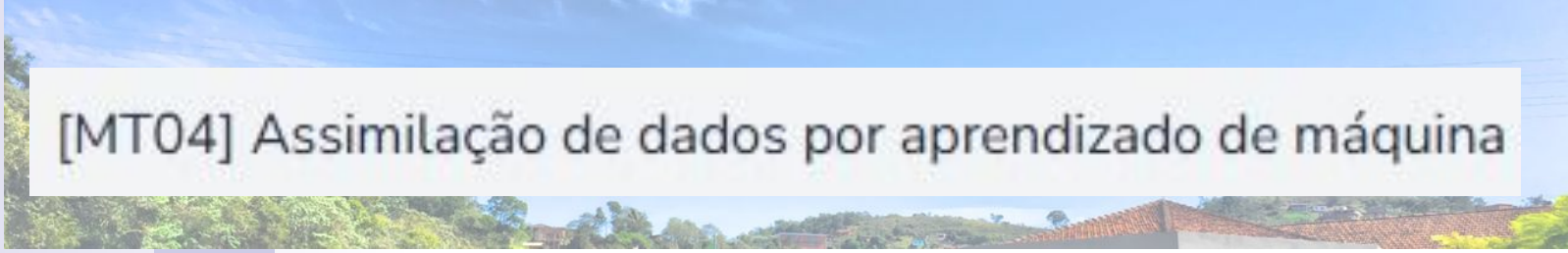


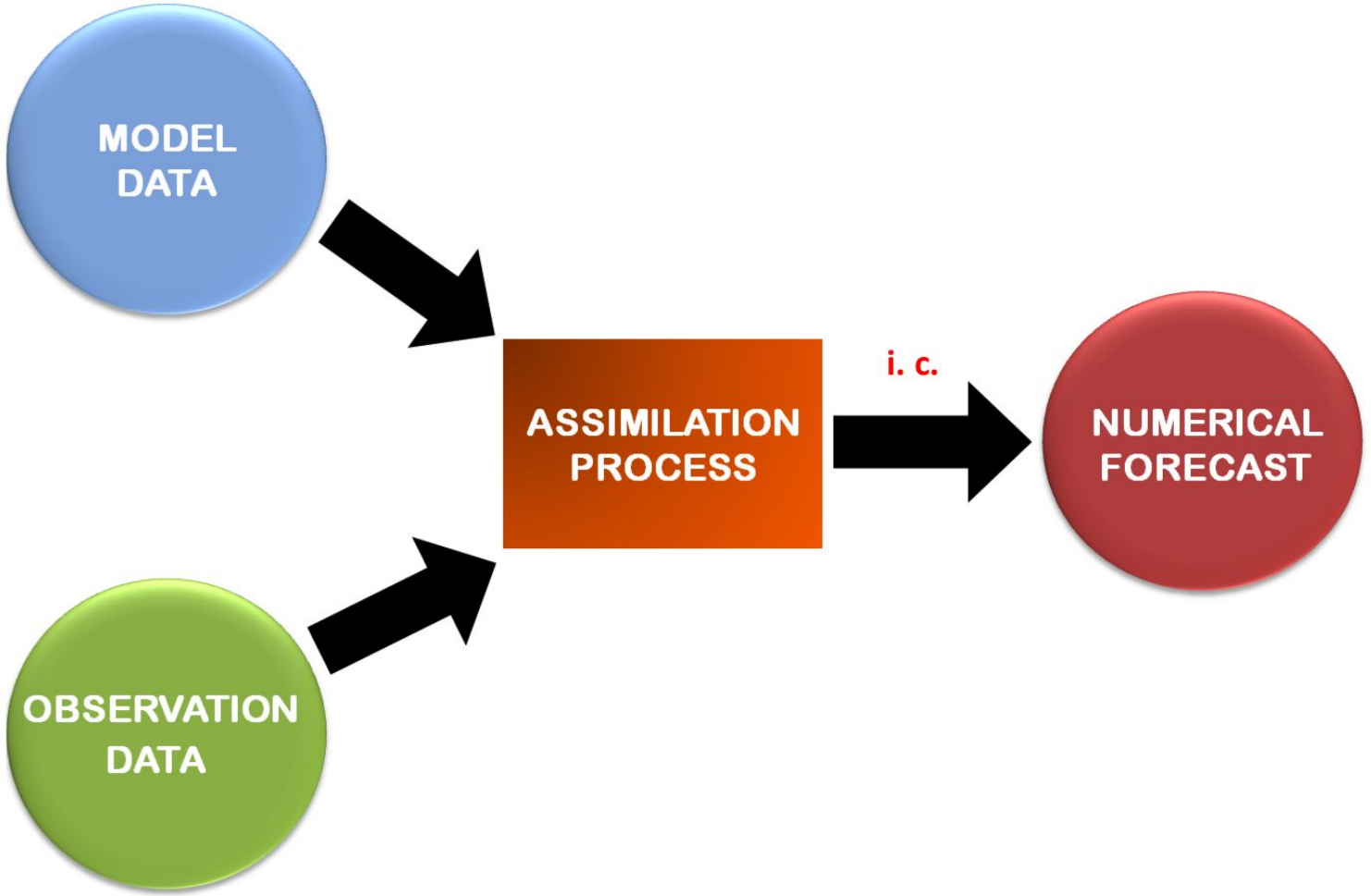
Assimilação de Dados por Redes Neurais Artificiais

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

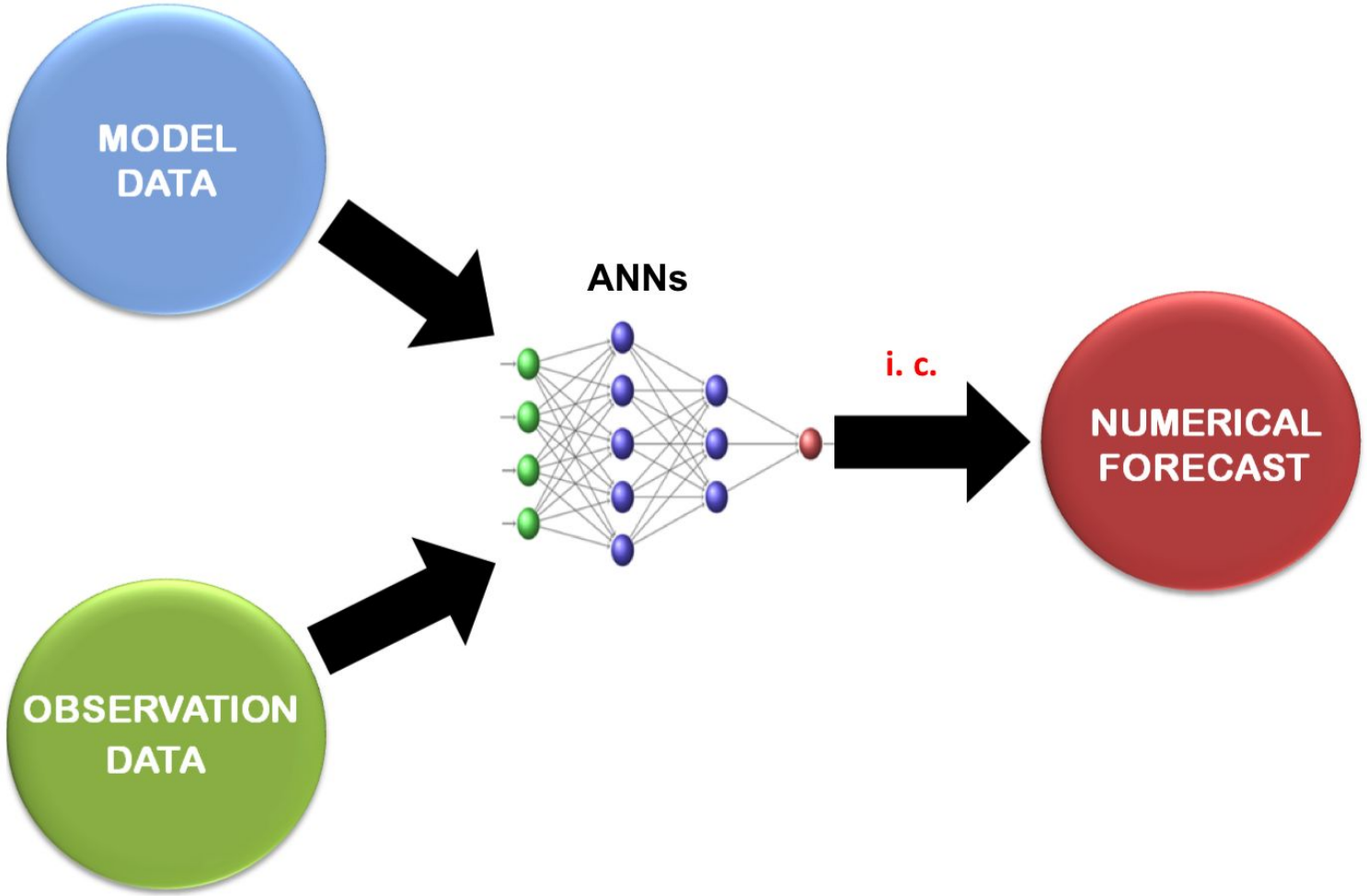
Assimilação de Dados por RNA

- 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.

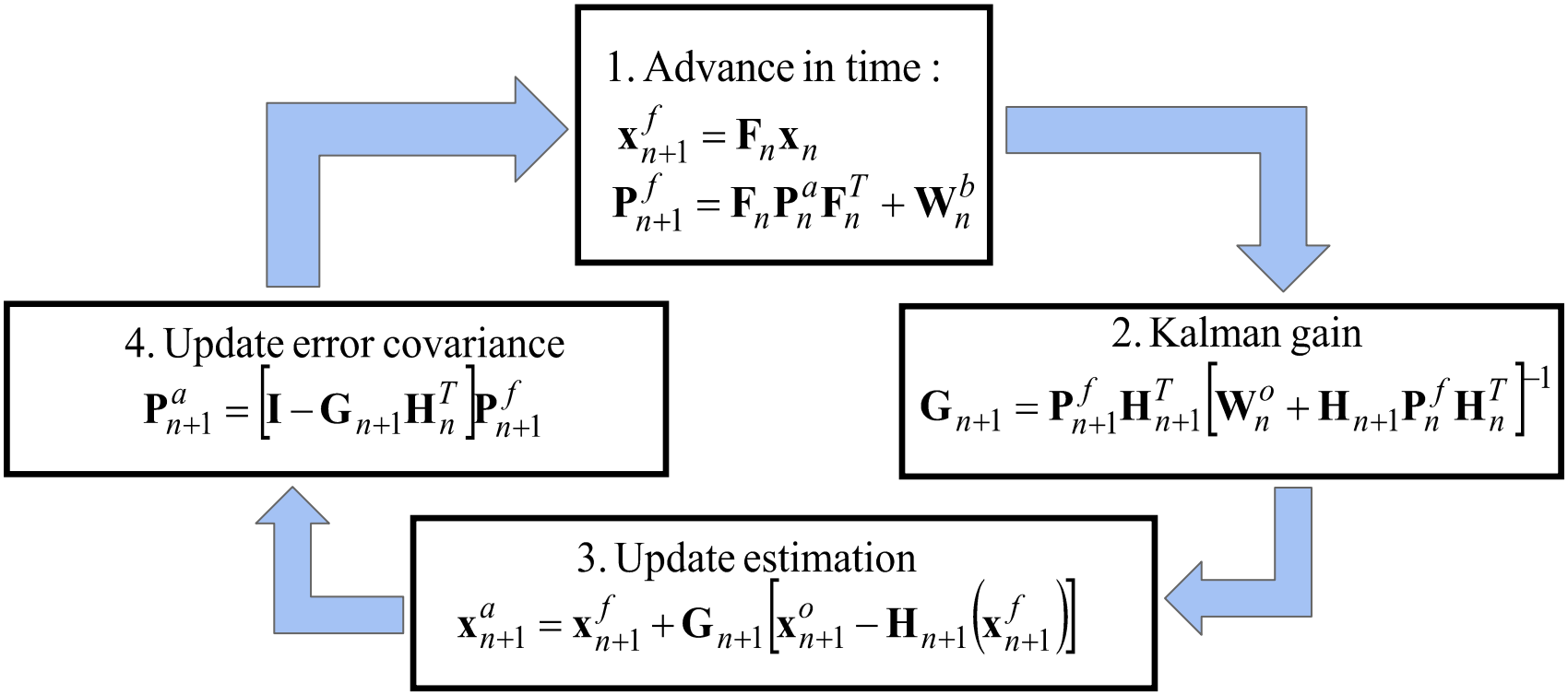
Assimilação de Dados



Assimilação de Dados por RNA

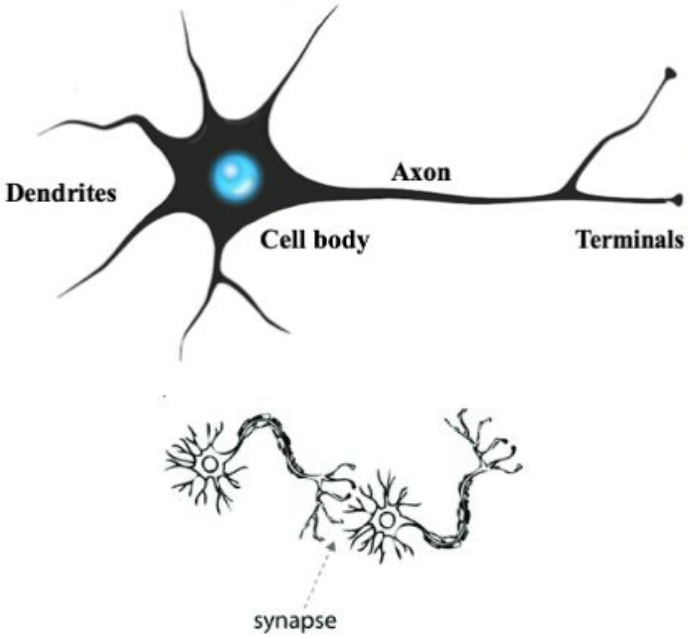


Assimilação de Dados - Filtro de Kalman (FK)

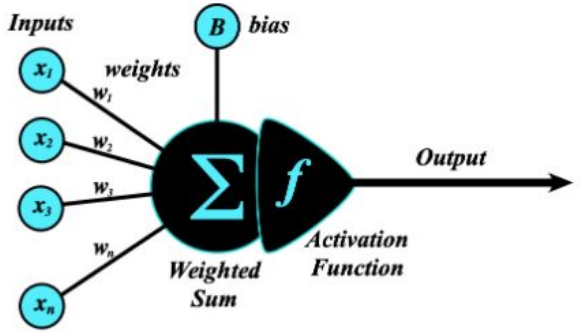


Assimilação de Dados - RNA

- Biological neuron

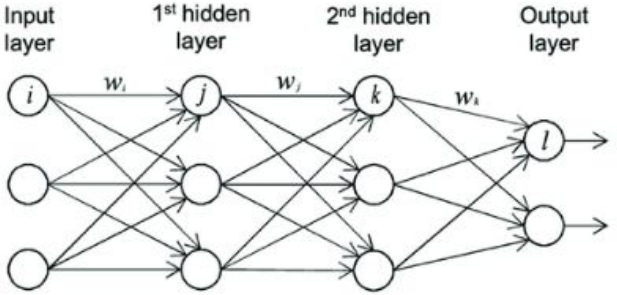


- Artificial neuron



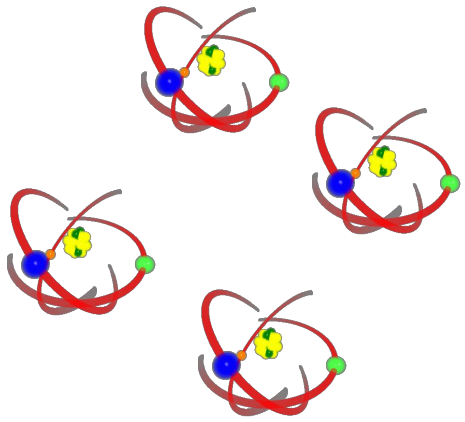
$$v_j(n) = \sum_{i=1}^{p} x_i w_{ij} + b_i$$

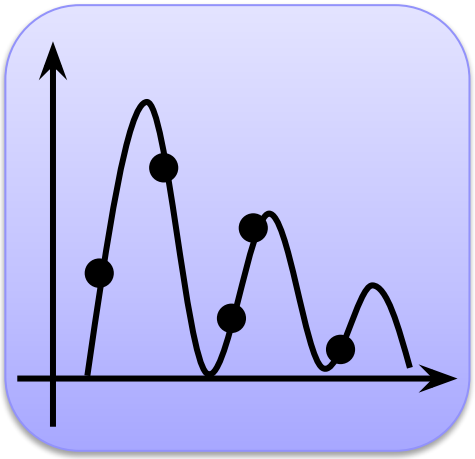
$$y_j(n) = \varphi_j(v_j(n))$$



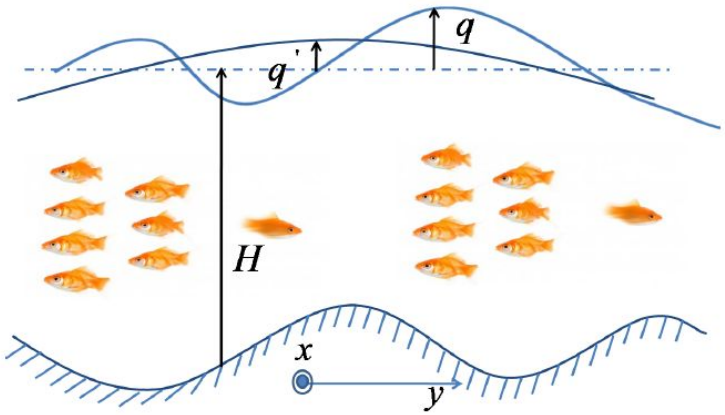
Multi-Particle Collision Algorithm (MPCA)

- 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



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

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

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

Where:

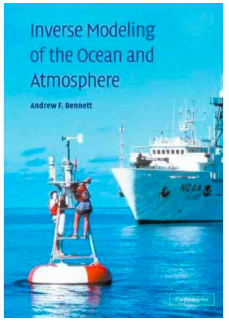
g - Gravitational force

H - Fluid depth

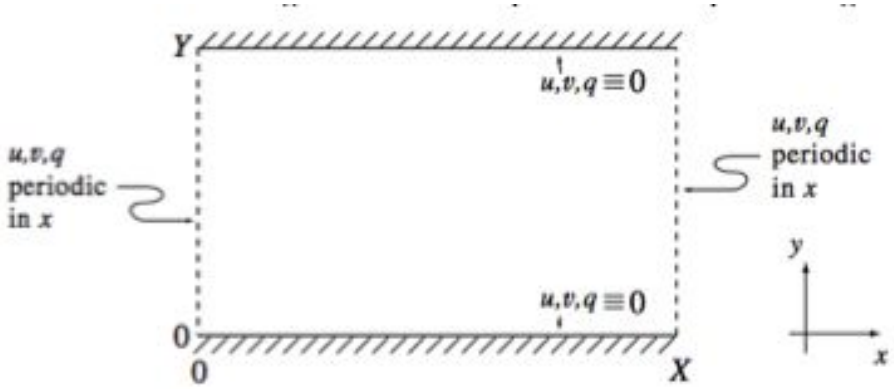
q - Surface disturbance

u - Speed in x direction

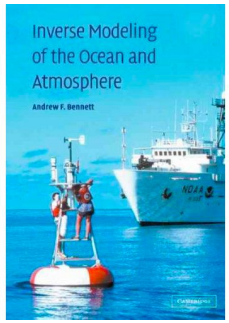
v - Velocity in y direction

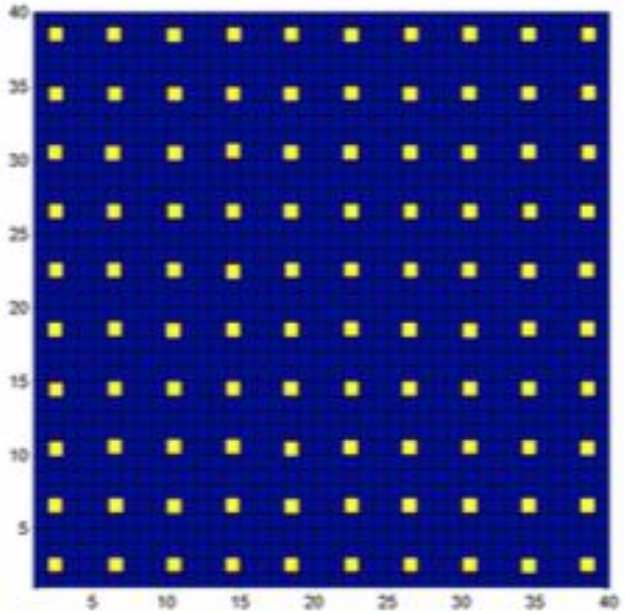


Modelo - Shallow Water 2D



(BENNETT, 2002)

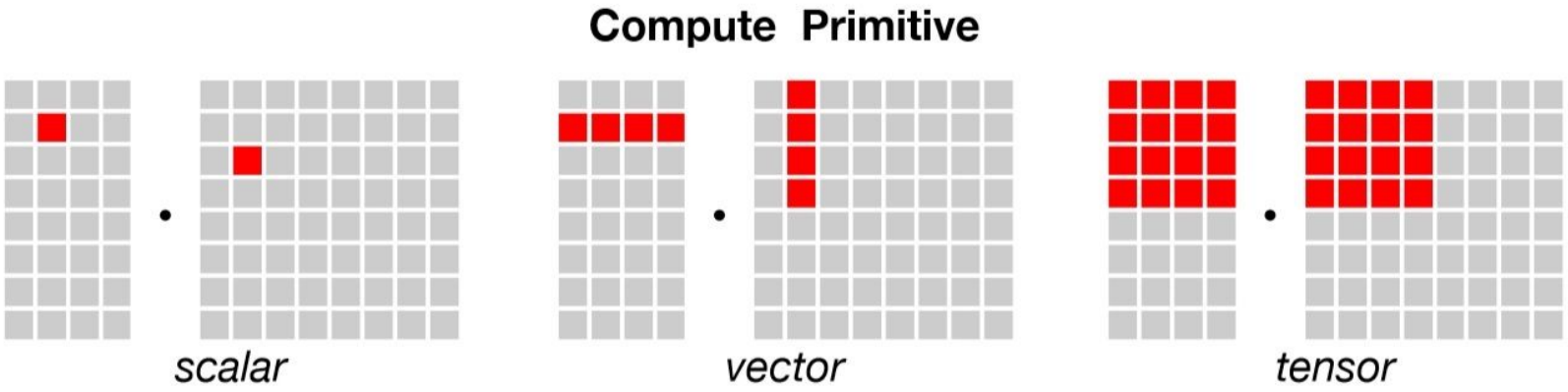




Parameter	Value	Parameter	Value
H	5000 m	r_u	1.8×10^4 s^{-1}
T	1.8×10^4 s	r_v	1.8×10^4 s^{-1}
g	9.806 m s^{-2}	r_q	1.8×10^4 s^{-1}
f	1.0×10^{-4} s^{-1}	ρ_a	1.275 kg m^{-3}
C_d	1.6 × 10−3	ρ_w	1.0×10^3 kg m^{-3}

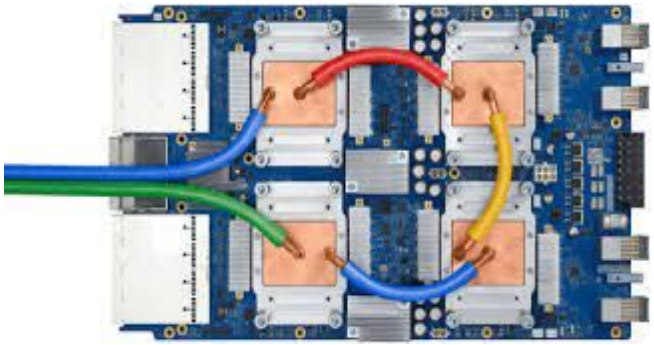
Grade: 40 x 40

Computação: escalar, vetorial e tensorial



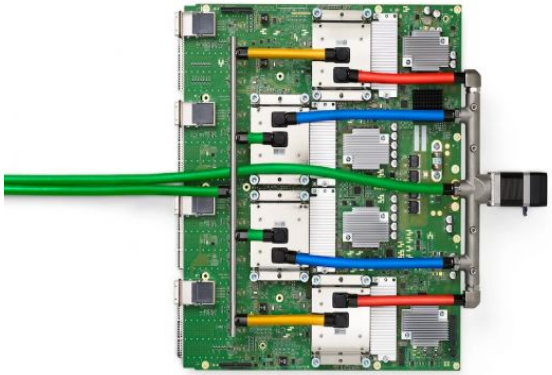
TPUs

TPU v1 (old)



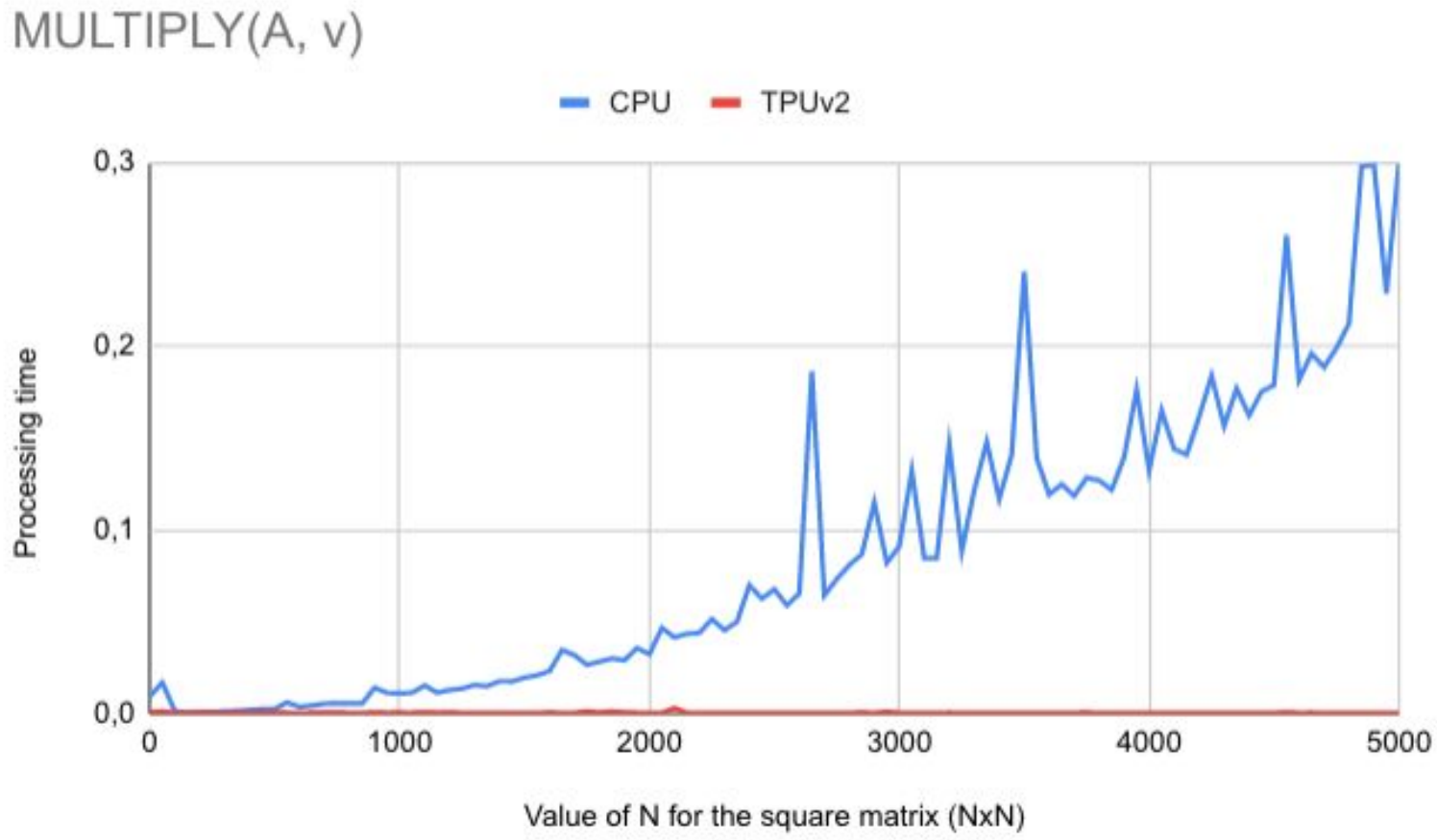
TPU v3

TPU v2 (Colab)

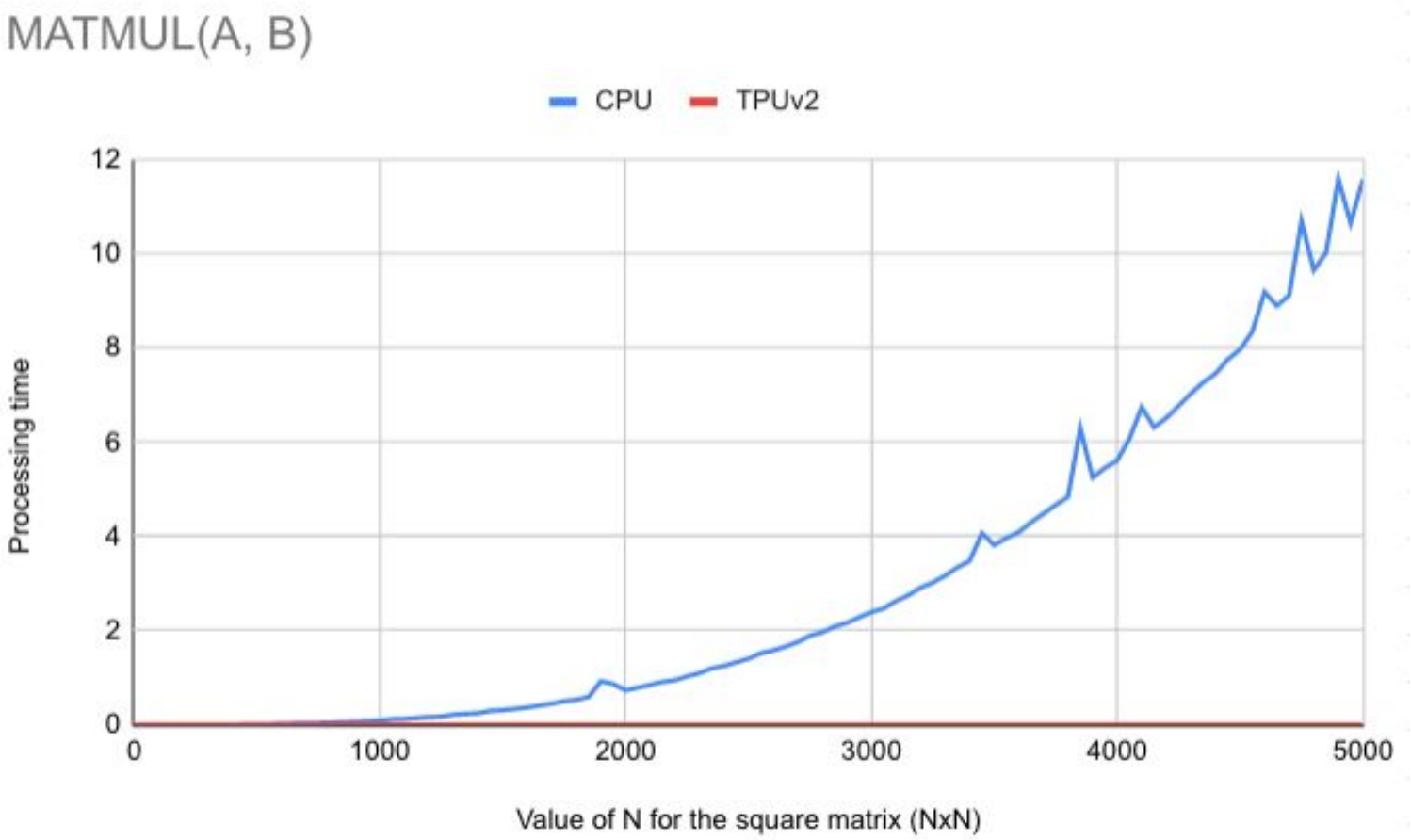


TPU v4

Teste - MULTIPLY(A, v)



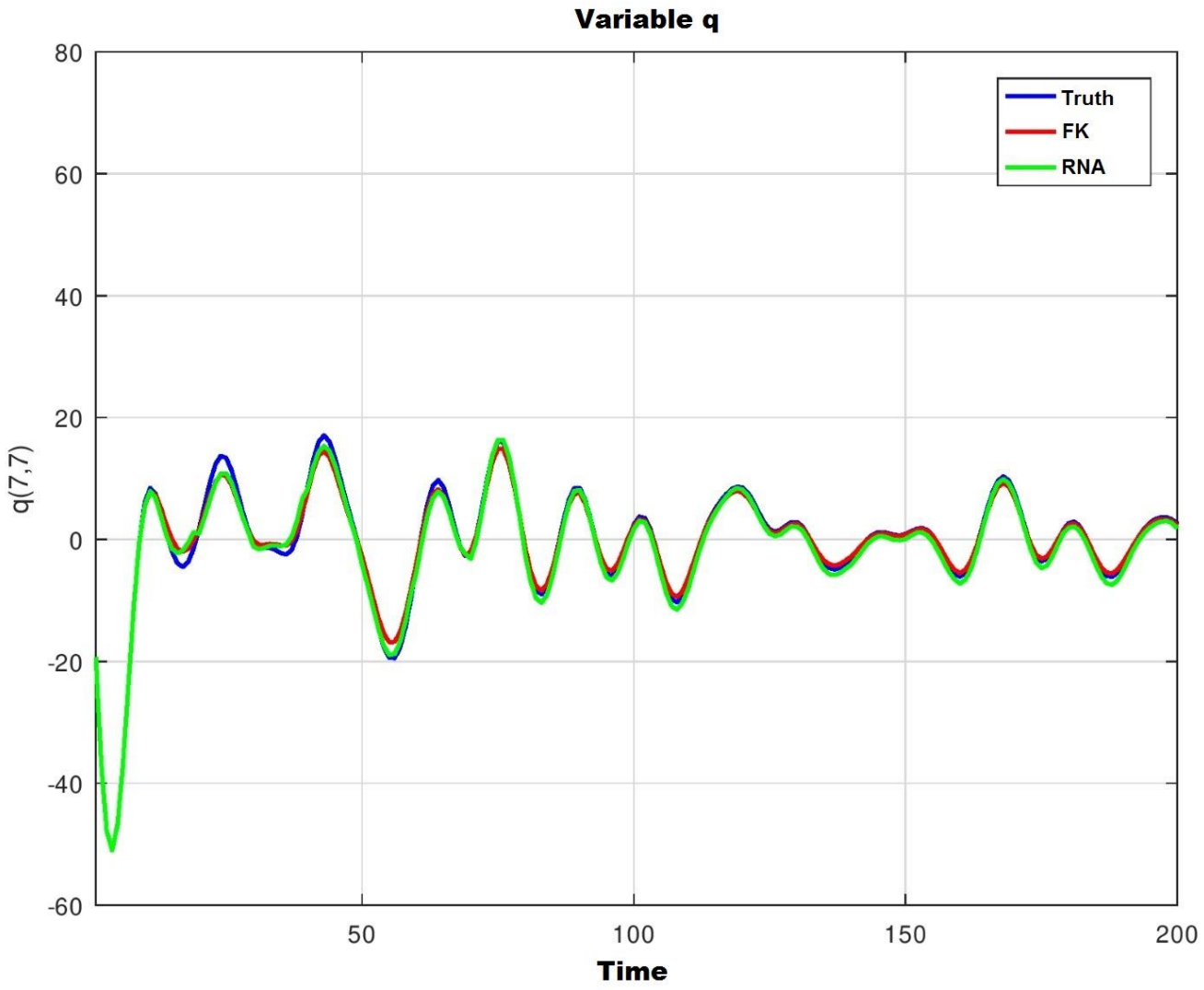
Teste - MATMUL(A, B)



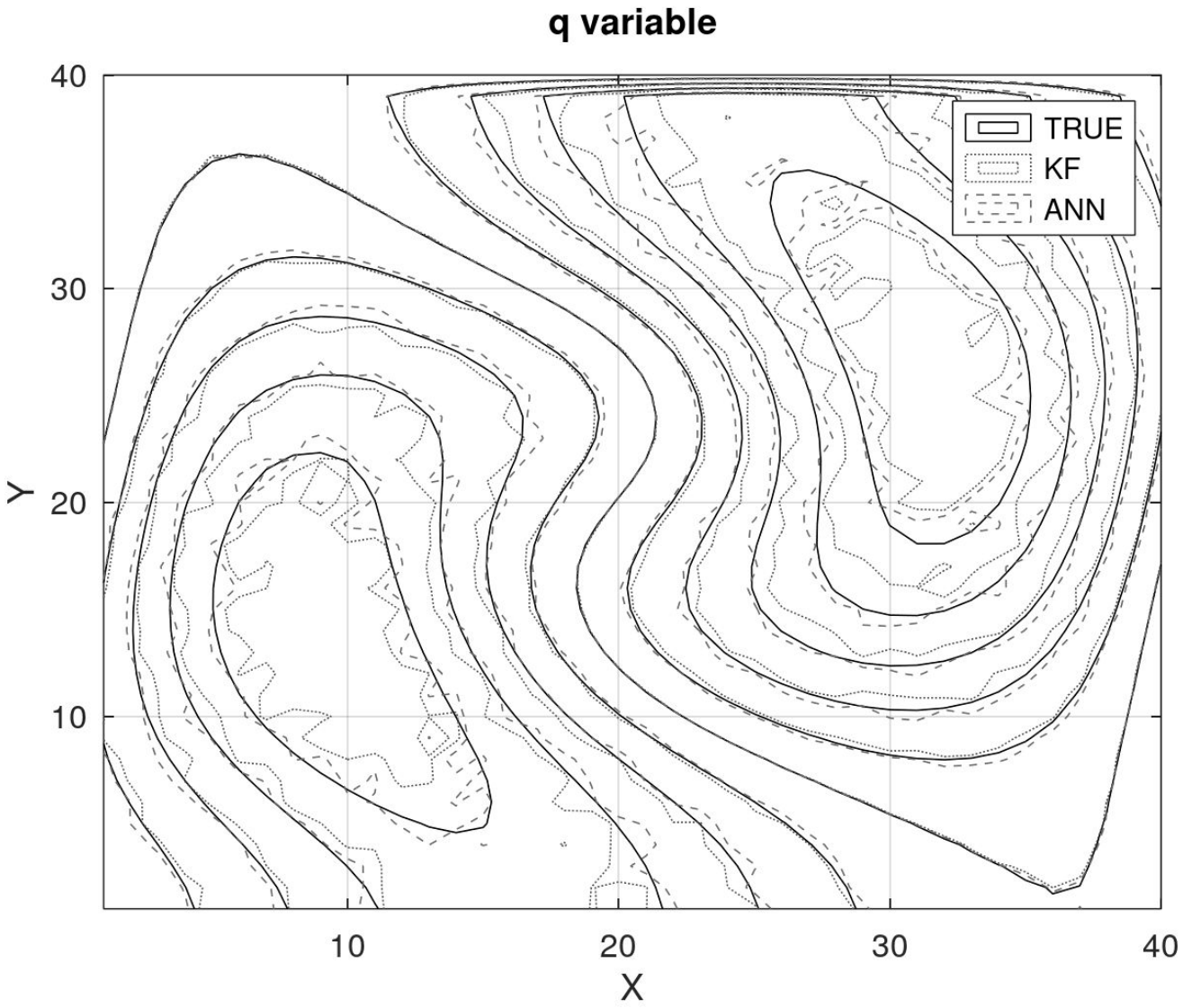
Resultados - Experimento SW2D

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

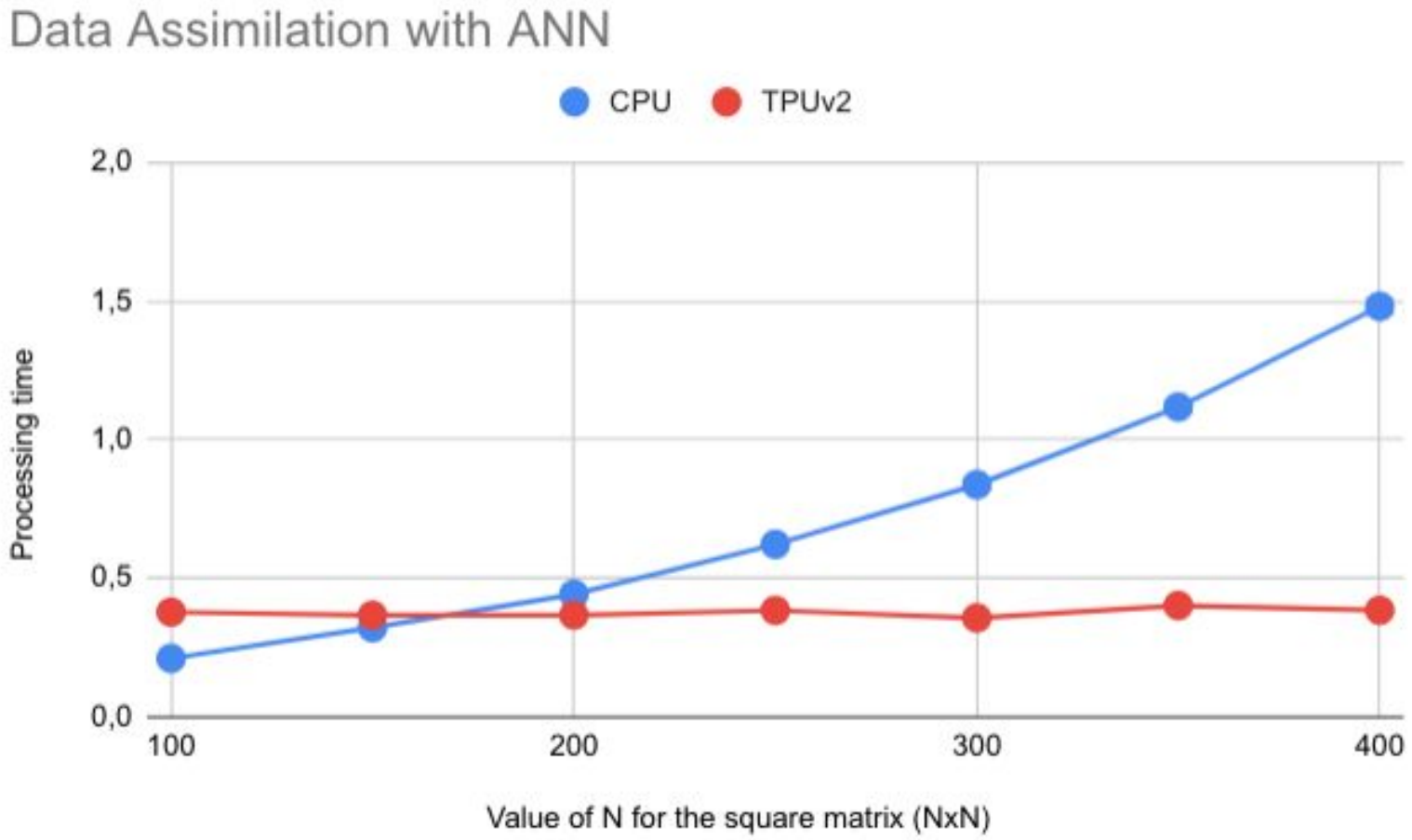
Verificação da qualidade



Verificação da qualidade



Desempenho


Data Assimilation with ANN
CPU
TPUv2
2,0
1,5
1,0
0,5
0,0
Processing time
100
200
300
400
Value of N for the square matrix (NxN)

Assimilação de Dados por RNA (TPU)

Muito obrigado pela atenção!!

Questões?

Comentários?