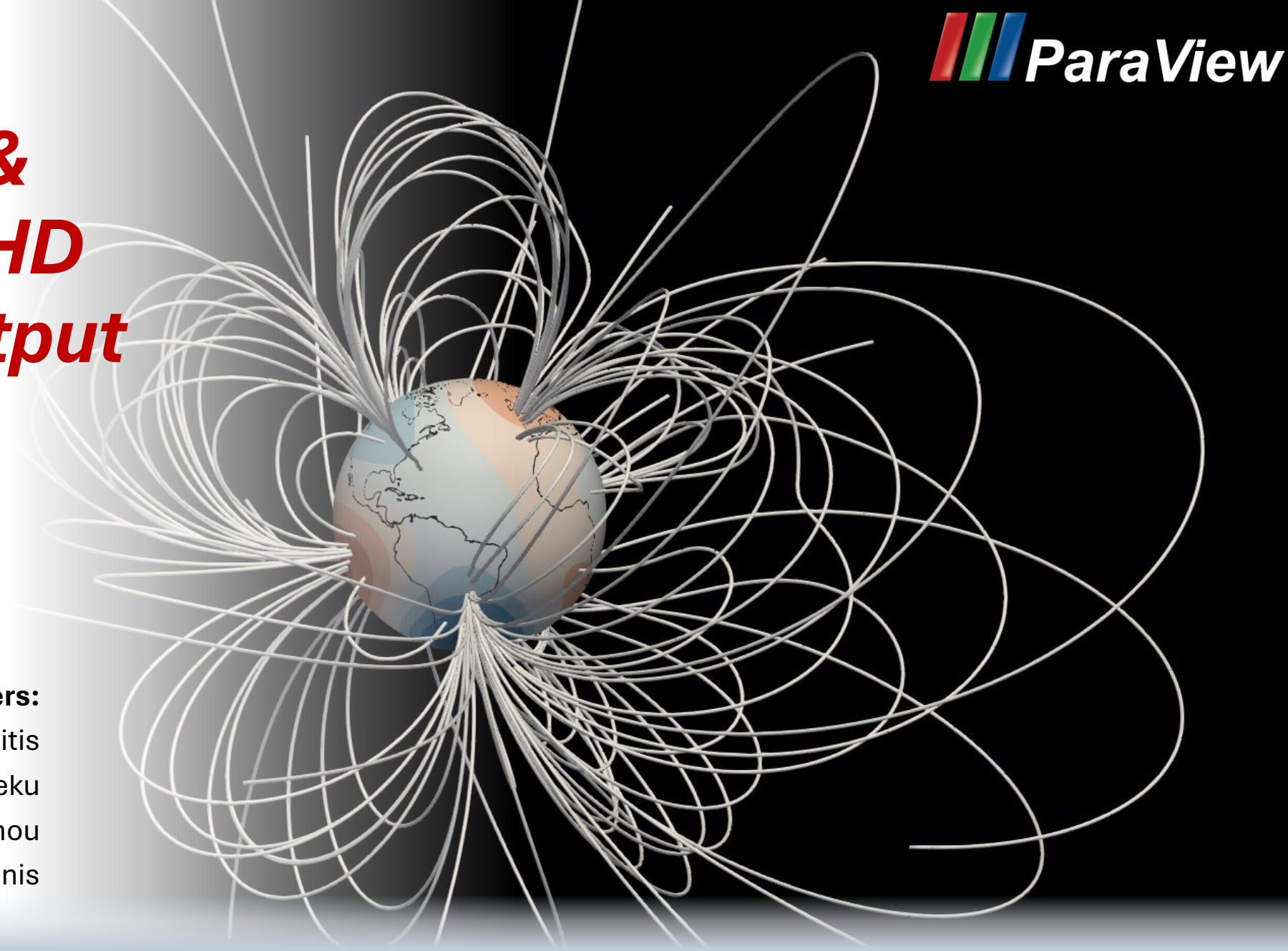
Practical Work 4

Visualization & Analysis of MHD simulation output



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Hel.A.S. 5th Summer School 2024
University of Ioannina

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Outline

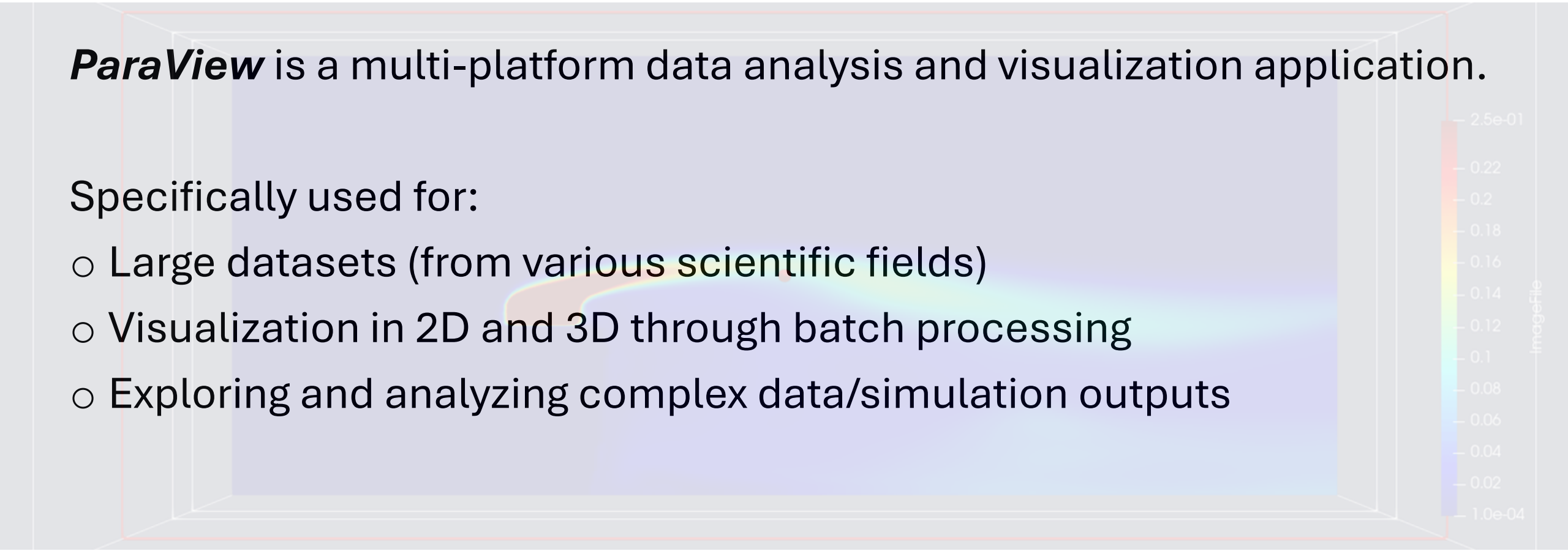
- ✓ What is Paraview
- ✓ Why did we use it?
- ✓ How we used it (Steps, Features)
- ✓ Results

ParaView

ParaView is a multi-platform data analysis and visualization application.

Specifically used for:

- Large datasets (from various scientific fields)
- Visualization in 2D and 3D through batch processing
- Exploring and analyzing complex data/simulation outputs

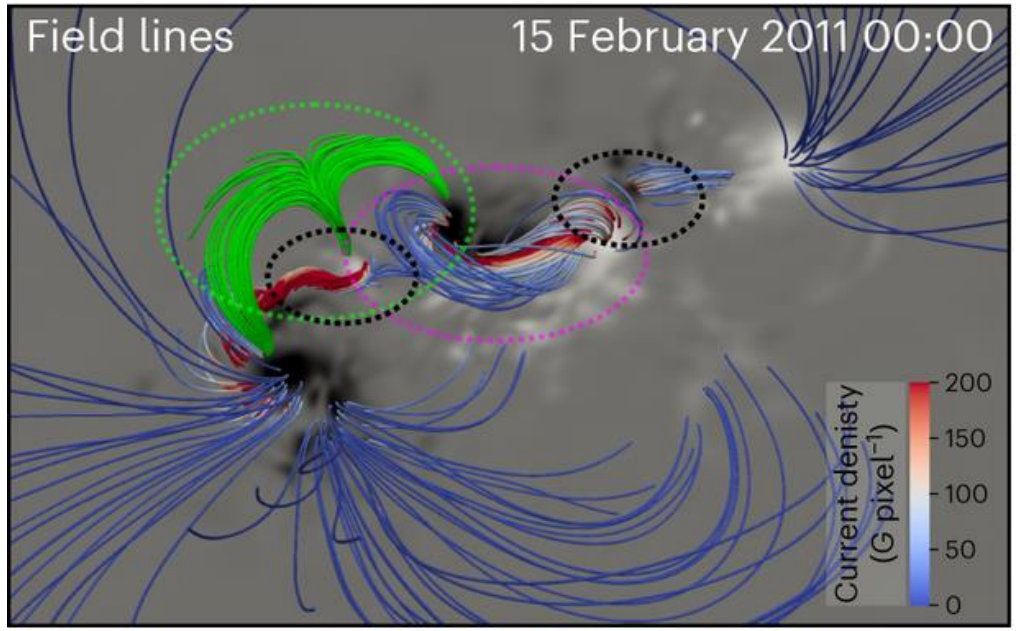


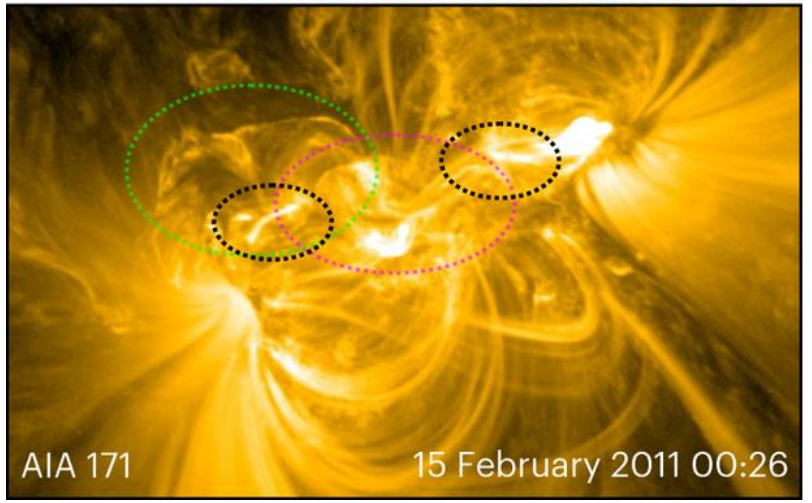
Why did we use Paraview

We used it to visualize complex MHD simulation outputs →

→ in our example, Solar (active) photosphere

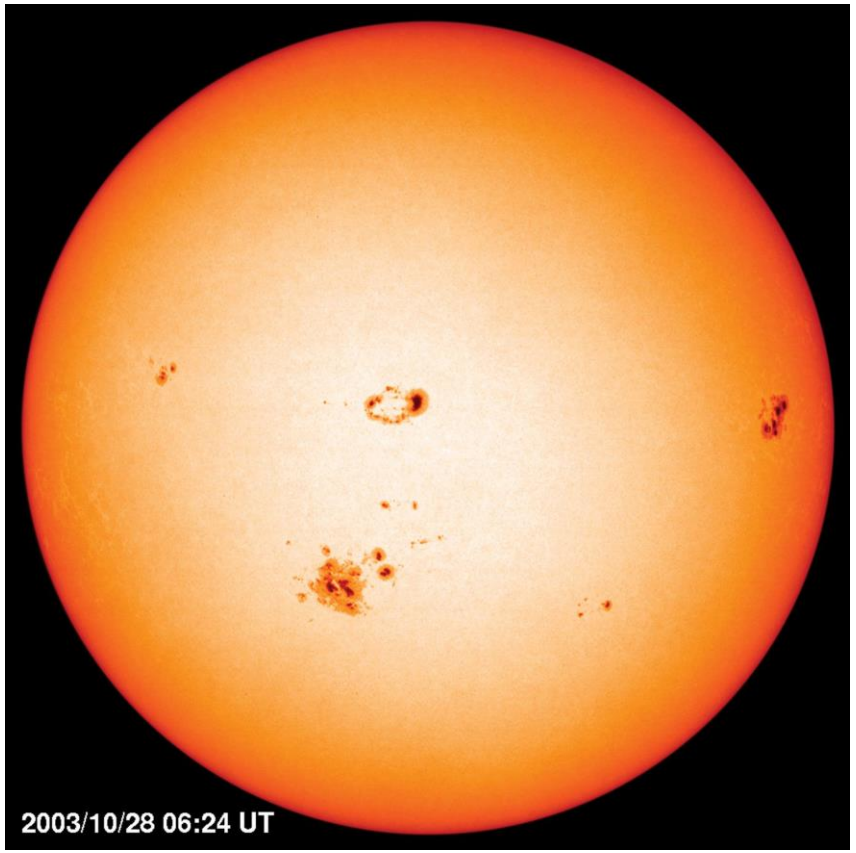
Like those:



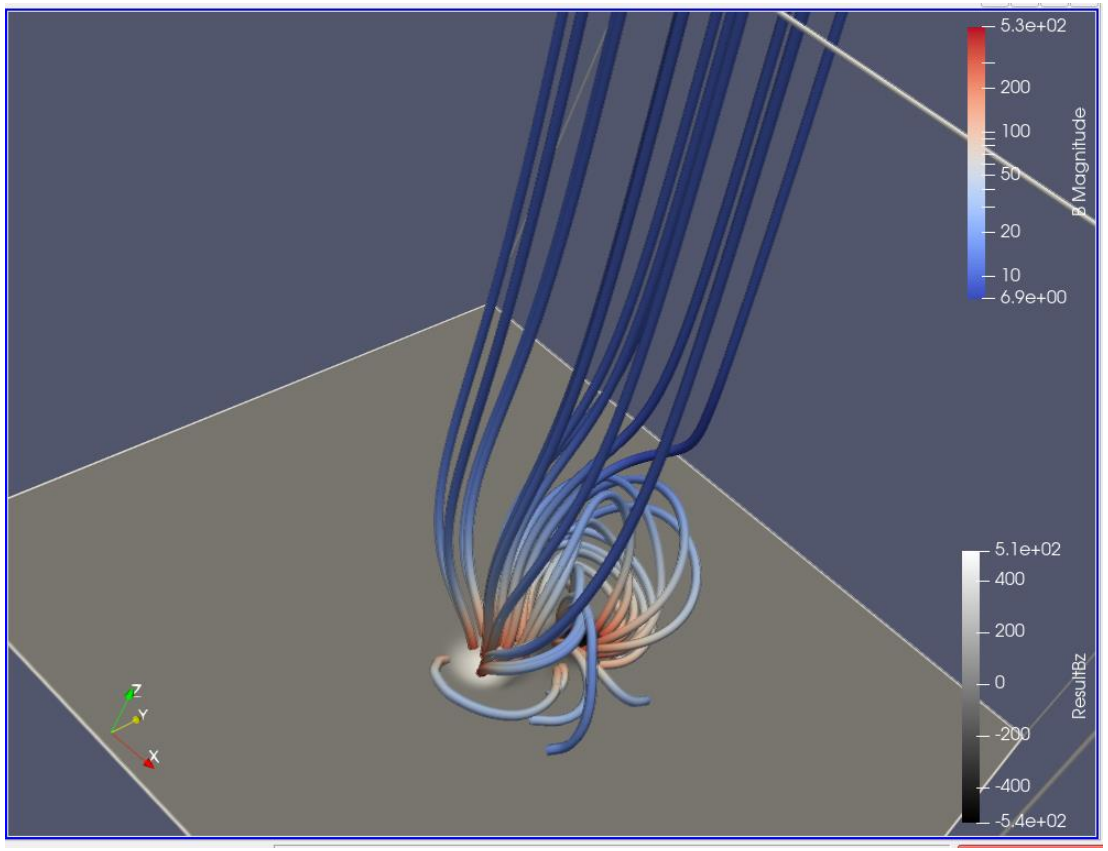


Robert Jarolim et al (2023)

Active regions in Sun's Photosphere



SOHO / NASA



Simulation (Paraview)

How we did it

Step 0 : Remember to download Paraview (somewhere with good WiFi connection!)

Step 1 : Have some data in hand (from MHD simulations)

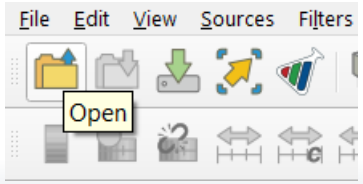
$$\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} = -\nabla p + \mathbf{B} \cdot \nabla \mathbf{B} + \nu \nabla^2 \mathbf{u}$$

$$\frac{\partial \mathbf{B}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{B} = \mathbf{B} \cdot \nabla \mathbf{u} + \eta \nabla^2 \mathbf{B}$$

$$\nabla \cdot \mathbf{u} = 0$$

$$\nabla \cdot \mathbf{B} = 0.$$

Step 2 : Open/Load your data (you can select that from File Option)

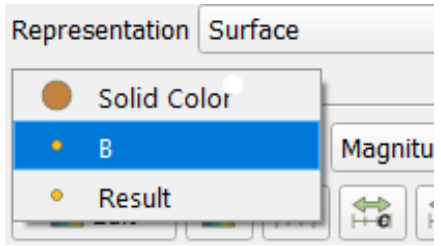


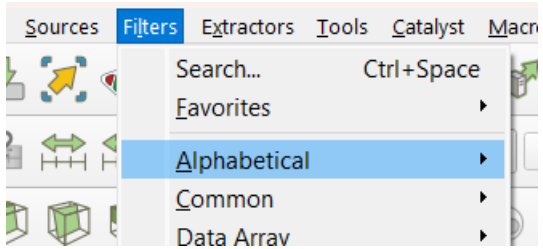
How we did it

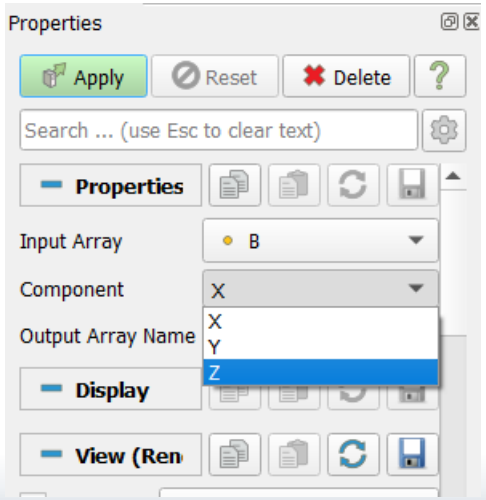
Step 3 : Apply Filters

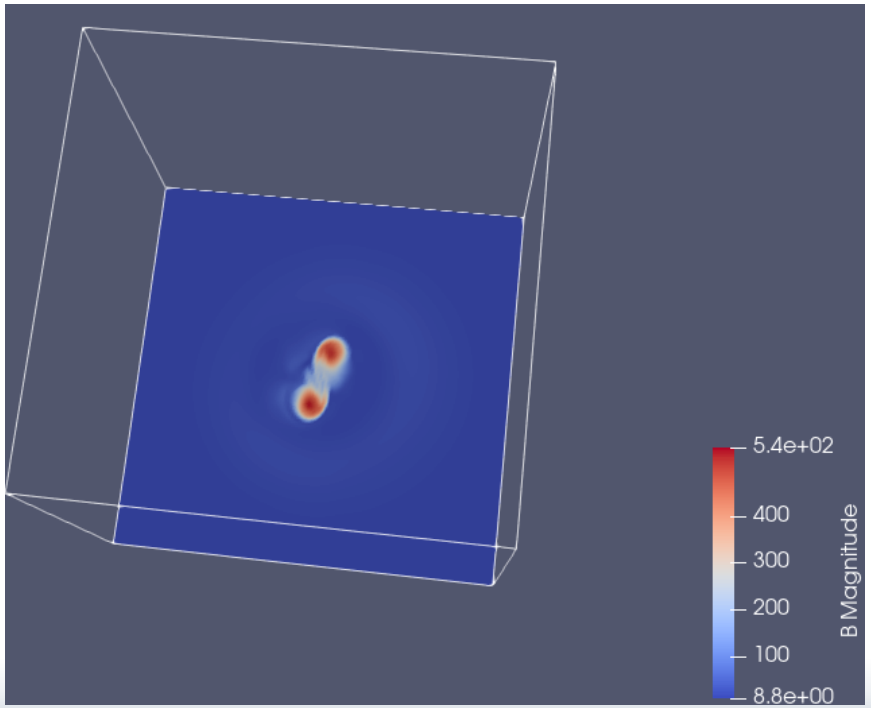
a) Extract component (B_z)

b) Visualize B_z in $z = 0$ plane (photosphere)









How we did it

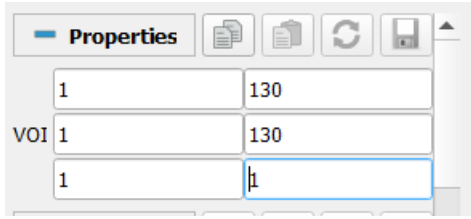
Step 3 : Apply Filters

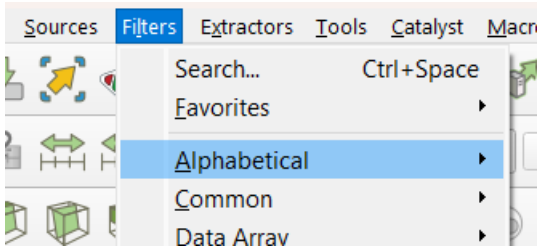
a) Extract component (B_z)

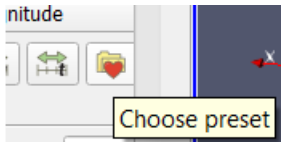
b) Visualize B_z in $z = 0$ plane (photosphere)

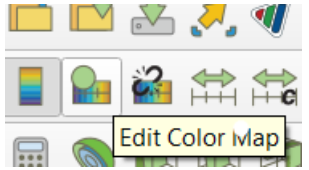
Volume of interest

Color scale: custom range, inverse, log etc.









How we did it

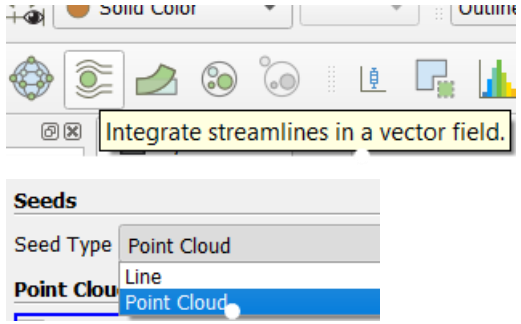
Step 4 : Magnetic lines

Integrate streamlines (seed)

Cloud parameters

Equation of magnetic lines:

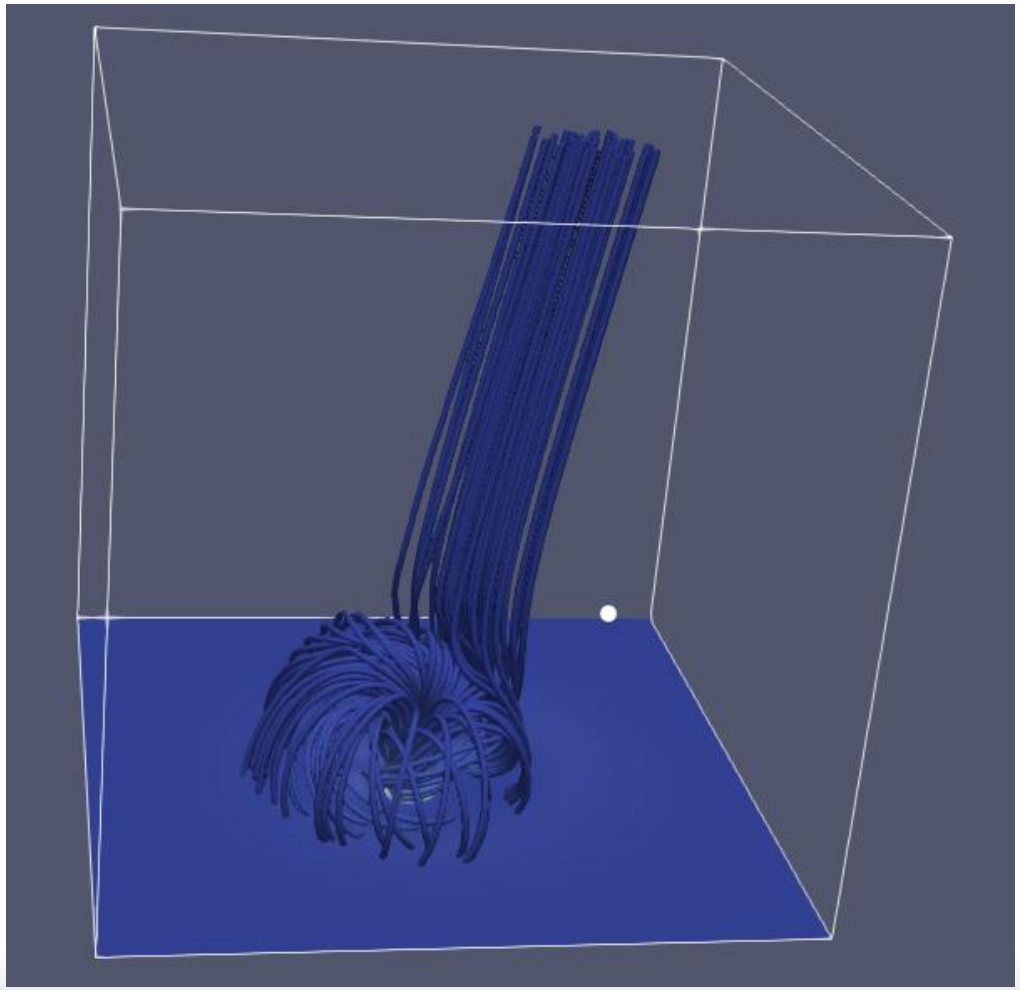
$$\frac{dx}{B_x} = \frac{dy}{B_y} = \frac{dz}{B_z}$$



How we did it

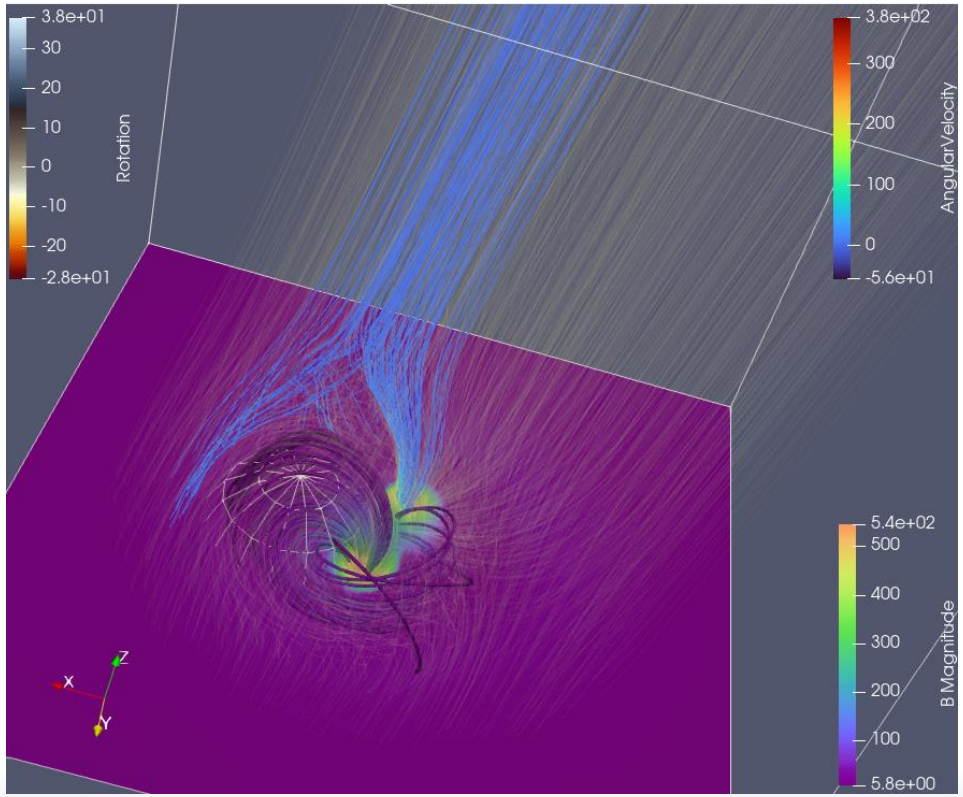
Step 4 : Magnetic lines

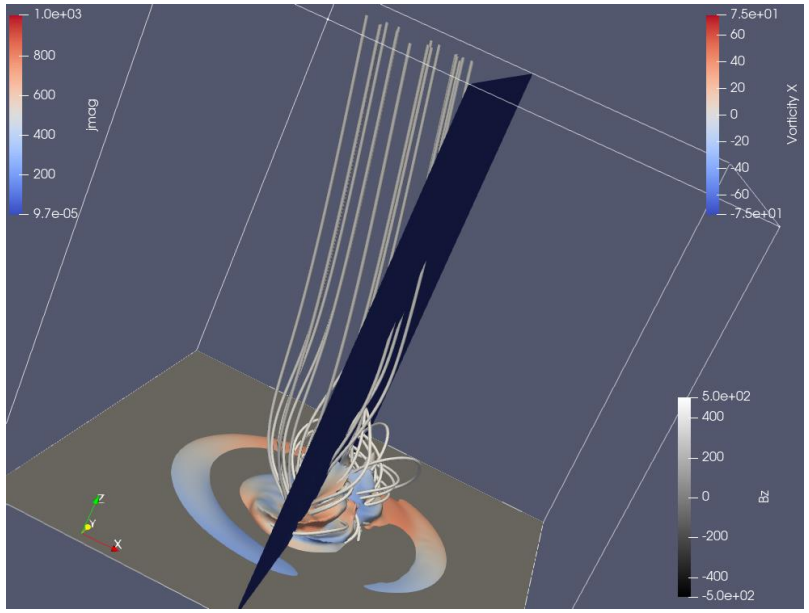
- Integrate streamlines (seed)
- Cloud parameters
- Number of points
- Colors and legend
- Tube “lines”



How we did it - Results

Step 5 : Depending on research interests, explore the possibilities!





- Final plot: Video or Pictures
- Visualization of every time step
- Extract to Python

ParaView

Thank you for your time and for this amazing week in Ioannina!

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