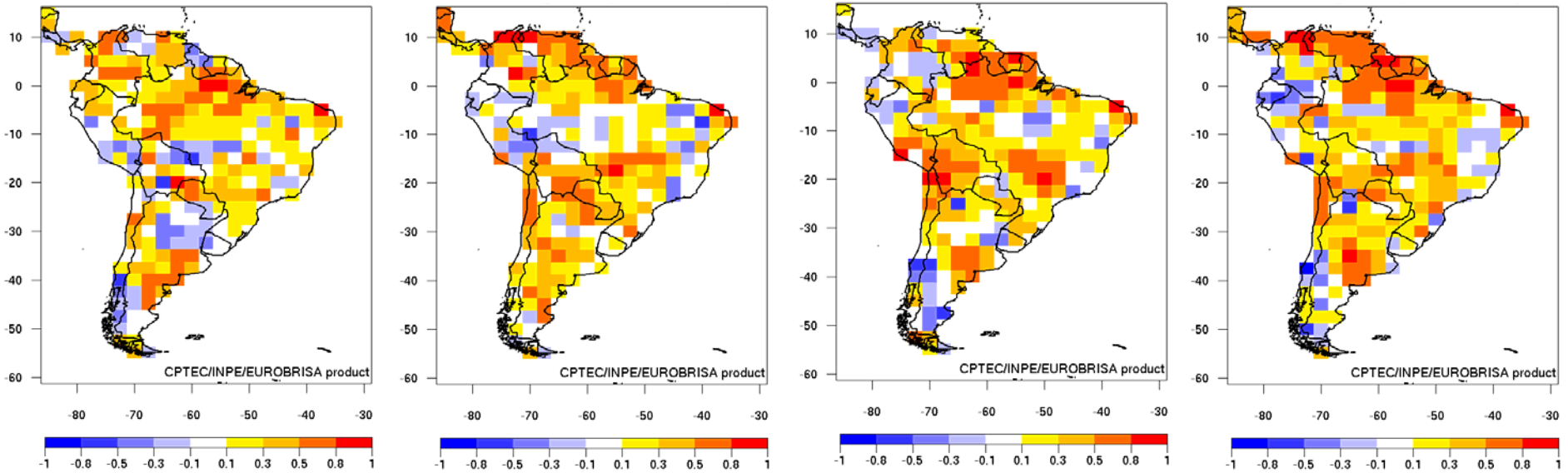


- Hindcast period: 1987-2001
- Start date 1st May (1-month lead for JJA)
- Empirical model uses Apr SST as predictor for JJA precip.
- Integrated forecasts (dynamical & empirical) with forecast assimilation

Forecast quality JJA

ROC skill score (2A-1) for positive anomalies of JJA precipitation over South America

ECMWF GloSea Empirical Integrated



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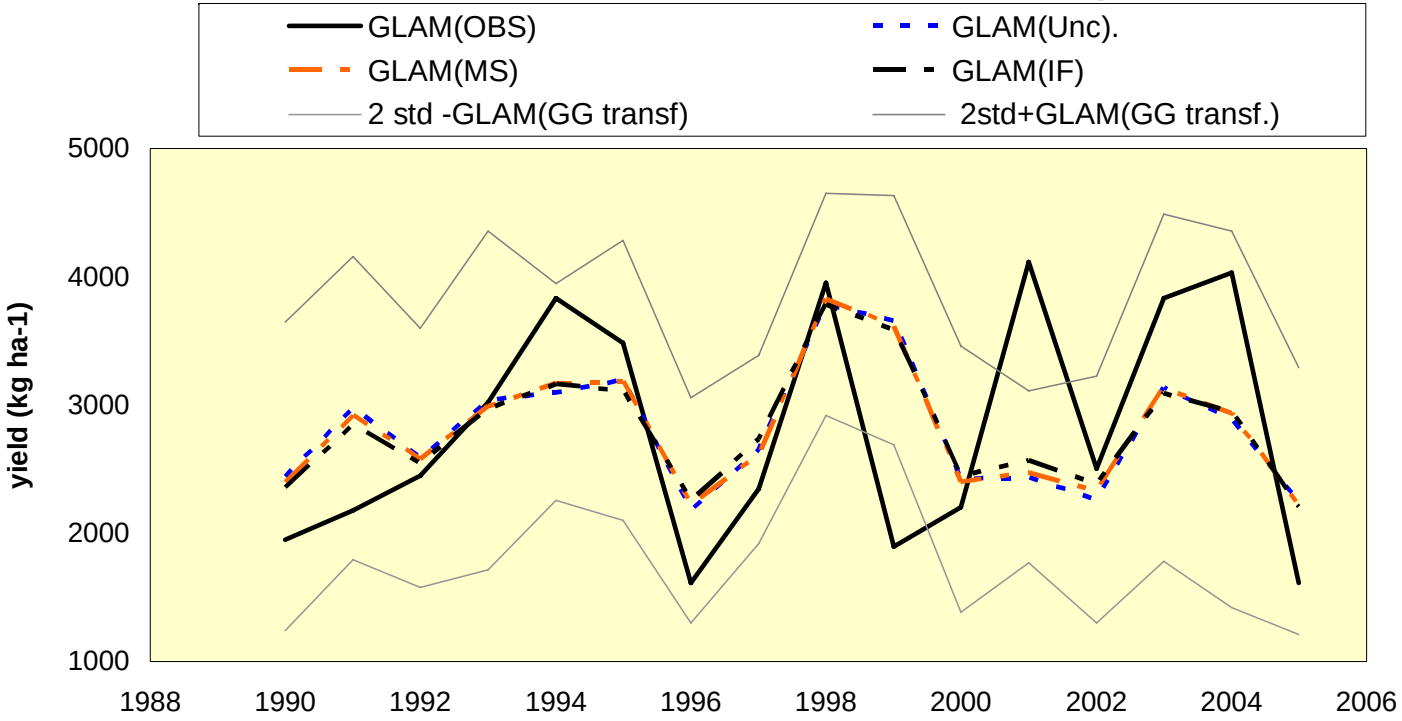
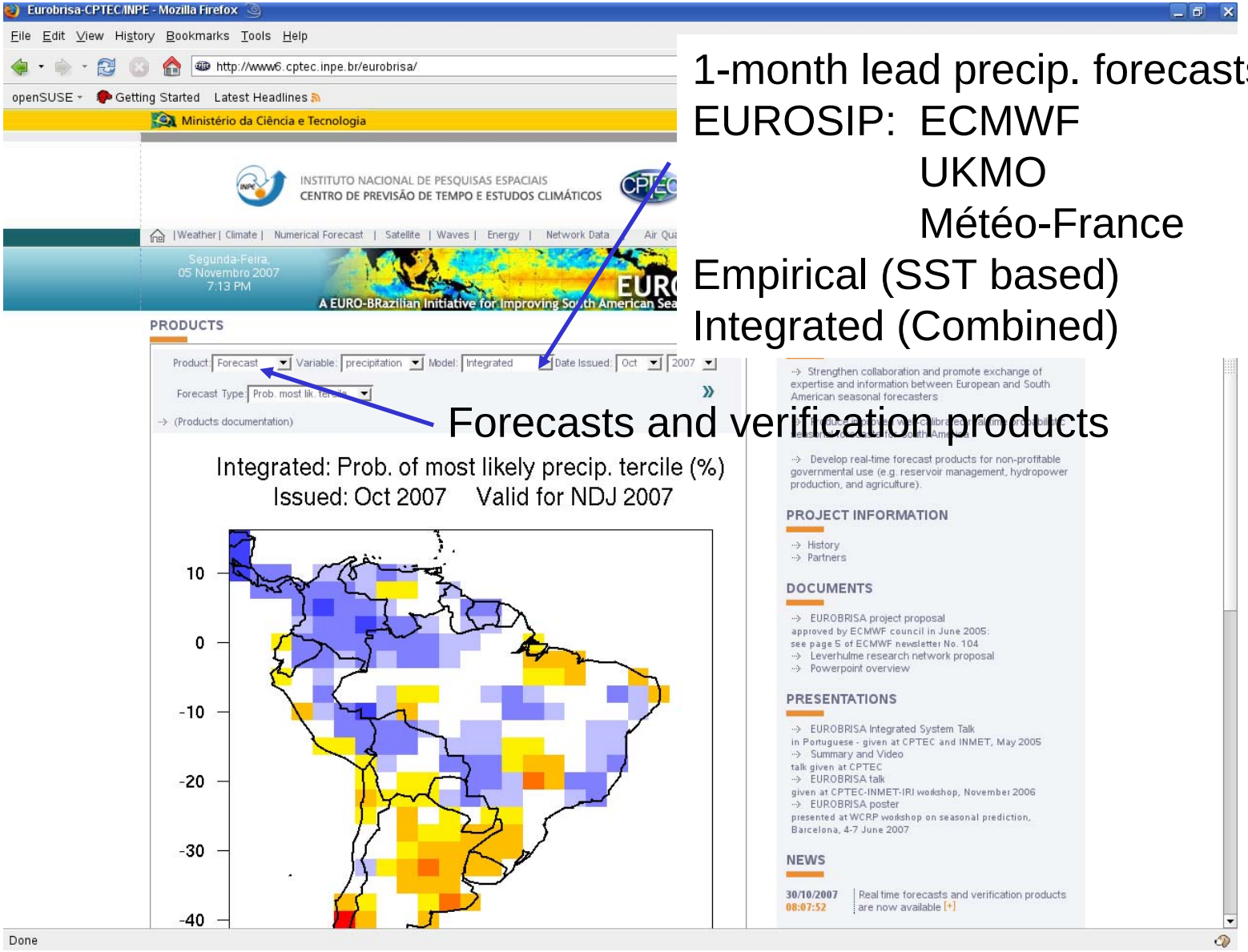
- Start date 1st May (1-month lead for JJA)
- Empirical model uses Apr SST as predictor for JJA precip.
- Integrated forecasts (dynamical & empirical) with forecast assimilation

Applications: Crop yield prediction

Maize yield over an area in Rio Grande do Sul, predicted with the GLAM crop model (Challinor et al., J. Appl. Meteor., 42, 175-192, 2003) and different weather data sources: OBS for station observation, MS for bias-corrected ECMWF System 3 data, IF for bias-corrected (intensity and frequency) ECMWF System 3 data and UNC for direct model output.



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



1-month lead precip. forecasts
EUROSIP: ECMWF
UKMO
Météo-France
Empirical (SST based)
Integrated (Combined)

Forecasts and verification products

Summary

- EUROBRISA is an operational hybrid (empirical-dynamical) probabilistic seasonal forecasting system for South America.
- Current system uses SST-based empirical model & two dynamical forecast systems (ECMWF and GloSea) integrated using forecast assimilation.
- Good performance over regions where forecasts have historically moderate to good skill.
- Results on the web, including verification and Météo-France dynamical forecasts.
- Additional information at **http://www6.cptec.inpe.br/eurobrisa** and in CLIVAR Exchanges No 43 (Volume 12 No 4).

First EUROBRISA workshop, Parati, Brazil, 17-19 March 2008

ECMWF Forecast Users Meeting, Reading 12 June 2008