MAX PLANCK INSTITUTE
FOR SOLAR SYSTEM RESEARCH
MPS

ZONAL WINDS IN THE GAS PLANETS DRIVEN BY CONVECTION ABOVE A STABLY STRATIFIED LAYER

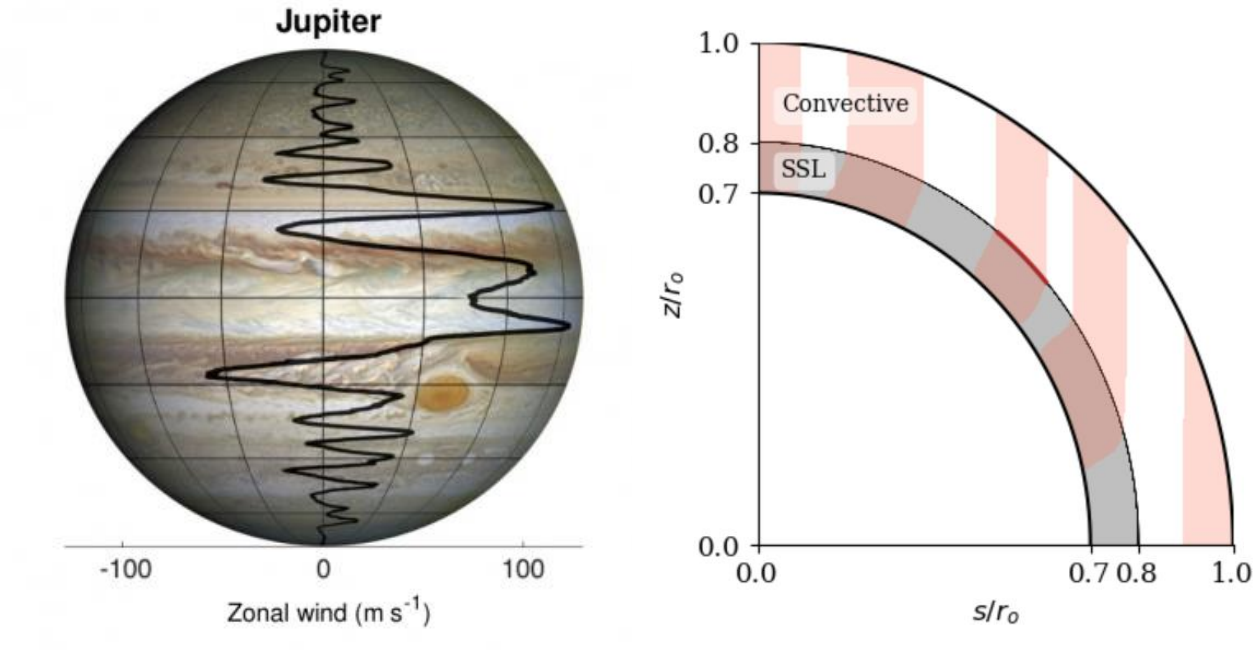
P. Wulff, W. Dietrich, U. Christensen, J. Wicht

INTRODUCTION

Both Gas Planets have zonal winds reading up to the higher latitudes

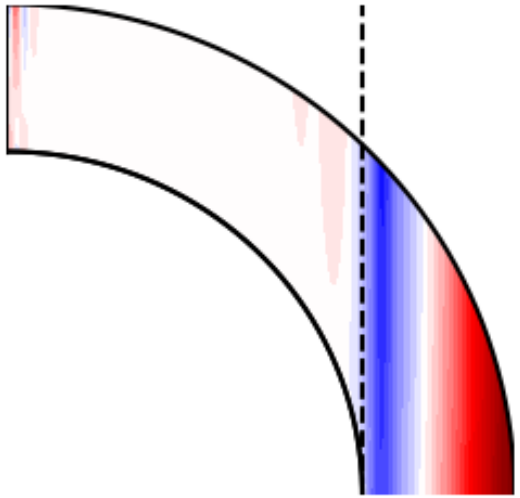
What we do:

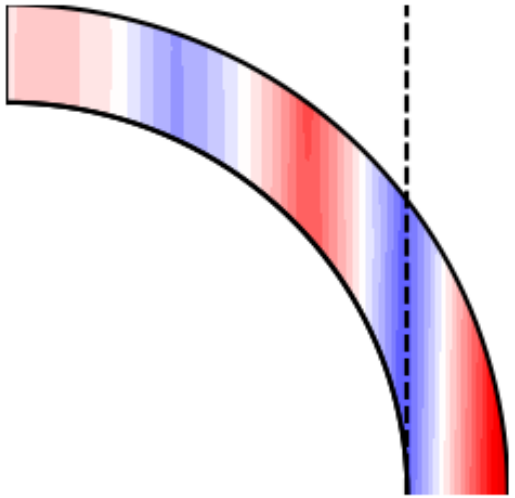
- Full 3D simulations, using code MagIC
- Zonal winds form in the outer 2/3 of the simulated spherical shell, driven by vigorous convection
- Lower 1/3 of the shell is stably stratified and the degree of stratification, N/Ω, is varied



Kaspi, Y. *et al.* Comparison of the Deep Atmospheric Dynamics of Jupiter and Saturn in Light of the Juno and Cassini Gravity Measurements (2020). https://doi.org/10.1007/s11214-020-00705-7ng

FORMATION OF ZONAL WINDS WITHIN THE TANGENT CYLINDER





Azimuthally averaged zonal flow

Prograde/eastward

Retrograde/westward

Rigid lower BC's: can act as a proxy for electromagnetic forces at depth. Viscous lower boundary layer precludes the development of geostrophic jets in regions where they would come into contact with the lower boundary.

Stress-free lower BC's: jets within the tangent cylinder, but unrealistic.

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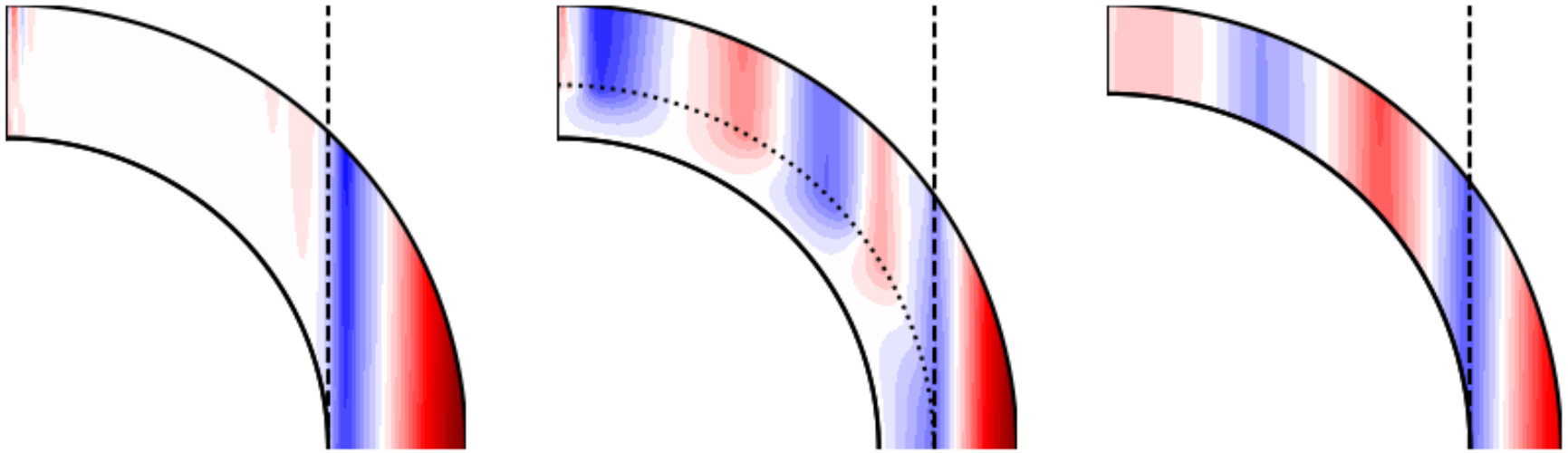

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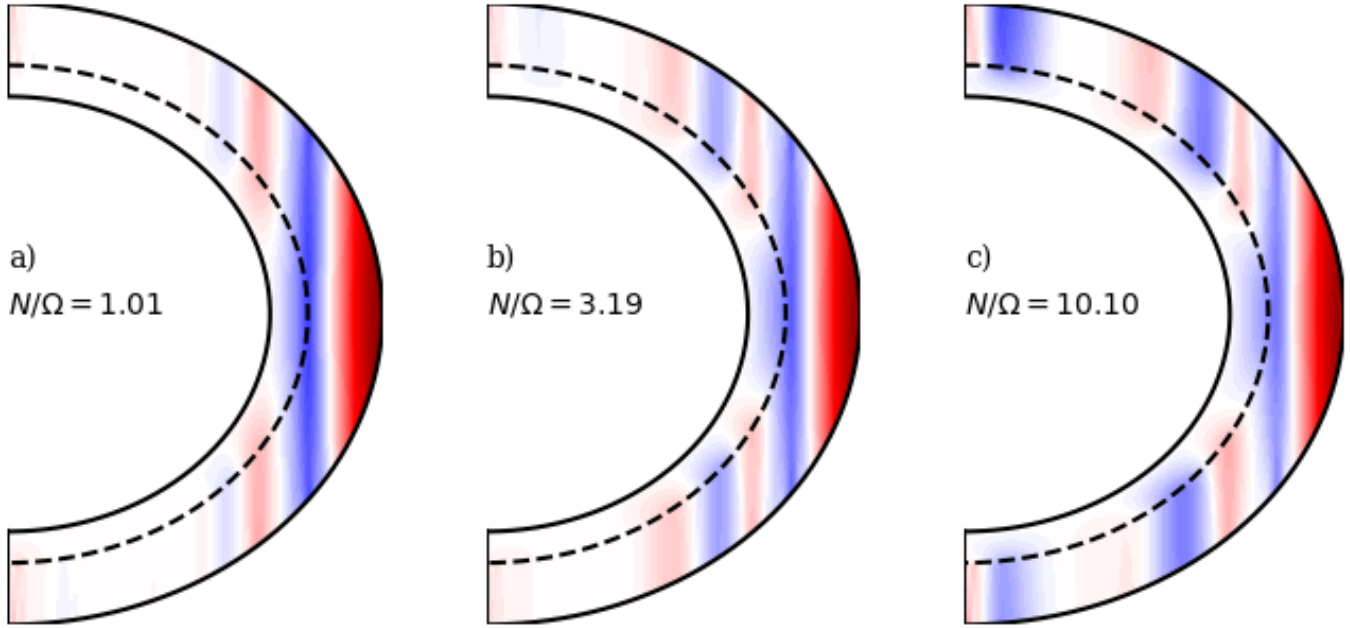
With a Stably Stratified Layer: jets form within the TC, despite rigid lower boundary.

INCREASING THE STRENGTH OF THE STRATIFICATION



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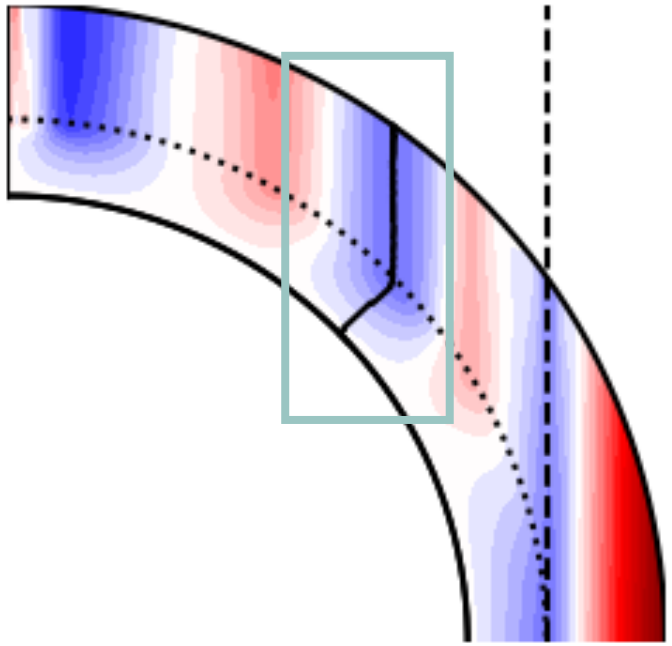
Weakly stratified layer: 2 weak jet pairs from inside the TC

Stronger stratification: Another jet pair forms, jets also gain in amplitude

Strong stratification: Jets reach all the way to the high latitudes

CONTINUATION OF ZONAL JETS INTO THE STABLY STRATIFIED LAYER

Using the first retrograde jet within the TC, we track the location of its peak with depth, for all simulations in the study.



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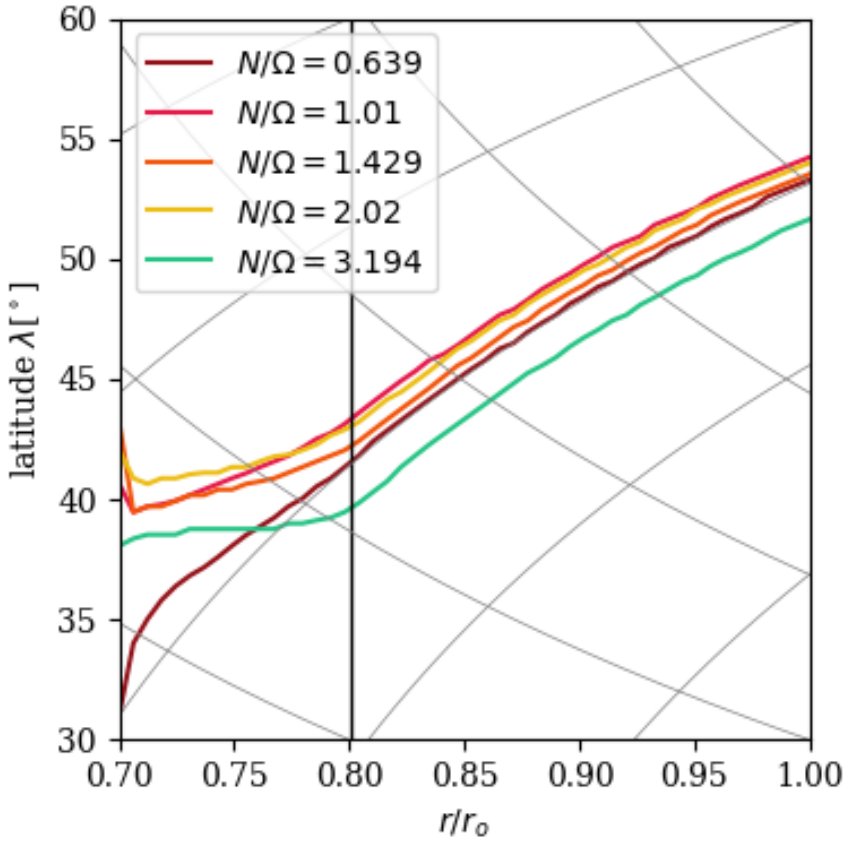
We plot the peak's latitude as a function of the normalised radius, with the grey grid indicating lines of constant s and z.

- **Jets are perfectly z-invariant in the convective region.**
- **Geostrophy is broken at the stable layer boundary.**
- **In strongly stratified layers, jet's peak locations become latitudinally invariant.**



CONCLUSIONS

- **Introducing a stable layer helps us produce simulations where zonal winds form inside the tangent cylinder, like observed on Jupiter.**
- **With increasing degree of stratification, more jets form at higher latitudes**
- **Geostrophy is broken when the zonal winds encounter the stable layer boundary**
  - In strongly stratified layers jet's peak locations become latitudinally invariant
  - Should we take this into account when interpreting the gravity moment measurements?

Thank you for your attention!