

# Modeling of the Flow Through the Forest

**Claudia Mazza Dias**

Laboratório Nacional de Computação Científica - LNCC/MCT  
Av. Getúlio Vargas, 333, CEP 25651-075  
Petrópolis, RJ, Brasil.  
mazza@lncc.br

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# GEOMA Network



*amazônia*  
Projeto GEOMA  
Rede Temática de Pesquisa em Modelagem Ambiental da Amazônia

- Carlos Carbonel, LNCC (collaborator)
- Claudio C. C. F. Barbosa, INPE
- Conrado M. Rudorff, INPE
- Evlyn M. L. M. Novo, INPE
- Helder L. Queiroz, IDSM
- Maria Teresa F. Piedade, INPA
- Maurício V. Kritz, LNCC



## Some Characteristics of Várzea

The Várzea is one of the richest ecosystems of the Amazonian Basin in terms of biological productivity, biodiversity and natural resources.

- **Wet areas that are periodically flooded by the rivers and lakes, promoting interactions between the aquatic and land ecosystems;**
- **flooding forests and macrophytes in the lakes, supplying food and shelter for the aquatic and land life and natural pastures.**



<http://www.ibama.gov.br/provarzea>

## Region of studies

Instituto de Desenvolvimento Sustentável Mamirauá (IDSMM)



<http://www.mamiraua.org.br/>

- The IDSM takes as a mission the development of model for great areas of tropical forests where, through participative handling, it could be maintained the biodiversity, the ecological and evolutive processes;
- One of his objectives is to develop or to finance studies and researches on the sustainable use of the natural resources of the flooded forests;
- The Reserve of Sustainable Development Mamirauá went to first unity of conservation of this category introduced in Brazil.



<http://www.mamiraua.org.br/>

# Objectives:

- Difficulty in modeling the drainage of the waters in the Amazonian region;
- A problem of scale - The vastness of the rivers and lakes presents very big horizontal dimensions likened to the heights of the water level;
- Great diversity in function of the different types of rivers, lakes and connections between rivers and lakes;
- Relations depth / width and depth / area vary along the basin.



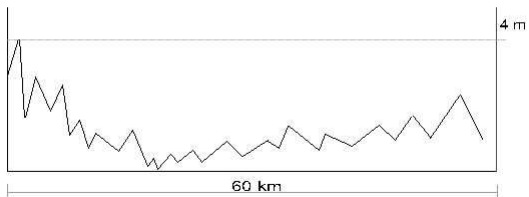
# Difficulty in the geometrical representation of the region of studies

- Representation of the variability of the topography;
- Representation of the presence of trunks as obstacles to the drainage.

In the approximation of the problem through computational methodologies, very often the size of the discreet elements is in agreement with the order of greatness of the unknowns of the problem (velocity, for example) but it prevents us from representing the geometry of trunks and other present obstacles in the region of studies.



Desenho: PC. Faria, LNCC/MCT, 1986 (aprox)



Flooded forest and Topography



# Our Goal

To represent the presence of trunks in the drainage through the inclusion of a constitutive term in the momentum balance equation. The presence of the obstacles is known through researches of laboratory to have viscous turbulent effect delaying the drainage.

$$\frac{\partial}{\partial t} \mathbf{u} + (\mathbf{u} \cdot \nabla) \mathbf{u} + \nabla p = \frac{1}{Re} \nabla (\mathbf{T} \cdot \nabla \mathbf{u}) + \mathbf{f}$$

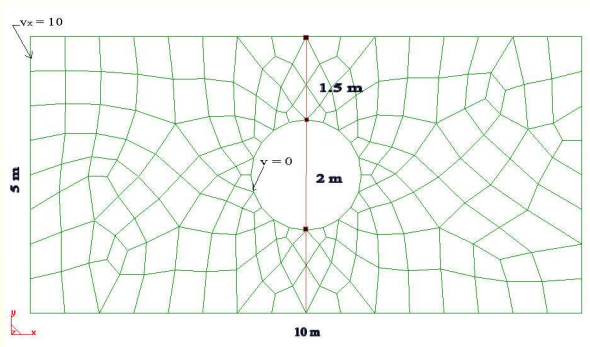
$$\text{div } \mathbf{u} = 0$$

- The identification of the Tensor  $T$  is the new challenge since it might have infinite solutions.
- We can restrict the choice of tensor from someone characteristics of the problem. The irregularity of the vegetation (in the size and in the distribution of sorts) or phyto-structure, suggests it anisotropy of the flow and the non-uniformity of  $T$ .
- So, if  $F$  it shows a mathematical representation of the phyto-structure, then it tensor  $T$  depends of  $F$ :  $T = T(F)$ .
- The determination of this tensor is part of a project of research where the data will be confronted with the results of the numerical simulation and with theoretical results.



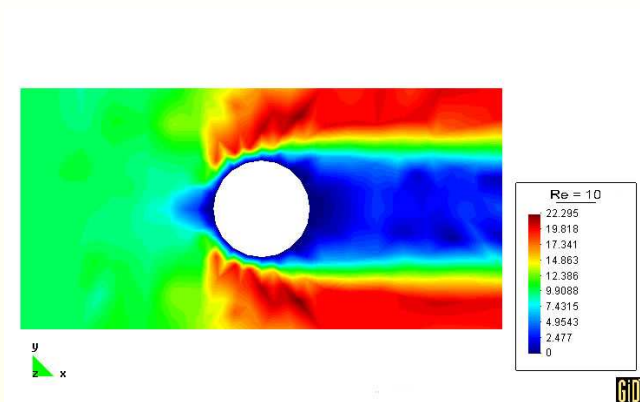
# Preliminary Experiments

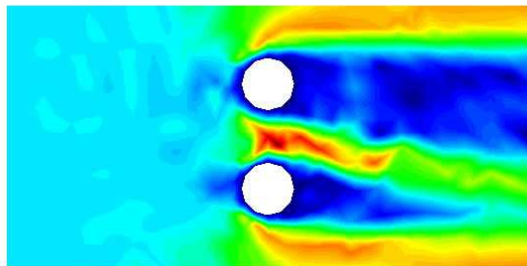
There were done some simple experiments to help in the observation of the field of velocities in a channel where the flow of water comes across one or more trunks.



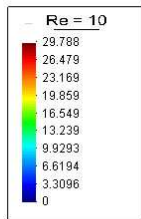
Domain and Finite Element Mesh

Velocity field obtained by numerical simulation when 1 and 2 trunks, with  $Re = 10 \dots$



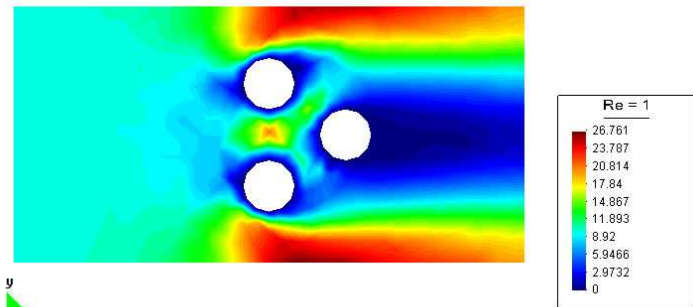


y  
z x



610

...and for 3 trunks with  $Re = 1$

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- when the drainage comes across with the presence of a trunk, represented in our model as the circle of diameter  $2m$ , there is a deviation in the field of velocities since it fluid is obliged diverting of the obstacle.
- This deviation causes one perturbation that takes great changes as a consequence in velocities.
- This perturbation can be better observed in the analysis with two trunks, where there is noticed the loss of symmetry of the solution. This effect occurs part because the non-symmetry of the finite elements mesh, and part by the turbulent resultant effect.
- In the case with three trunks, the same phenomenon also can be observed, even for  $Re = 1$ .



# Determination of the Canopic Viscosity

The new term called of Canopic Viscosity, is being developed, in the form to reduce the velocity of the drainage in function of the space distribution of the trunks.





# Representation of the Real Velocity Field Through the Forest

Tests of measurements of velocity of the flow inside the flooded forest, in area with phyto-fisionomy and phyto-structure known with two methodologies:

- Punctual measurements to 0,5 m of depth, using a current meter;
- Measurements of profiles of the water collum , using a acoustic Doppler current profiler.

The measures obtained by both instruments are being compared to check the adaptation of the instruments to the environment of flooded forest and his sensibility to provide data of validation of the modeling of the flow.



# DDDAS - Dynamic Data-Driven Application System

- The data is not easy to obtain presenting one more difficulty.
- Use of DDDAS.

