Plankton Barbecue

Juan D. Chacon

Simon Fraser University Spring 2019

Introduction

Natural Thermal Convection

Those plumes comming out from our BBQ grill are caused by a differences on density consequence of temperature varitions.

Governing Equations

- **(≈) Momentum:**

$$\frac{\partial \omega}{\partial t} + \frac{\partial \psi}{\partial y}\frac{\partial \omega}{\partial x} - \frac{\partial \psi}{\partial x}\frac{\partial \omega}{\partial y} = \frac{1}{Re}\nabla^2\omega + \beta g \frac{\partial T}{\partial x}$$

- **Stream fnc - Vorticity - Velocity:**

$$\nabla^2\psi = -\omega, \;\; u = \frac{\partial \psi}{\partial y}, \;\; v = -\frac{\partial \psi}{\partial x}$$

- **Energy:**

$$\frac{\partial T}{\partial t} + (\vec{u} \cdot \nabla T) = \frac{1}{RePr}\nabla^2 T$$

- **(Bonus!!!) Mass Transfer:**

$$\frac{\partial c}{\partial t} + (\vec{u} \cdot \nabla c) = \frac{1}{Pe}\nabla^2 c$$

The last Eq. models a substance moving with the fluid.

Method

To solve numerically the equations:

1. Set up the initial conditions for ψ, u and v.
2. Solve the vorticity equation. (Exp FTCS).
3. Solve the Poisson equation for ψ. (Std. discr. ∇^2).
4. Compute the new velocity from ψ.
5. Solve the Energy equation for T. (Exp FTCS).
6. Solve the Mass transfer equation. (Exp FTCS).
7. Go to step 2.

BBQ Grill: Air Thermal Convection

As benchmark paramenters we chose:

$$Re = 4365.30, \; Pr = 0.72, \; Pe = 0.07$$

For a rectangular Cavity width dimensions: 0.65m height, and 2.6m wide, and normalized temperatures Tc=-0.5, Th=0.5. As shown in the figure the fluid shows some cell formations at long term.

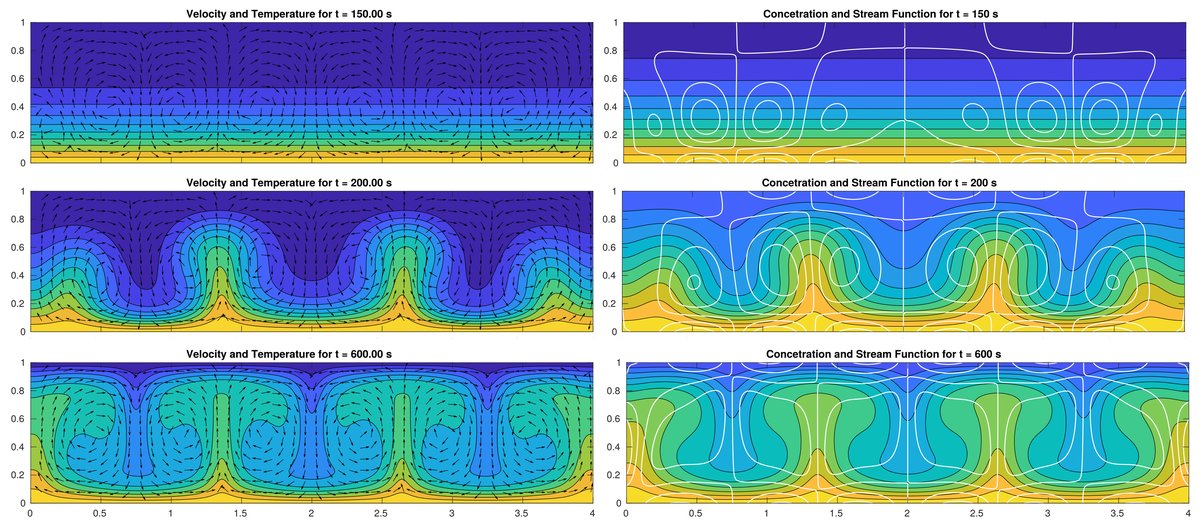

Figure 2:Cell behaviour

Numerical Convergence

Spatial Convergence order					
u	1.5339	v	1.3119	T	0.3145

Cells and Spatial grid Dependence

1. Factorise $x^2 - x - 12$.

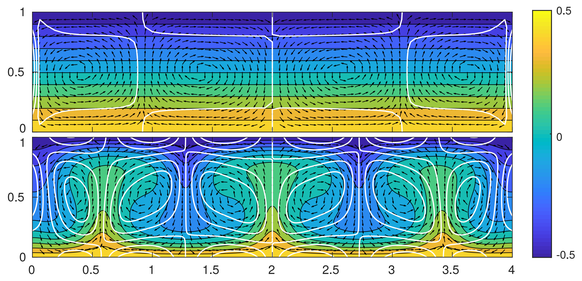

Figure 1:Cell behaviour

Proof of Vieta's Formulas

The same we could do with another pattern, which state that $x_1 x_2 = \frac{c}{a}$, but proving this is going to be your task in next section.

And the plankton?

Pythoplackton sinks in the ocean (passive swimmers), the temperature in the ocean varies upto 10C in a year, Is the convection what have this important individuals

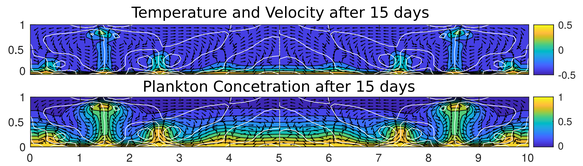

Figure 3:Cell behaviour

Final Thoughts!

Conclusions

- The number of cells depends on the geometry, aspect ratio, as well as the fluid parameters.
- The evidence of thermal cells depends on the size of the spatial discretization.
- (n.) factor → two multiplied factors give result

Pendings

- A solver using the projection method was considered, however, the stagered grid was an issue for the energy equation.
- An implentation using the second order FTBS scheme will help to deal with higher Reynolds numbers.
- The time convergence order might be improved using Crank Nicholson.