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PREDICTABILITY STUDY OF HEAVY PRECIPITATION EVENTS OVER SOUTHEAST BRAZIL USING SHORT-RANGE ENSEMBLE PREDICTION SYSTEMS

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Introduction

There are two major sources of uncertainties in numerical weather prediction: uncertainties in the initial conditions and in model equations. Ensemble approach is the technique used to incorporate these uncertainties in the forecasts in order to improve them. There are some issues in the design of an Ensemble Prediction System (EPS) such as the ensemble size and the perturbation technique. To develop an EPS, it is necessary to include appropriately these uncertainties in the forecasts. Ensemble techniques have been applied using mesoscale models in order to improve forecasts of mesoscale weather systems.

Objective

The main goal of this work is to test and evaluate a Short-Range Ensemble Prediction System based on the Eta Model using perturbations in initial conditions (SREPH) and combining perturbation in model physics parameters (SREPF).

Methodology

Eta Model

Model: Eta Model (Black, 1994);
Horizontal resolution: 10 km; vertical levels: 38;
Forecast range:72h (Frontal System cases) or 144 h (South Atlantic Convergence Zone cases);
Initial Condition: analysis from NCEP T126L28;
Lateral Boundary Conditions: CPTEC GCM T126L28, 6/6h;
Convection schemes available:Betts-Miller-Janjic scheme (Janjic, 1994) ;
Kain-Fristch scheme (Kain, 2004);
Land-surface scheme: Noah (Chen et al. 1997).

Short Range Ensemble Prediction System (SREPT - 11 members)
- 1 member: Unperturbed analysis from NCEP + CPTEC GCM forecasts
- 4 IC perturbed members (SREPH – 5 members)
Initial Conditions: 4 perturbed analyses;
Lateral Boundary Conditions: CPTEC GCM forecasts;
IC perturbation technique based on EOF .
- **6 Physics members (SREPF – 7 members)**
Initial Conditions: unperturbed NCEP analyses;
Lateral Boundary Conditions: CPTEC GCM forecast;
Physics perturbations according to the table below:

	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Control
Cumulus parametrization	BMJ2 Sea profile everywhere	BMJ2 Sea and land profiles	BMJ2 Sea profile everywhere	KF Modified	KF Momentum Flux	KF Modified + Momemtum Flux	BMJ1 Sea profile everywhere
Surface parameter	ZTMAX = 10 EPSUST = 0,01	CZIL = 0,5 WWST = 1,1 ZTMAX = 10	ZTMAX = 10	____	_____		_____

Deep convection parameters	DSPBFL (Pa)	DSPBFS (Pa)	DSP0FL (Pa)	DSP0FS (Pa)	DSPTFL (Pa)	DSPTFS (Pa)	FSS (no dim)	FSL (no dim)
BMJ1	-4500	-3875	-5500	-5875	-2000	-1875	0.85	0.85
BMJ2	-5000	-3875	-7000	-5875	-1500	-1875	1.0	1.0

KF modified: KF scheme with resolution dependence
KF + momentum flux: KF scheme with convective momentum fluxes

Surface parameter Control member	CZIL= 0,2	WWST = 1,2	ZTMAX = 1	EPSUST = 0,07

South Atlantic Convergence Zone Cases (SACZ)

The accumulated precipitation during every FS episode are shown in Figure 1.

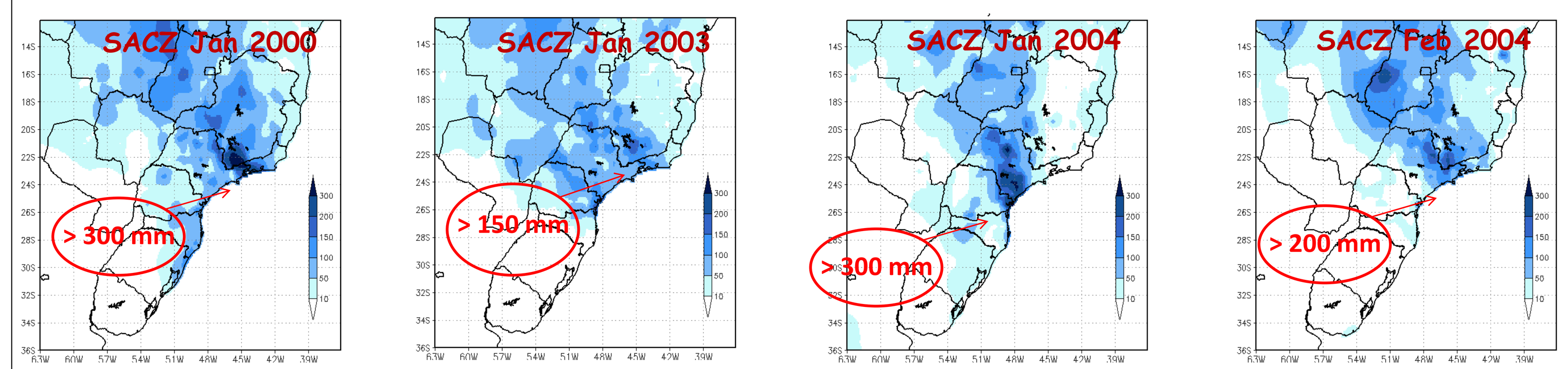

Figure 1: 6 day accumulated precipitation for SACZ events.

Frontal Systems Cases (FS)

The 24-hr accumulated precipitation during every FS episode are shown in Figure 2.

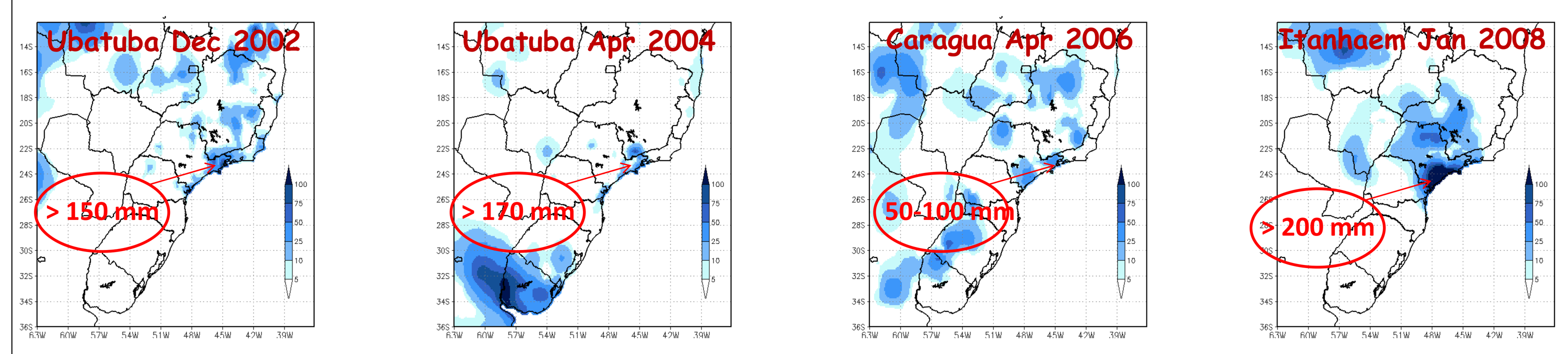

Figure 2: 24-hr accumulated precipitation for FS events.

Root Mean Square Error (RMSE) and Ensemble Mean Spread (SPR)

SREPH – Short-Range Ensemble Prediction using perturbations in Initial Conditions (green lines)
SREPF – Short_range Ensemble Prediction using perturbations in the model (blue lines)
SREPT – Combination of SREPH and SREPF (11 members) (purple lines)
Control – member unperturbed (black line)

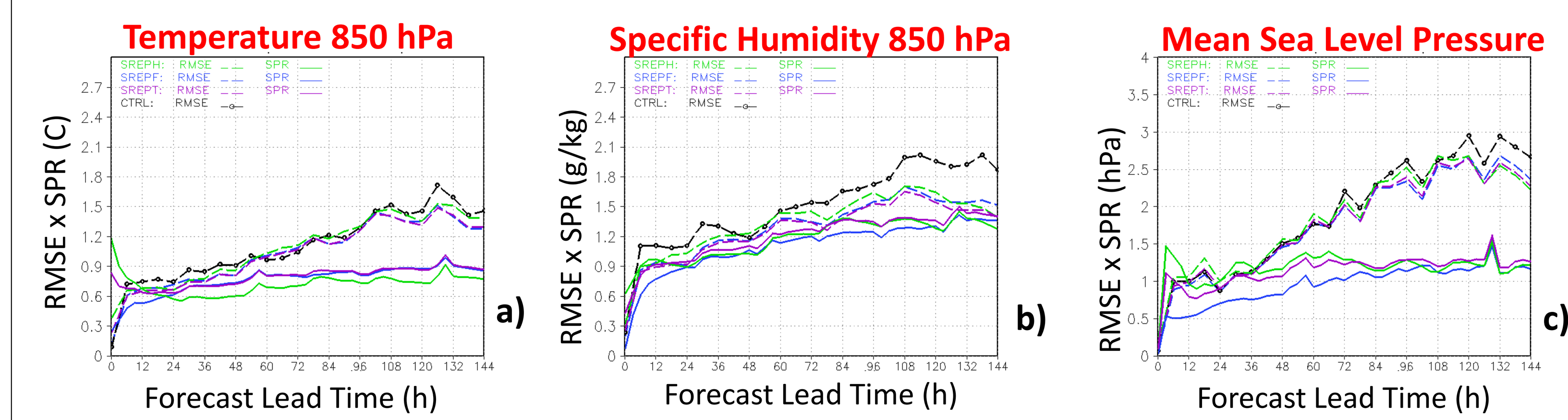

Figure 3: RMSE and SPR for ZACS Cases: a) Temperature at 850 hPa, b) Specific Humidity at 850 hPa, c) Mean Sea Level Pressure. SREPH (green line); SREPF (blue line); SREPT (purple line)

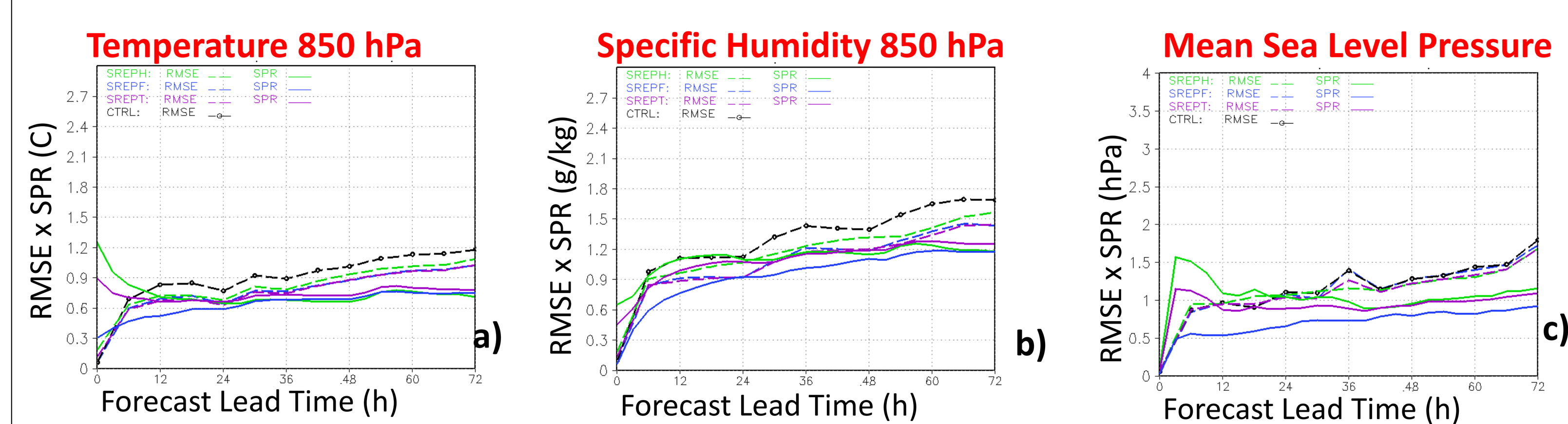

Figure 4: RMSE and SPR for FS Cases: a) Temperature at 850 hPa, b) Specific Humidity at 850 hPa, c) Mean Sea Level Pressure. SREPH (green line); SREPF (blue line); SREPT (purple line)

ETS and BIAS

The Equitable Threat Score (ETS) and the related BIAS score are objective indices used to evaluate precipitation in different thresholds. The ensemble mean performance was evaluated according to its ability to forecast precipitation amounts above certain thresholds.

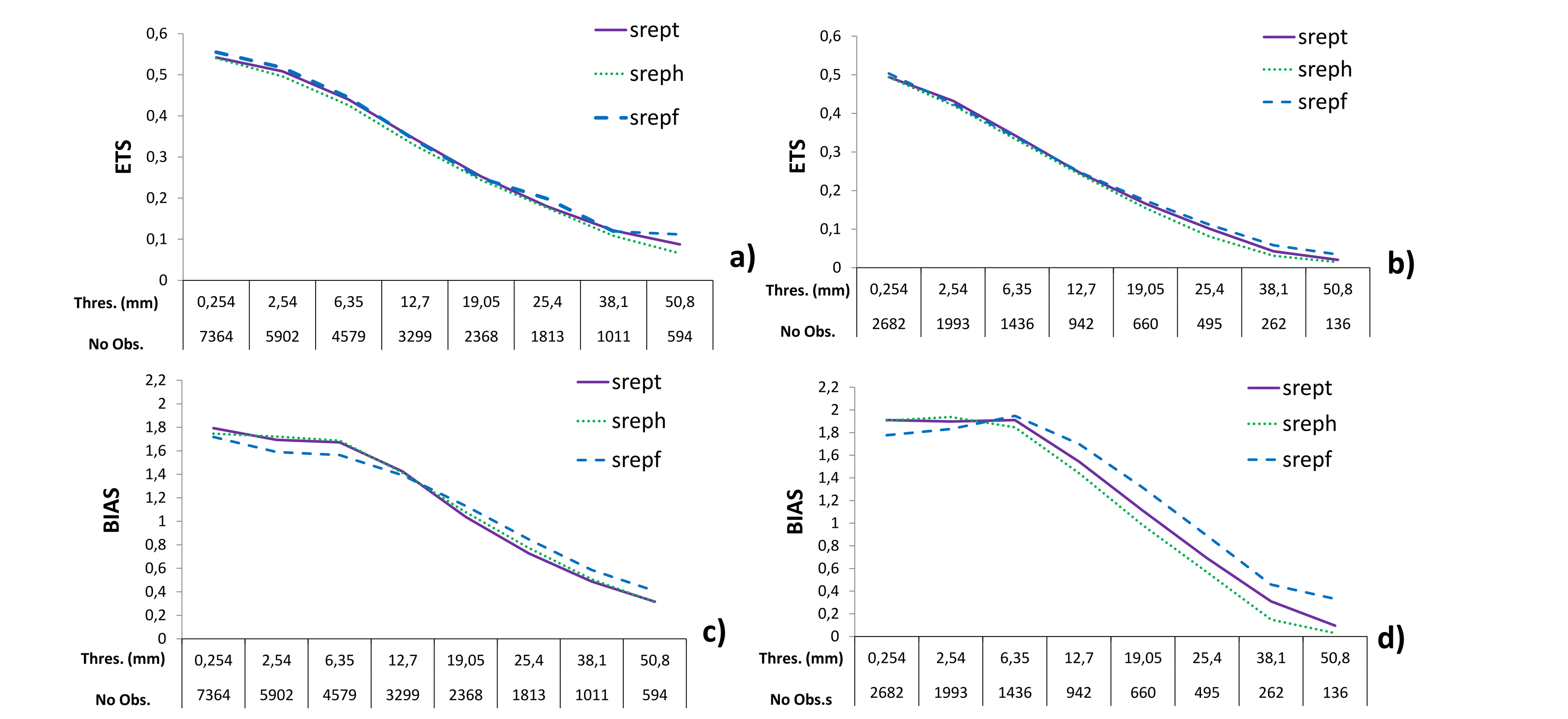

Figure 5: a) ETS for SACZ cases, b) ETS for FS cases, c) BIAS for SACZ cases, d) BIAS for FS cases. SREPH (doted green line); SREPF (dashed blue line); SREPT (solid purple line).

Talagrand Diagram

Talagrand diagrams are used to measure the distribution of an ensemble prediction system with respect to observations. Talagrand diagrams are constructed by ordering the forecast value at each grid point from each ensemble member from the smallest to the largest value. The ensemble member number plus one is the number of bins of the diagram. An ideal ensemble shows a flat rank histogram, a slope toward right (left) side indicate that the ensemble has positive (negative) bias. A U-shaped histogram indicates insufficient spread while an inverted U-shaped indicates excessive spread among the ensemble members.

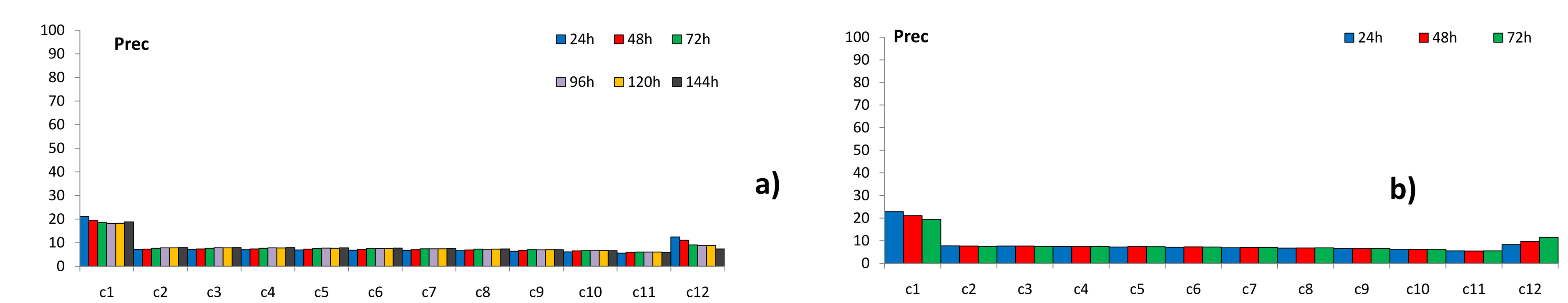

Figure 6: The 24-hr accumulated precipitation Talagrand Diagram: a) SACZ cases, b) FS cases.

Conclusions

- For most variables the ensemble mean RMSE is smaller than the control RMSE, in all cases;
- For all experiments (SREPH, SREPF and SREPT), the RMSE showed a growth rate larger than the spread growth rate, which means that there is some underdispersion in the ensemble prediction system;
- There is a fast growth rate in spread in the first 12 hours probably because of the model adjustment period;
- SREPF RMSE is smaller than SREPH RMSE;
- Precipitation ETS and the associated BIAS showed advantages of the SREPF over SREPH runs , mainly for heavier rains in SACZ cases;
- Talagrand Diagram for 24-hr accumulated precipitation showed a flat distribution in SREPT runs;
- The increased number of members and the inclusion of member with perturbed model physics in the SREPT produced better results in general;
- In general, the results indicated the potential use of this methodology to construct a regional ensemble prediction system.

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