



MC-A01

Assimilação de Dados por Redes Neurais Artificiais

# Assimilação de Dados por Redes Neurais Artificiais

Haroldo F. de Campos Velho – INPE

Helaine C. M. Furtado – UFOPA

Juliana A. Anochi – INPE

Roberto P. Souto – LNCC

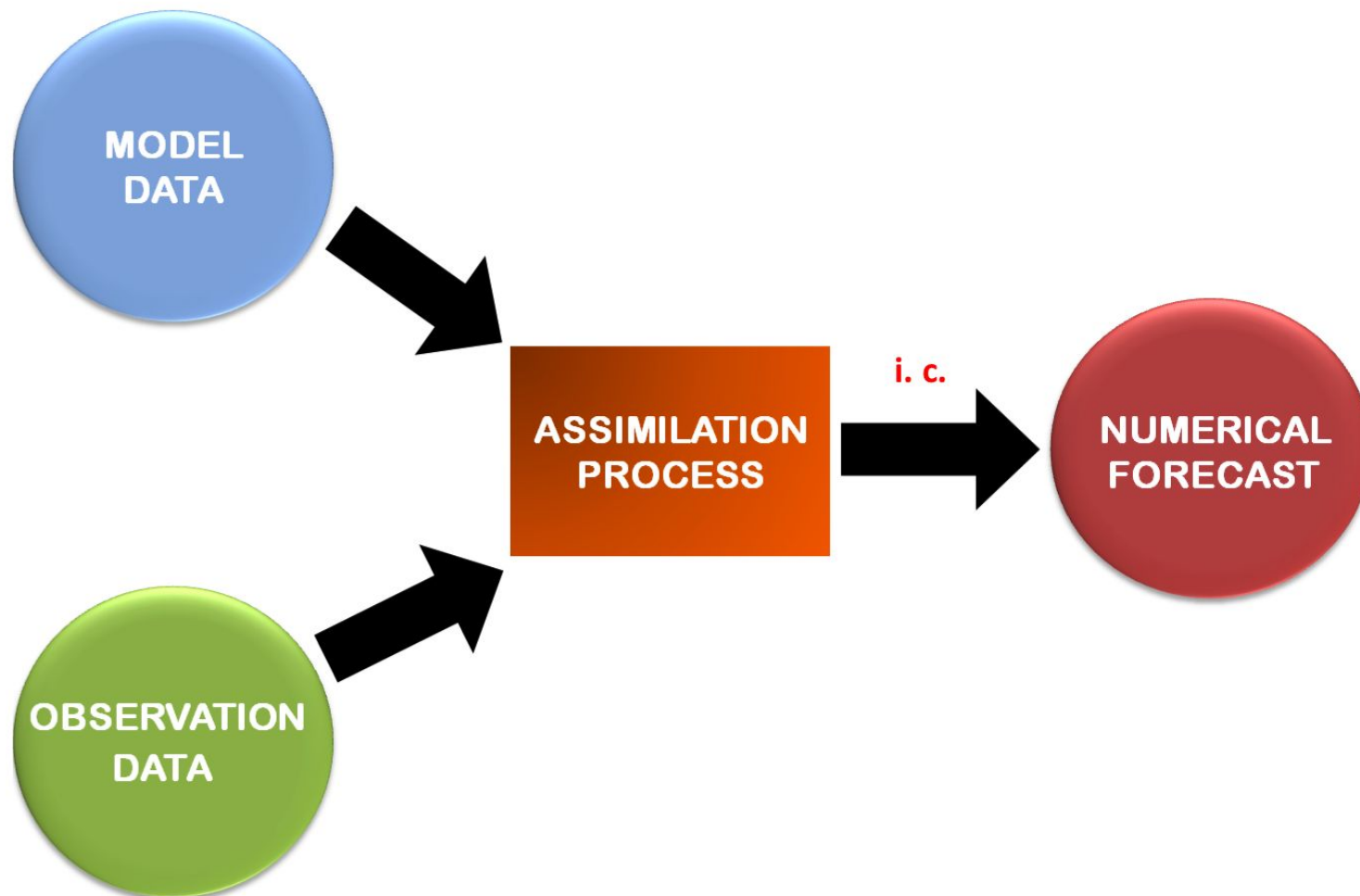
Gerônimo Lemos – INPE

Marcelo Paiva Ramos – INPE

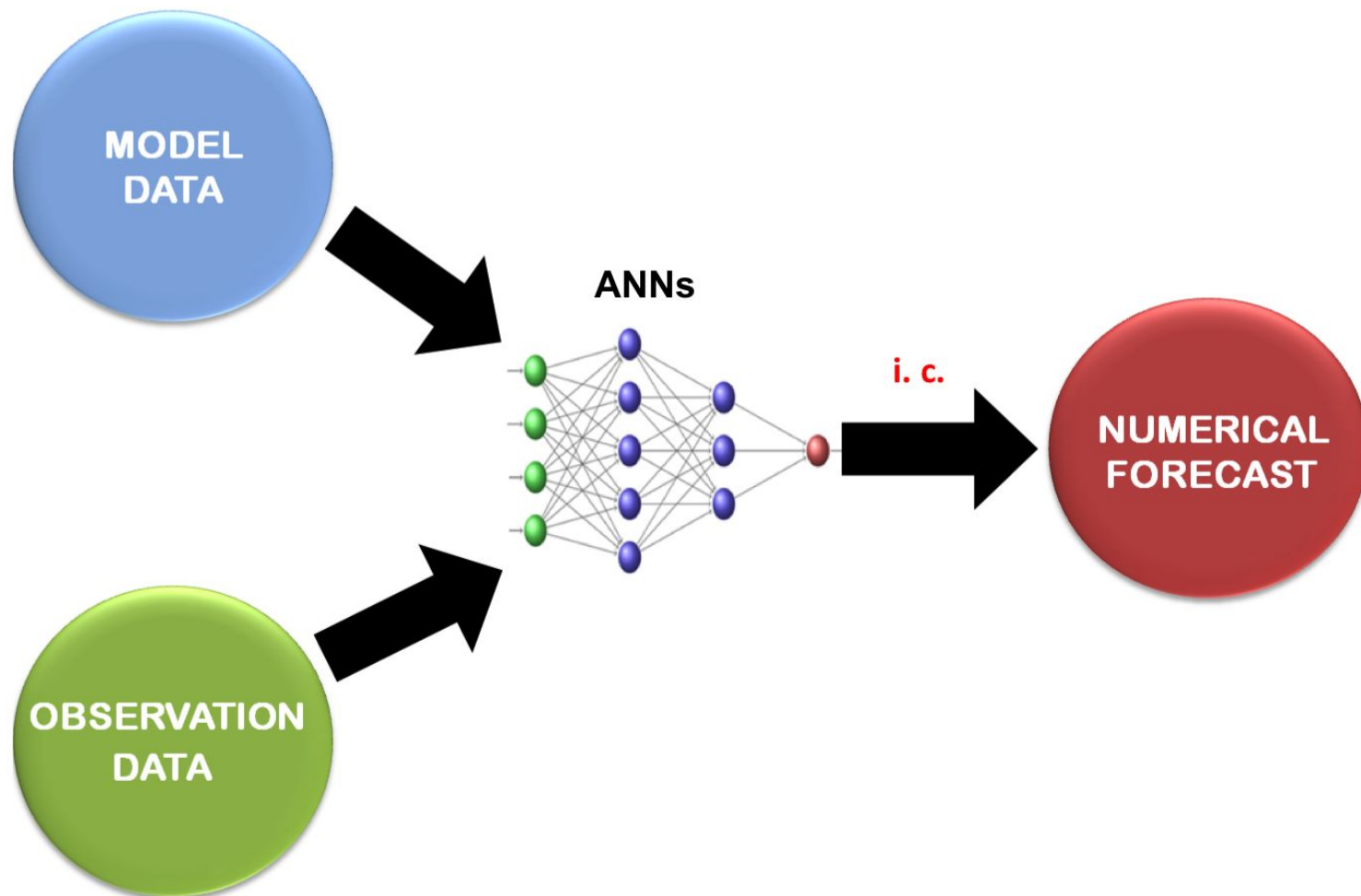
# Assimilação de Dados por RNA

- Assimilação de Dados
  - RNA
  - MPCA (Hiperparâmetros e treinamento)
- Modelo
  - Shallow Water 2D
- Processamento paralelo
  - Unidade de Processamento de Tensor (TPU)
- Artigo
  - RAMOS, Marcelo Paiva; CAMPOS VELHO, Haroldo Fraga de.; DIAS, Luiz Alberto Vieira. Data Assimilation for Ocean Dynamics by Neural Networks on TPUs. **Em preparação, 2025.**

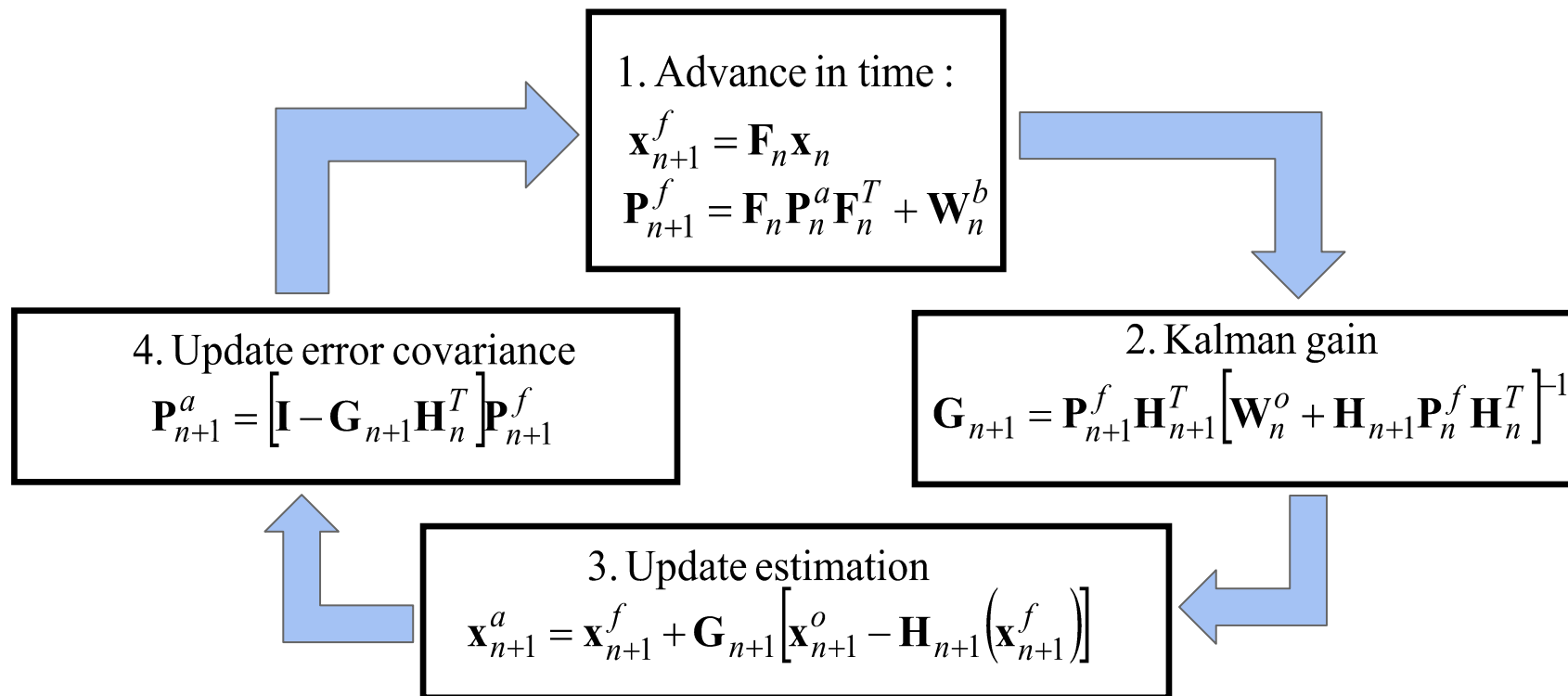
# Assimilação de Dados



# Assimilação de Dados por RNA

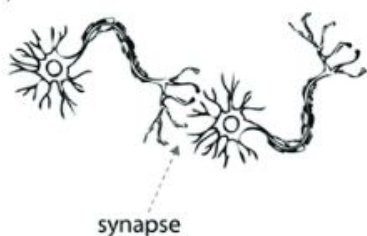
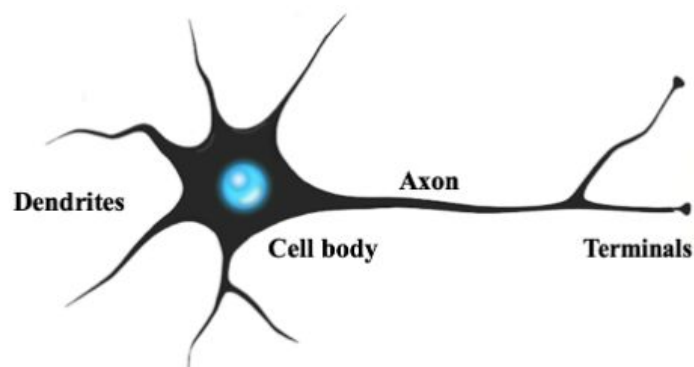


# Assimilação de Dados - Filtro de Kalman (FK)

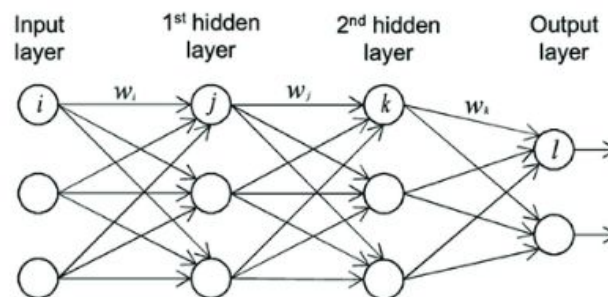
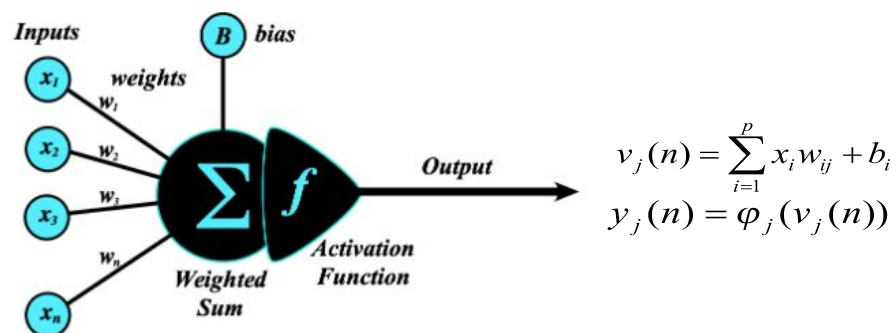


# Assimilação de Dados - RNA

- Biological neuron

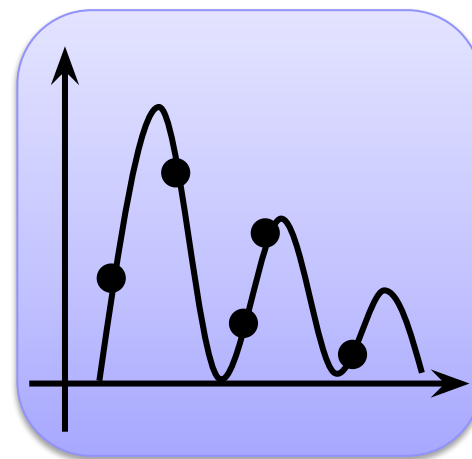
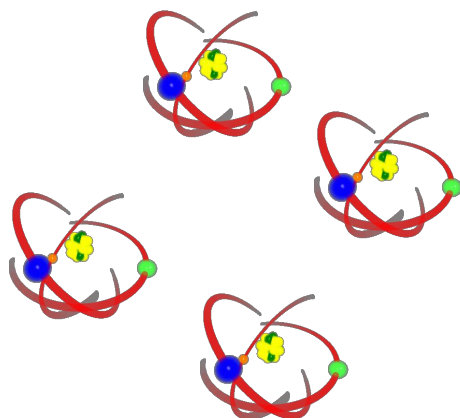


- Artificial neuron

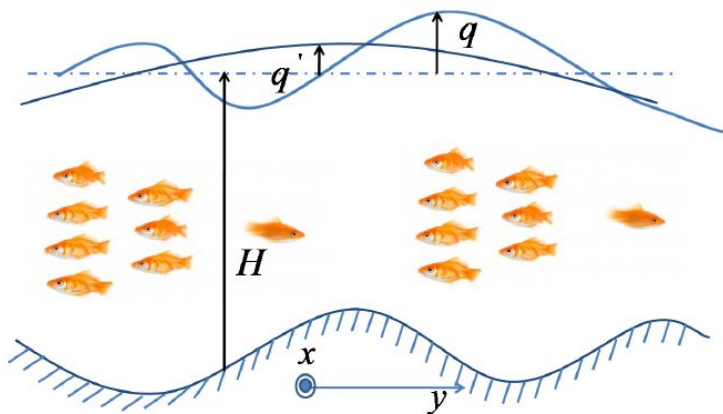


# Multi-Particle Collision Algorithm (MPCA)

- Versão do PCA
- Nêutron viajando dentro de um reator nuclear
- Cada partícula é uma solução candidata (absorção e espalhamento)
- Multipartícula: várias partículas em cooperação



# Modelo - Shallow Water 2D



Where:

$g$  - Gravitational force

$H$  - Fluid depth

$q$  - Surface disturbance

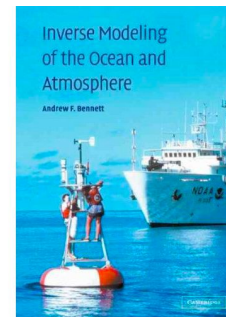
$u$  - Speed in  $x$  direction

$v$  - Velocity in  $y$  direction

$$\frac{\partial u}{\partial t} - fv + g \frac{\partial q}{\partial x} + r_u u = F_u$$

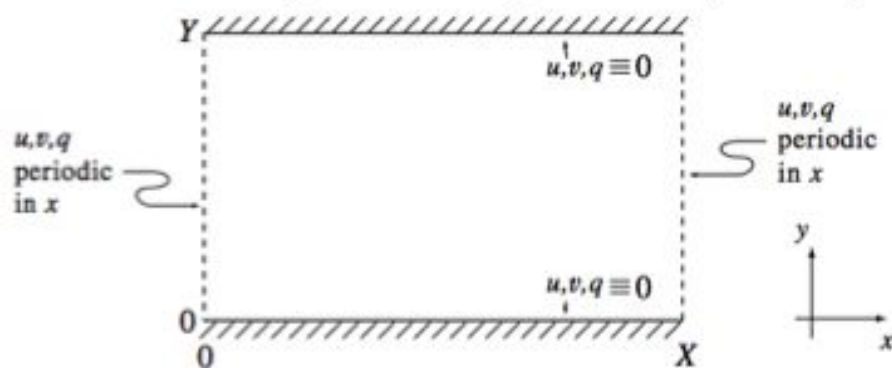
$$\frac{\partial v}{\partial t} + fu + g \frac{\partial q}{\partial y} + r_v v = F_v$$

$$\frac{\partial q}{\partial t} + H \left( \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) + r_q q = 0$$

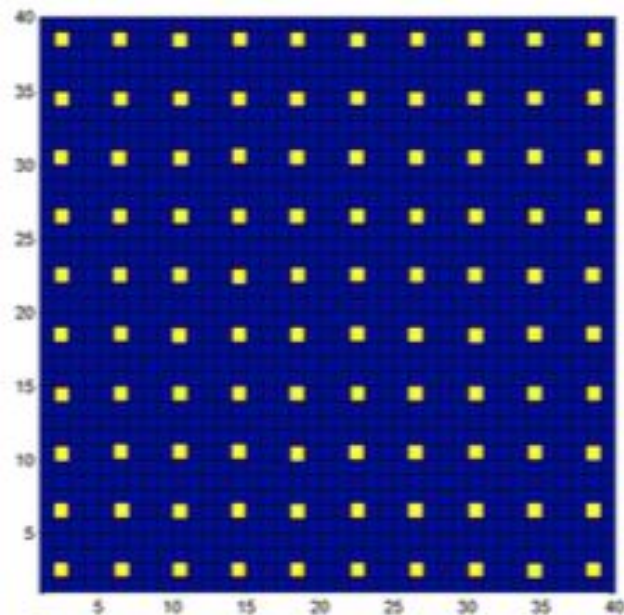
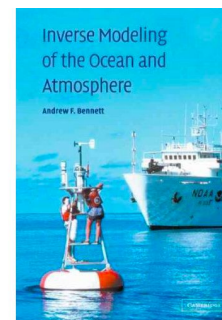




# Modelo - Shallow Water 2D



(BENNETT, 2002)

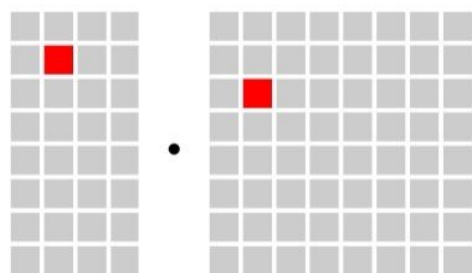


Parameter	Value	Parameter	Value
$H$	5000 m	$r_u$	$1.8 \times 10^4 \text{ s}^{-1}$
$T$	$1.8 \times 10^4 \text{ s}$	$r_v$	$1.8 \times 10^4 \text{ s}^{-1}$
$g$	$9.806 \text{ m s}^{-2}$	$r_q$	$1.8 \times 10^4 \text{ s}^{-1}$
$f$	$1.0 \times 10^{-4} \text{ s}^{-1}$	$\rho_a$	$1.275 \text{ kg m}^{-3}$
$C_d$	$1.6 \times 10^{-3}$	$\rho_w$	$1.0 \times 10^3 \text{ kg m}^{-3}$

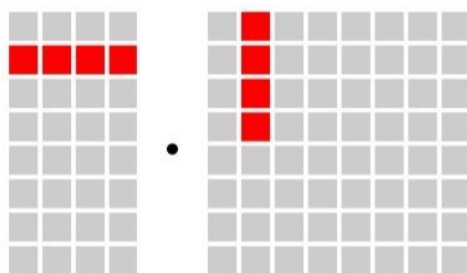
Grade: 40 x 40

# Computação: escalar, vetorial e tensorial

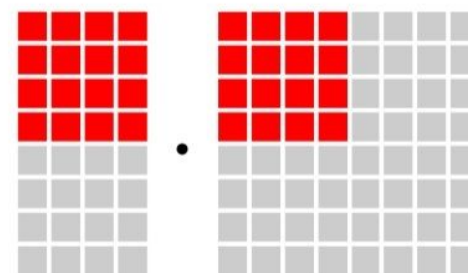
## Compute Primitive



*scalar*



*vector*

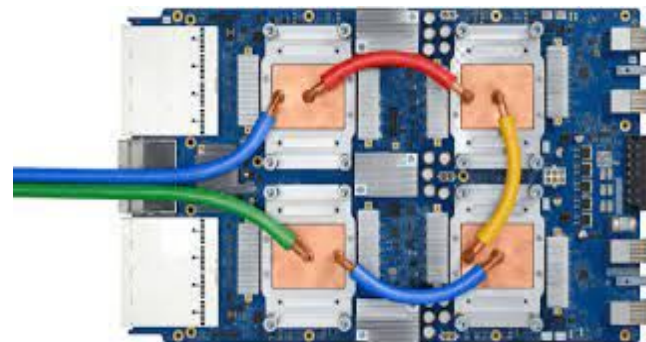


*tensor*

# TPUs



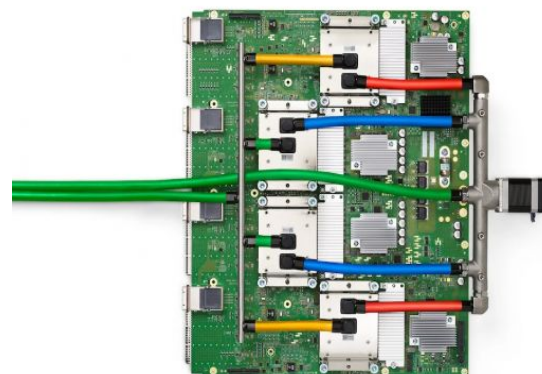
TPU v1 (old)



TPU v3



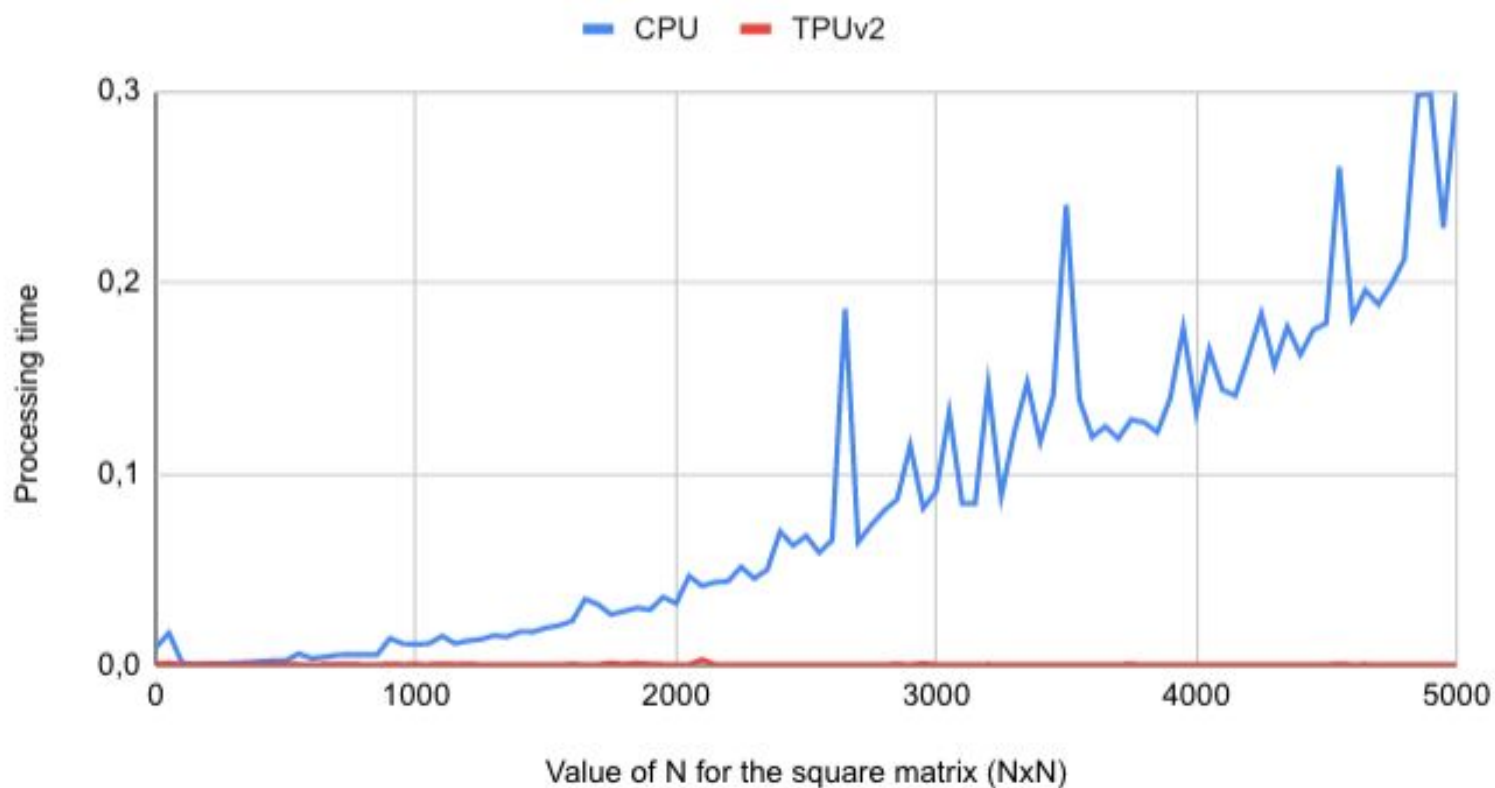
TPU v2 (Colab)



TPU v4

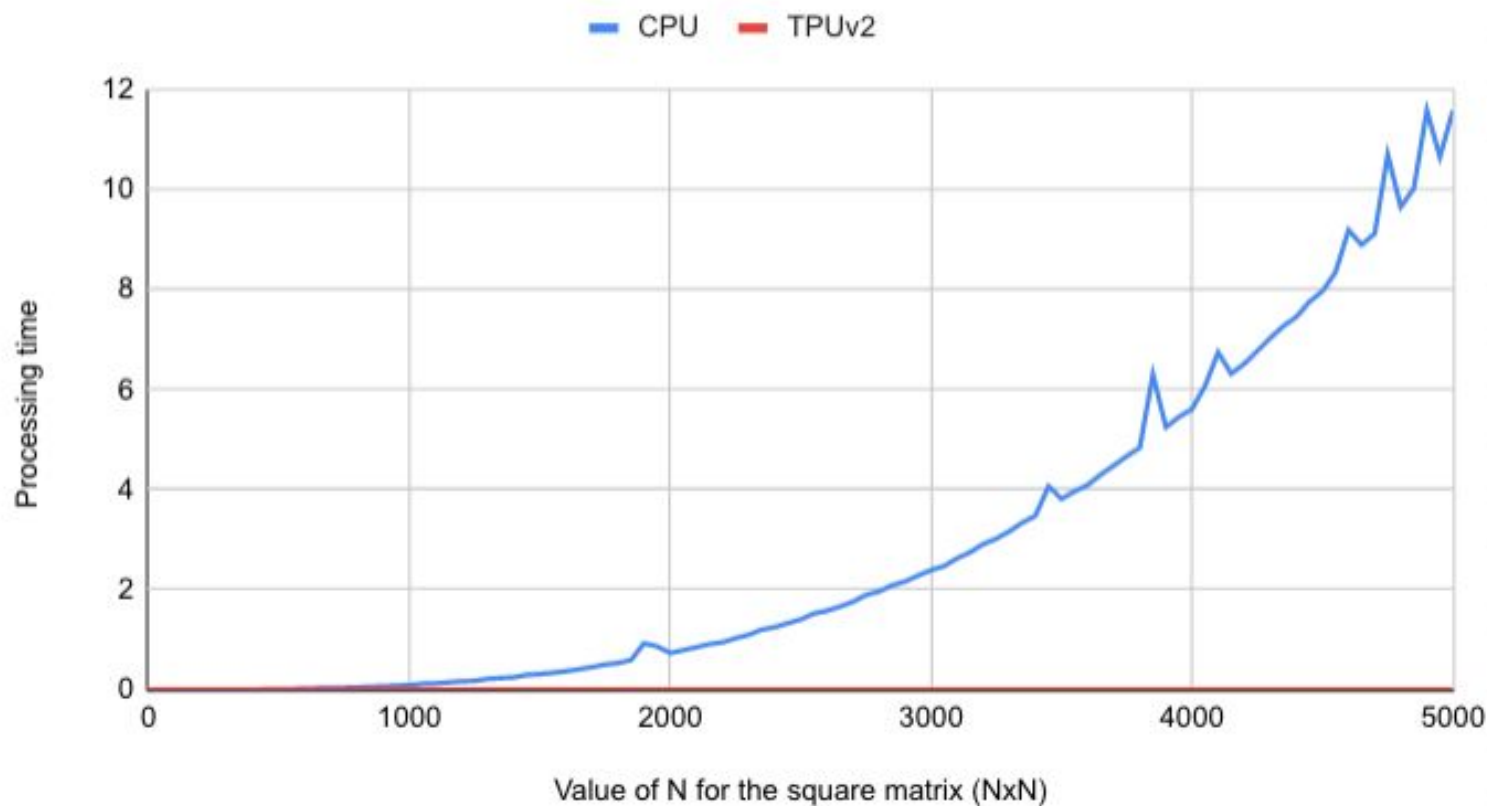
# Teste - MULTIPLY(A, v)

MULTIPLY(A, v)



# Teste - MATMUL(A, B)

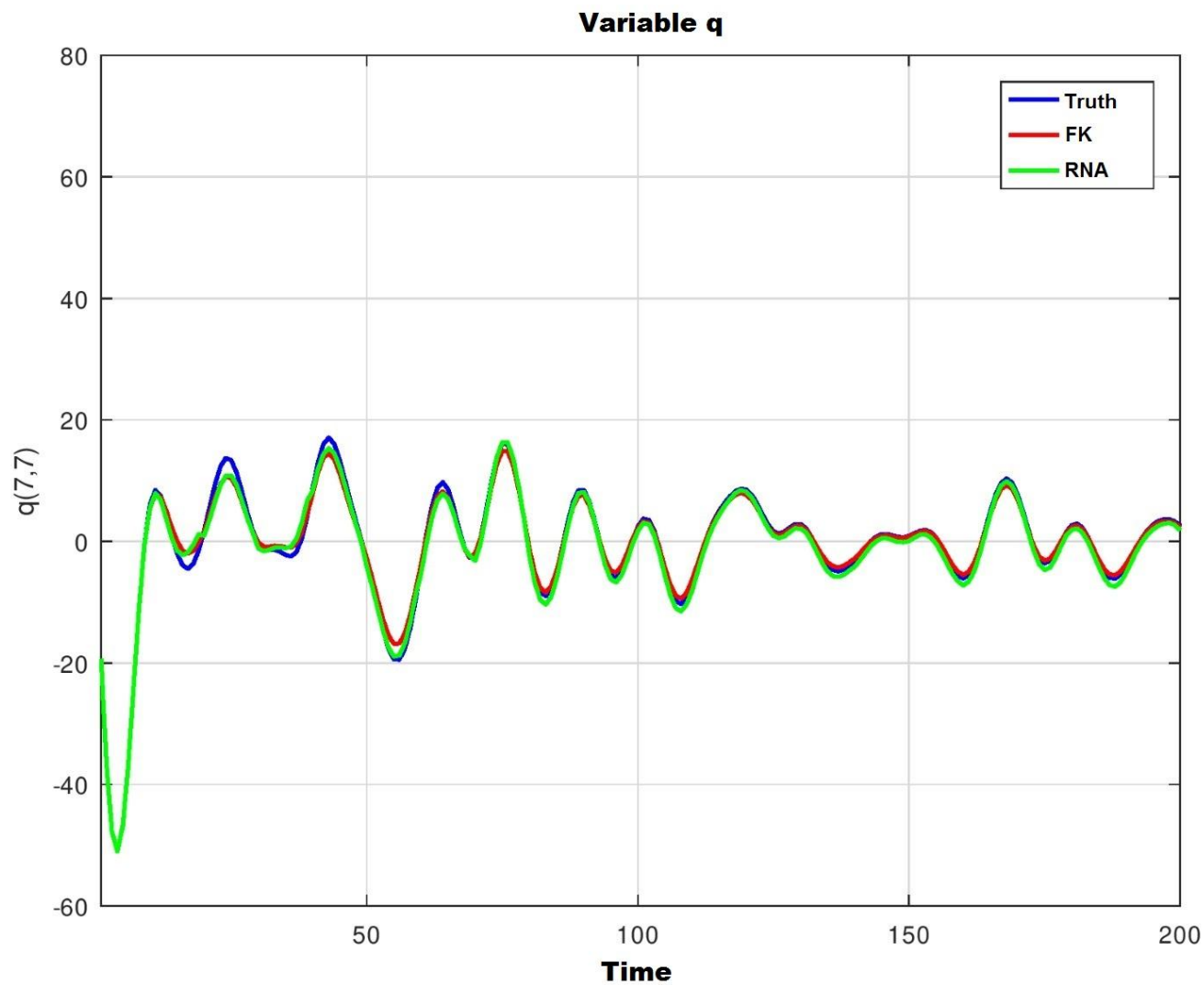
MATMUL(A, B)



# Resultados - Experimento SW2D

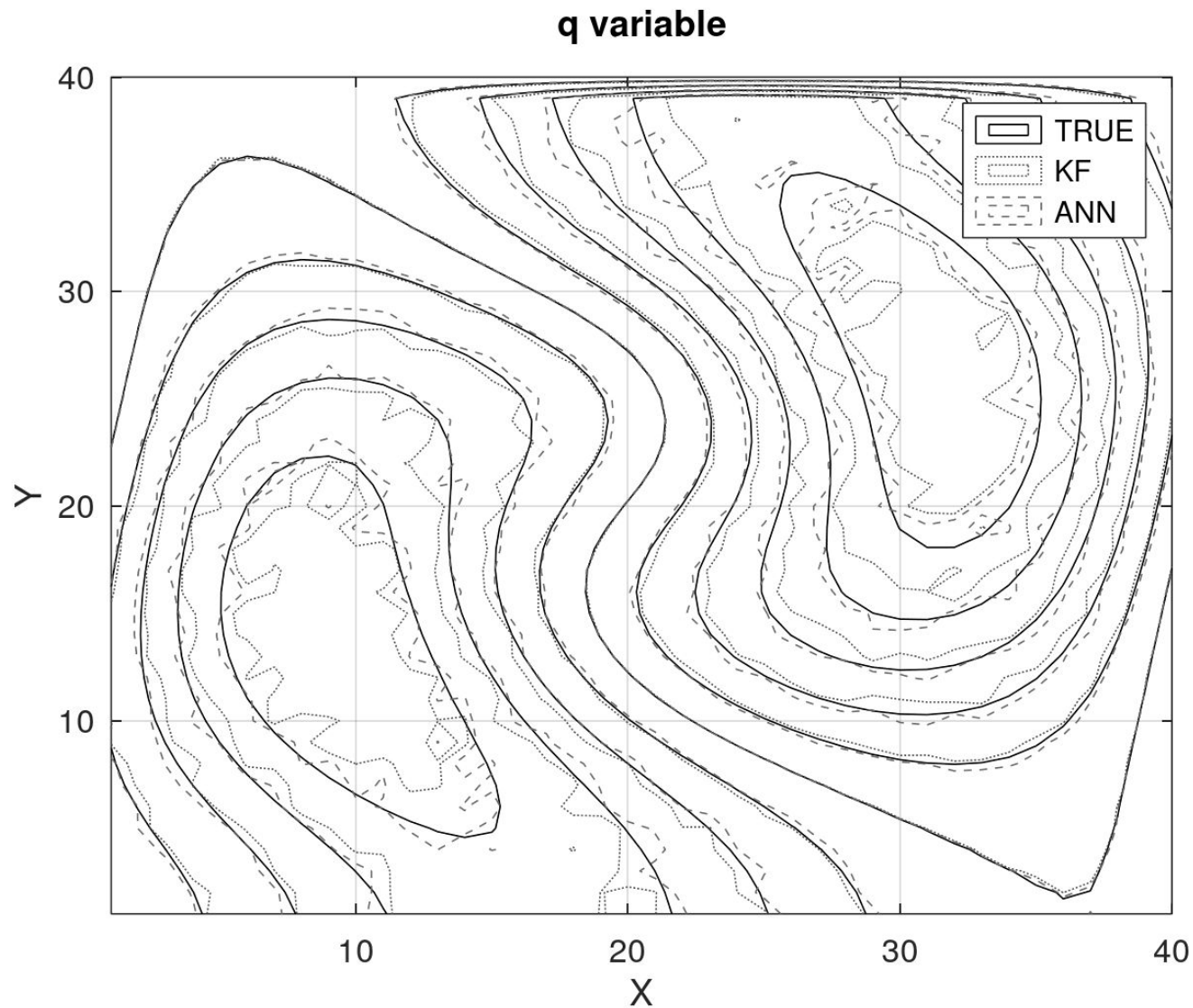
- Modelo
  - SW2D
- Assimilação de Dados
  - KF
  - RNA
- MPCA
  - Hiperparâmetros
  - Treinamento
- Computação
  - CPU
  - TPU

# Verificação da qualidade





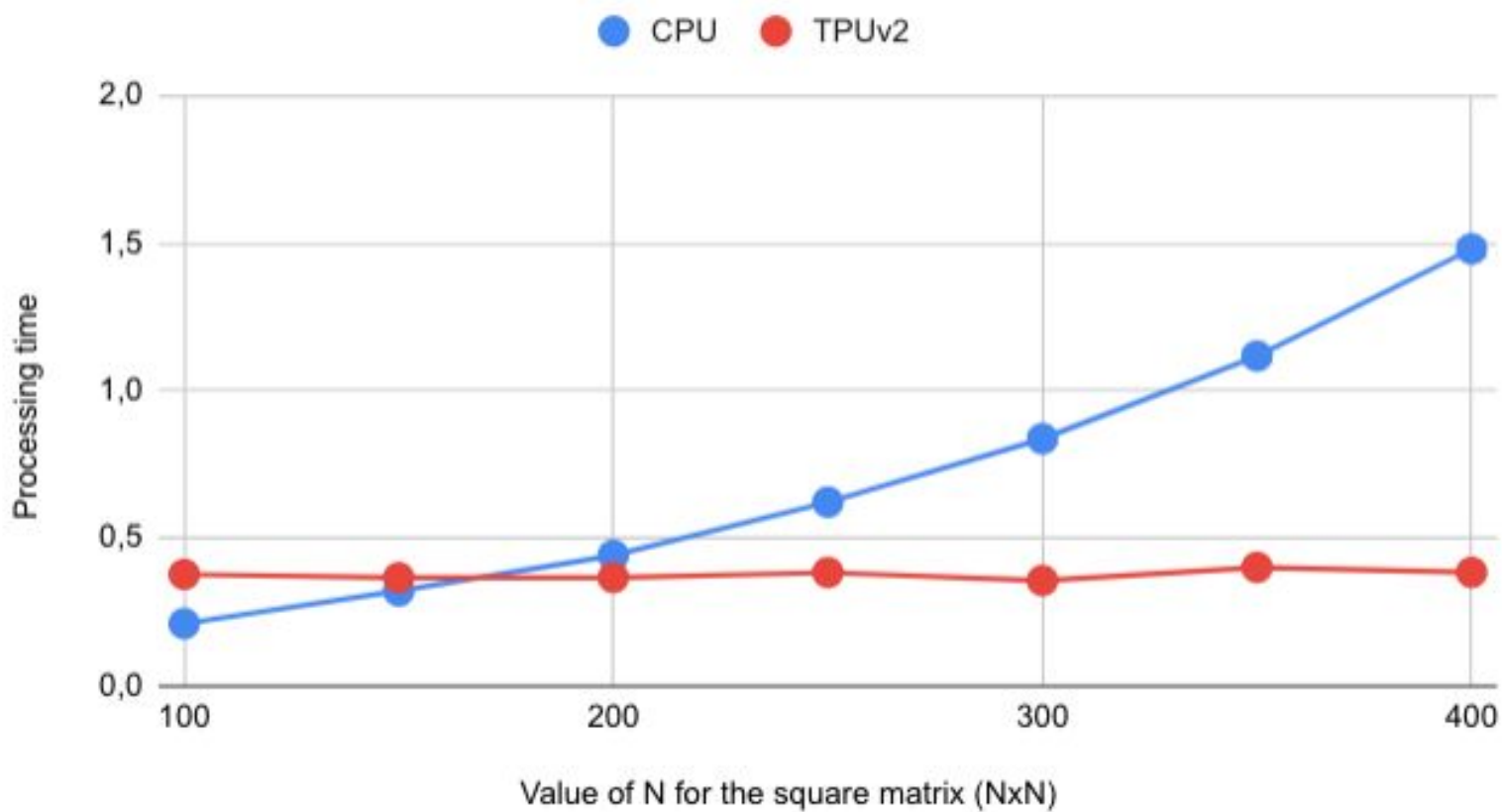
# Verificação da qualidade





# Desempenho

## Data Assimilation with ANN



## Assimilação de Dados por RNA (TPU)

Muito obrigado pela atenção!!

Questões?

Comentários?