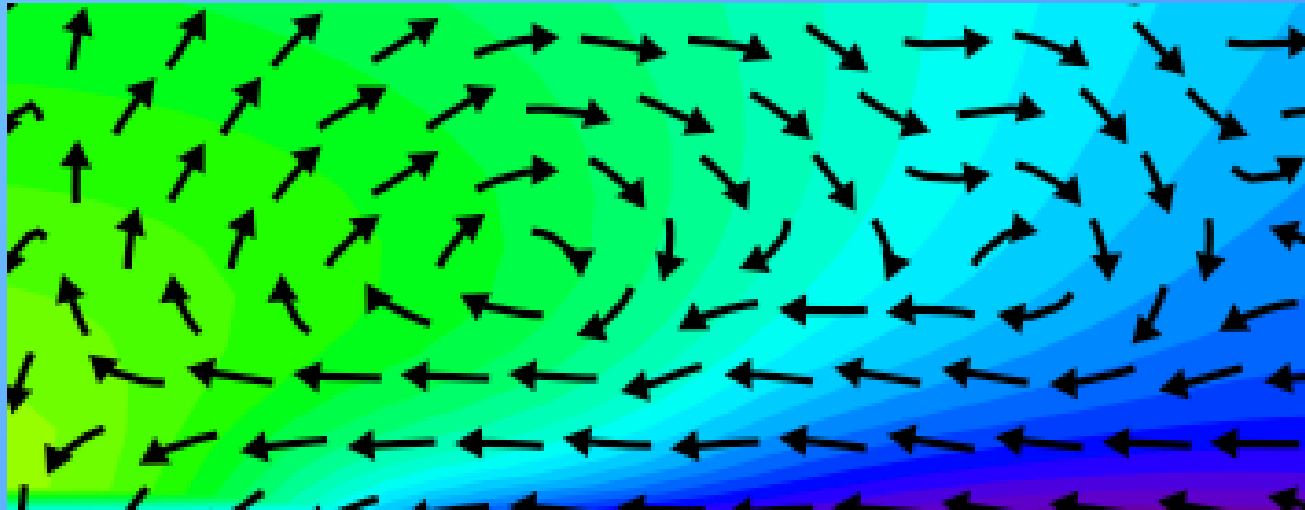


# Thermospheric Dynamics at Jupiter and Saturn



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University College, London, UK

# Why is the thermosphere interesting?

**1**

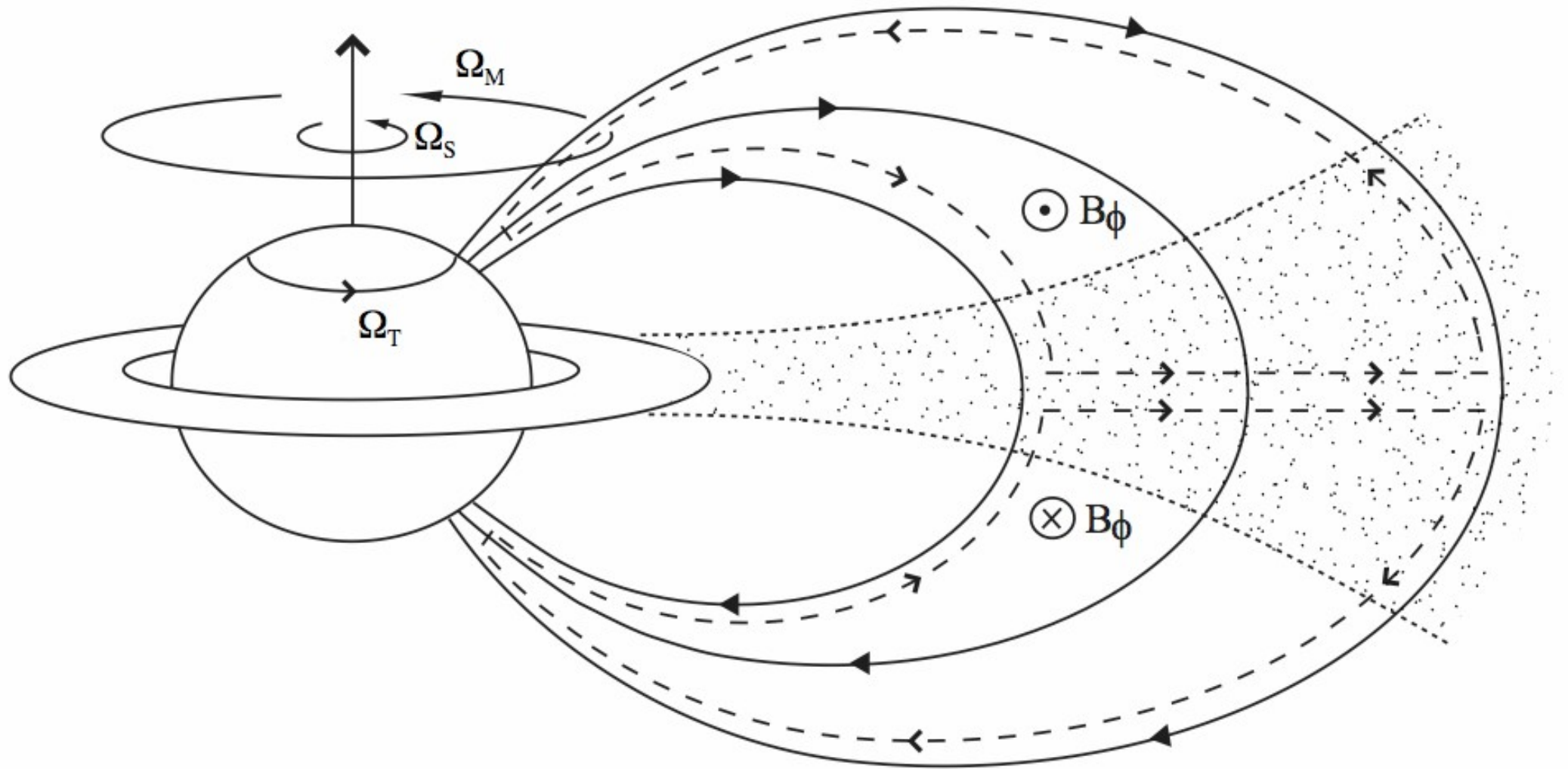
**Angular momentum** transfer from the planet to the magnetosphere is a consequence of ion-neutral collisions in the thermosphere: the structure of the thermosphere is imprinted on the magnetosphere.

**2**

**The “Energy Crisis”**: Jupiter and Saturn both exhibit high thermospheric temperatures which have yet to be satisfactorily explained.

# Angular momentum transfer

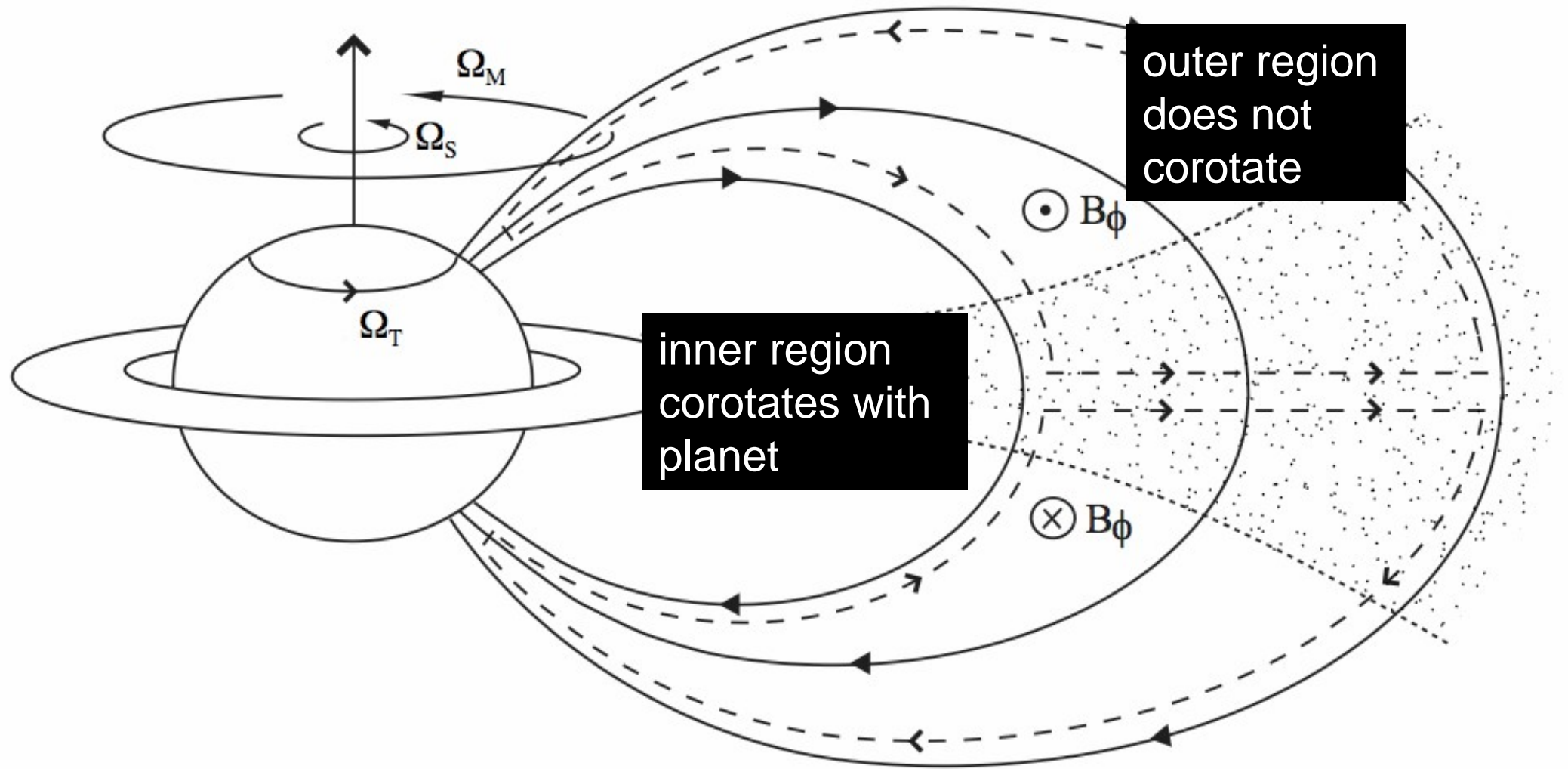
1



adapted from Cowley & Bunce (2003)

# Angular momentum transfer

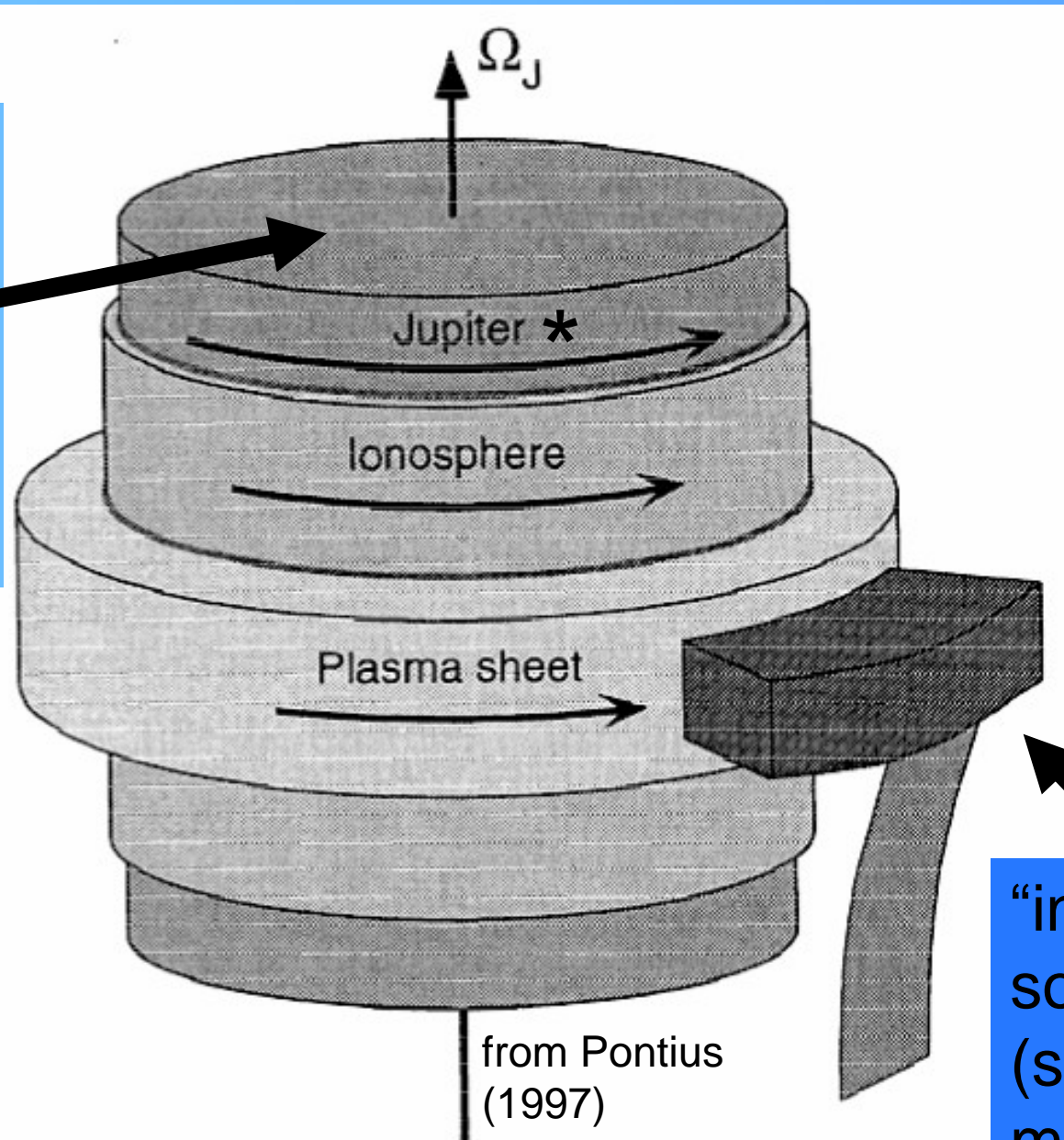
1



adapted from Cowley & Bunce (2003)

# Mechanical Analogue

“infinite”  
source of  
angular  
momentum  
(sink of  
inertia)



“infinite”  
source of inertia  
(sink of angular  
momentum)

\* or Saturn

# Supply of AM by viscosity

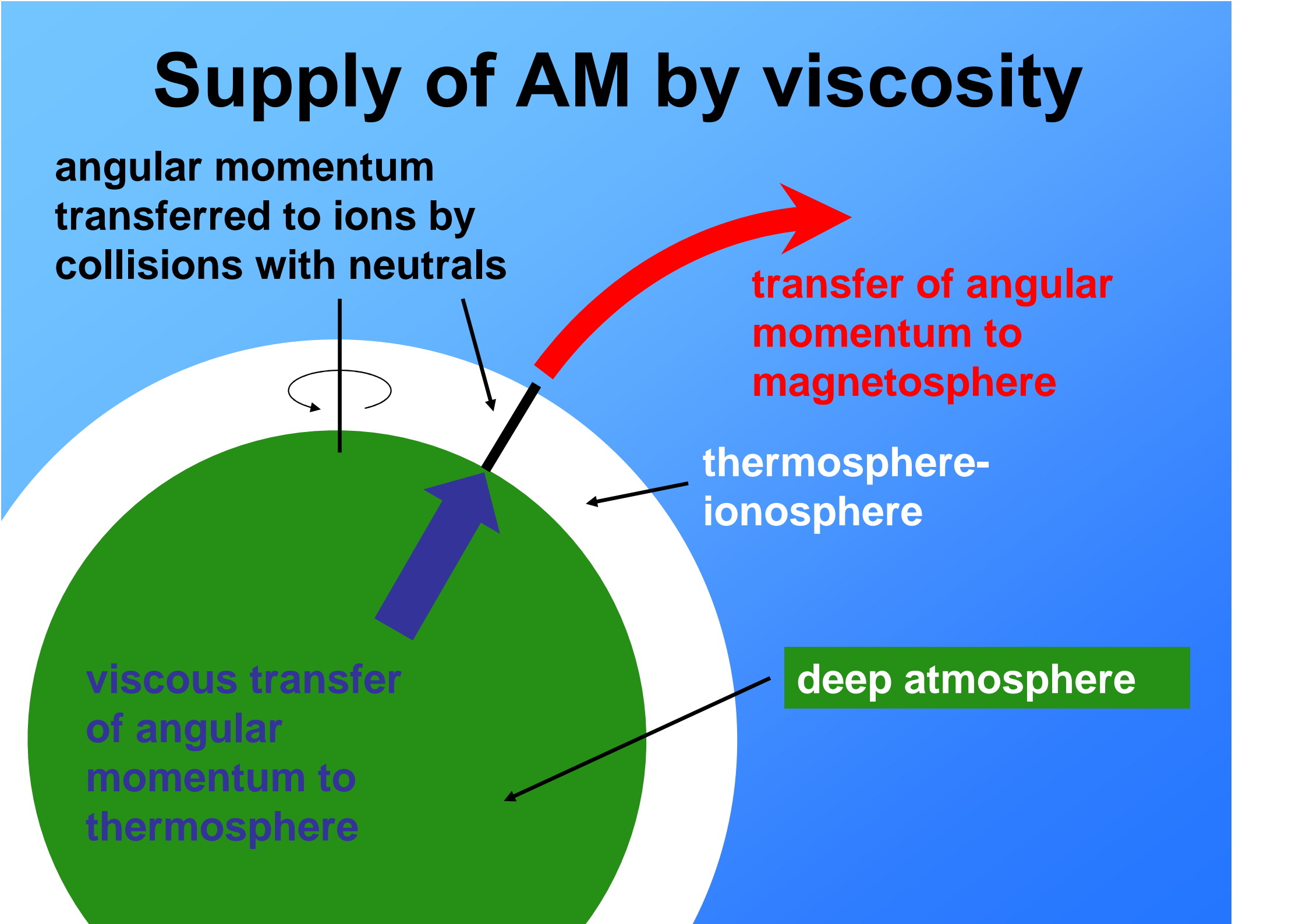
angular momentum  
transferred to ions by  
collisions with neutrals

transfer of angular  
momentum to  
magnetosphere

thermosphere-  
ionosphere

viscous transfer  
of angular  
momentum to  
thermosphere

deep atmosphere



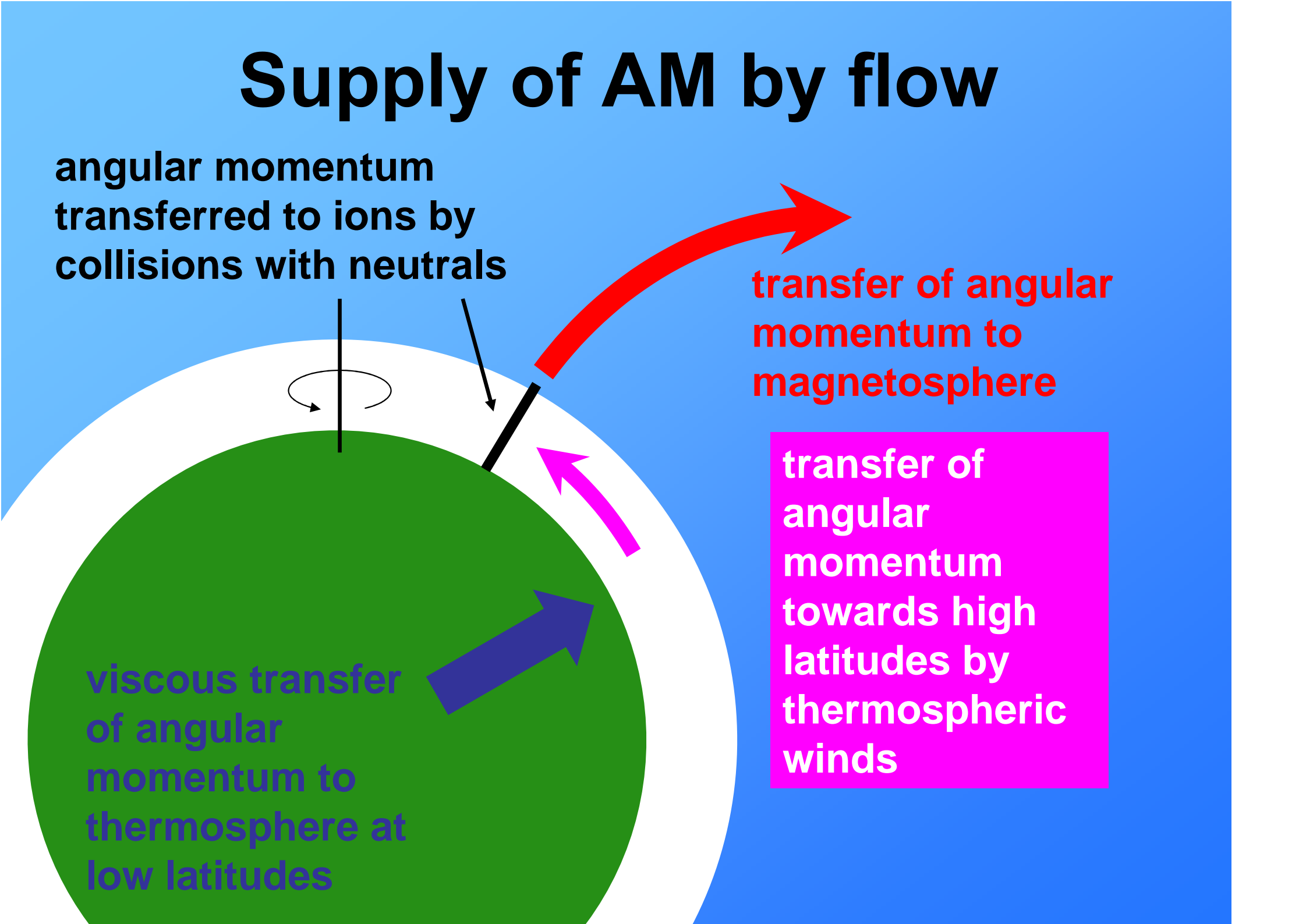
# Supply of AM by flow

angular momentum  
transferred to ions by  
collisions with neutrals

transfer of angular  
momentum to  
magnetosphere

transfer of  
angular  
momentum  
towards high  
latitudes by  
thermospheric  
winds

viscous transfer  
of angular  
momentum to  
thermosphere at  
low latitudes

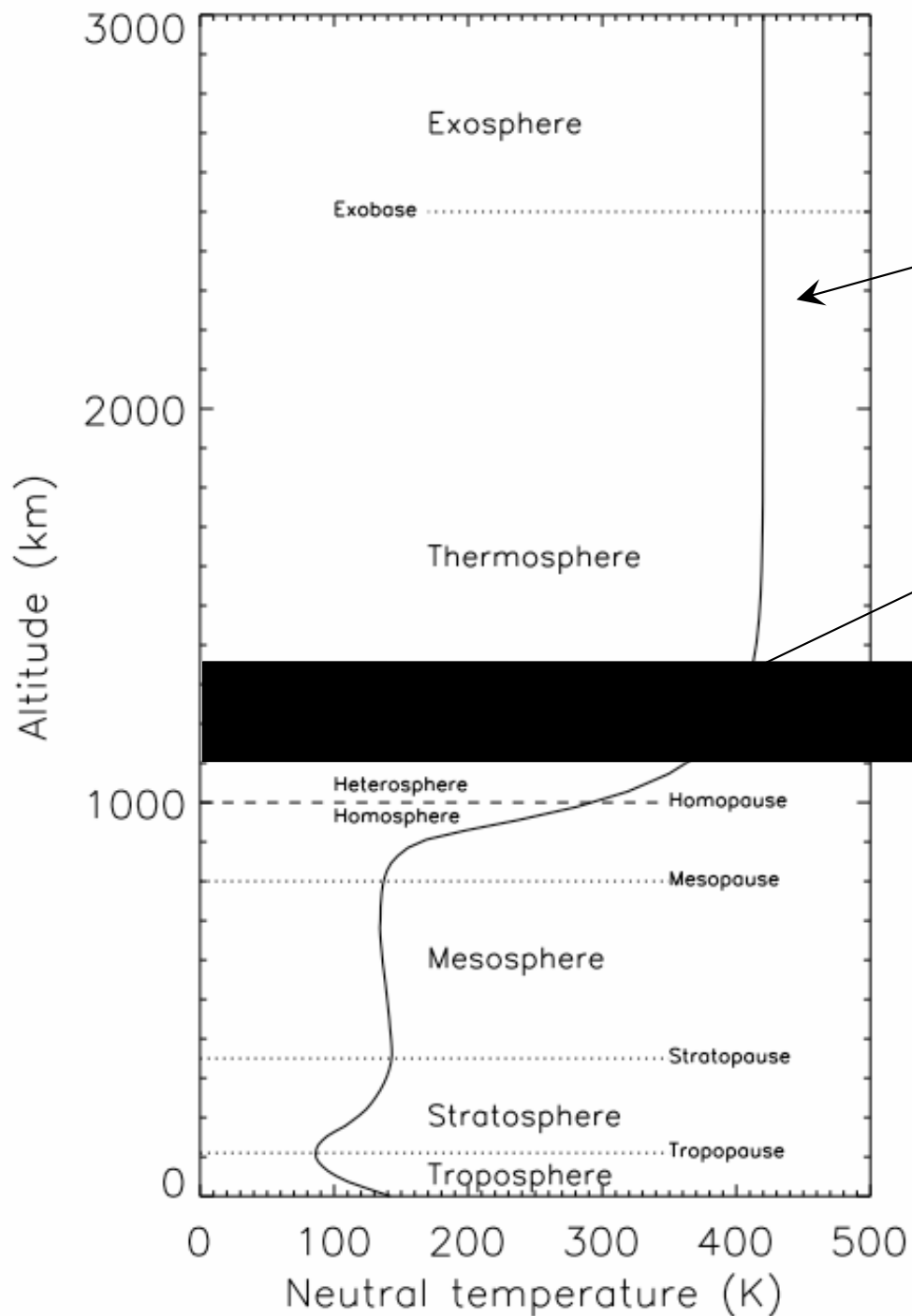


# Consequences...

- thermospheric winds couple regions of the magnetosphere that are otherwise uncoupled
- the concept of an “effective” conductivity becomes less useful

**see my poster for details...**





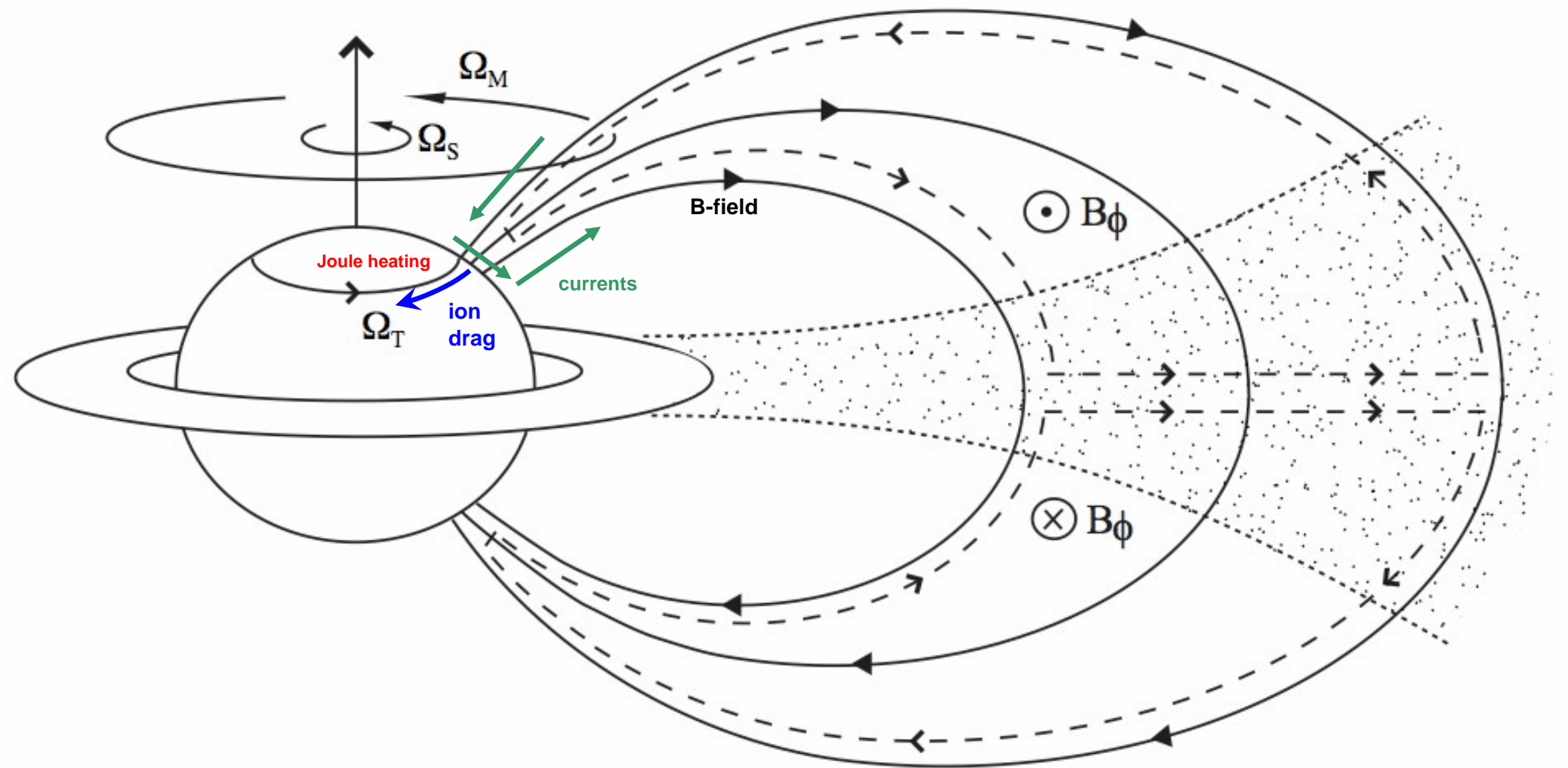
this region is **too hot**

could Joule heating and ion drag **here** explain the high temperatures?

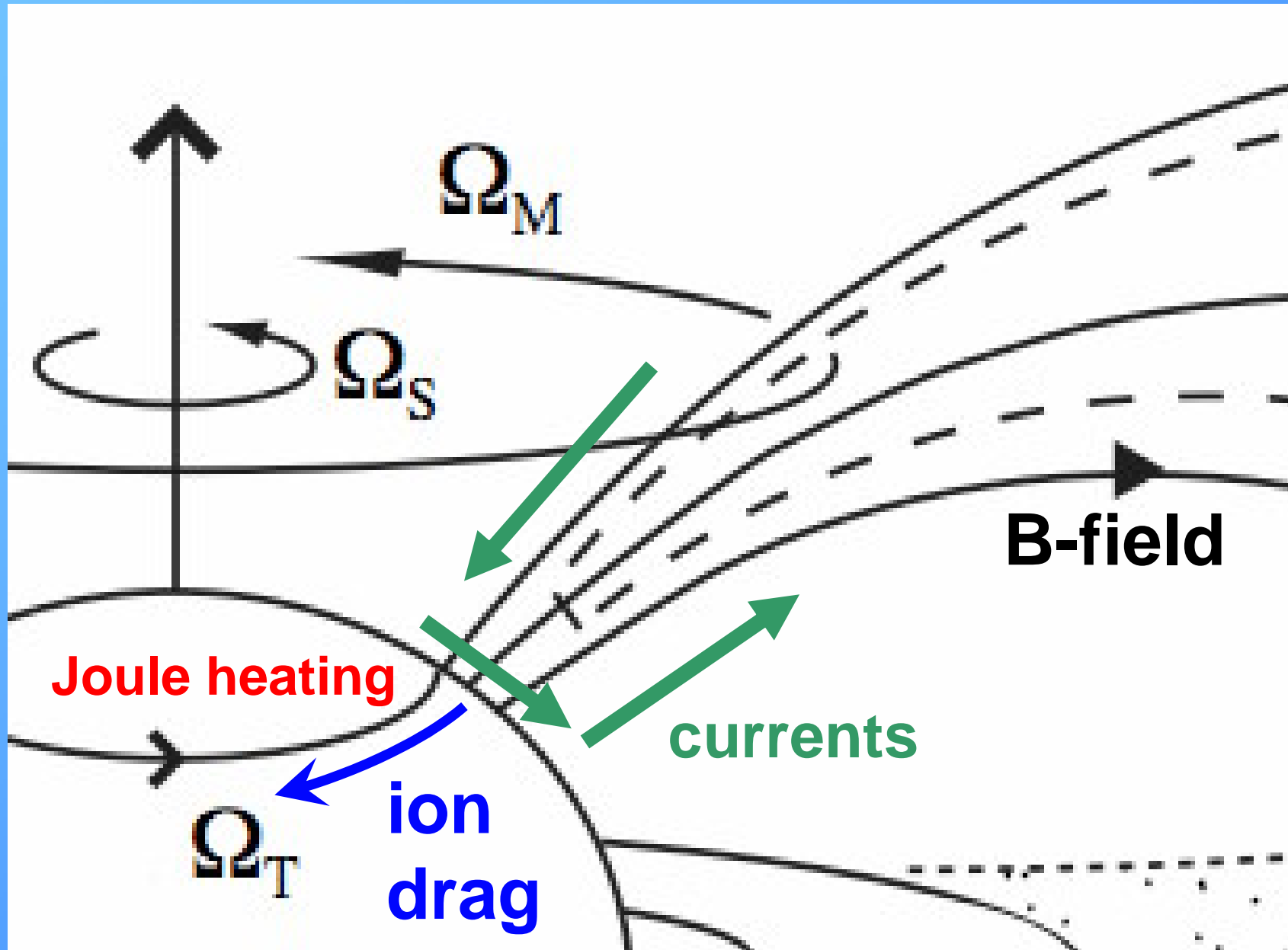
**2**

# The Energy Crisis

# Joule heating/ion drag



# Joule heating/ion drag



# This study

We apply Joule heating and ion drag to a 3D numerical model of the thermosphere...

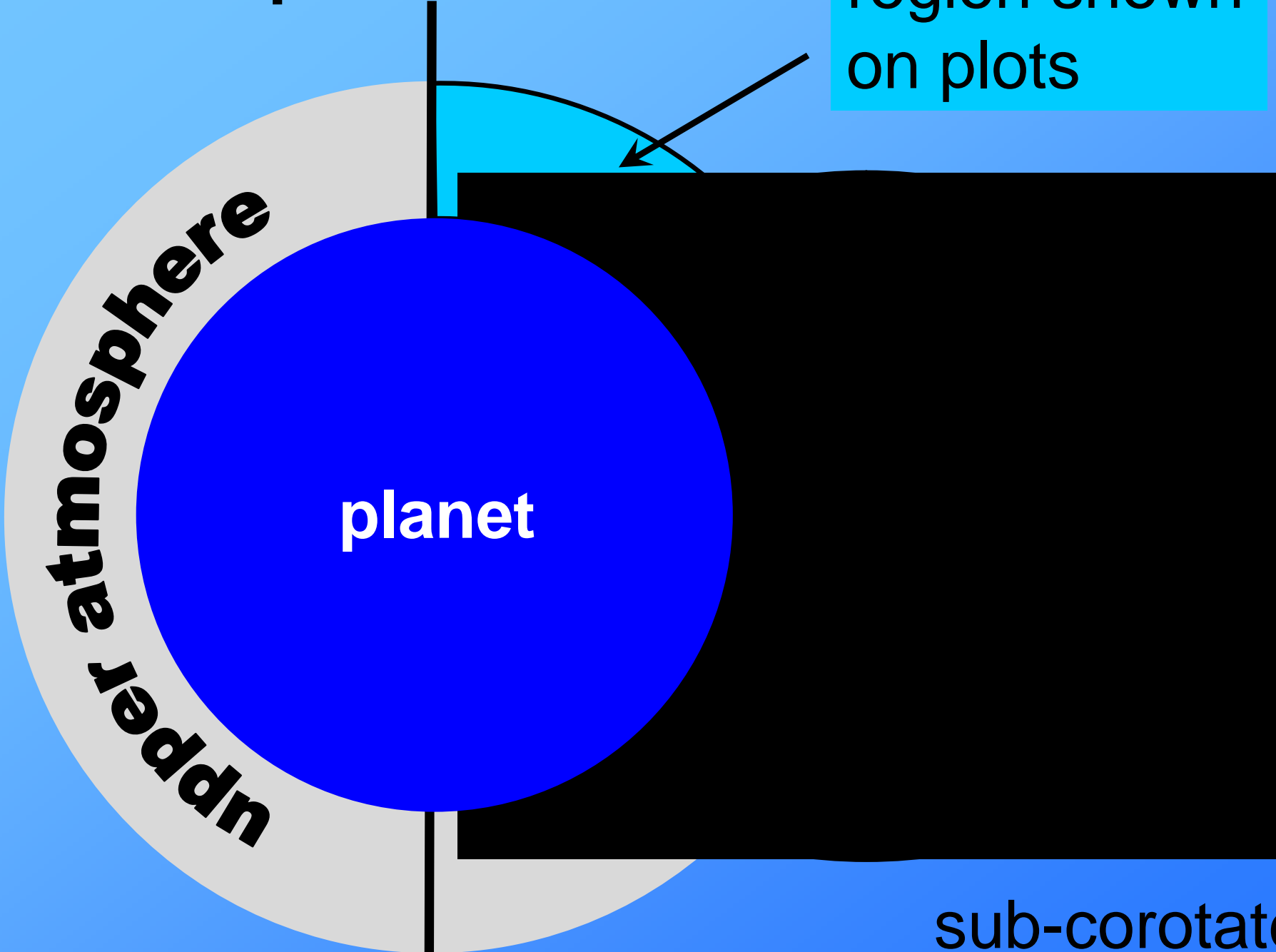
*... and see what happens*

some of our assumptions/omissions

- *axial symmetry*
- *fixed ionosphere model*
- *fixed temperature lower boundary*
- *no radiative cooling included in the model*

North pole

region shown  
on plots

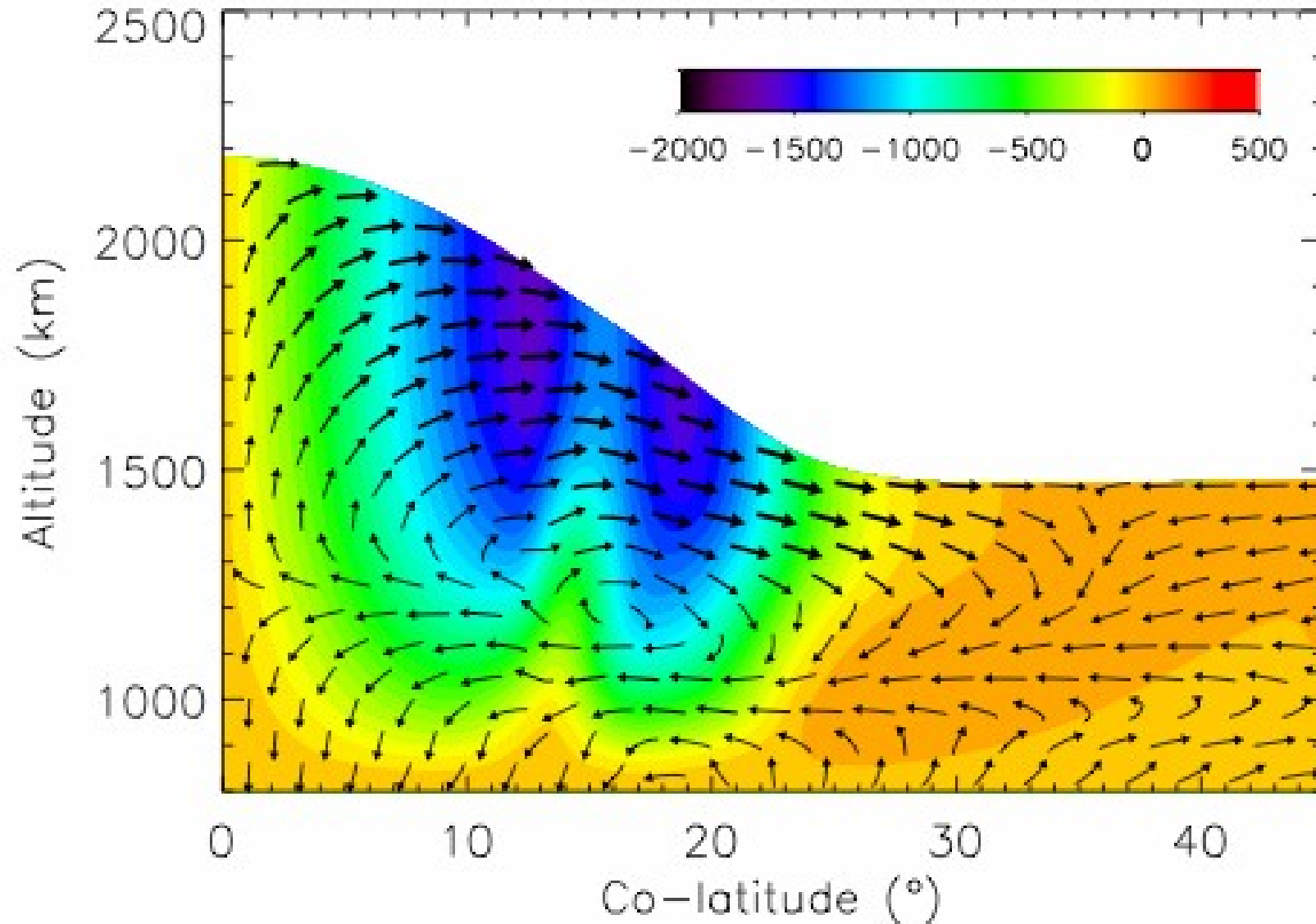


outer atmosphere

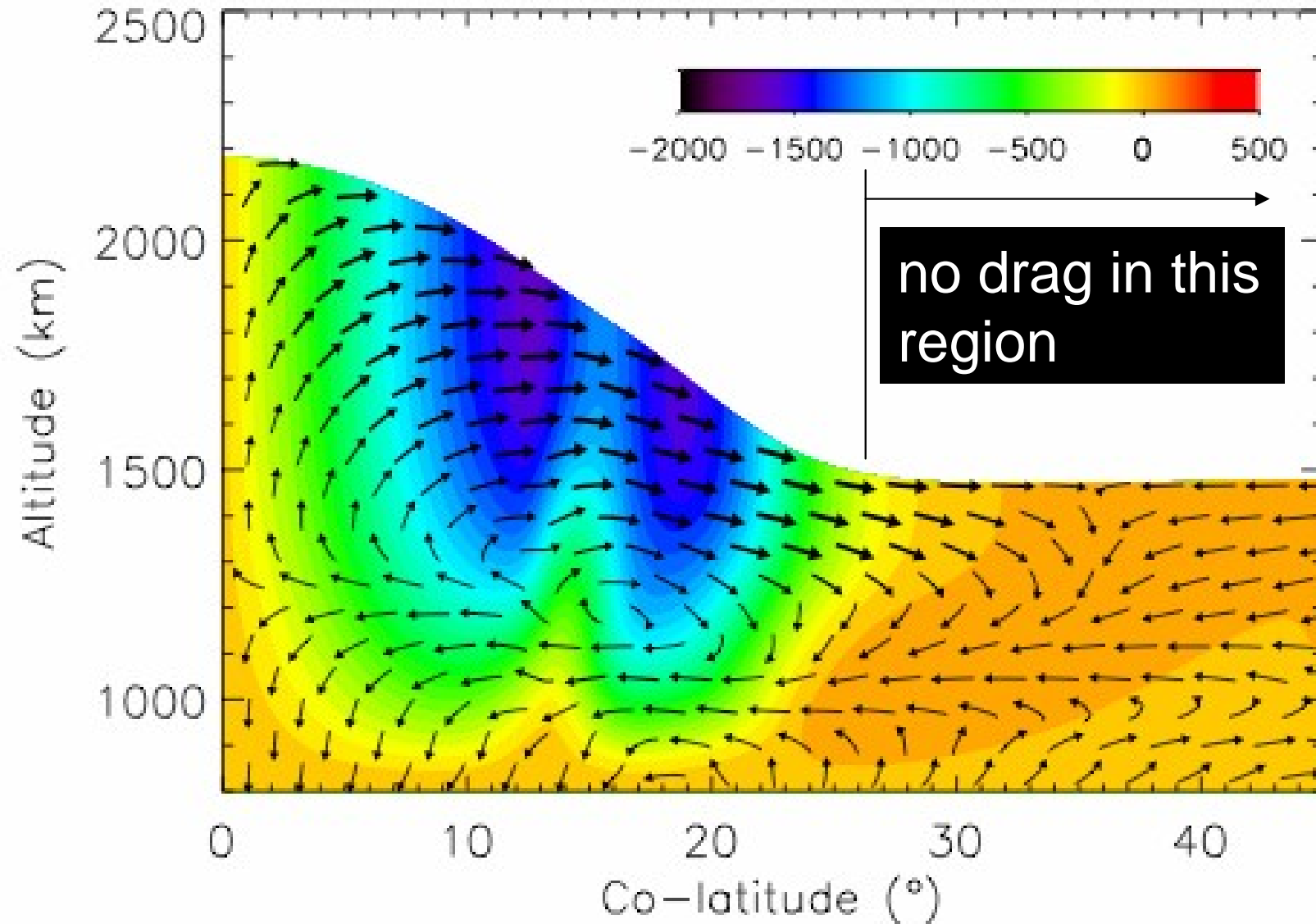
planet

sub-corotates

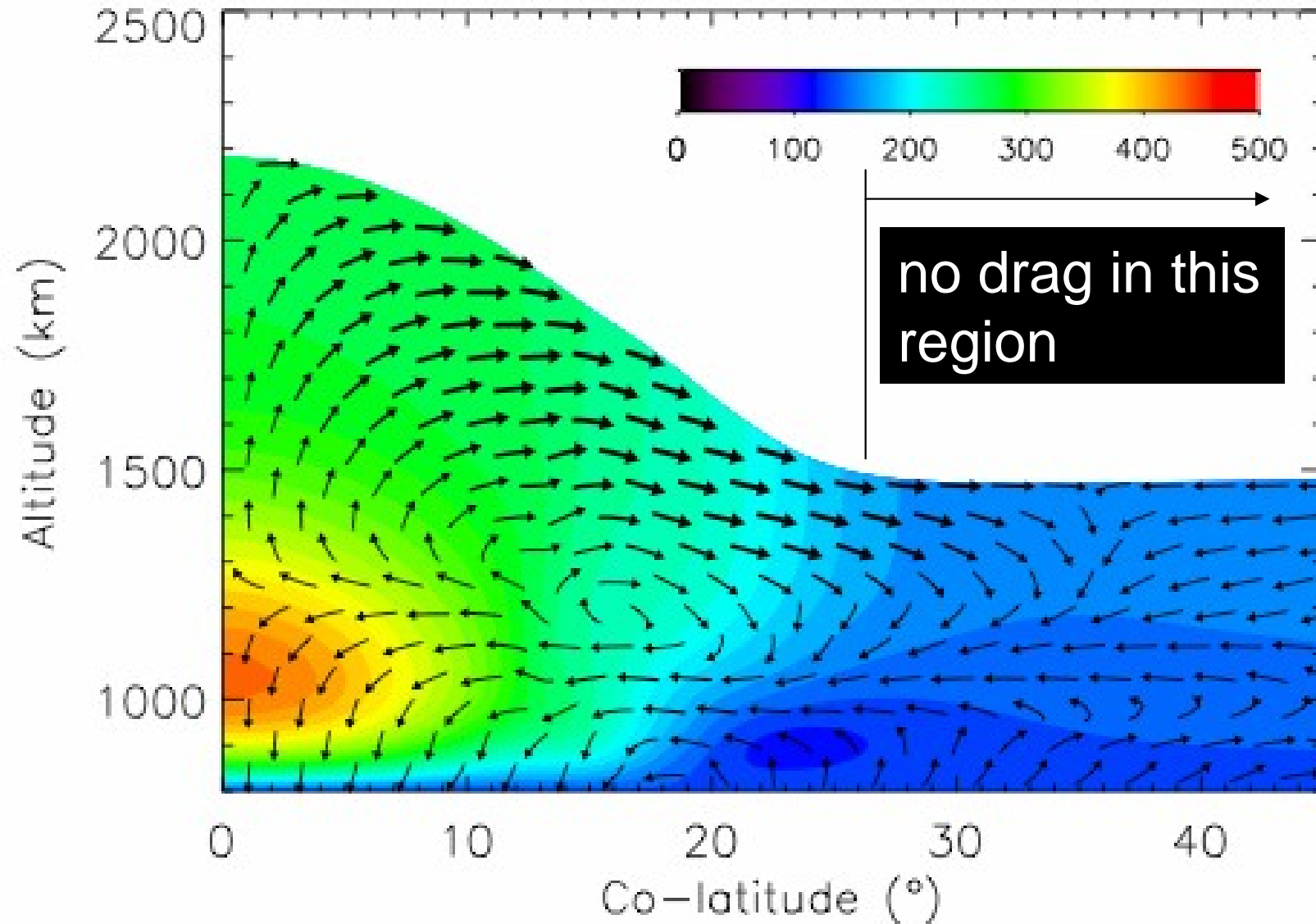
# Results: winds



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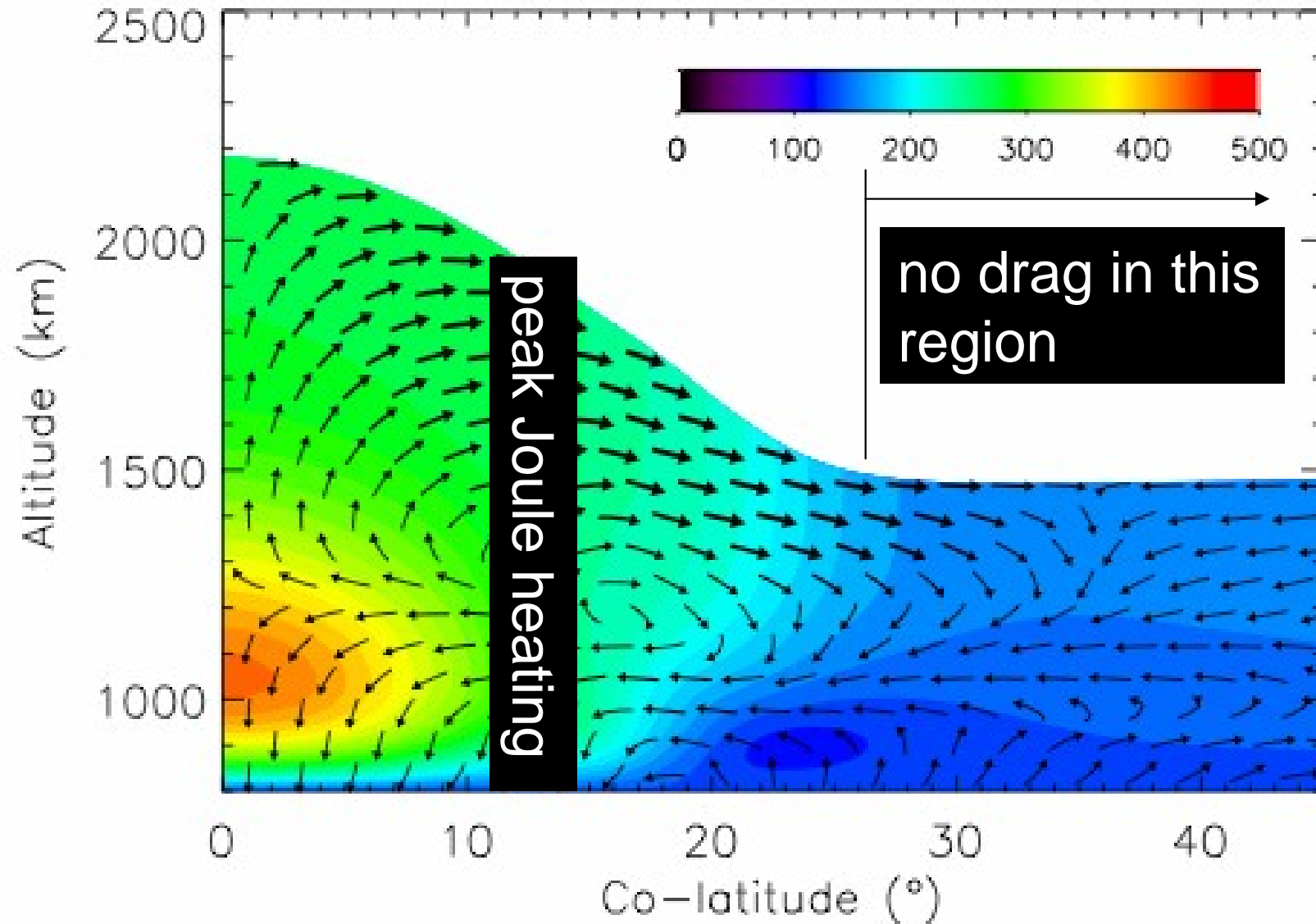


# Results: temperatures

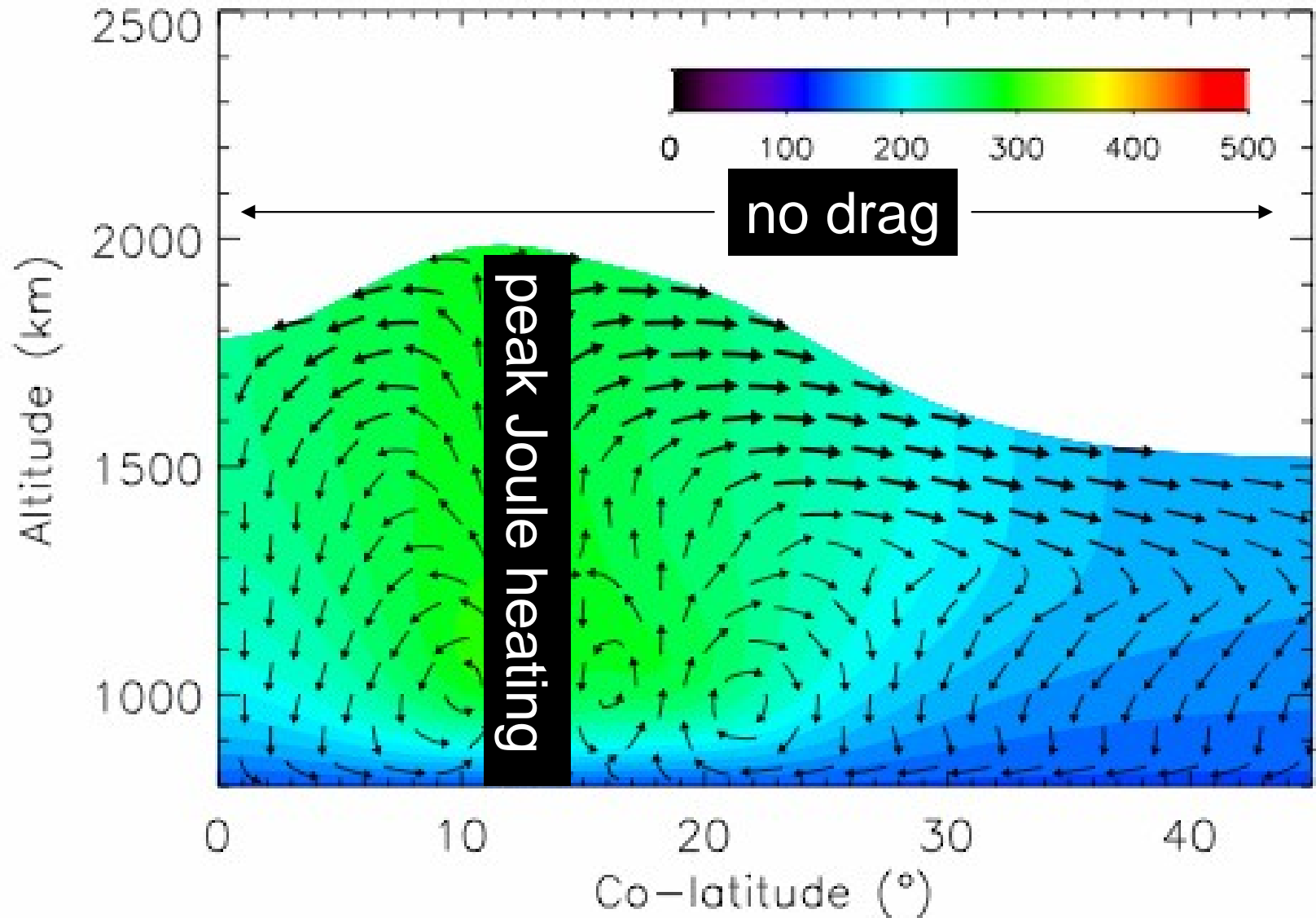




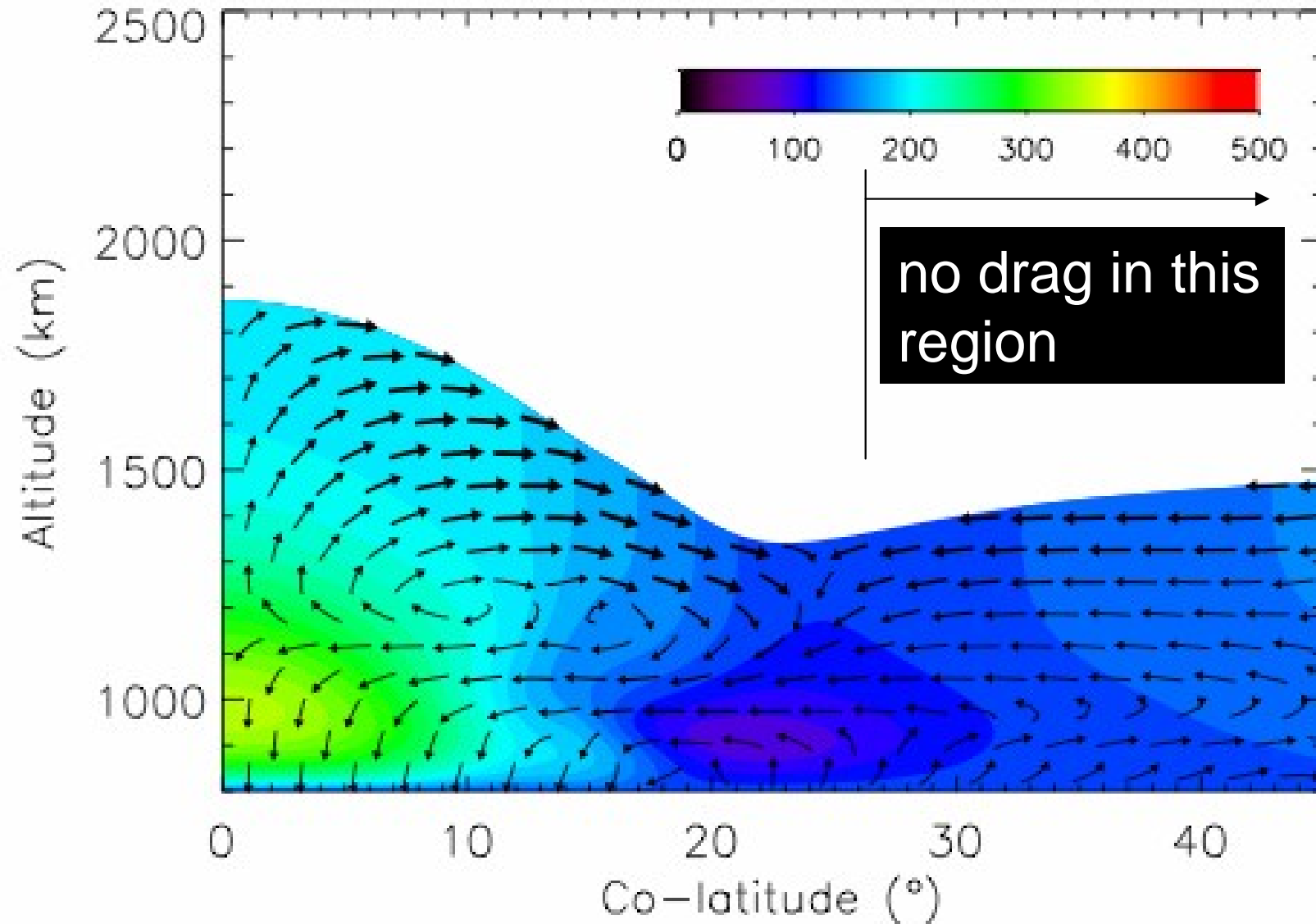
# Results: temperatures



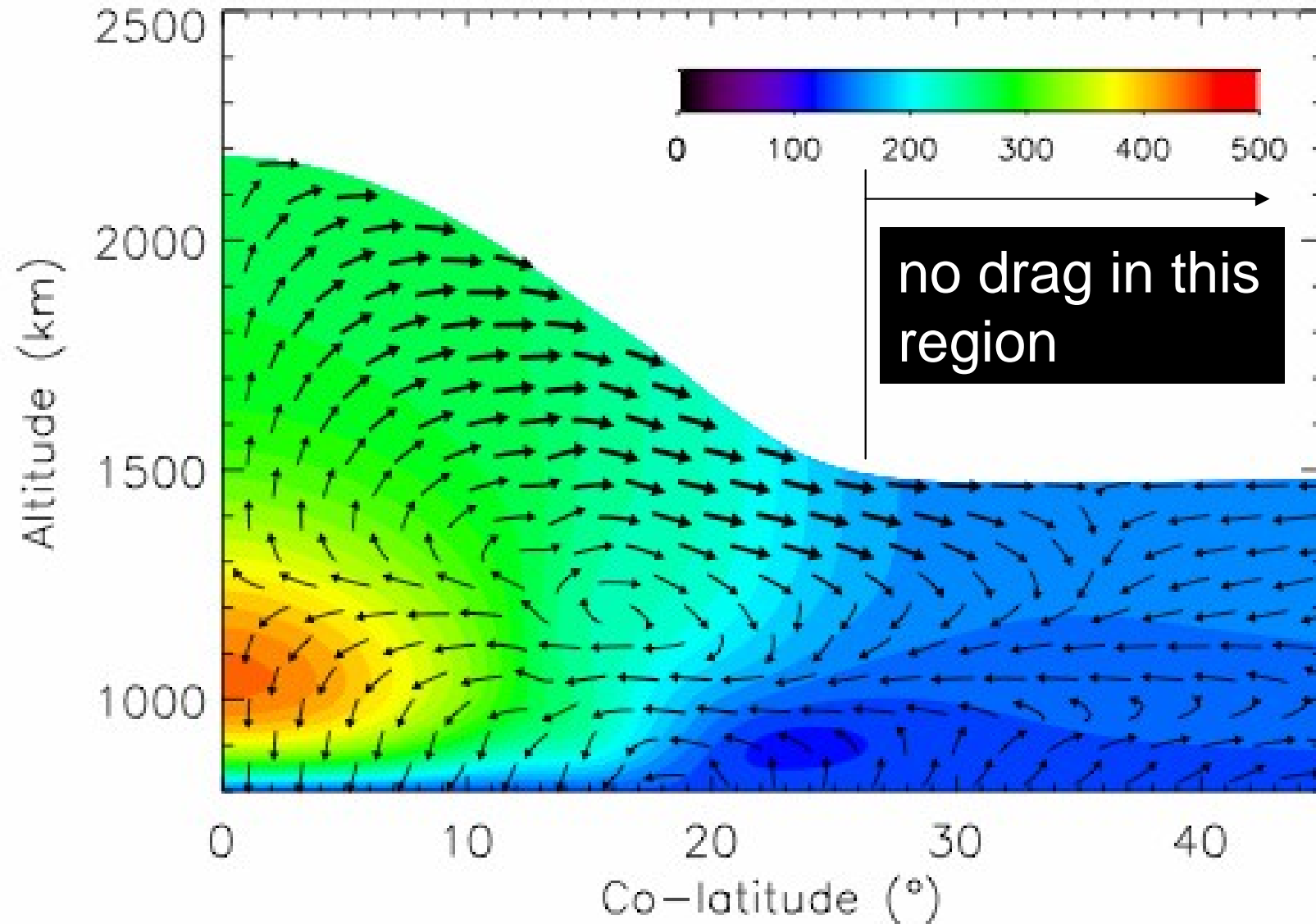
# Temperatures: no ion drag



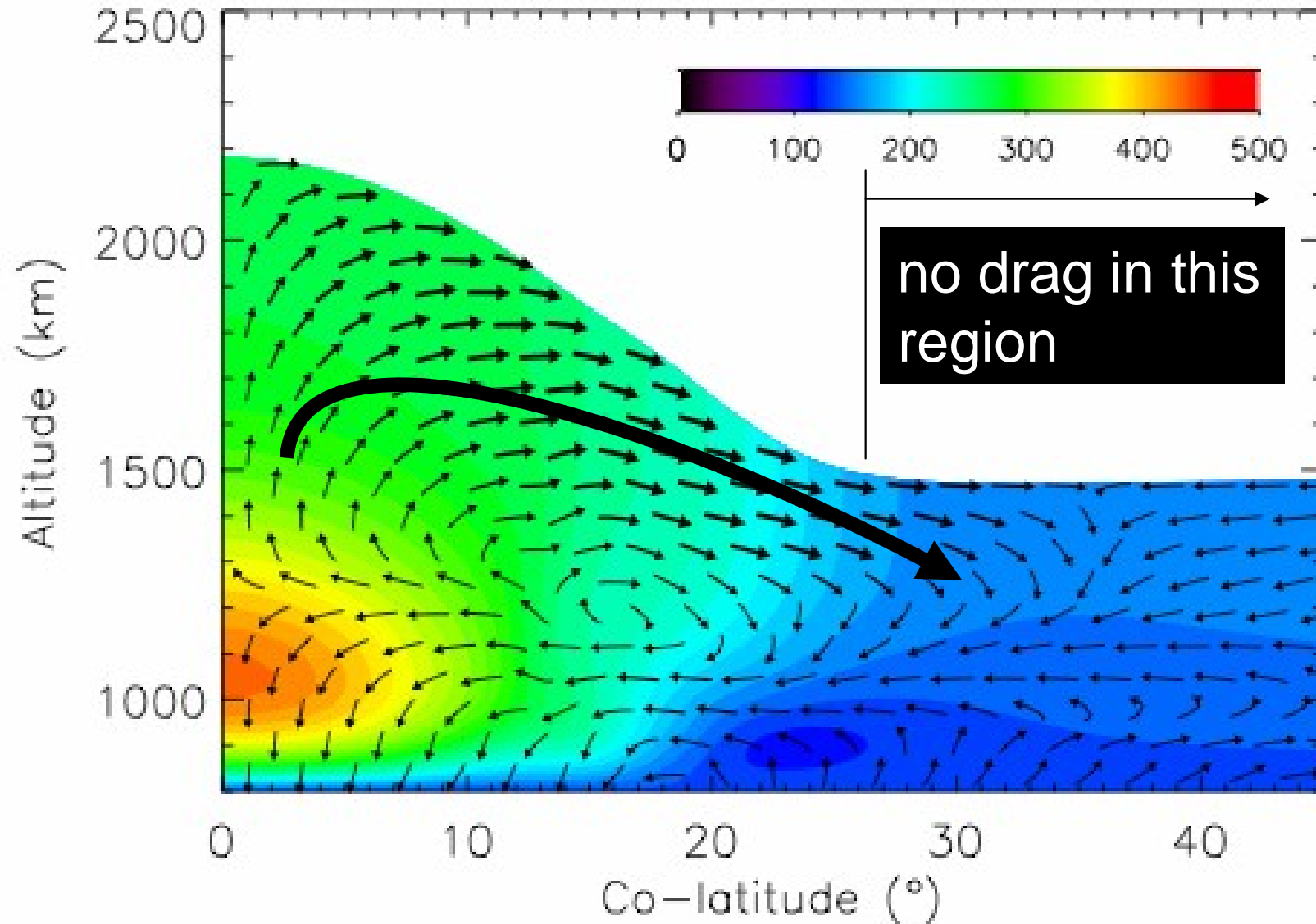
# Temperatures: no Joule heating



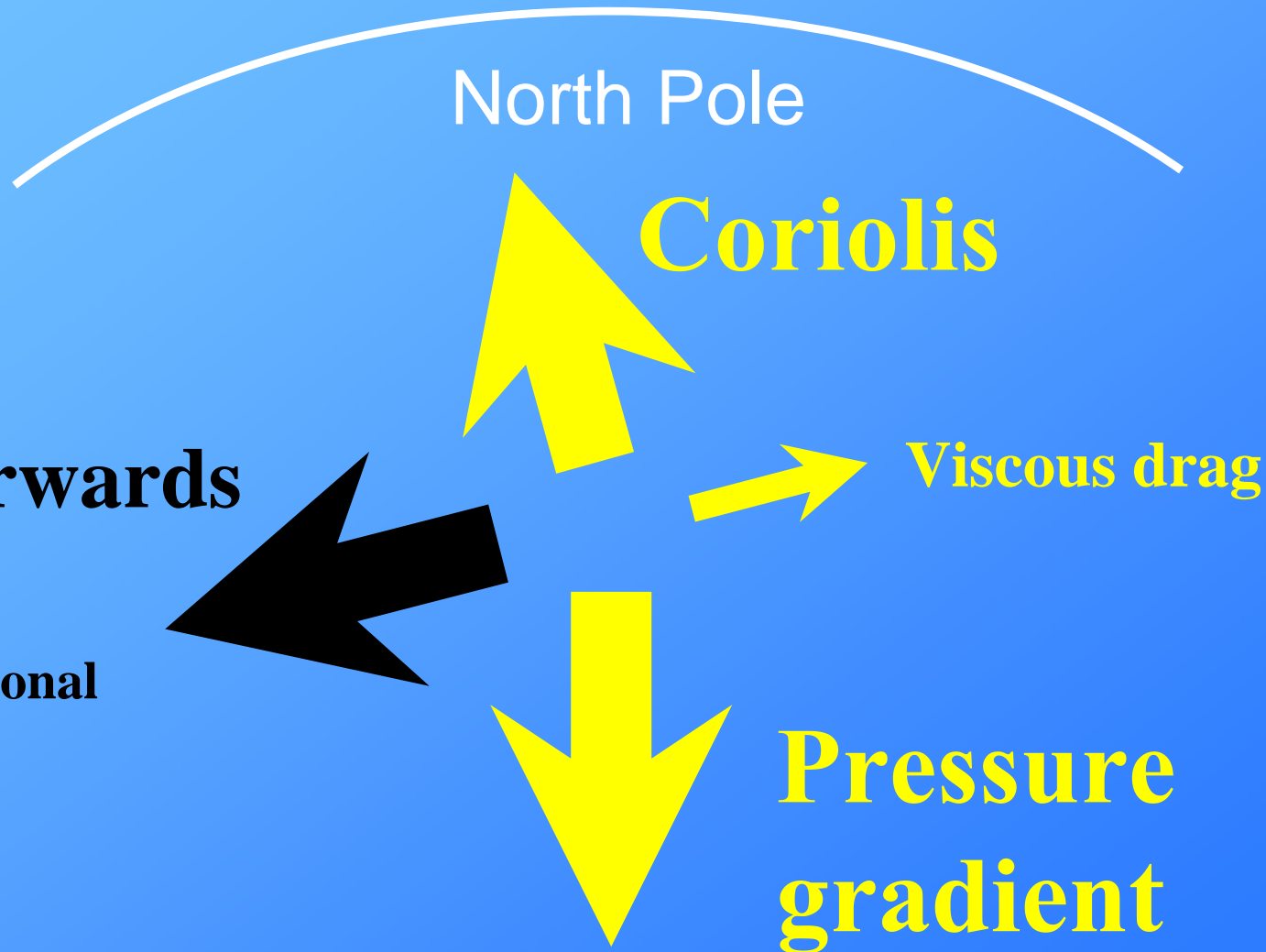
# Temperatures: full model



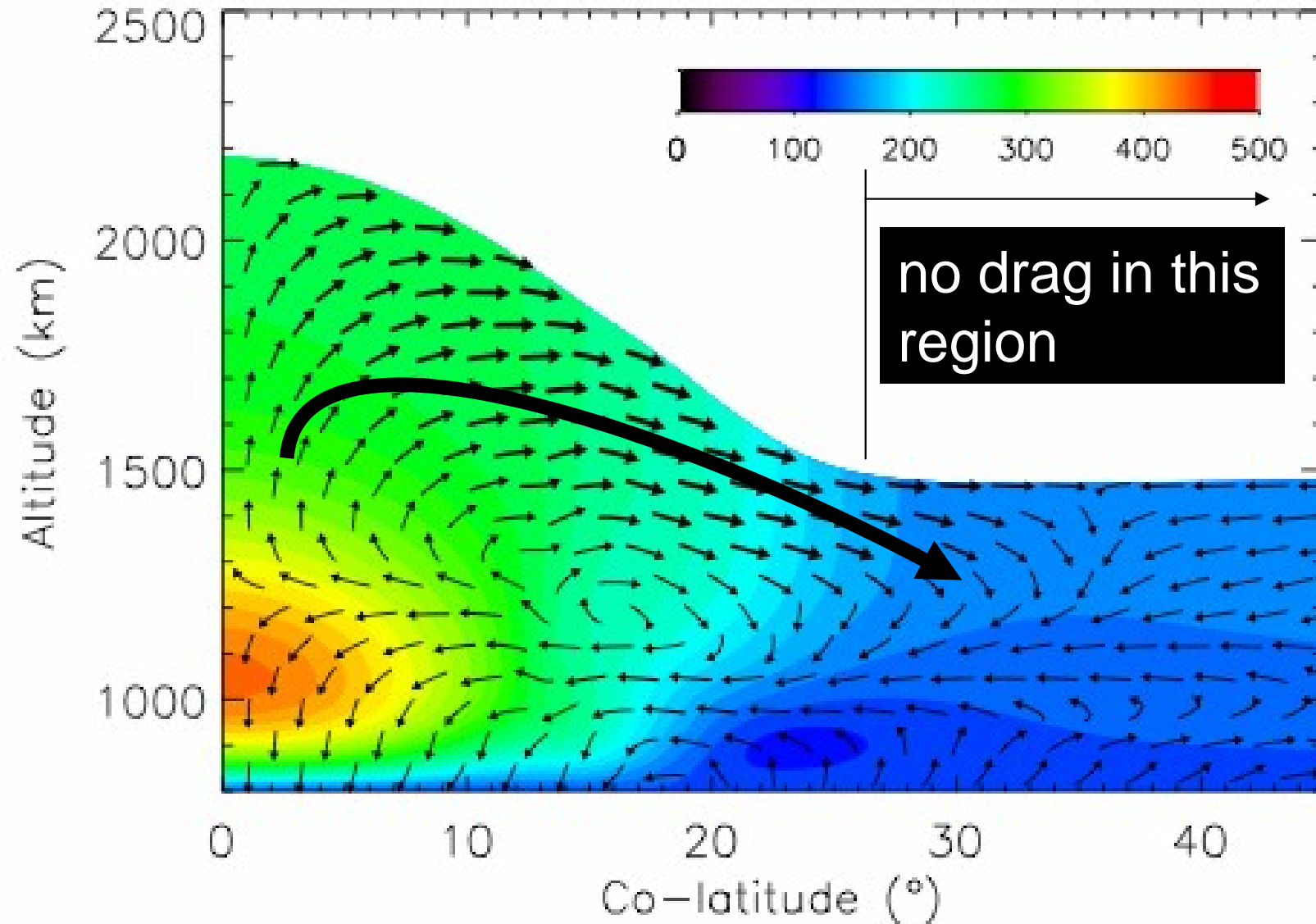
# Temperatures: full model



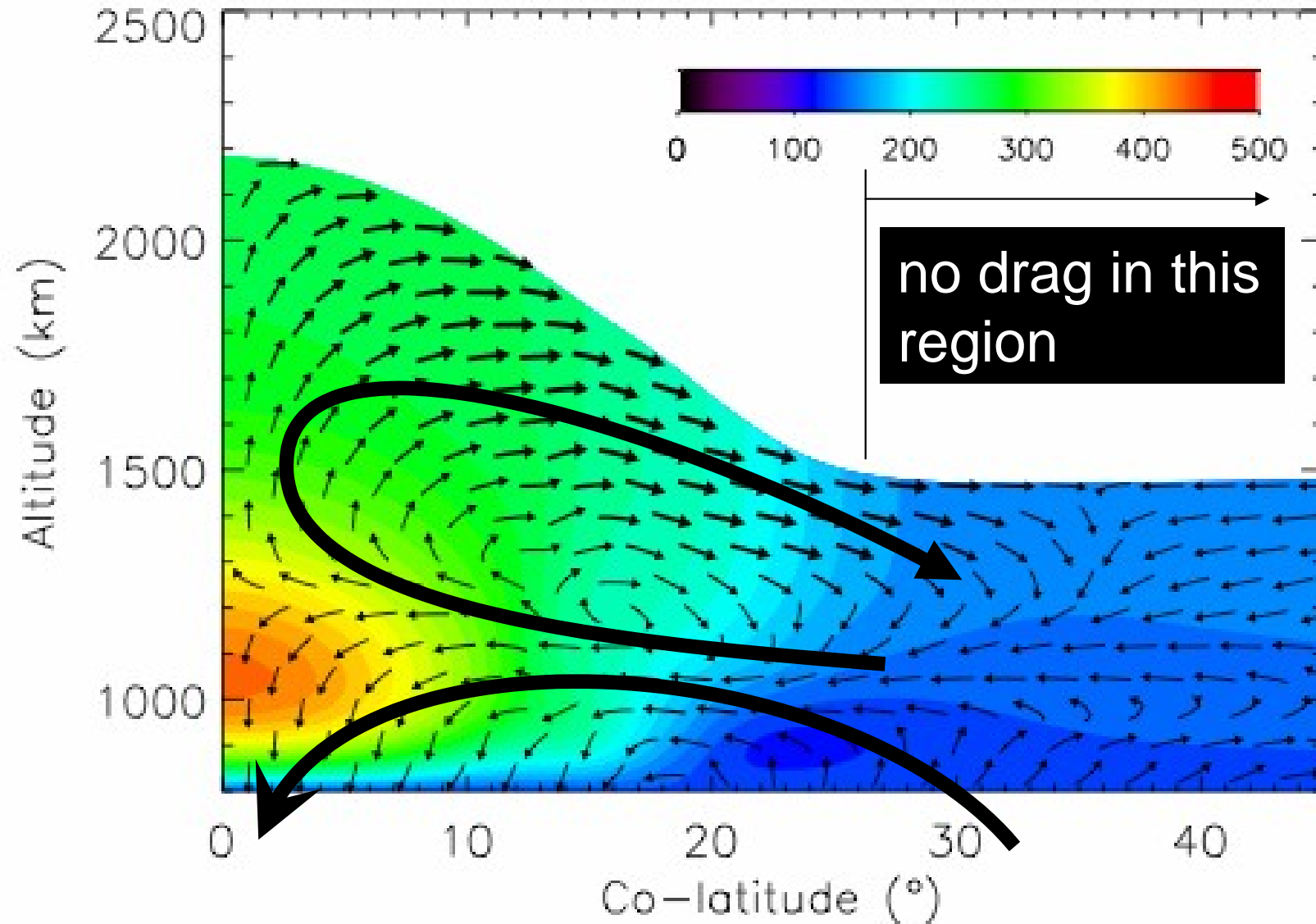
# Cause of equatorwards wind



# Temperatures: full model

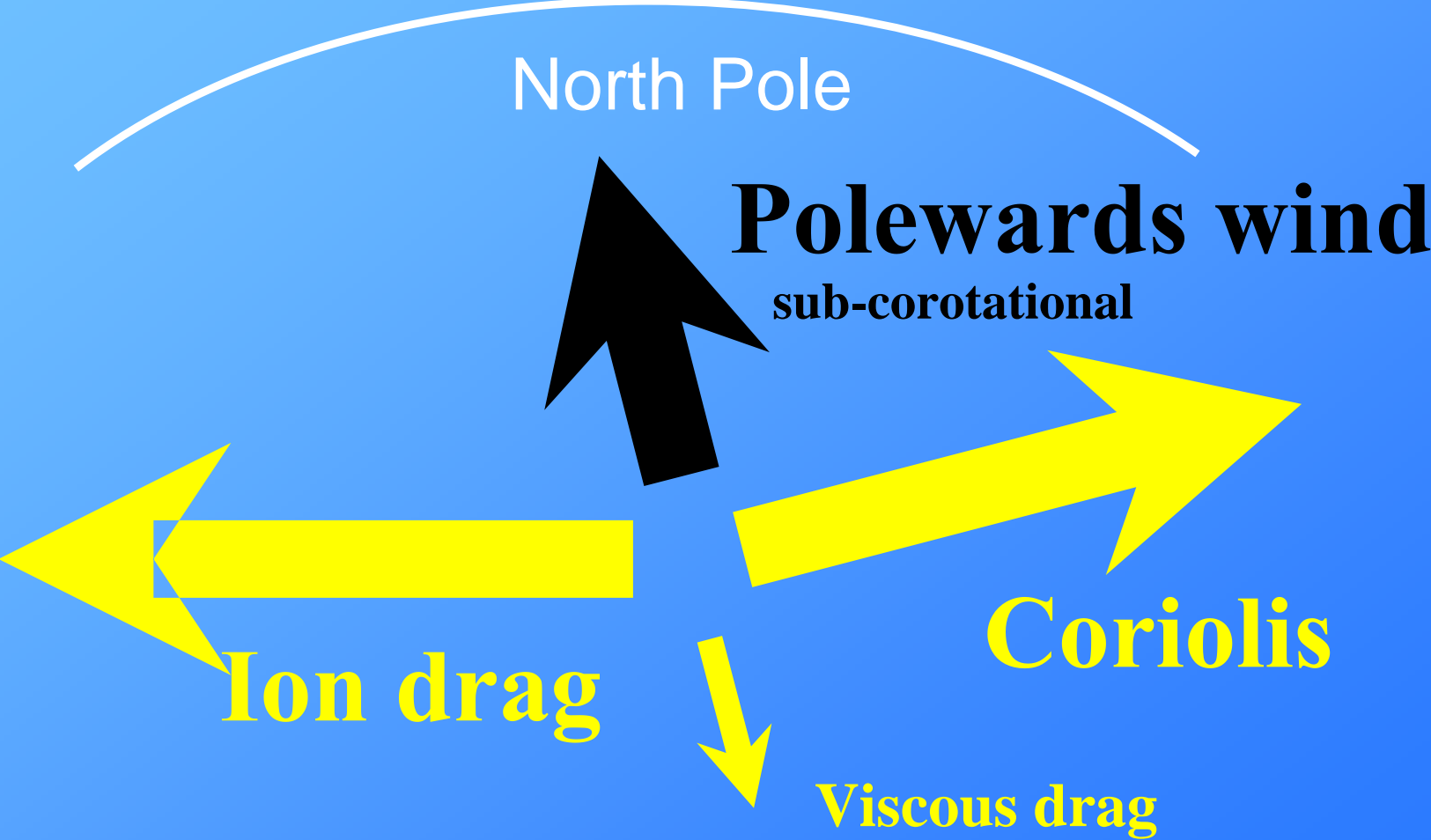


# Temperatures: full model

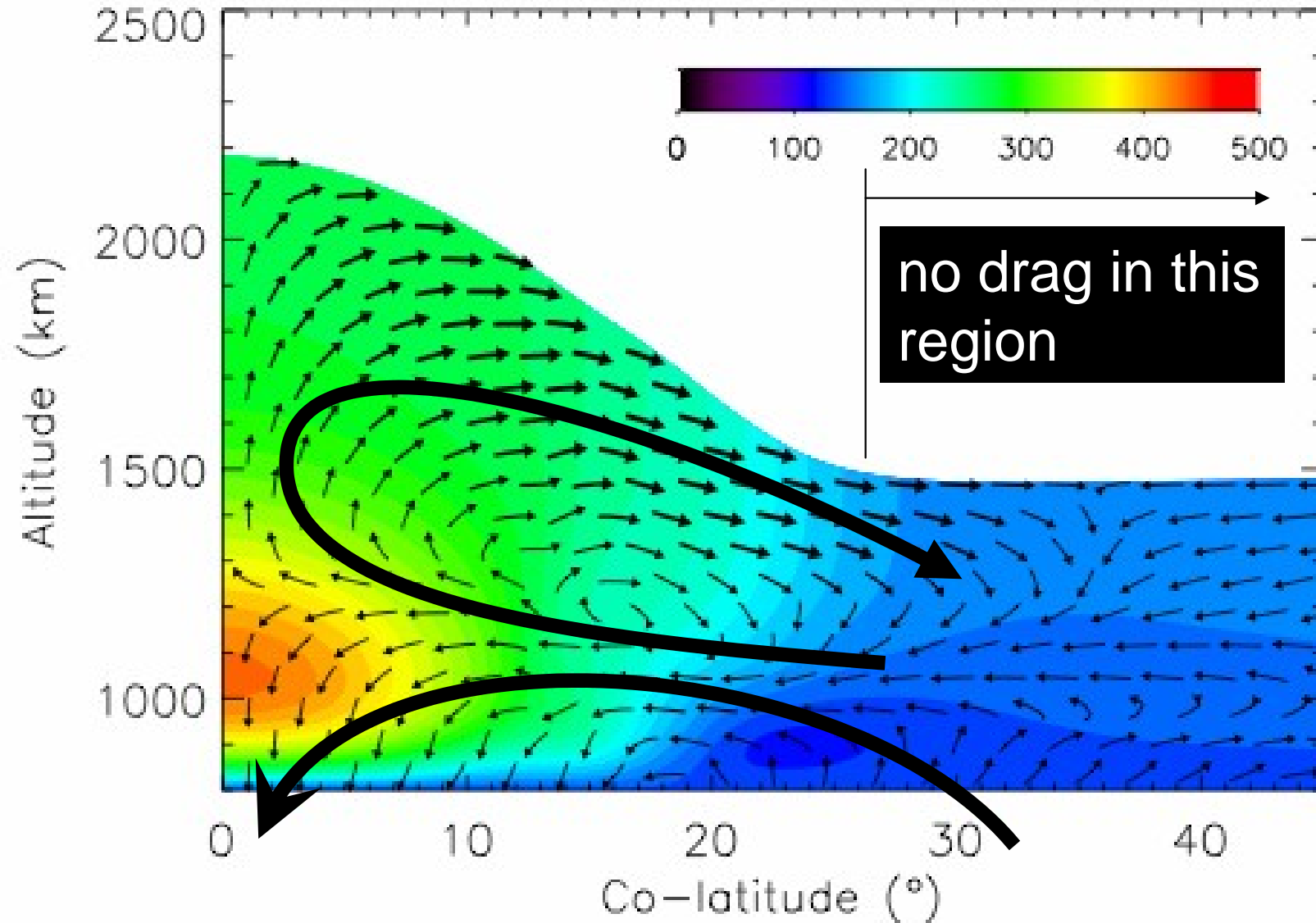




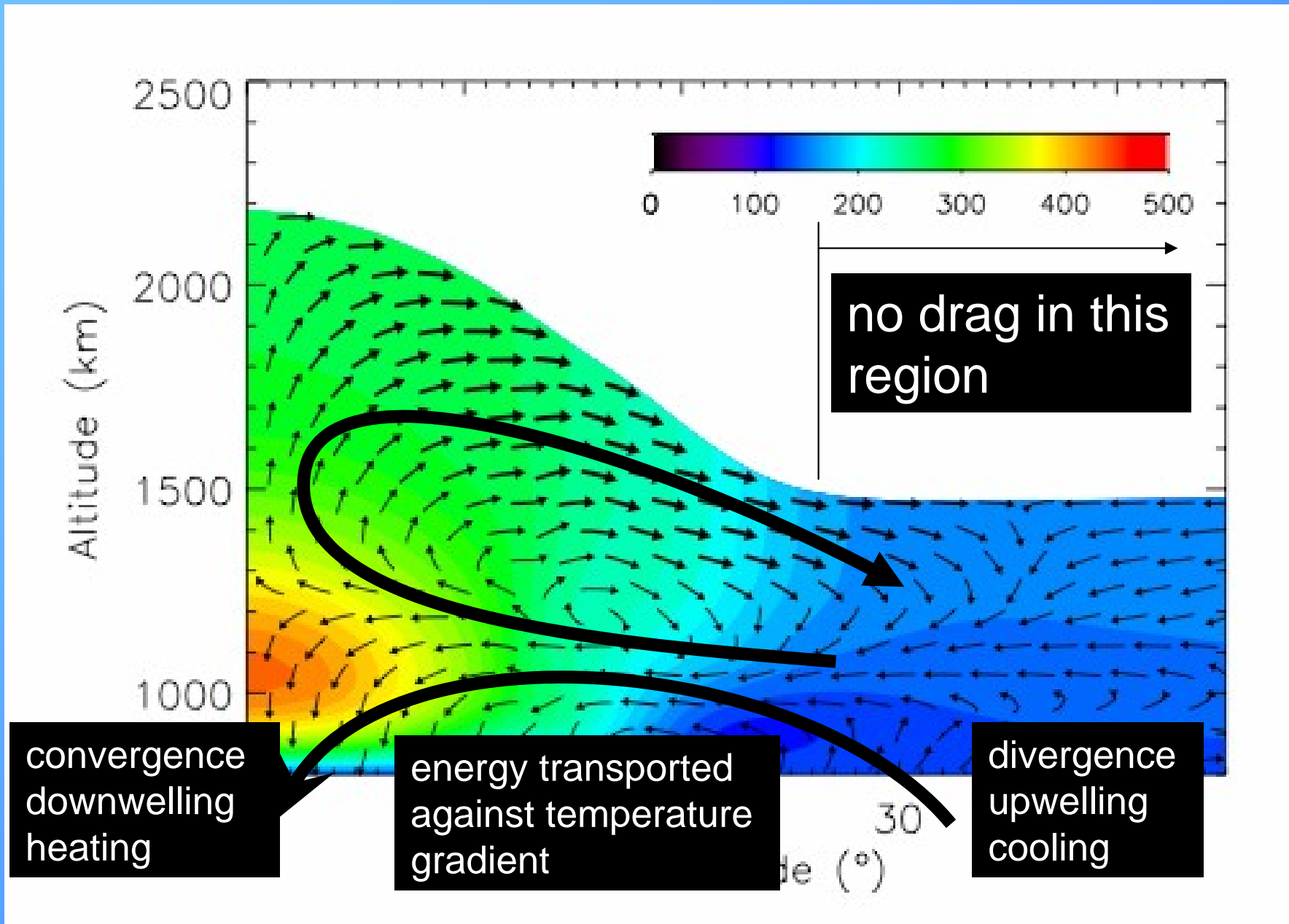
# Cause of polewards wind



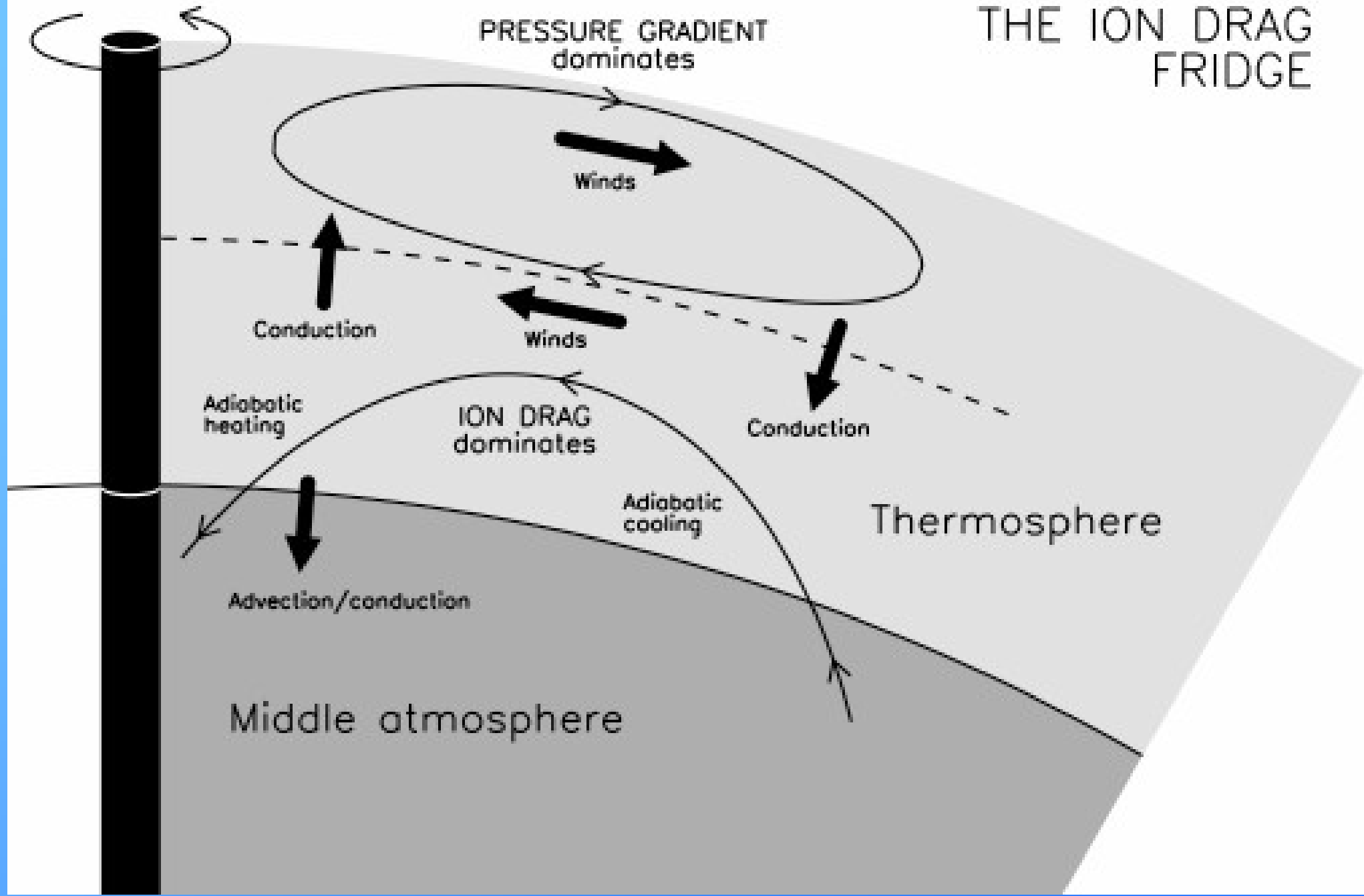
# Temperatures: full model



# Temperatures: full model



# THE ION DRAG FRIDGE



# Conclusions

## Jupiter/Saturn

- ion drag dominates the thermal structure of the polar upper atmosphere
- the “fridge” flow restricts the distribution of heat from high to low latitudes by meridional winds
- so polar heating is probably not responsible for the high thermospheric temperatures
- **dynamics cannot be ignored: we need three-dimensional models**

# Conclusions

other planets

- Earth
  - “fridge” probably does not exist: magnetosphere is not sufficiently rotation dominated
- Uranus/Neptune
  - magnetospheres are much more complicated
  - non-aligned magnetic fields/slower rotation speed
- exoplanets
  - in principle should exhibit similar behaviour
  - could the “fridge” regulate the thermospheric temperatures?
  - require some simple 3D models of exoplanet thermospheres/ionospheres/magnetospheres

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