IN13A-22: OPTIMIZATION FIREFLY METHOD FOR WEIGHTED ENSEMBLE OF CONVECTIVE PARAMETERIZATIONS. PART I: RESULTS WITH A SYNTHETIC PRECIPITATION FIELD

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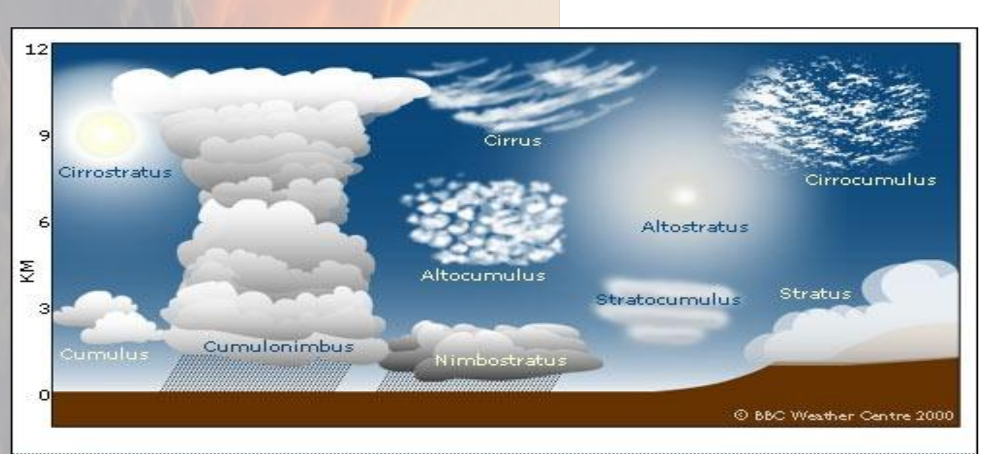
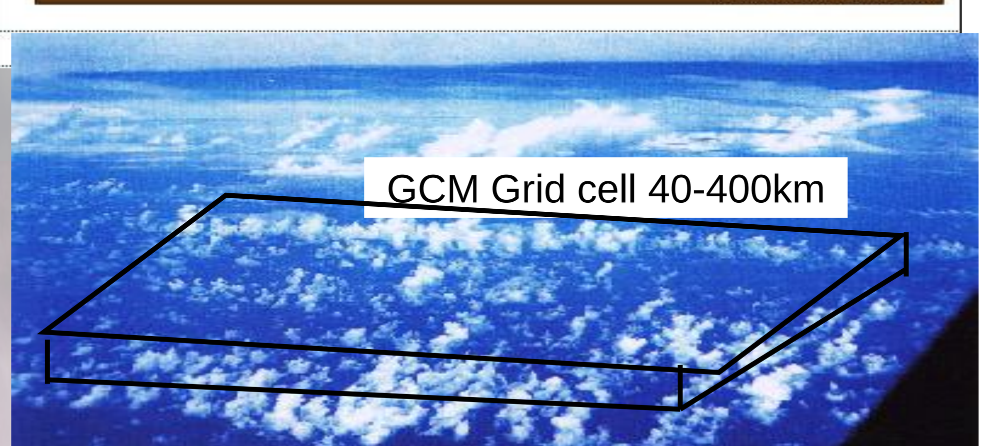
ABSTRACT

The inverse problem methodology for parameter estimation is applied to a challenging meteorological phenomenon that causes intense rainfall over South America. It is formulated as an optimization problem, where the goal is to apply and to evaluate the Firefly method (FA) as an optimizer for retrieving the weights of the ensemble of convective parameterizations of Grell and Dévényi. The forward problem is addressed by the Coupled Chemistry-Aerosol-Tracer Transport-Brazilian developments on the Regional Atmospheric Modeling System (CCATT-BRAMS), and the ensemble of convective parameterizations is expressed by several methodologies used to parameterize convection.

INTRODUCTION

Why is so difficult represent clouds in the numerical models?





FIREFLY METHOD

Pseudo code

```
begin
 Objective function f(x),        x=(x1, ..., xd)^T
Generate initial population of fireflies xi (i=1, 2, ..., n)
Light intensity Ii at xi is determined by f(xi)
Define light absorption coefficient γ
while (t < MaxGeneration)  (Number of iterations)
      for i = 1 : n all n fireflies
          for j = 1 : d loop over all d dimensions
            if (Ij > Ii), Move firefly i towards j: end if
             Attractiveness varies with distance r via exp[- γr]
            evaluate new solutions and update light intensity
          end for j
     end for i
     Rank the fireflies and find the current best
end while
Postprocess results and visualization
end
```

Adapted of Yang (2008)

Light intensity

$$I(x) \propto f(x)$$

In a simplest form

$$I_r = \frac{I_{fonte}}{r^2}$$

Movement of the firefly i toward firefly j (brightest)

$$x_i = x_i + \underbrace{\frac{\beta_0}{1+r^2\gamma}(x_j - x_i)}_{\text{atraction}} + \underbrace{\alpha\left(rand - \frac{1}{2}\right)}_{\text{randomness}}$$

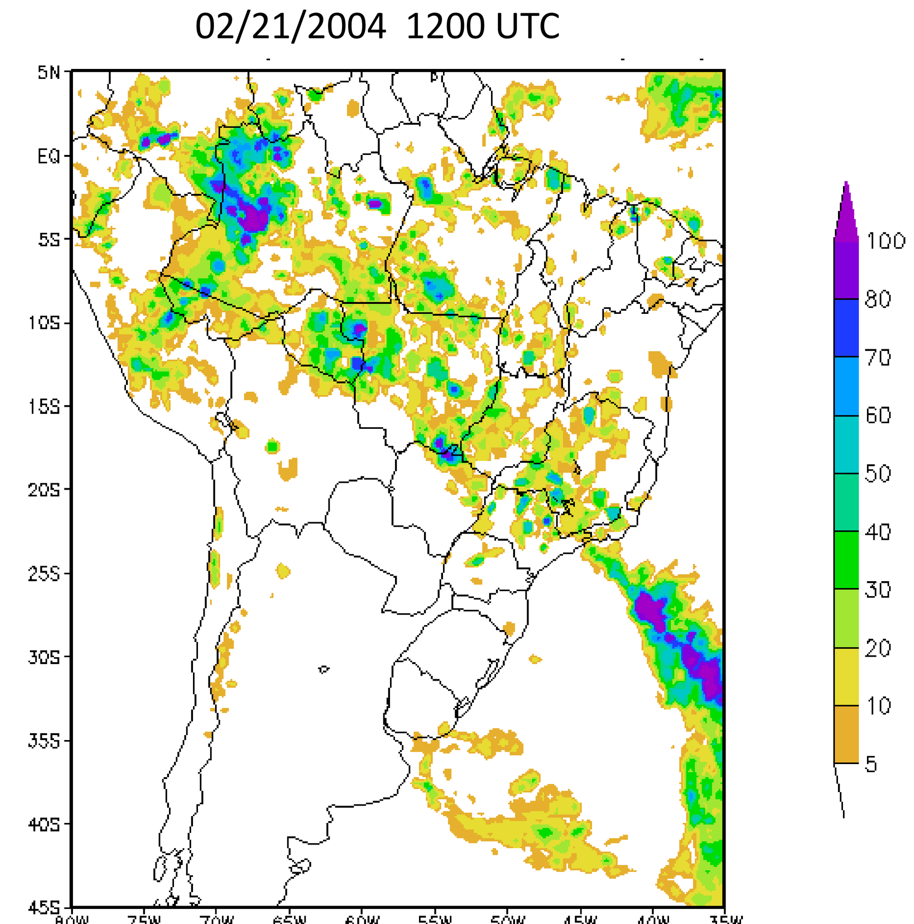
γ =O(1) => determines the convergence velocity

To an environment light absorption coefficient fix γ

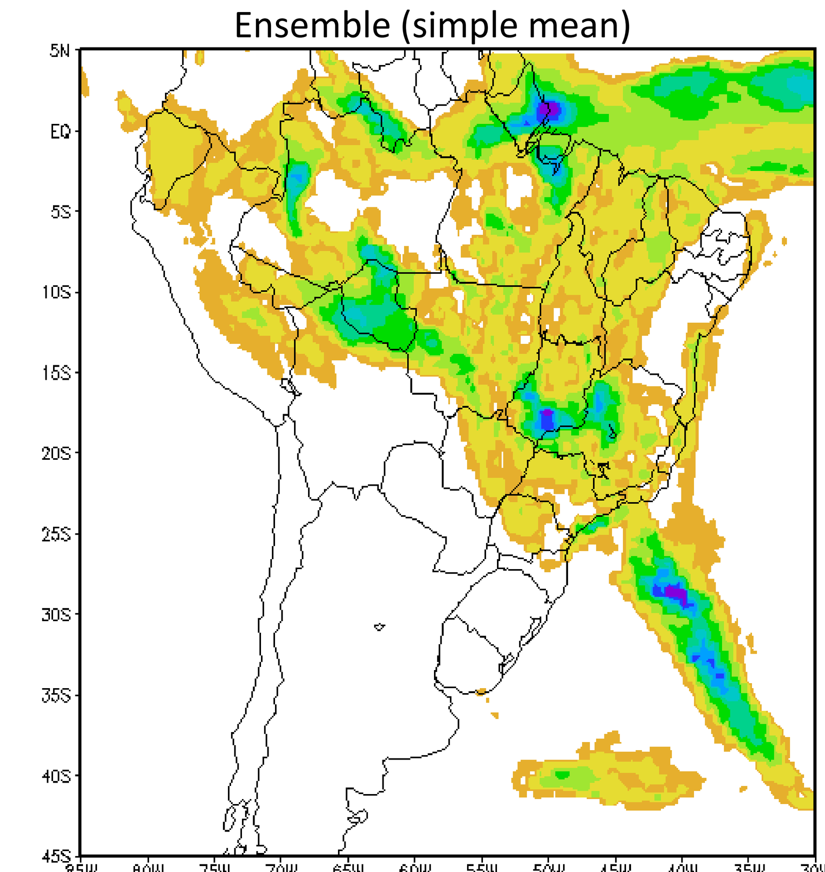
$$I = I_0 e^{-r\gamma} \Rightarrow I = I_0 e^{-r^2\gamma} \Rightarrow I_r = \frac{I_{fonte}}{1+r^2\gamma}$$

RESULTS

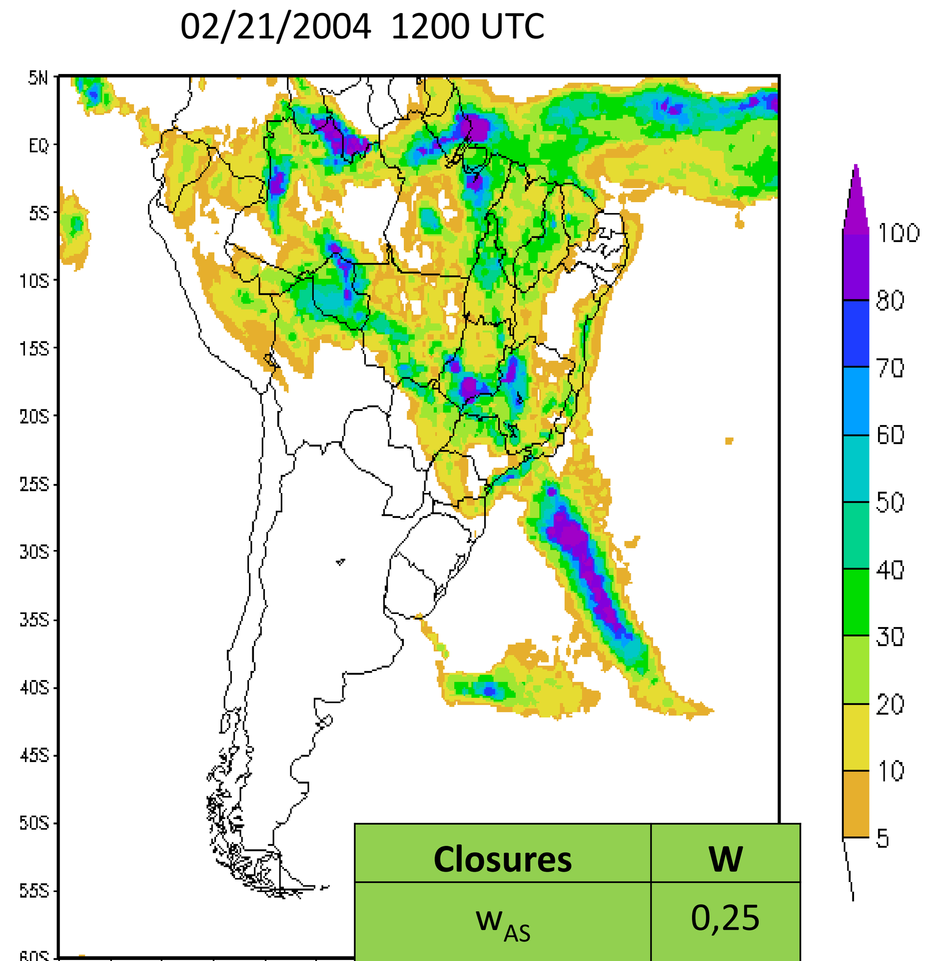
TRMM rainfall (mm)
02/21/2004 1200 UTC



CCATT-BRAMS simulated Convective railfall (mm) 02/21/2004 1200 UTC
Ensemble (simple mean)

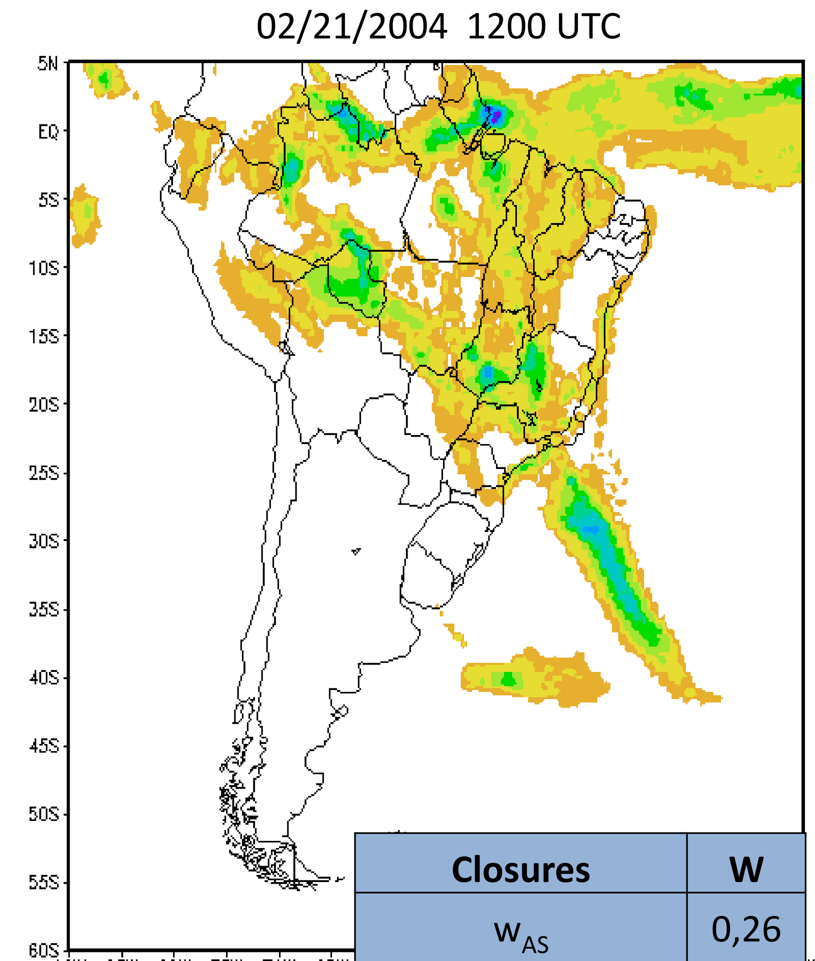


Synthetic rainfall (mm)
02/21/2004 1200 UTC



Closures	W
w_{AS}	0,25
w_{GR}	0,35
w_{KF}	0,20
w_{MC}	0,15
w_{LO}	0,05
Sum	1

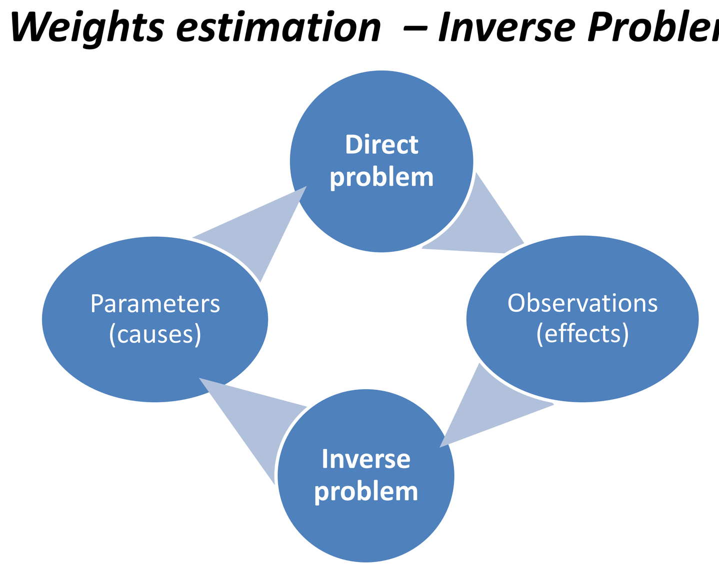
n=20, MaxGeneration=1000
Retrieval convective rainfall (mm)
02/21/2004 1200 UTC



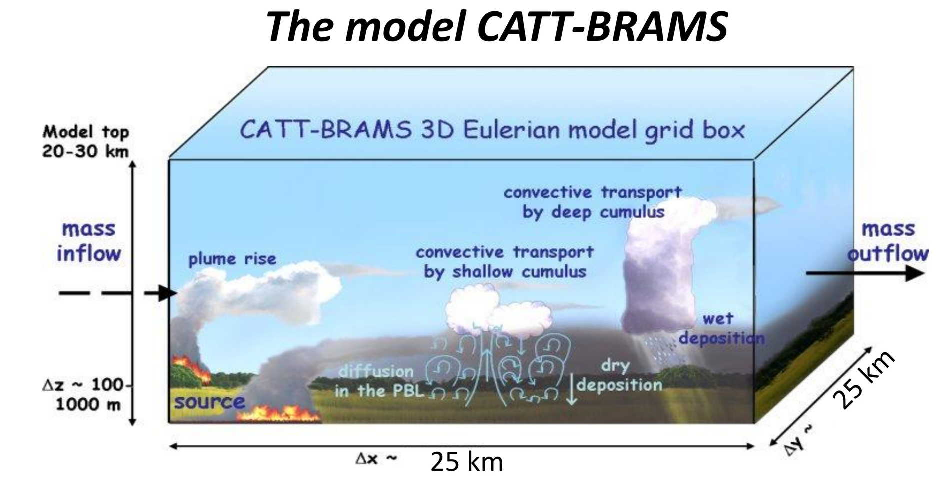
Closures	W
w_{AS}	0,26
w_{GR}	0,36
w_{KF}	0,18
w_{MC}	0,16
w_{LO}	0,04
Sum	1

METHODOLOGY

Weights estimation – Inverse Problems



The model CATT-BRAMS



Synthetic experimental data

$$P_S = w_{AS}P_{AS} + w_{GR}P_{GR} + w_{KF}P_{KF} + w_{MC}P_{MC} + w_{LO}P_{LO}$$

$$J(\overrightarrow{W}^T) = \min \left\| P_M^{w_i} - P_S \right\|_2^2 \quad \text{where} \quad P_M = \sum_i^5 w_i P_i$$

P – precipitation fields using cumulus parameterization of Grell & Dévényi (2002): Closures used

- **Grell (GR)**
- **Arakawa & Schubert (AS)**
- **Kain e Fritsch (KF)**
- **Moisture convergence (MC)**
- **Low-level omega (LO)**

Numerical experiment: the use of the firefly algorithm, with different number of iterations and number of fireflies

Iterations (MaxGeneration)= 1000
Nº fireflies (n) = 20

B_0= 1
α = 0,2
γ = 1

CONCLUSION

Results showed a very good inverse solution, and the retrieved field was in agreement with the synthetic precipitation field.

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