Dynamical Downscaling Forecasts and Verification over Northeast Brazil

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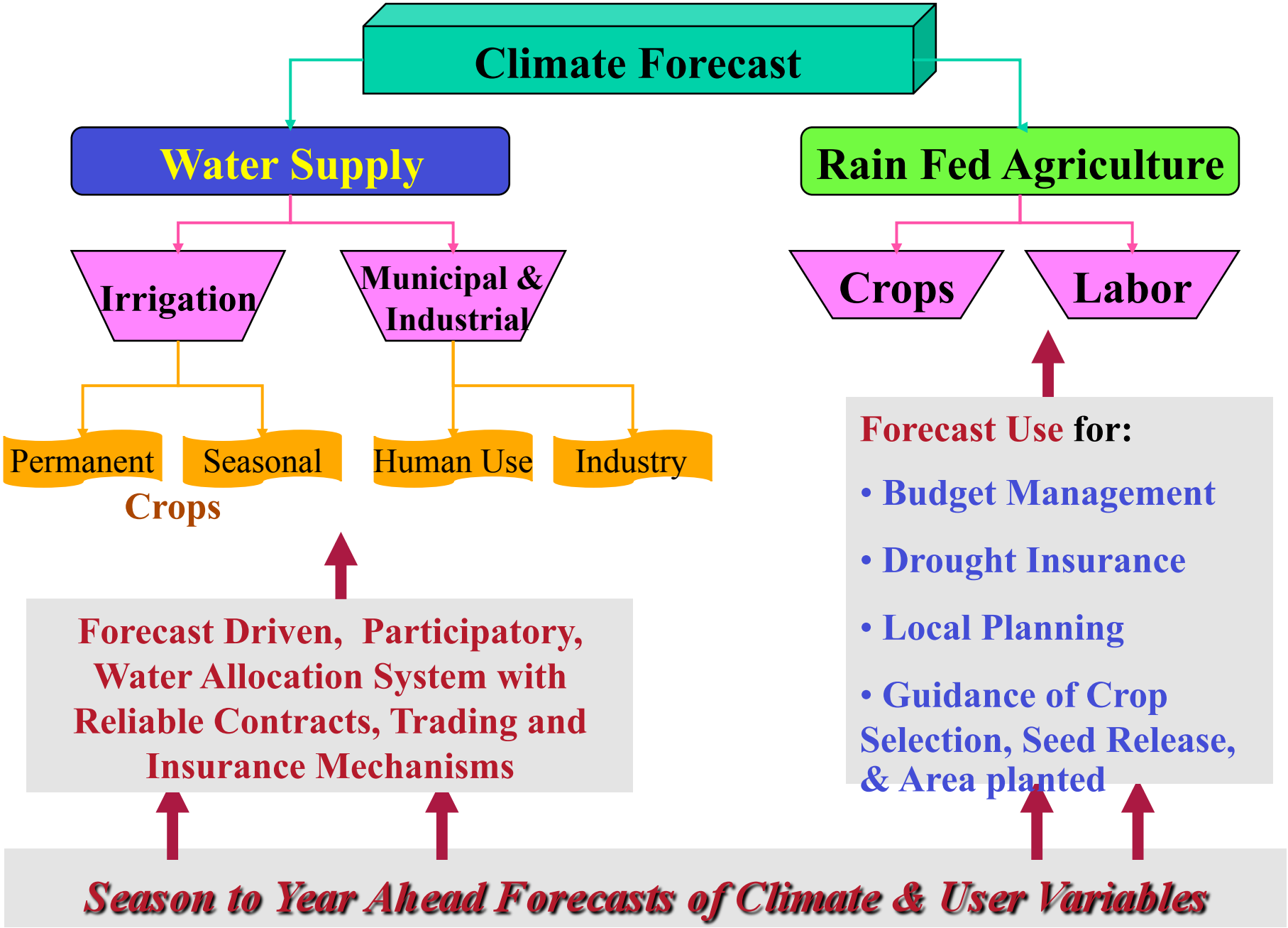
Downscaling forecasts Using the RSM

- IRI since 1997
- ECPC since 1997
- NR&M (Queensland)/IRI 1998
- FUNCEME/IRI since 2001
- NCEP since 2002
- CWB/IRI since 2003
- ICPAC/IRI since 2004
- SAWS/IRI 2006 & 2007
- ZCC/IRI 2007 & 2008
- ECPC/NTU,HKO, BIU 2003

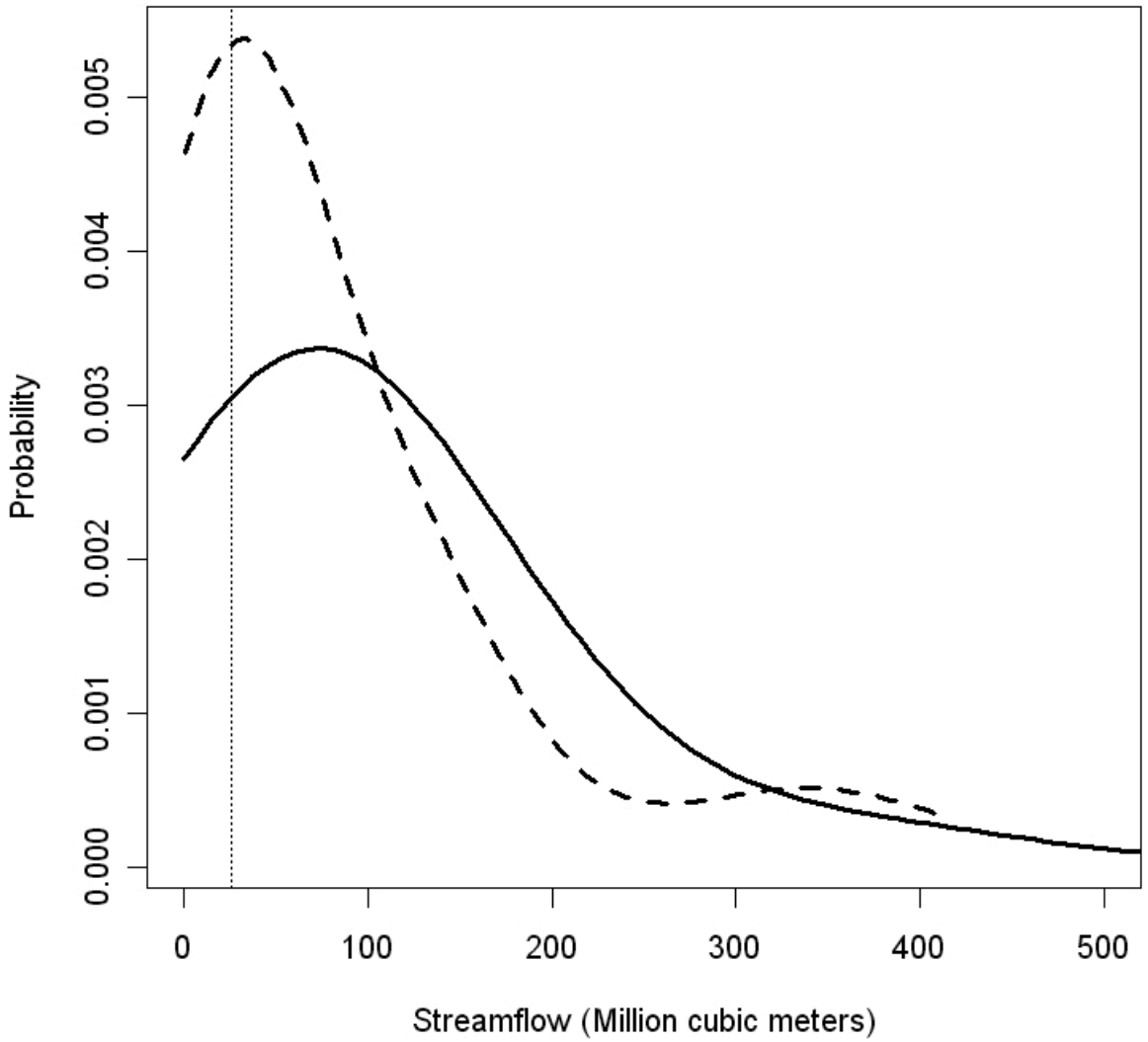
Four key factors make Northeast Brazio an appropriate site to develop and implement an integrated approach to dealing with recurrent drought conditions:

- ***High skill*** **in forecasting climate variability**
- ***High vulnerability*** **of a large segment of the population**
- ***Need for adaptability*** **of the socioeconomic and water management system**
- ***Political Will & Technical Skill*** **to implement policy measures toward adaptability**

Potential Values of RCMs for Decision Making



Multi-model Combination Results

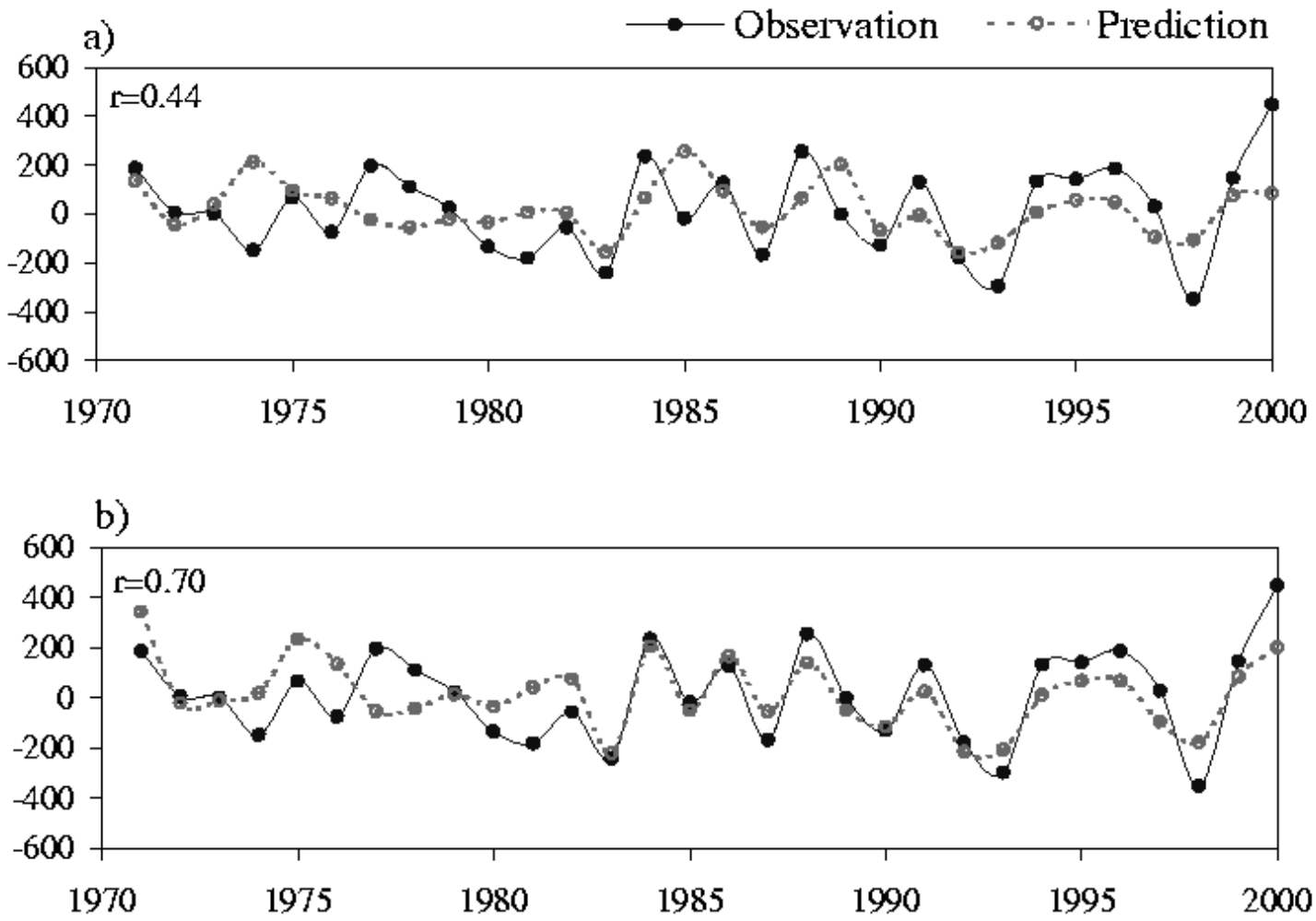


PDFs of Climatology (solid) and Pooled ensemble hindcast (dashed) for Jan-June 1991
Observed streamflow shown as dotted vertical line

Block et al. 2009

Corn Yield Hindcasts Using

a) seasonal mean rainfall, b) weather index



Sun et al. 2007

Forecast Verification

- Are the downscaling forecasts "good"? Where are the forecasts skillful? Where are the forecast errors?
- Are the forecasts improved during the last decade? How can the forecasts be improved in the future?
- Do the forecasts represent the climate changes (trend)?
- Are the downscaling forecasts better than the IRI GCM forecasts?
- Are the official forecasts produced at the forecast fora better than the downscaling forecasts?

Outline

- Scientific basis for dynamical downscaling
- Downscaling forecasts
- Downscaling forecast verification
- Summary

Publications

1 Kwon, H., U. Lall, **L. Sun**, P. Block, F.A.S. Filho, and J. Lee, 2010: Assessment of uncertainty of hydrological model and climate forecast model in Northeast Brazil. *Hydrological Processes*. In review.

2 Hastenrath, S., **L. Sun**, and A. D. Moura, 2009: Climate prediction for Brazil's Nordeste by empirical and numerical modeling methods, *Int. J. of Climatolo.,* **29***,* 921-926.

3 Block, P., F. A. Souza Filho, **L. Sun**, and H. Kwon, 2009: Accounting for Uncertainty Propagation: A Streamflow Forecasting Framework using Multiple Climate and Hydrological Models. *Journal of the American Water Resources Association*, **45**, 828-843.

4 **Sun, L.,** and M. N. Ward, 2007: Chapter 2 Climate downscaling: Assessment of the added values using regional climate models. *Climate Prediction and Agriculture: Advances and Challenges*, Springer, ISBN-10: 3-540-44649-4, 300pp.

5 **Sun, L**., H. Li, M. N. Ward, and D. Moncunill, 2007: Climate variability and corn yields in semi-arid Ceara Brazil. *Journal of Applied Meteorologyand Climatology*, **46**, 226-240.

6 **Sun, L**., D. F. Moncunill, H. Li, A. D. Moura, F. A. S. Filho, and S. E. Zebiak, 2006: An operational dynamical downscaling prediction system for Nordeste Brazil and the 2002-04 real-time forecast validation. *J. Climate*, **19**, 1990-2007.

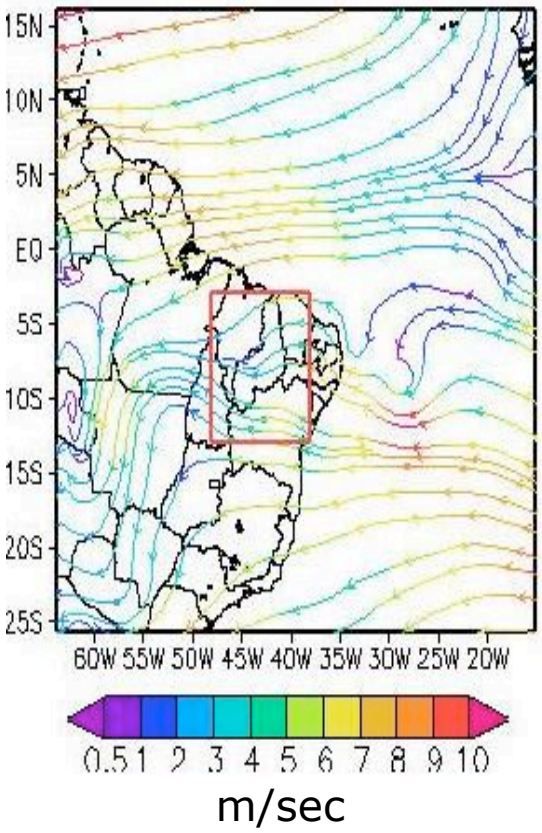
7 **Sun, L**., D. F. Moncunill, H. Li, A. D. Moura, and F. A. S. Filho, 2005: Climate Downscaling over Nordeste Brazil using NCEP RSM97. *J. Climate*, **18**,551-567.

8 Alevs, J. M. B., J. N. B. Campos, F. D. A. D. S. Filho, D. F. Moncunnil, E. M. D. Silva, W. L. Barbosa, A. G. Ferreira, **L. Sun**, and A. D. Moura, 2005: An evaluation of climate simulations from a regional spectral model nested in a global model (ECHAM4.5) over the north sector of northeast Brazil region (1971-2000). *Brazilian Society of Meteorology*, **20**, 191-206.

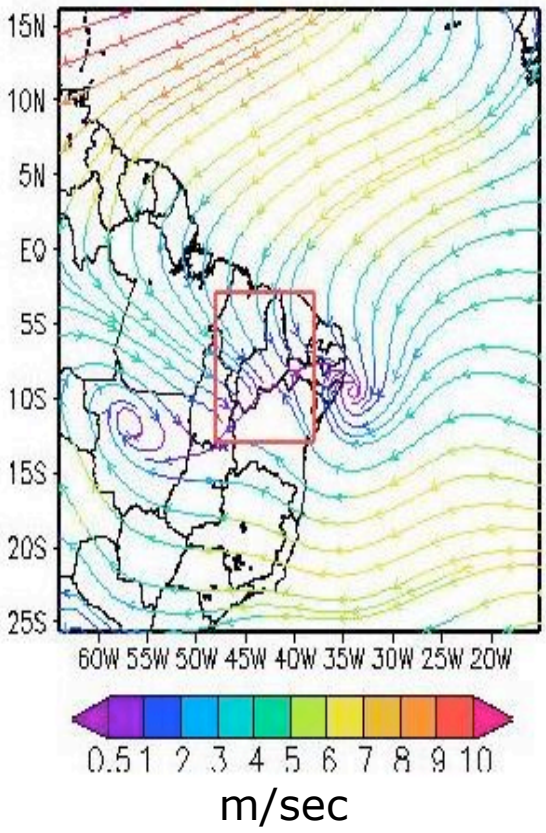
9 Nobre, P., A.D. Moura, and **L. Sun**, 2001: Dynamical Downscaling of Seasonal Climate Prediction over Nordeste Brazil with ECHAM3 and NCEP's Regional Spectral Models at IRI. *Bull. Amer. Meteor. Soc.* **82**, 2787-2796.

Circulation Comparison at 850mb: FMA1974

RSM



ECHAM



NCEP

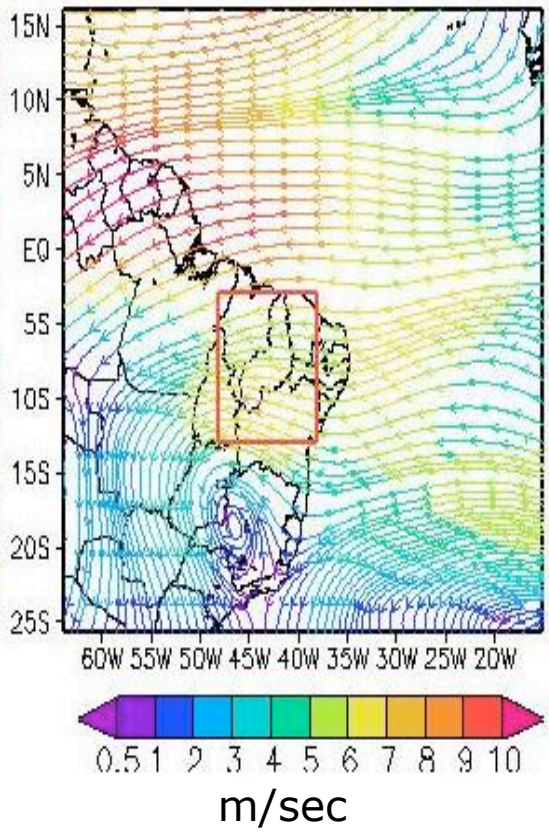
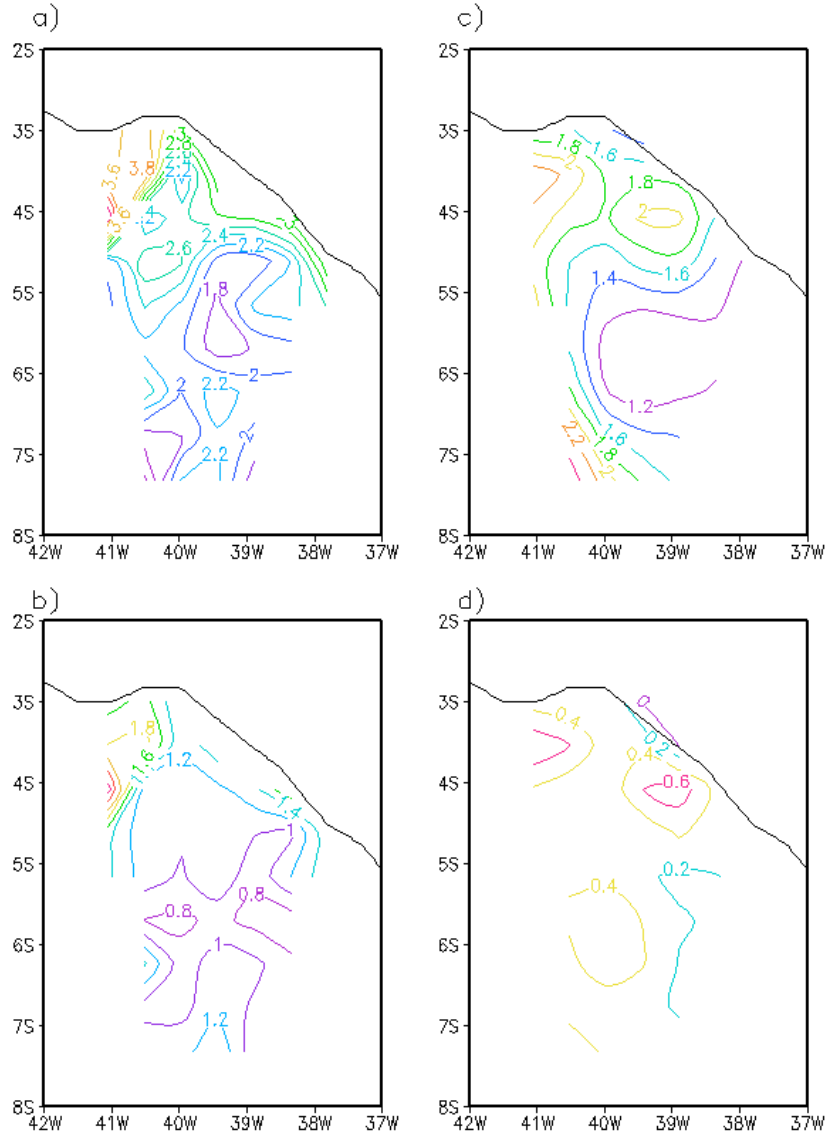
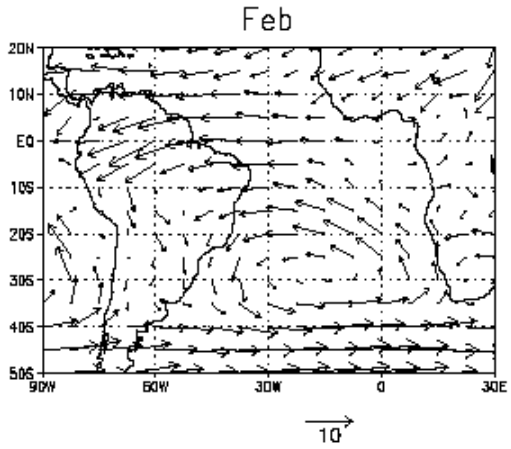


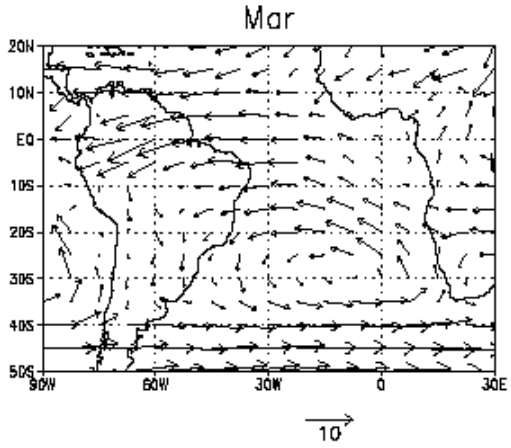
Fig. 10. Standard deviation of precipitation (mm/day) for the period February–March–April 1971–2000 in Ceara. (a)total field of observation; (b)local scale component of observation; (c)total field of RSM simulation; and (d)local scale component of RSM simulation. The contour interval is 0.2 mm/day.

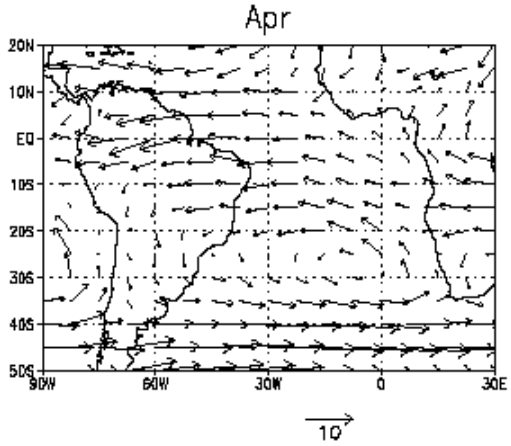


Sun et al. 2005

NCEP 850hPa Wind Climatology



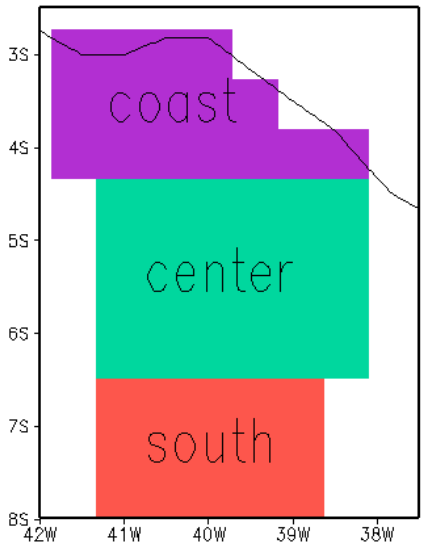




Spatial scale separation

$$P=P_{LS}+P_{RS}$$

homogeneous subregions



Contingency tables for 3 subregions of Ceara State at **local scales** (FMA 1971-2000)

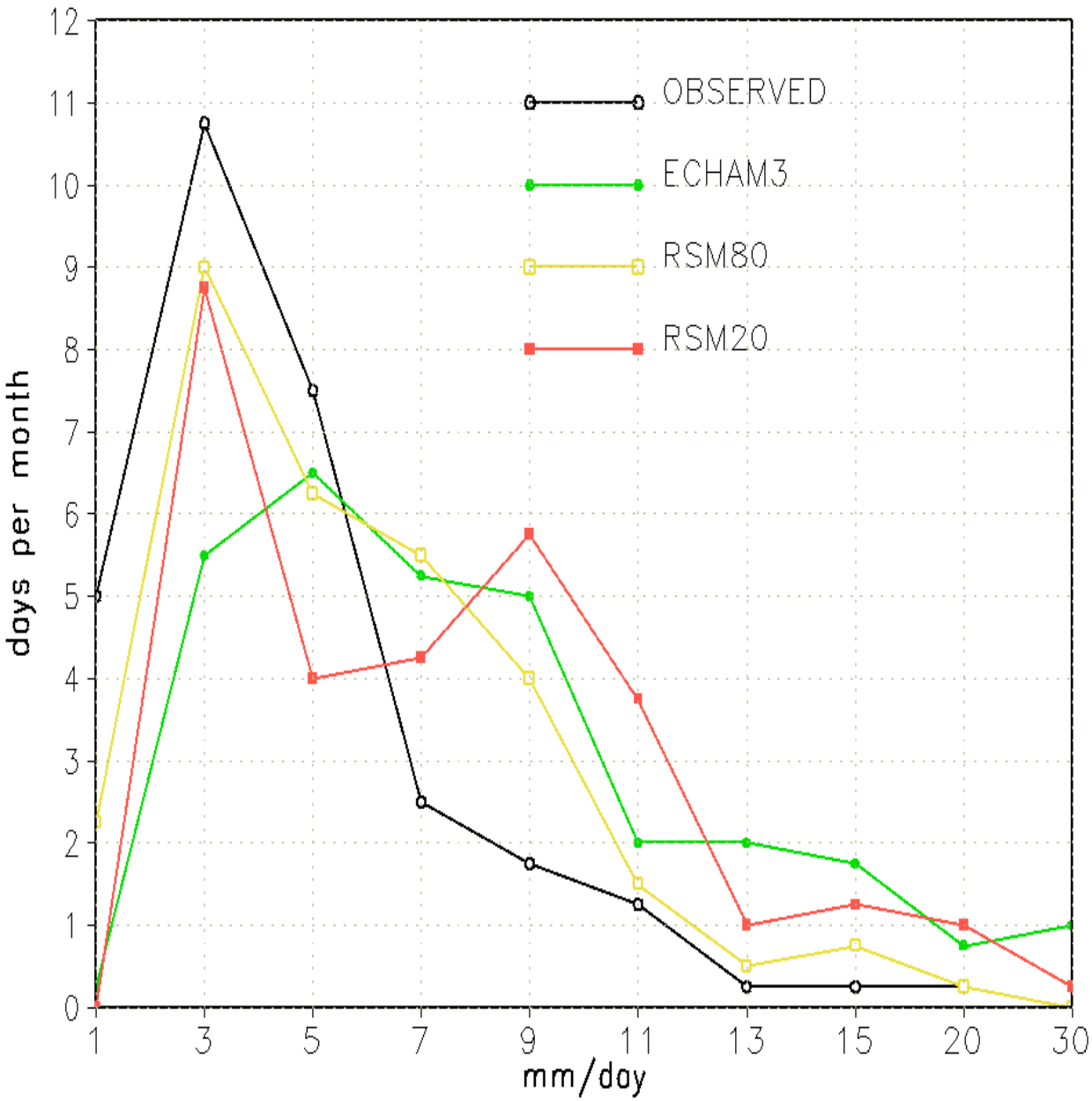
OBS

R S M	*Coast*	B	N	A
	B	5	3	2
	N	3	4	3
	A	2	3	5

R S M	*Central*	B	N	A
	B	5	2	3
	N	4	5	1
	A	1	3	6

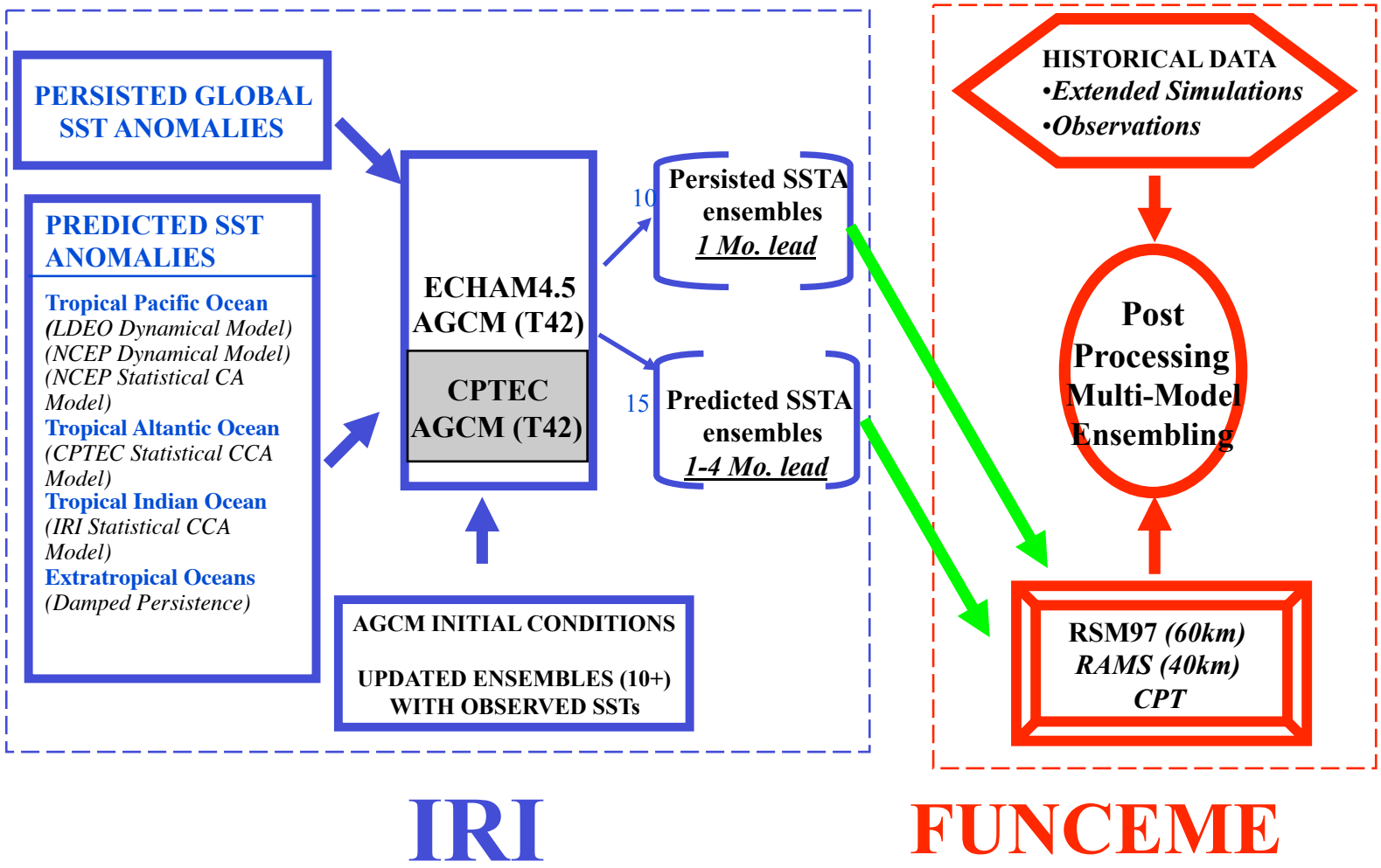
R S M	*Southern*	B	N	A
	B	4	3	3
	N	3	5	2
	A	3	2	5

Sun and Ward (2007)



Nobre et al. 2001

CLIMATE DYNAMICAL DOWNSCALING FORECAST SYSTEM FOR NORDESTE

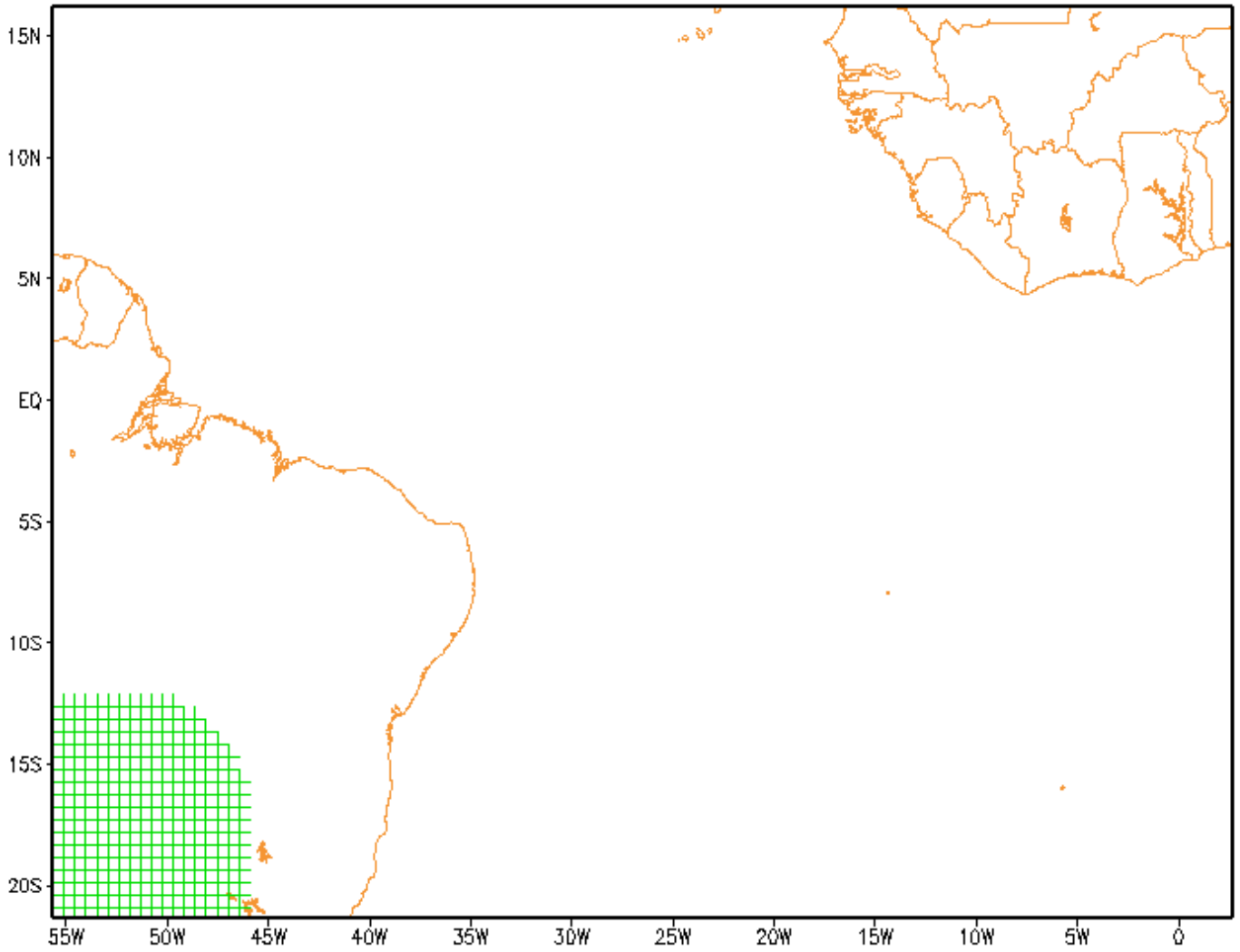


Sun *et al.* 2006

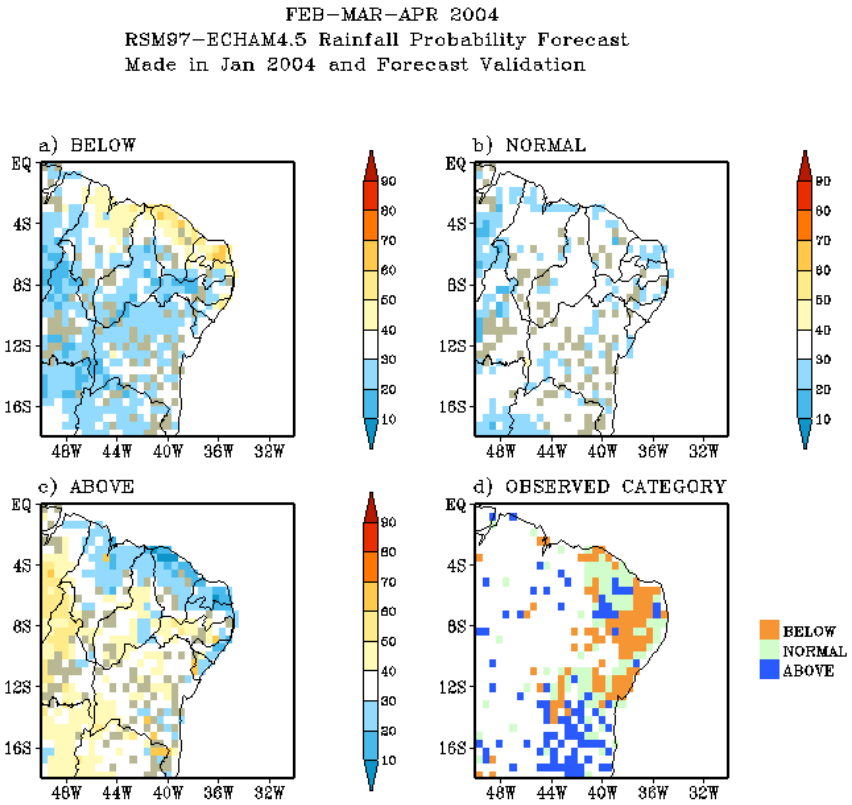
Intensive Course on Dynamical Downscaling of Seasonal to Interannual Climate Predictions (2001)

Infrastructure

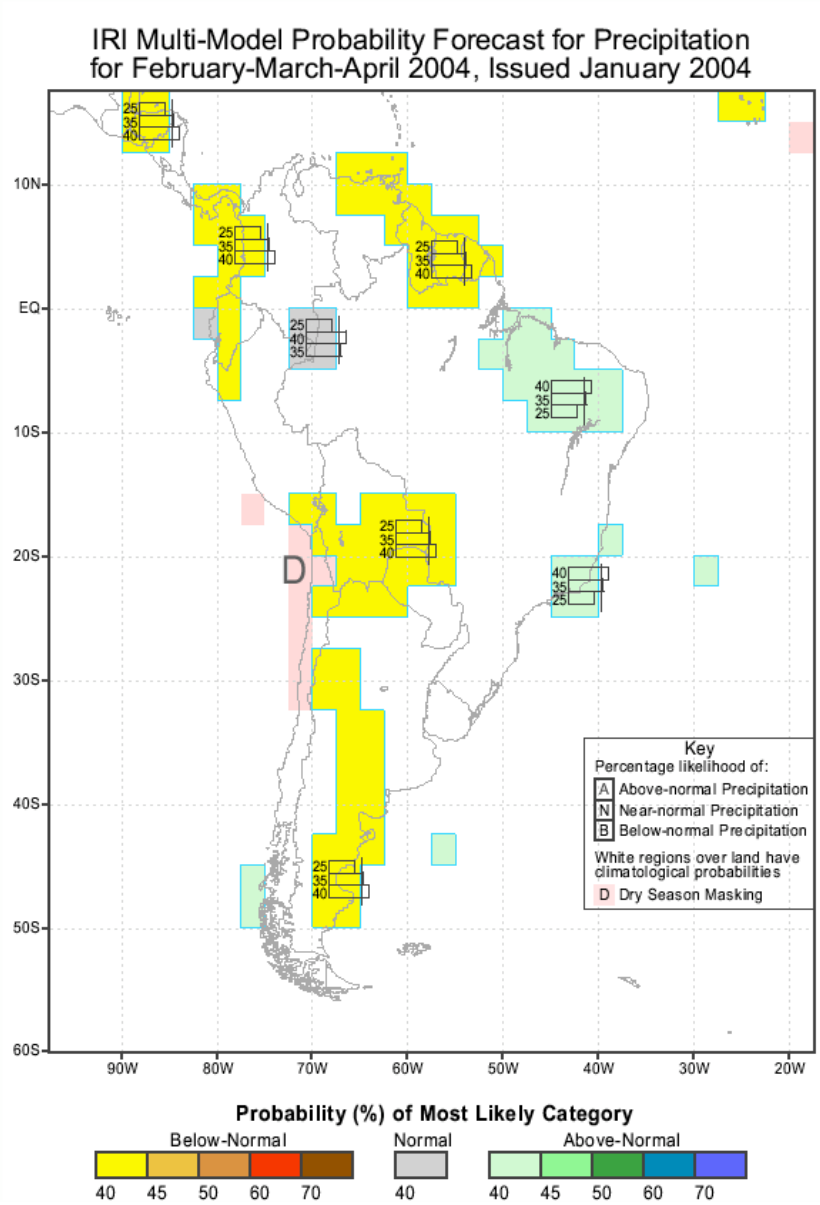
RSM MODEL DOMAIN WITH A PRTION OF GRID RESOLUTION



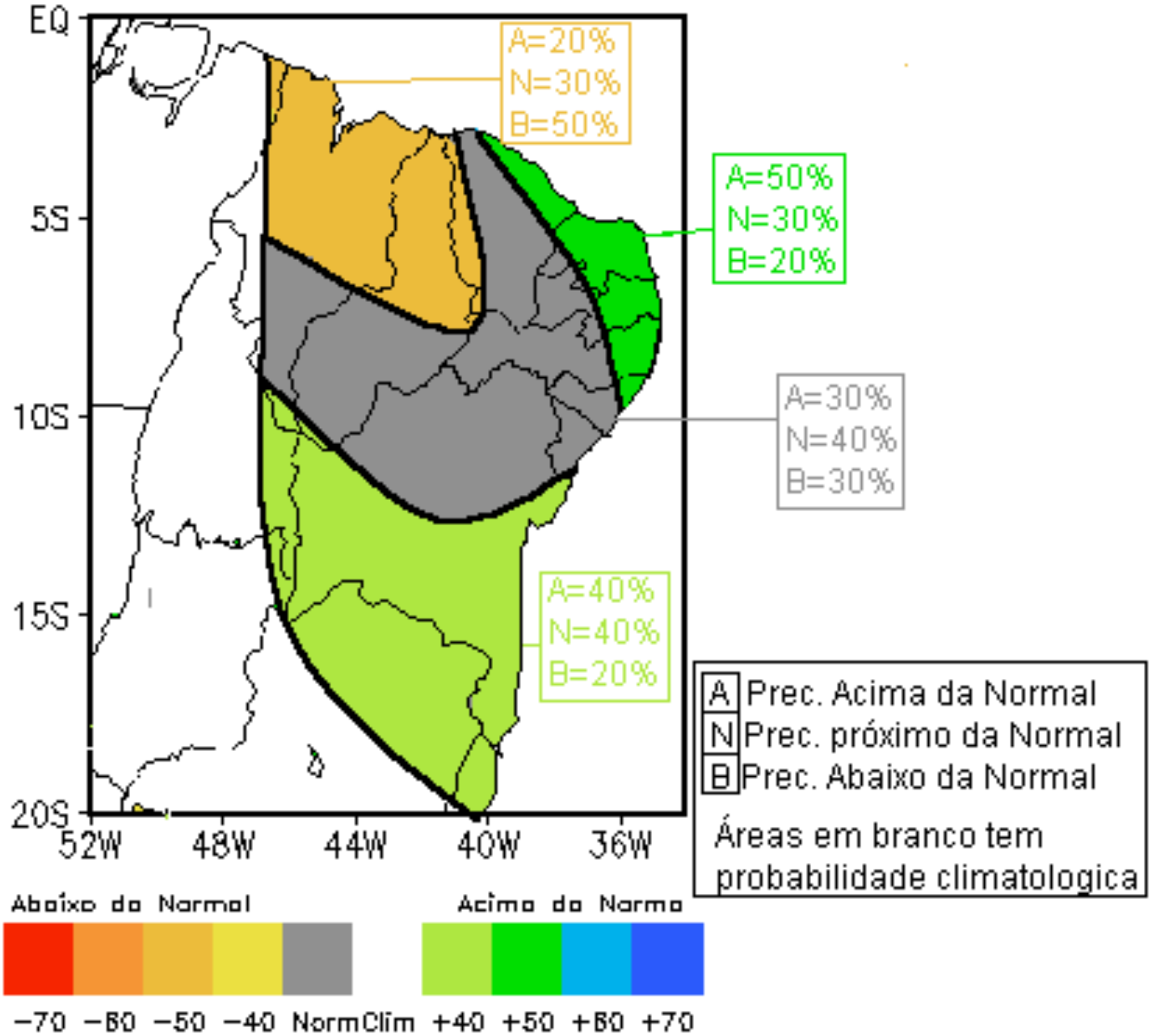
RCM Forecast



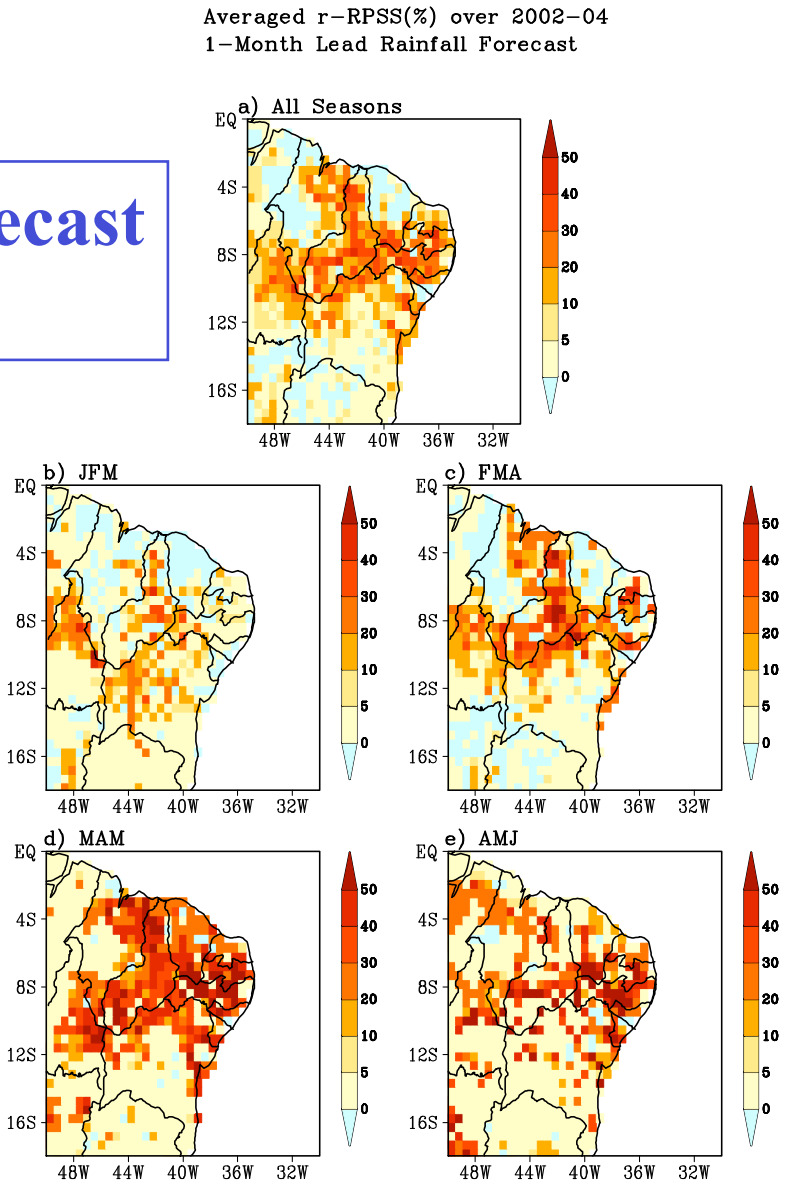
http://www.funceme.br/DEMET/index.htm


IRI Multi-Model Probability Forecast for Precipitation
for February-March-April 2004, Issued January 2004
10N
EQ
10S
20S
30S
40S
50S
60S
90W
80W
70W
60W
50W
40W
30W
20W
D
Key
Percentage likelihood of:
A Above-normal Precipitation
N Near-normal Precipitation
B Below-normal Precipitation
White regions over land have climatological probabilities
D Dry Season Masking
Probability (%) of Most Likely Category
Below-Normal
Normal
Above-Normal
40 45 50 60 70
40
40 45 50 60 70

Previsão de probabilidade de precipitação para Fev-Mar-Abr de 2002
(Realizada em janeiro de 2002)



Real-Time Forecast Validation



Sun *et al.* 2006

A Major Goal of Probabilistic Forecasts - *Reliability!*
Forecasts should "mean what they say"

Confidence Level

40%

	B_o	N_o	A_o
B_f	46	41	13
N_f	48	36	16
A_f	37	27	36

50%

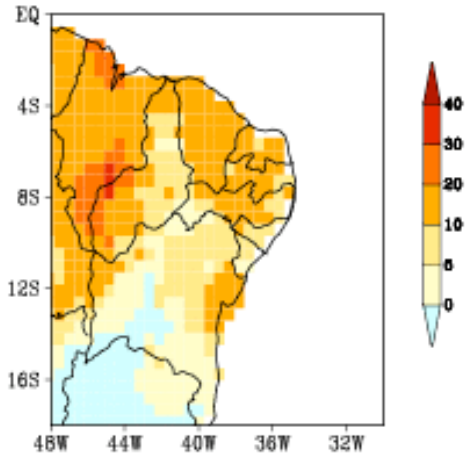
	B_o	N_o	A_o
B_f	49	41	10
N_f			
A_f	25	27	48

60%

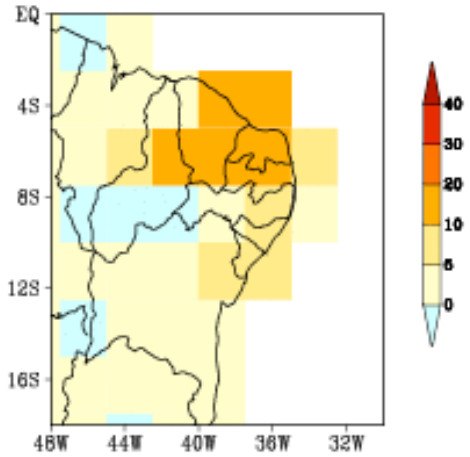
	B_o	N_o	A_o
B_f	45	48	15
N_f			
A_f	31	24	45

Average RPSS(%): JFM 2005–2010
0.5–Month Lead Rainfall Forecasts

a) RSM

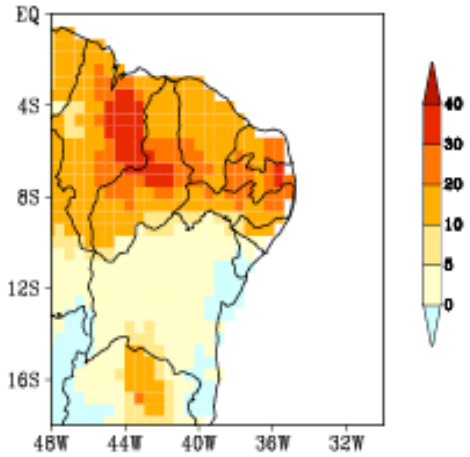


b) IRI

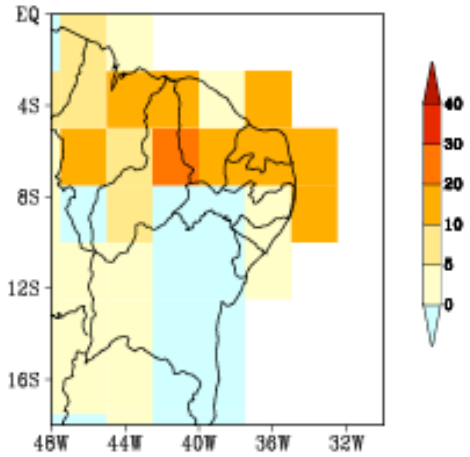


Average RPSS(%): FMA 2005–2010
0.5–Month Lead Rainfall Forecasts

a) RSM

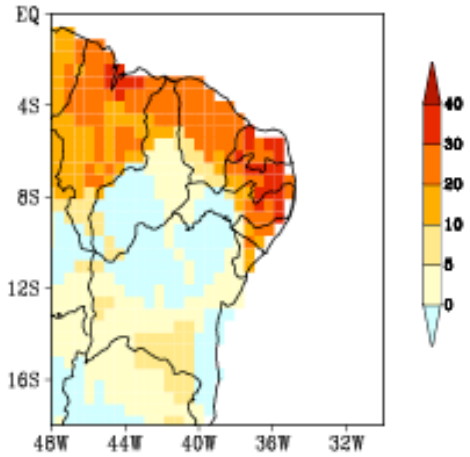


b) IRI

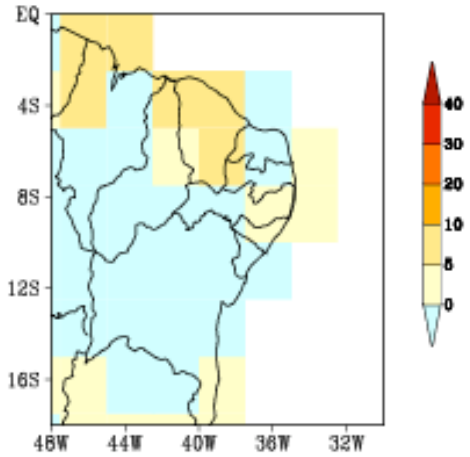


Average RPSS(%): MAM 2005–2010
0.5–Month Lead Rainfall Forecasts

a) RSM

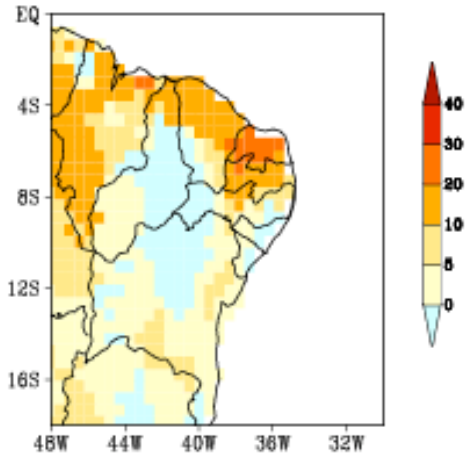


b) IRI

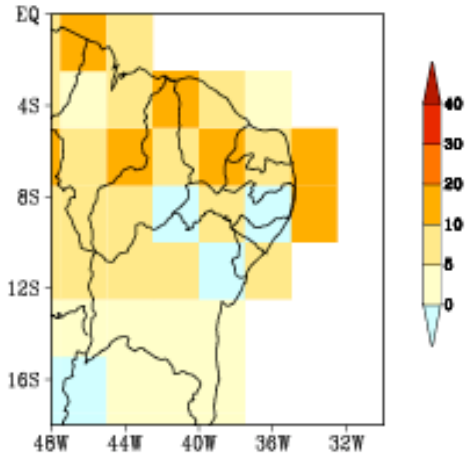


Average RPSS(%): AMJ 2005–2010
0.5–Month Lead Rainfall Forecasts

a) RSM

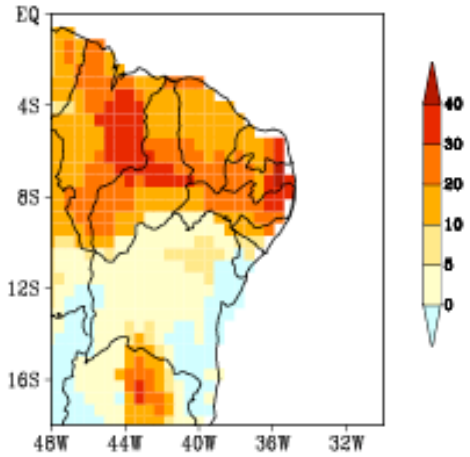


b) IRI

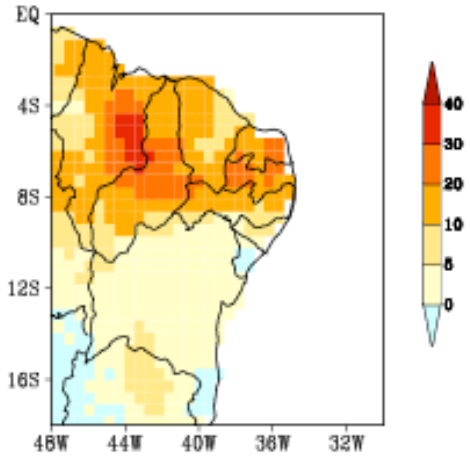


Average RPSS(%): FMA 2005–2010
0.5–Month Lead Rainfall Forecasts

a) PSST

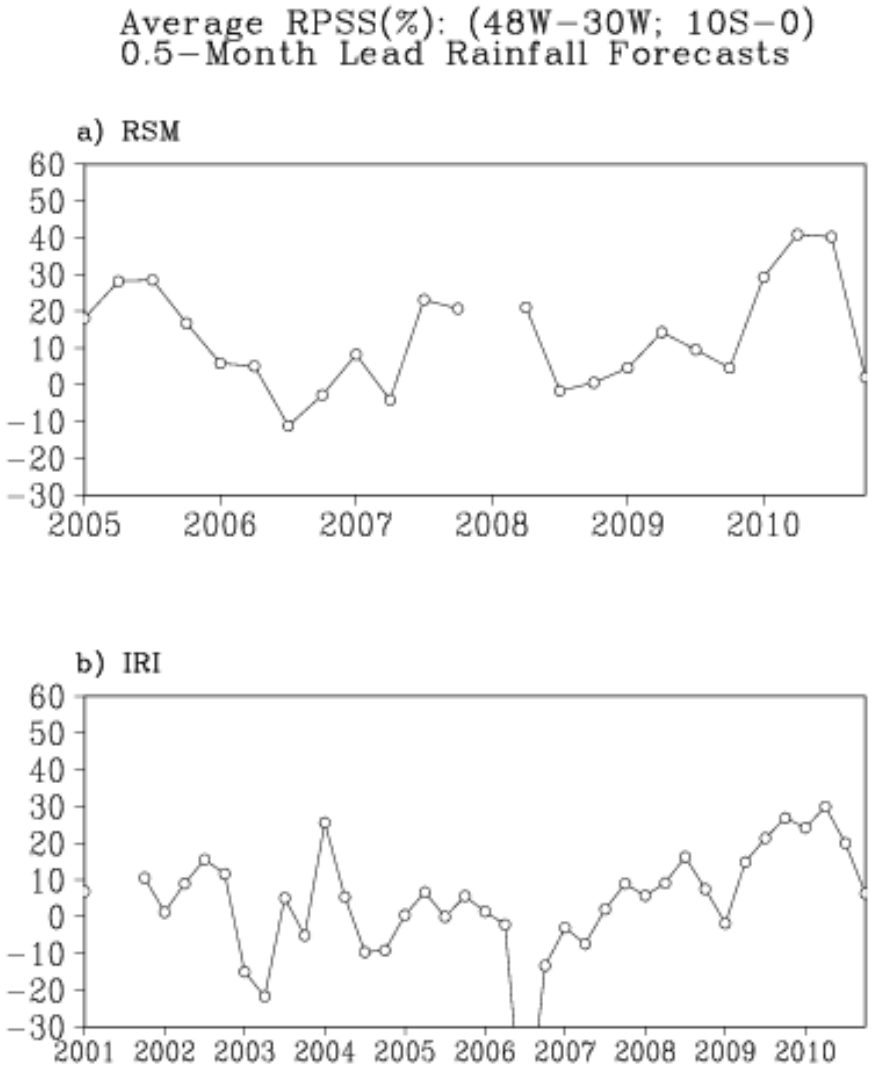


b) SSST

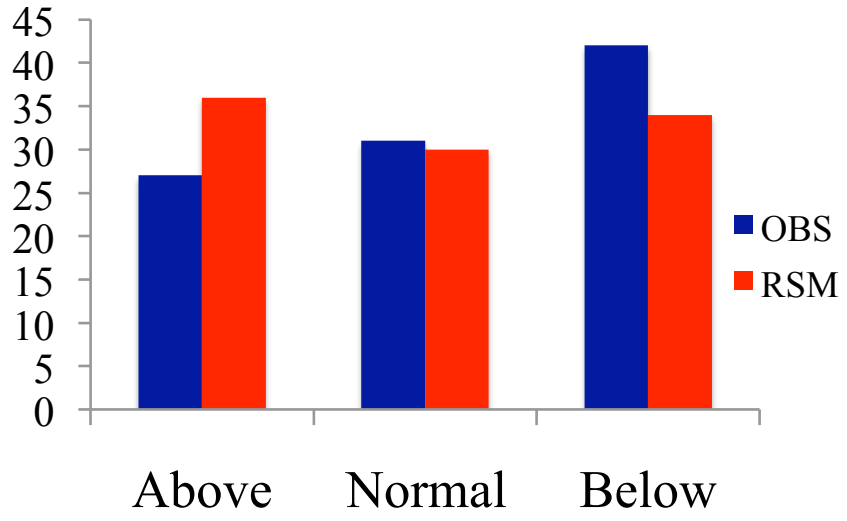


Heidke Score over Nordeste (FMA 2002)

	Grid	Hit	Score
Simulation	327	269	0.73
FCST(PSST)	327	166	0.26
FCST(ASST)	327	84	-0.11


Average RPSS(%): (48W−30W; 10S−0)
0.5−Month Lead Rainfall Forecasts
a) RSM
60
50
40
30
20
10
0
−10
−20
−30
2005
2006
2007
2008
2009
2010
b) IRI
60
50
40
30
20
10
0
−10
−20
−30
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

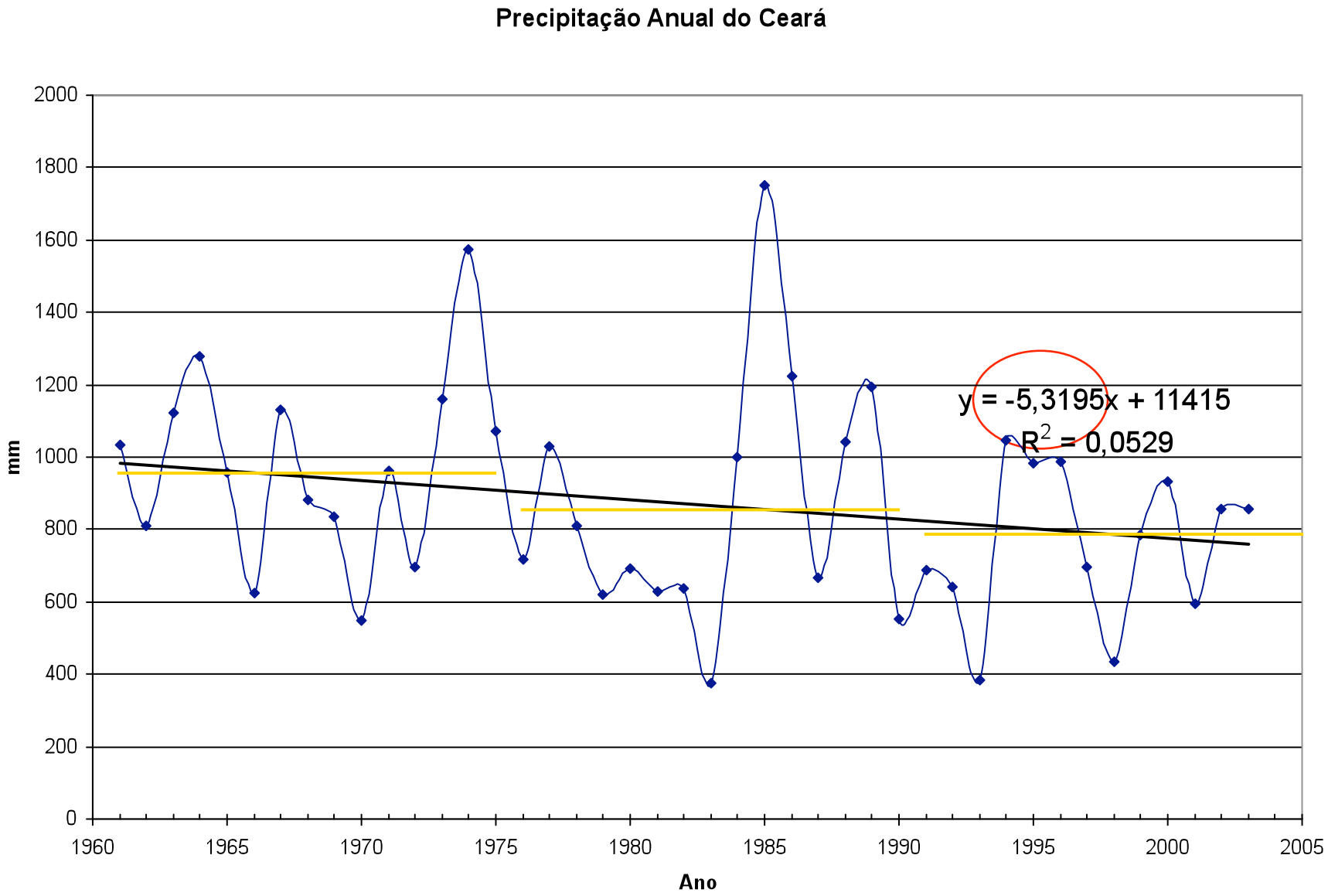
Frequency/Averaged Probability
MAM 2005-2010 Northeast Brazil



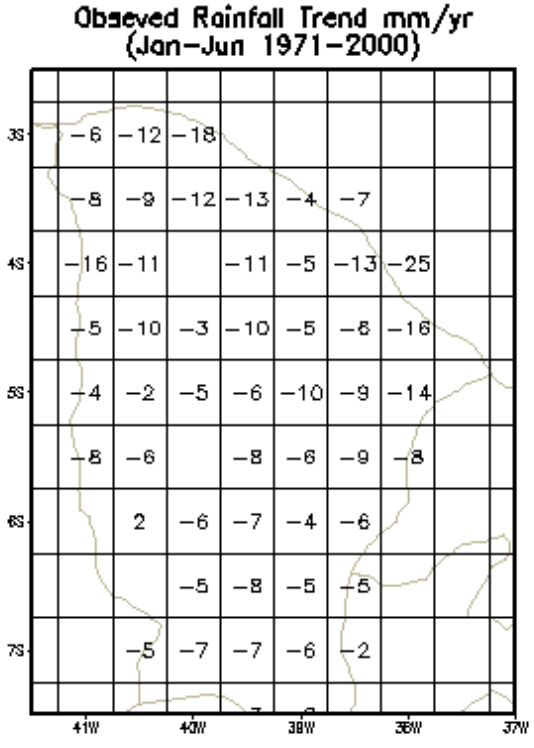
The average forecasts fail to forecast the shift towards dry conditions.

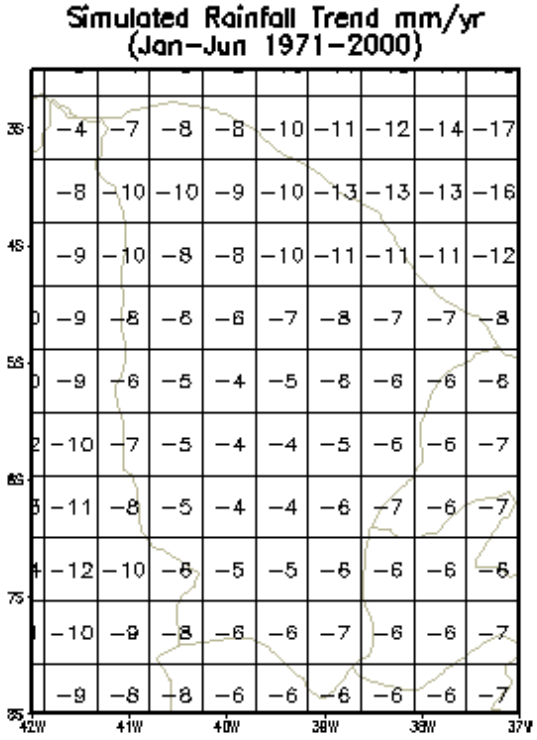
Dados de grade de 0,5 Graus

Total anual



Os parâmetros calculados neste modelo tem um nível de significancia de 0,1% no teste t de student.





Moncunill1 Sun (2007)

Summary

- Downscaling forecasts using the RSM show some evidence of skill over Northeast Brazil. Prediction skill varies with seasons and geographical regions.
- The forecasts with the persisted SST anomalies show higher skill than those with predicted SST anomalies.
- The skill of downscaling forecasts is often higher than that of the IRI global model forecasts
- The downscaling forecasts do not capture the shifts in the climatology.