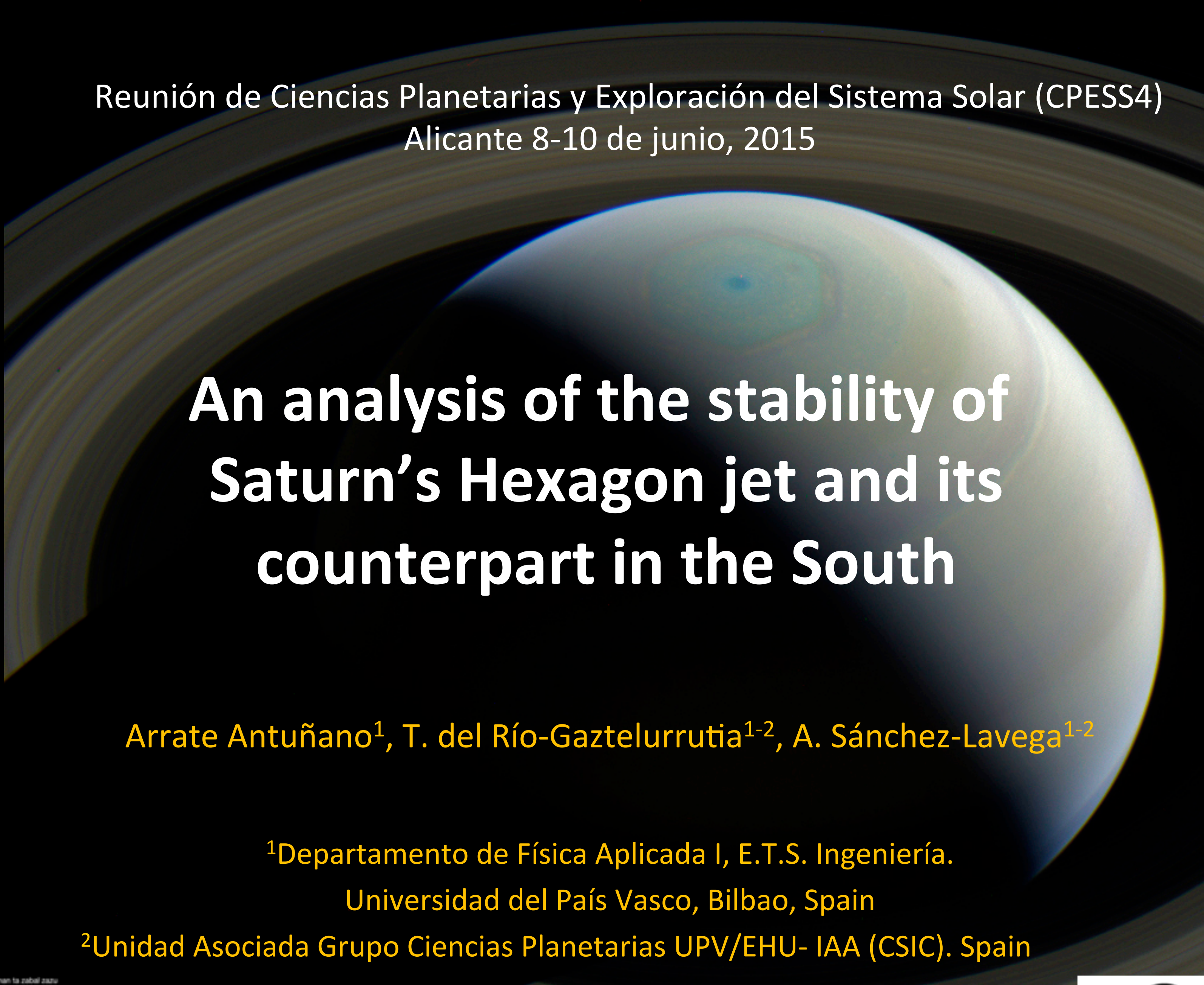

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An analysis of the stability of Saturn's Hexagon jet and its counterpart in the South

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Saturn’s Polar Regions : Introduction

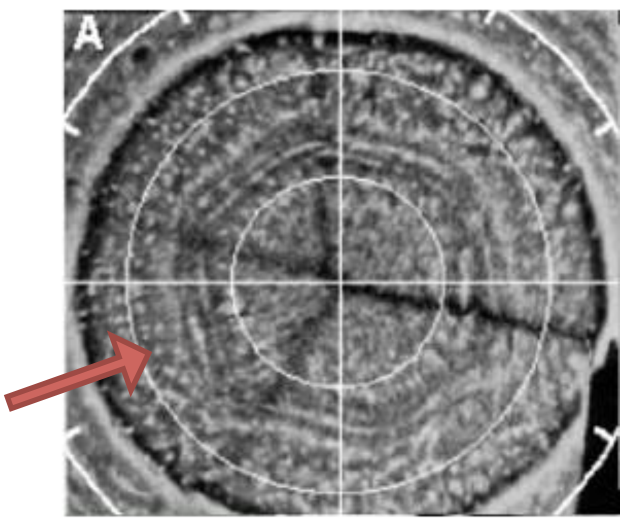
A) North:

- Images from Voyager flybys I-II in 1980-1981 showed a hexagonal feature in the North at 75ºN, which enclosed a fast eastward jet [Godfrey,1988].

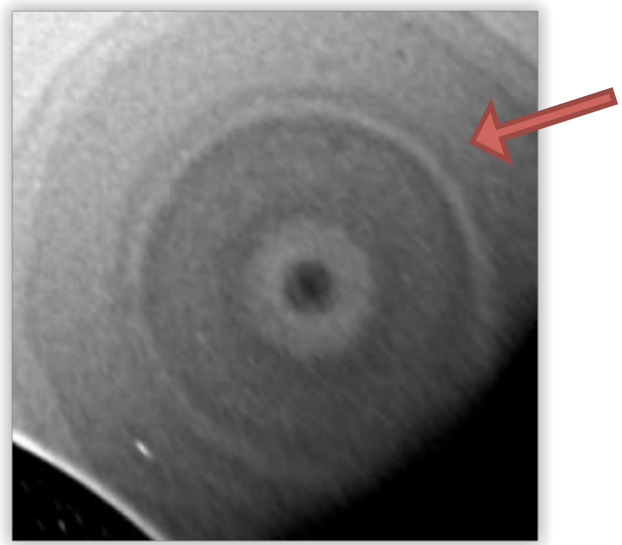
- During 1990-1995 this feature was reobserved by the Hubble Space Telescope (HST) and with ground based telescopes [Sánchez Lavega et al. 1993].

B) South:

- 1997-2002 HST images showed a non hexagonal fast rotating eastward jet. [Sánchez-Lavega et al.,2002]



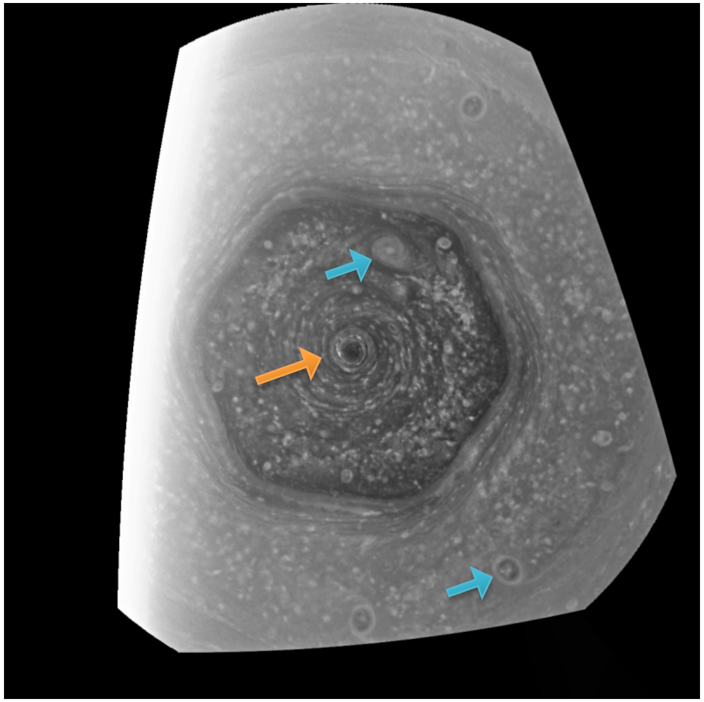
(Godfrey, 1988)



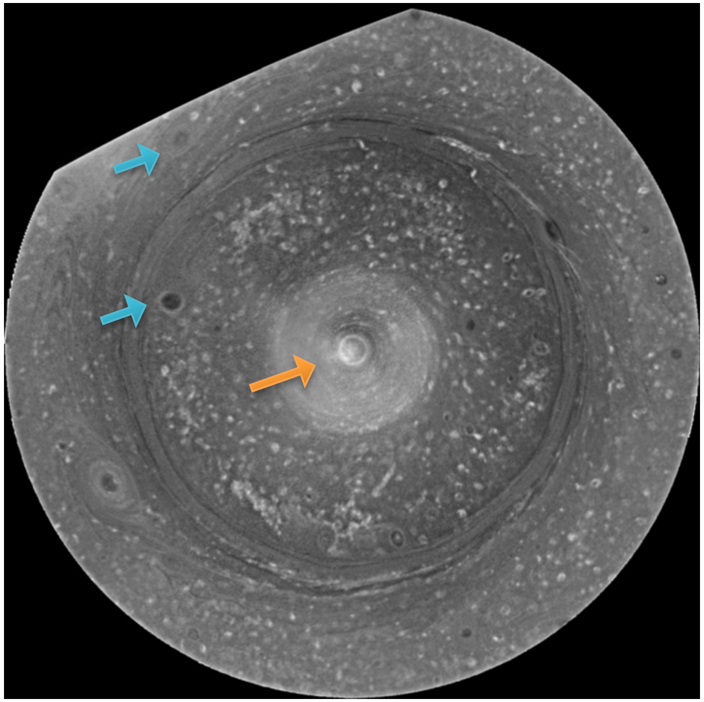
HST image, 2001.
(Sánchez-Lavega et al. 2002)

- Cassini arrival in 2004

Hexagon observed first in2008 by CIRS and VIMS and after 2009 by ISS.
No hexagonal feature exists in the south.



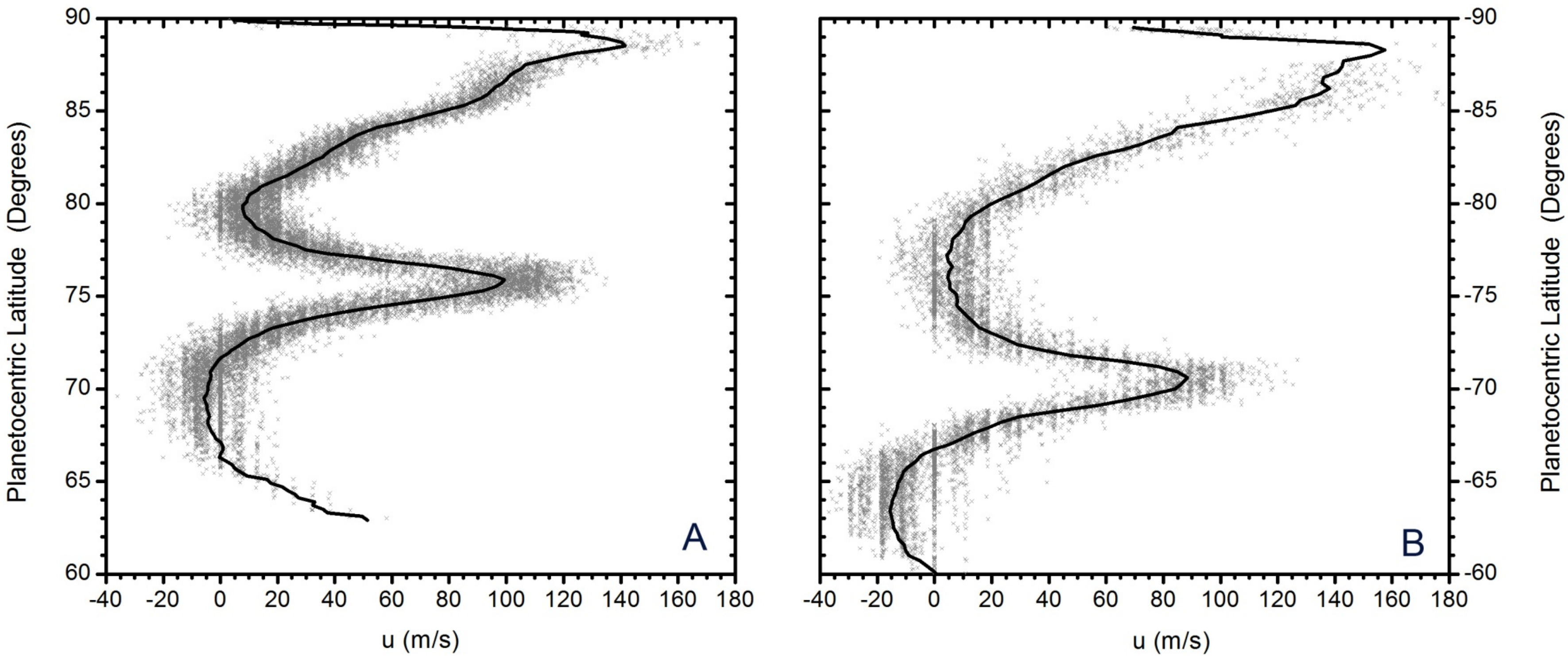
Cassini ISS image, 2013.
(A.Antuñano et al. 2015)



Cassini ISS image, 2008.
(A.Antuñano et al. 2015)

Zonal wind profile:

- similar peak velocity
- similar FWHM

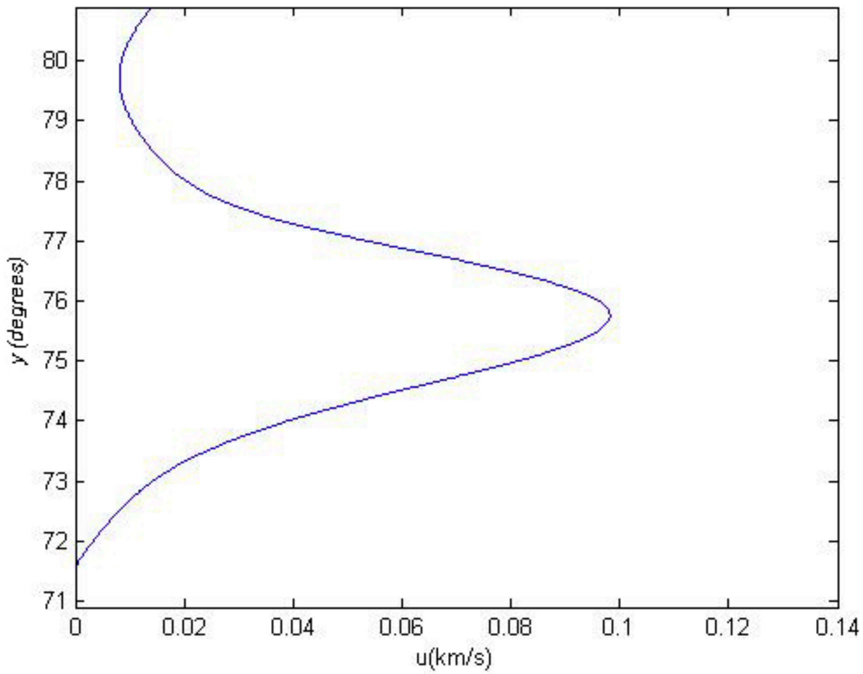


Barotropic Stability Analisis

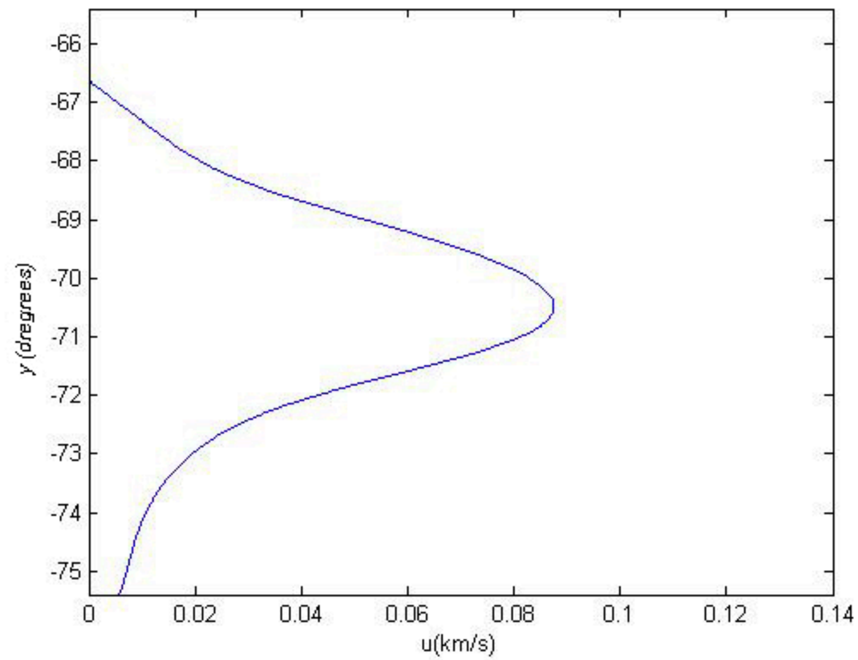
- There are no temperature gradients on constant pressure surfaces

→ vertical shear in the zonal flow is zero. *u=u(y)*

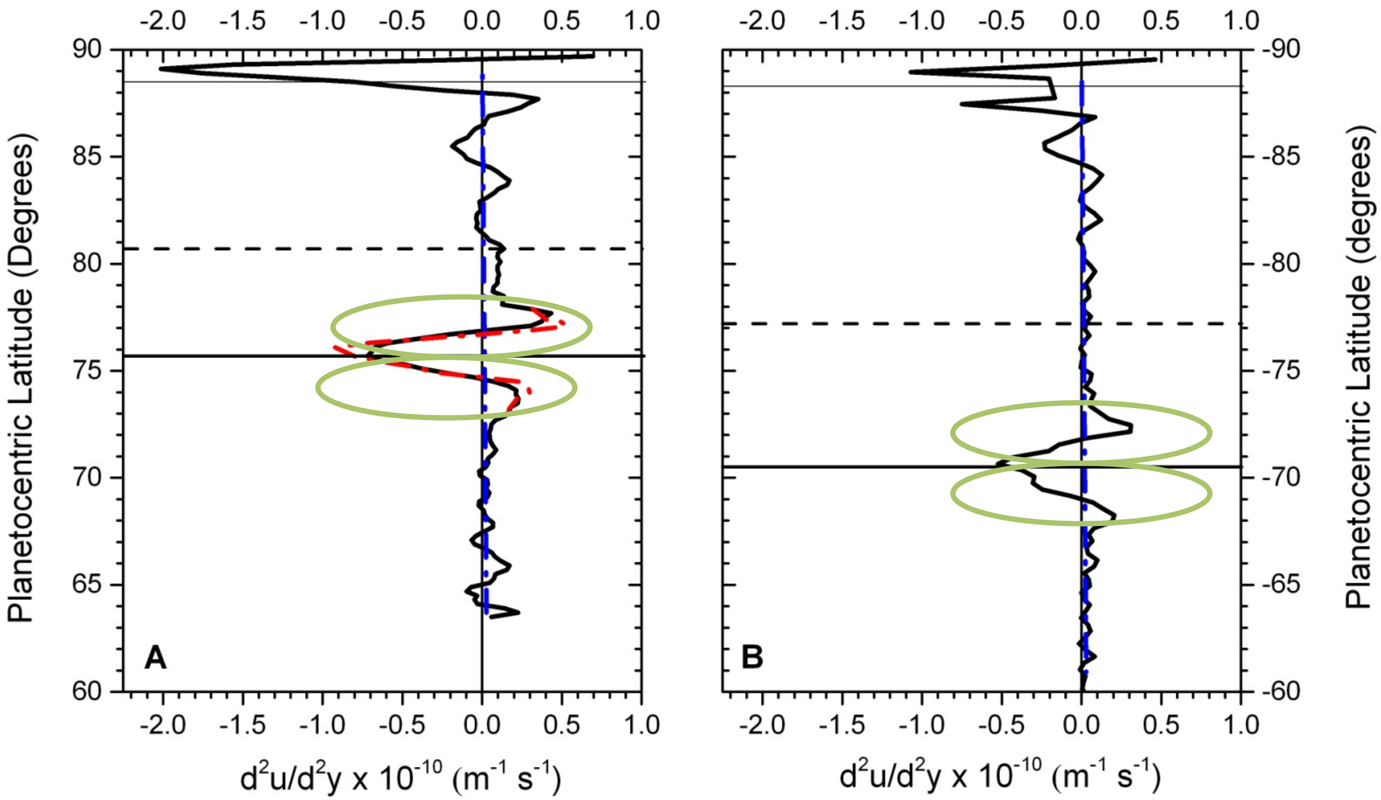
North



South



Instability criterion → Rayleigh-Kuo criterion: $\partial^2 \overline{u} / \partial y^2 > \beta$



- For an inviscid flow the absolute vorticity is conserved: $\frac{D\,(q'+f)}{Dt}=0$

Where $q'=\nabla^2\psi'-\frac{\pi^2}{L_D^2}\psi'$ is the shallow water quasi-geostrophic potential vorticity.

Rossby deformation Radius (L_D)

eddy stream function (ψ')

- We seek solution of the type : $\psi'=\Psi(y)e^{ik(x-ct)}$ where k is the zonal wave number.

- The perturbation is confined in the jet : $\partial\Psi/\partial y=0$

- The linearized vorticity equation:

$$u(y)\left[\partial_{yy}-k^2-\frac{\pi^2}{L_D^2}\right]\Psi+\left[\beta-u_{yy}\right]\Psi=c\left[\partial_{yy}-k^2-\frac{\pi^2}{L_D^2}\right]\Psi$$

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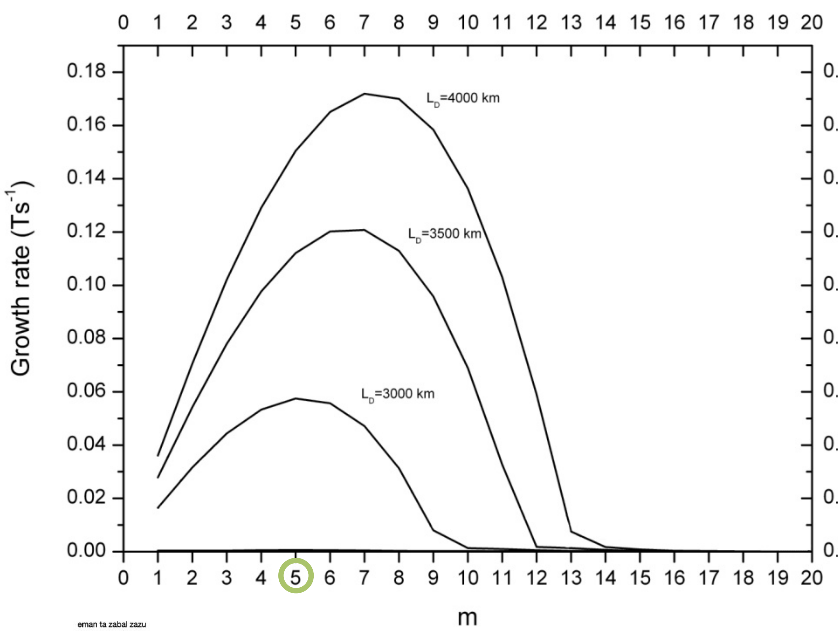
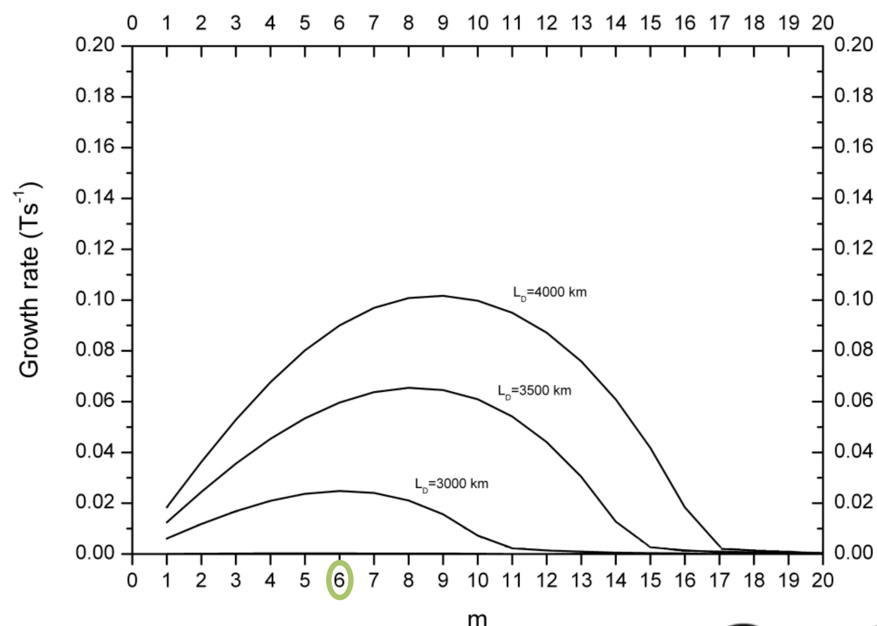
- The equation is solved by Finite Difference Method.

  - c real → stable jet
  - c with a positive imaginary part → the perturbation grows exponentially.

- Both hexagonal jet and its counterpart in the south have positive imaginary phase speed.

  → Which mode will prevail and whis is its growth rate?





Barotropic Instability's problem

• Jet of the Hexagon → Seems that the barotropic instability could explain the formation of an hexagon.

• Jet in the south → Growing mode 6-7. Does not match with the observations.

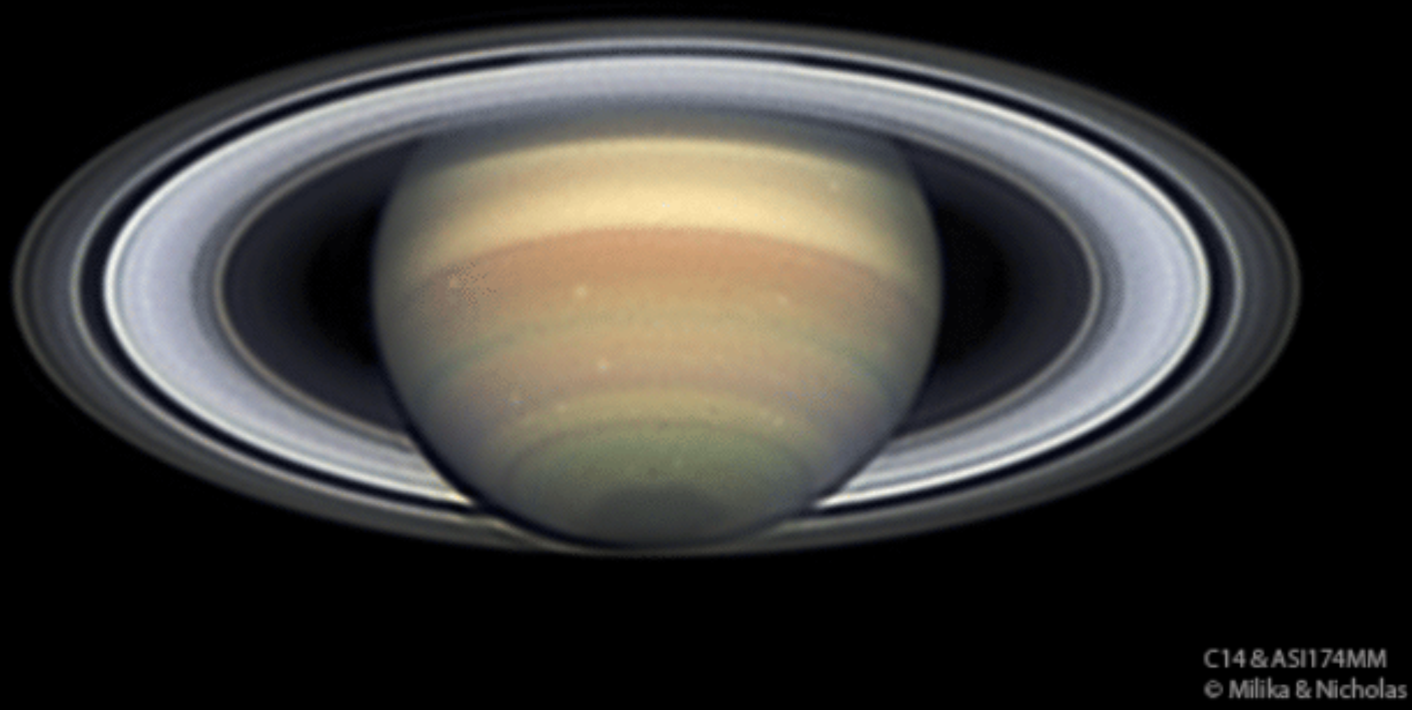
Both jets are similar dynamically speaking and are located at similar latitudes

Barotropic Instability cannot model the formation of a hexagon in the north and a circular jet in the south ☹

Future work: Baroclinic instability

- Meridional temperature gradient ≠ 0
- U(y,z)
- Seek solutions of the type: $\Psi' = \psi(y,z)e^{ik(x-ct)}$
- Boundary conditions:
  - $\frac{\partial \psi}{\partial y} = 0$ at y= ± 5000 km.
  - $\frac{\partial \psi}{\partial z} = 0$ at the top
  - $\psi = 0$ at the bottom

Thank you!



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