

# Galileo Spacecraft Explores Jupiter's atmosphere

Andrew Ingersoll

Pioneer 1972

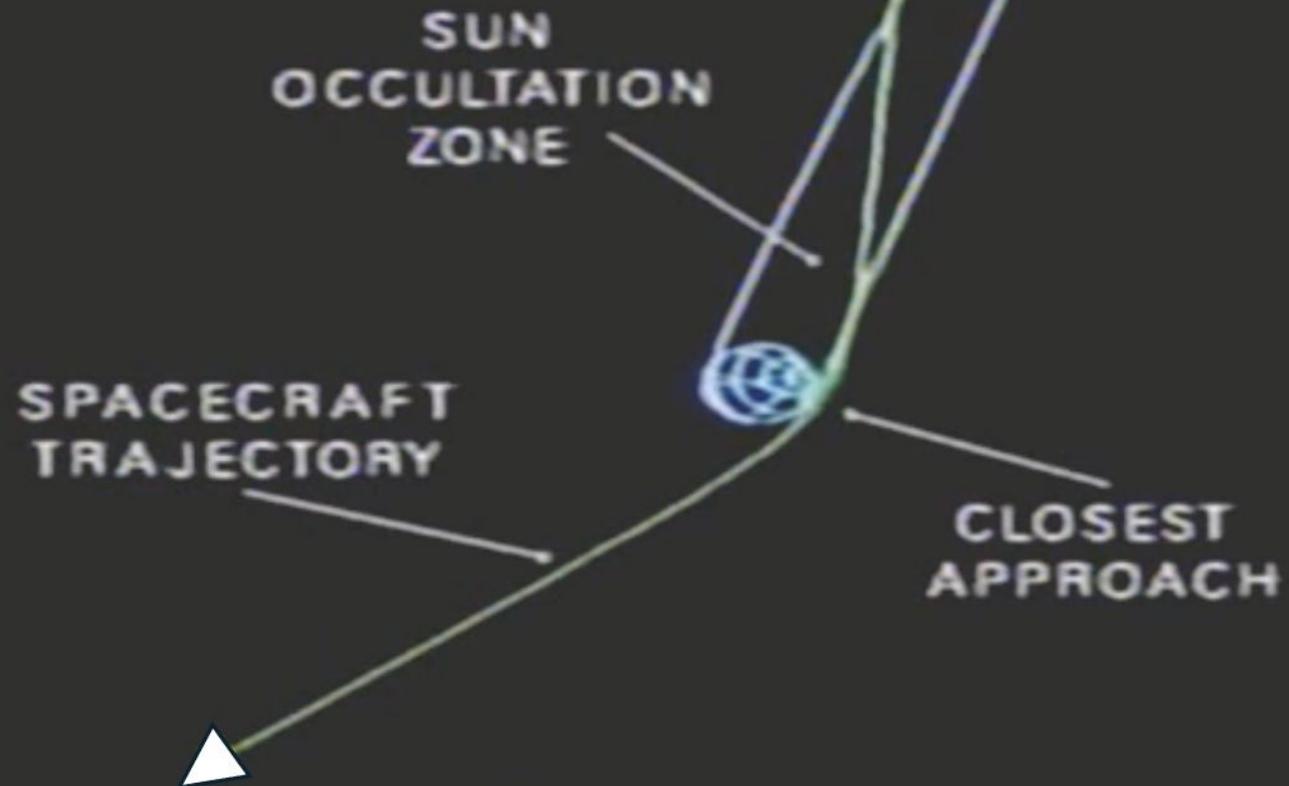
Voyager 1979

Galileo 1995-2003

Cassini 2000

Juno 2016-present

# Galileo EARTH 1 FLYBY



1990 Dec 8 23:01:16 GMT



Earth Flyby 1  
Dec 8, 1990

Rich Terrile  
Carl Sagan  
Andy Ingersoll



Galileo Earth Flyby  
Dec 10, 1990



## Elemental abundances

Sun and meteorite both  
normalized by silicon

Anderson and  
Grevesse, 1989:

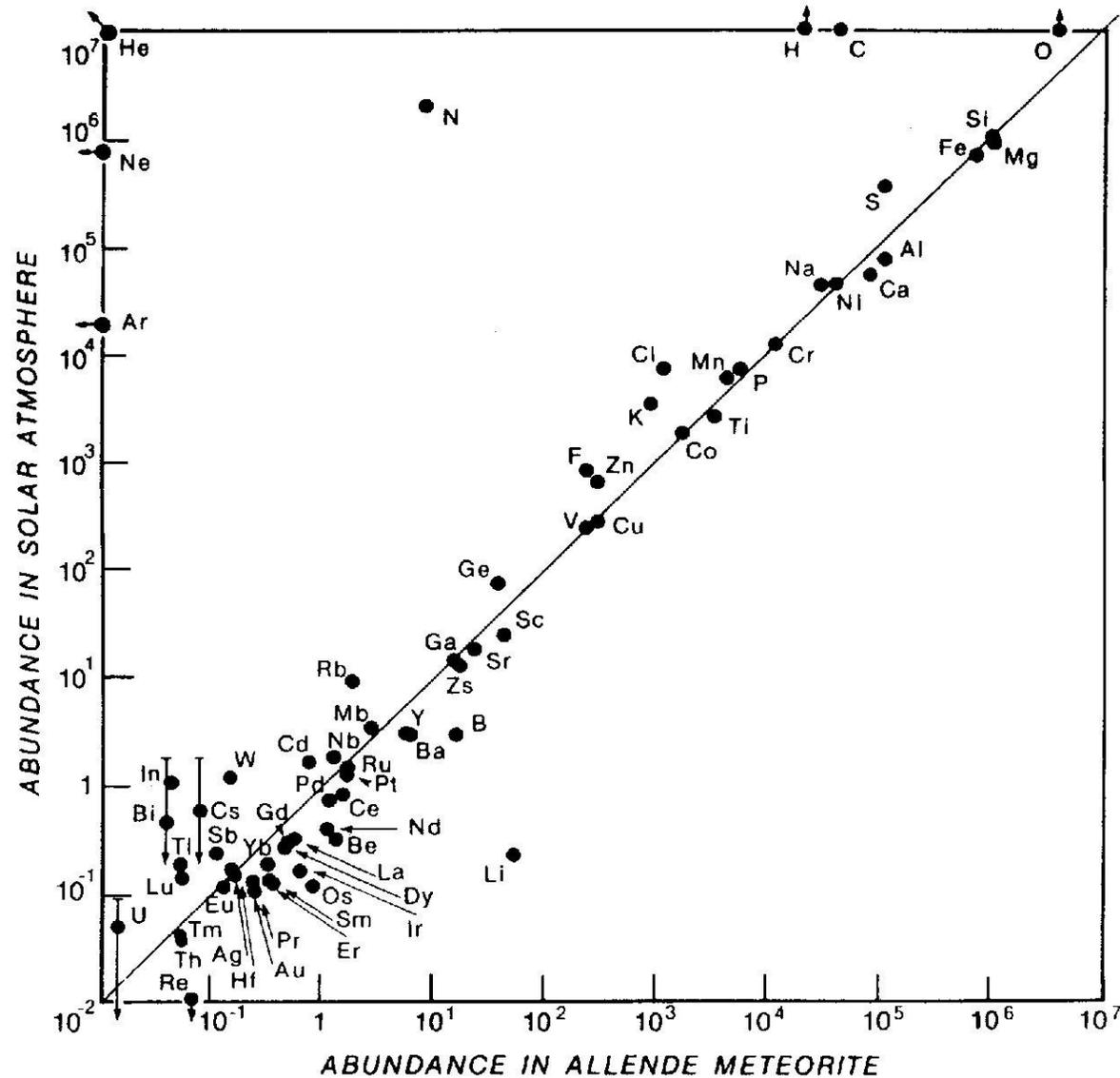
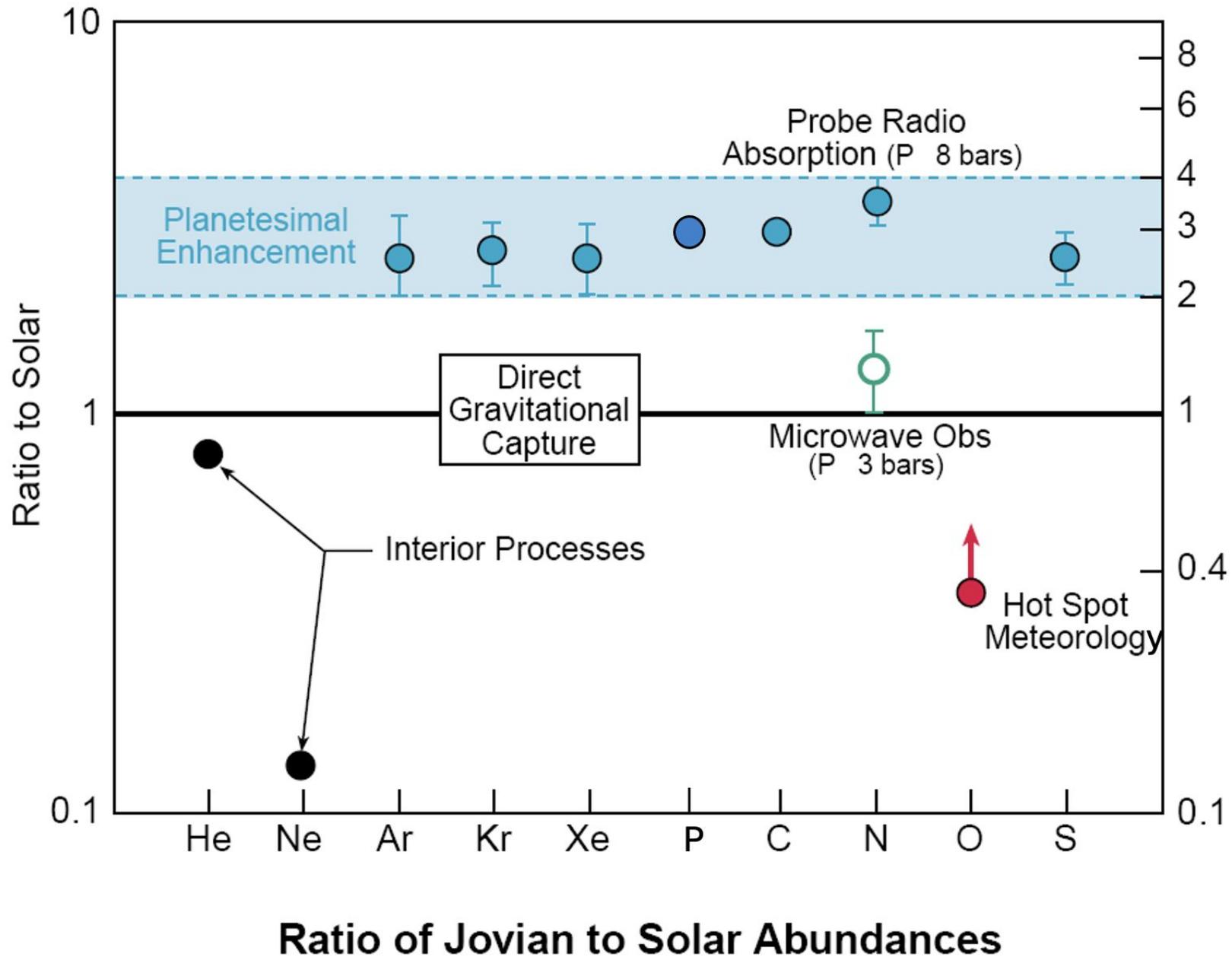


FIGURE 8.2 The abundance of elements in the Sun's photosphere plotted against their abundance in the Allende CV3 chondrites. Most elements lie very close to the curve of equal abundance (normalized to silicon). Several volatile elements lie above this curve, presumably because they are depleted in meteorites (rather than being enriched in the Sun), whereas only lithium, which is depleted in the solar photosphere because it is destroyed by nuclear reactions near the base of the Sun's convective zone, lies substantially below the curve.

Galileo probe mass spectrometer Dec 7, 1995

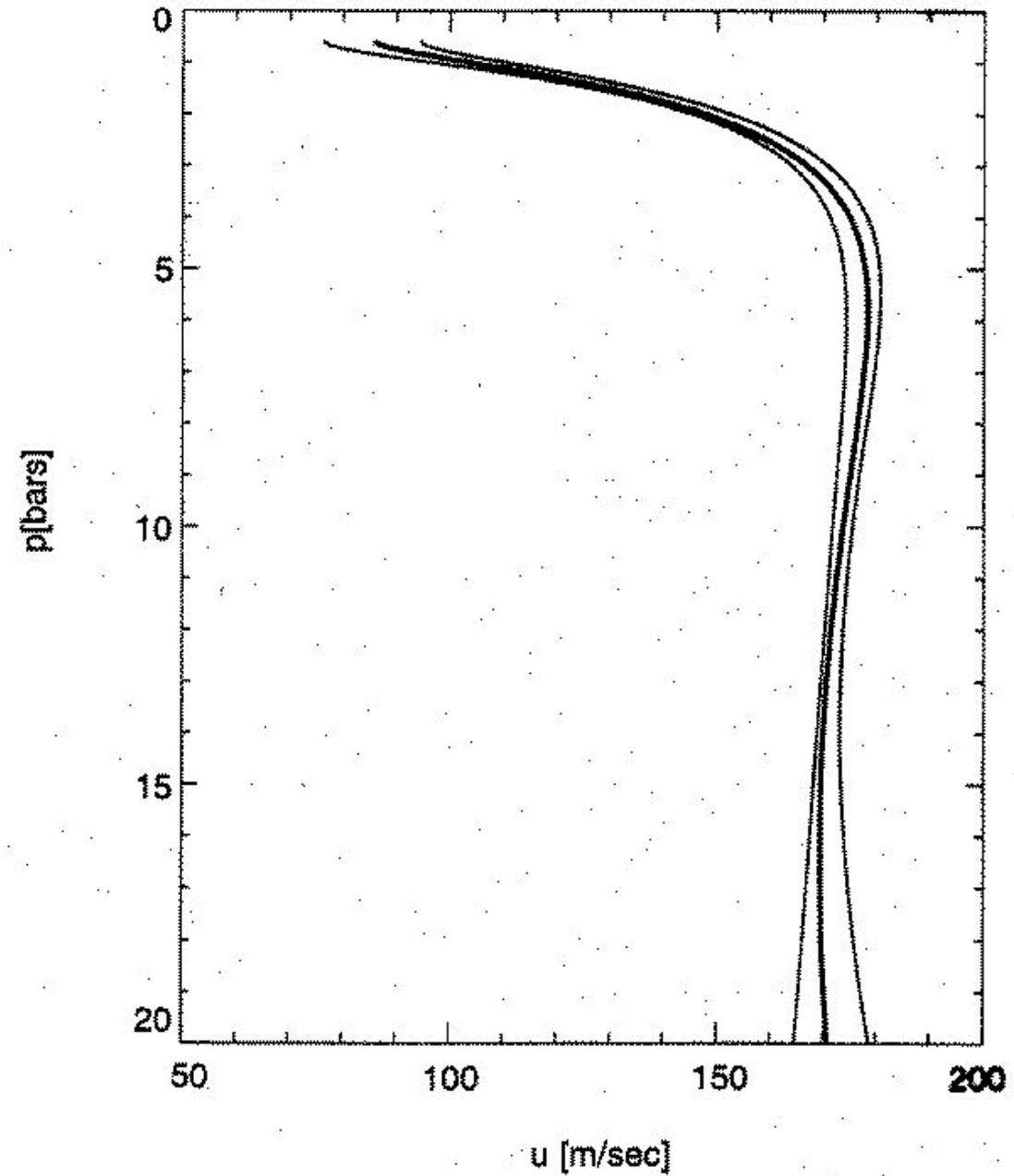
Elements normalized by hydrogen: Loss of H leads to enhancement of other elements relative to the Sun

Niemann et al., 1998  
Folkner et al., 1998  
Atreya and Wong, 2005



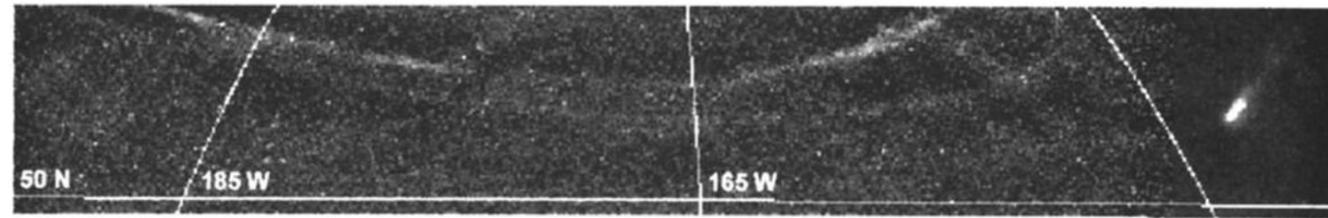
Galileo probe: Doppler tracking  
yields zonal wind vs depth

D. Atkinson et al. 1998

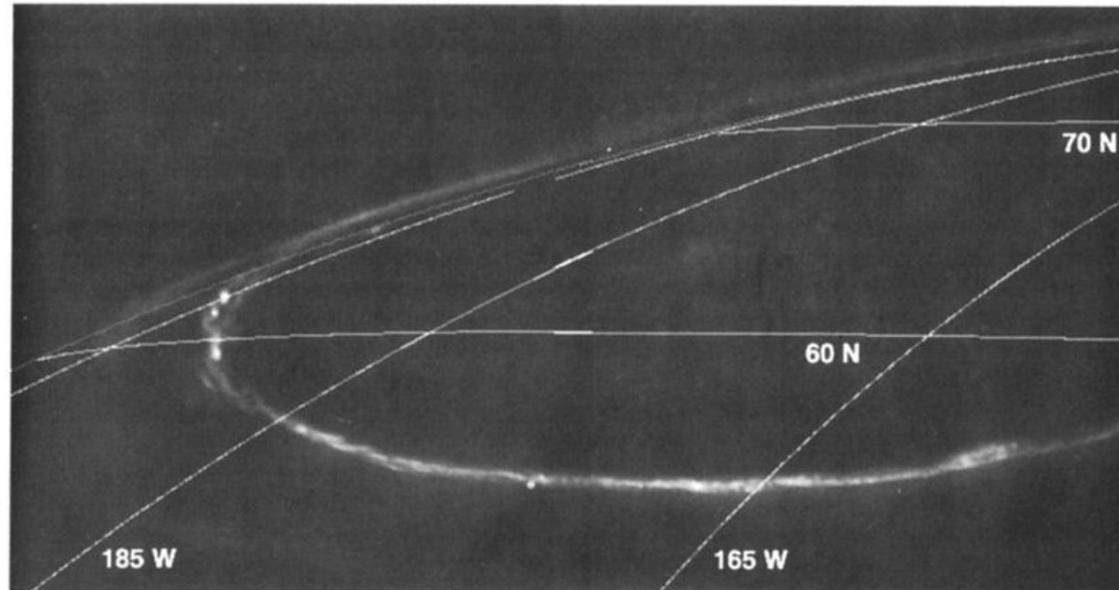


Galileo orbiter  
Dark side imaging of  
the auroral oval

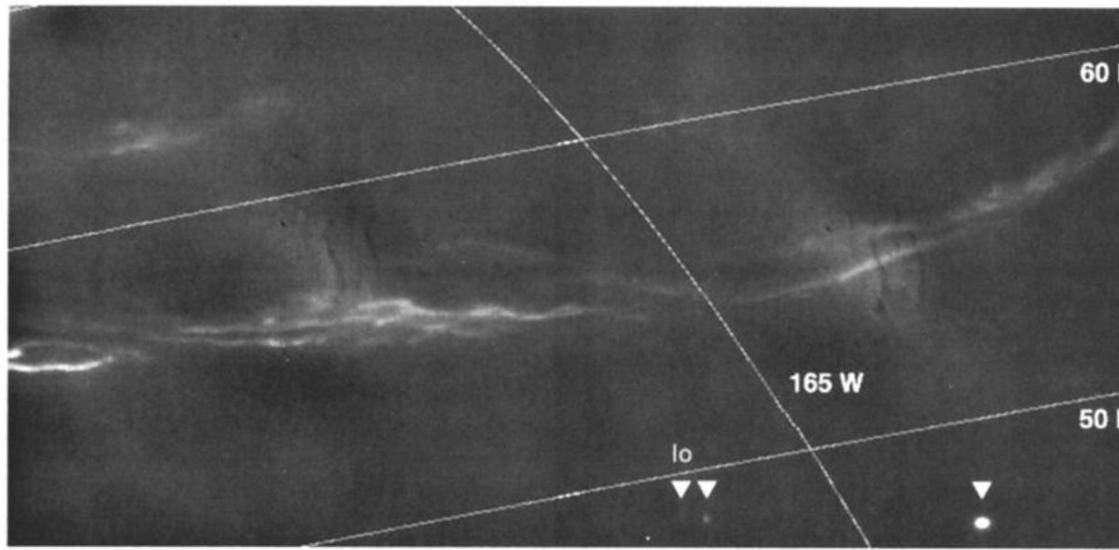
Vasavada et al., 1999



**A**



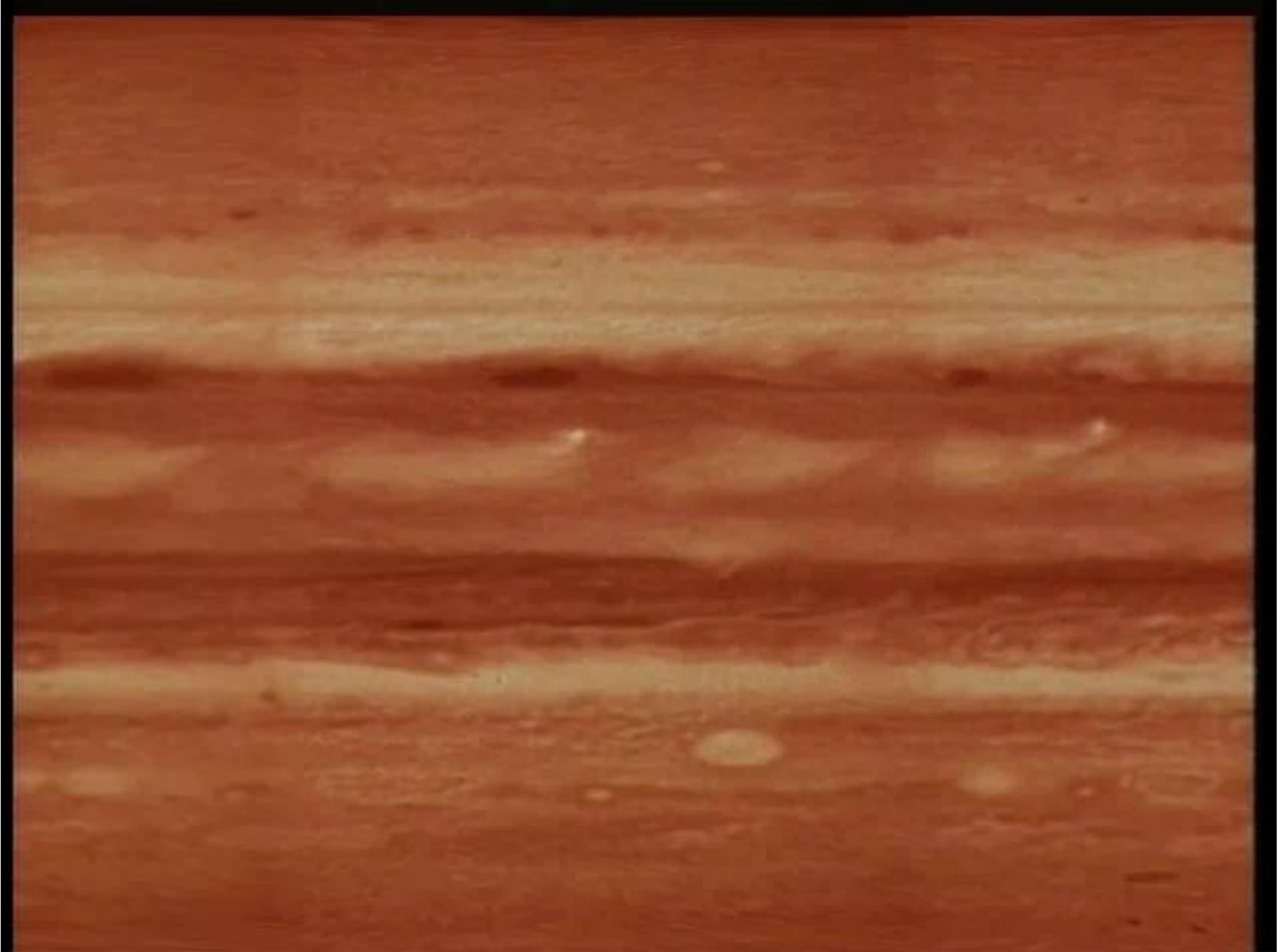
**B**

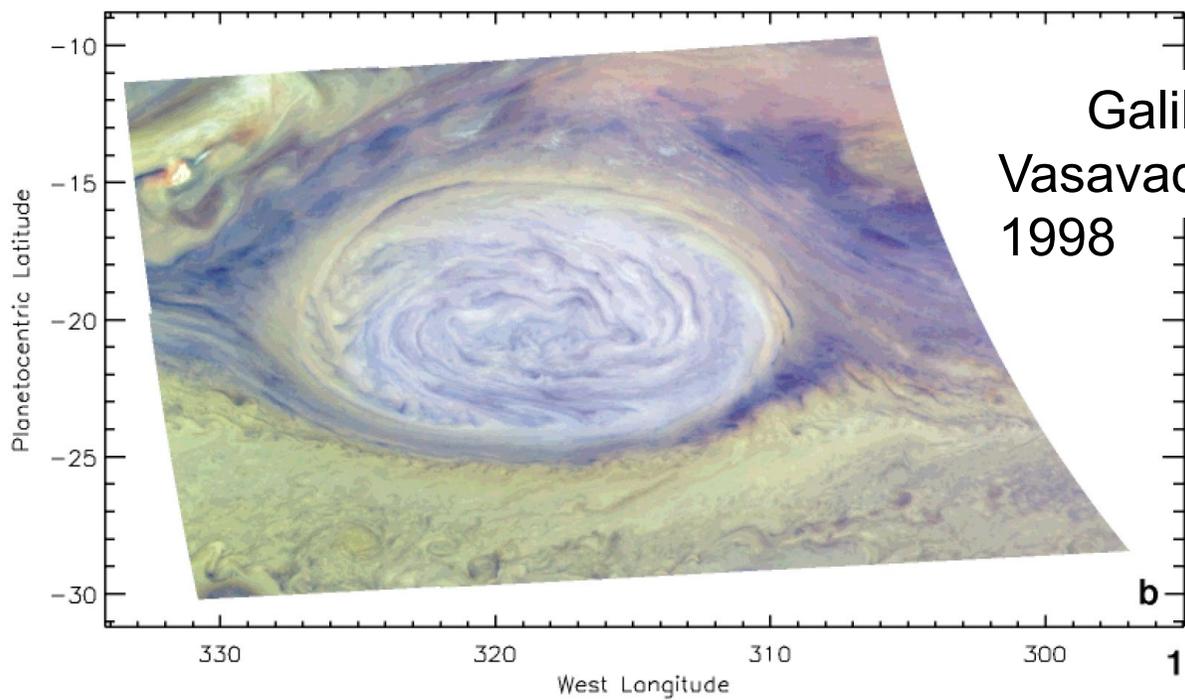
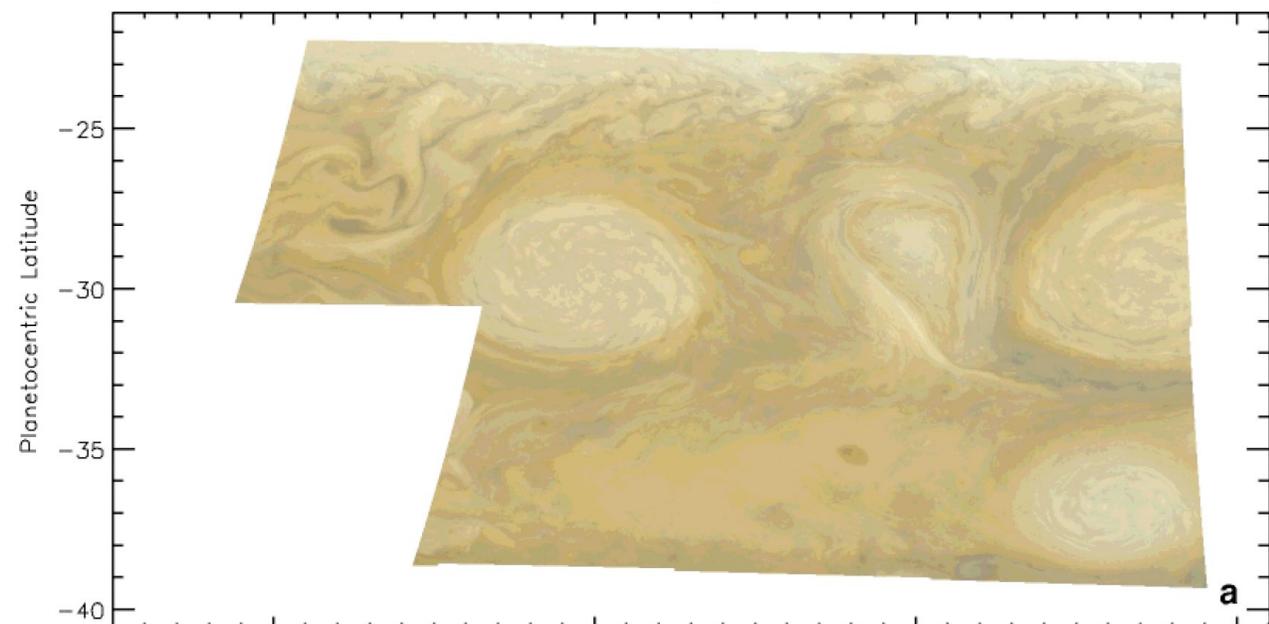
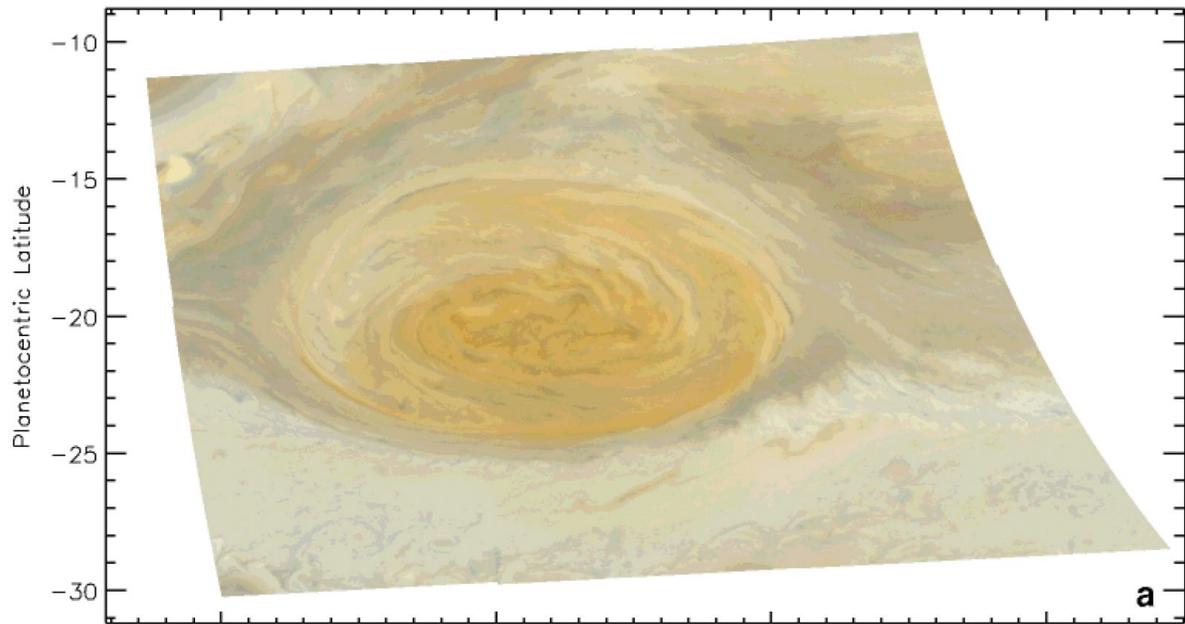


**C**

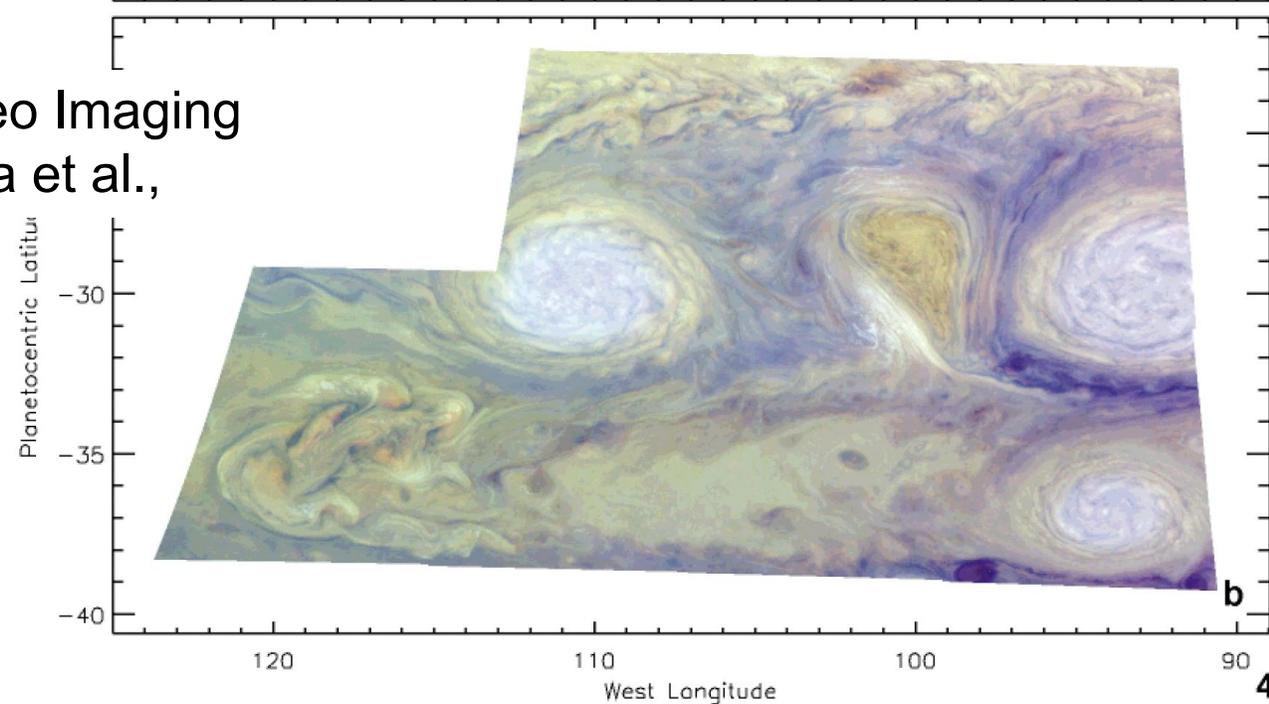
Voyager 1  
approach movie

duration 60 days  
time step 10 hours



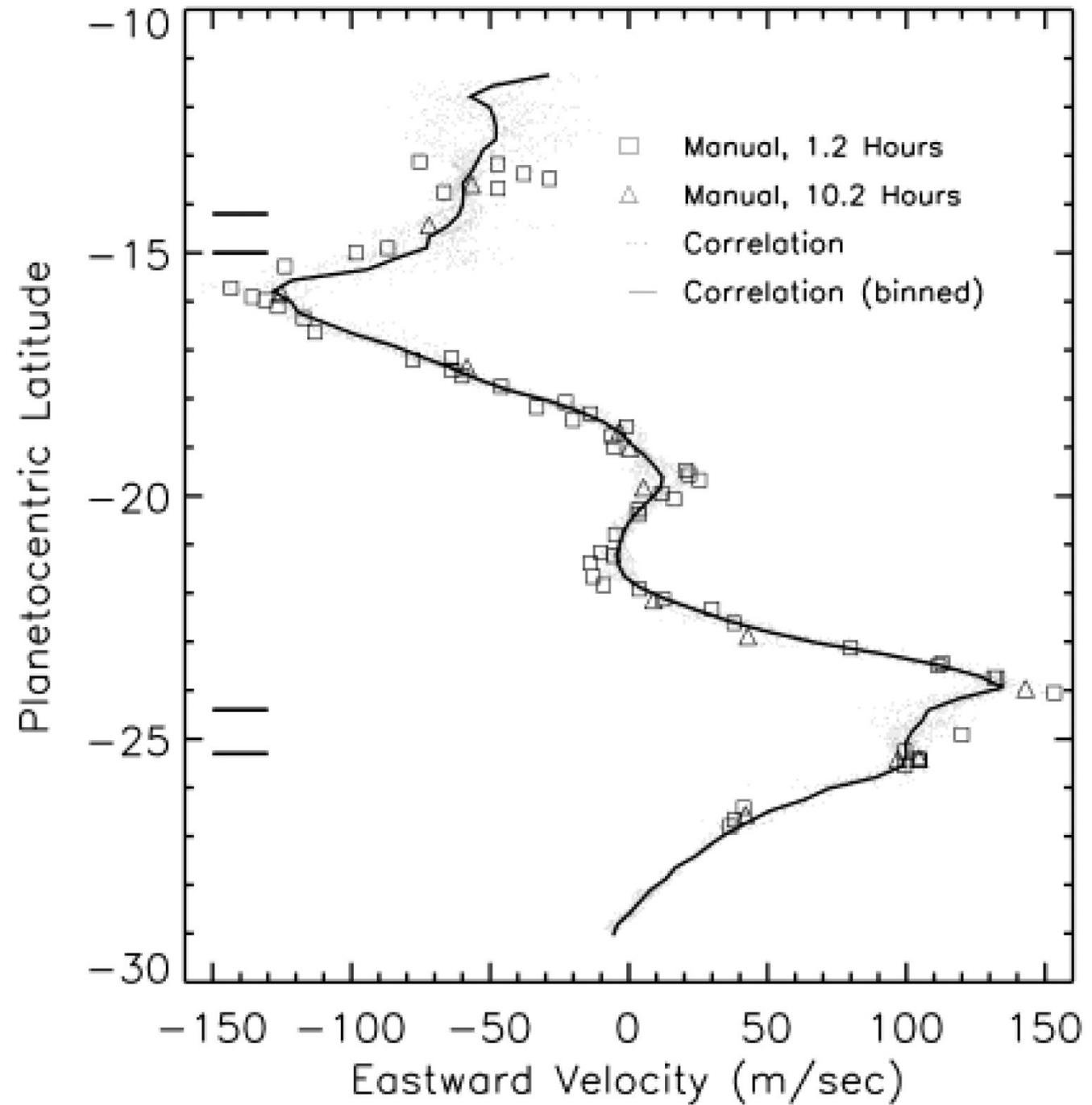


Galileo Imaging  
Vasavada et al.,  
1998



Galileo cloud  
tracking  
Great Red Spot  
Central meridian

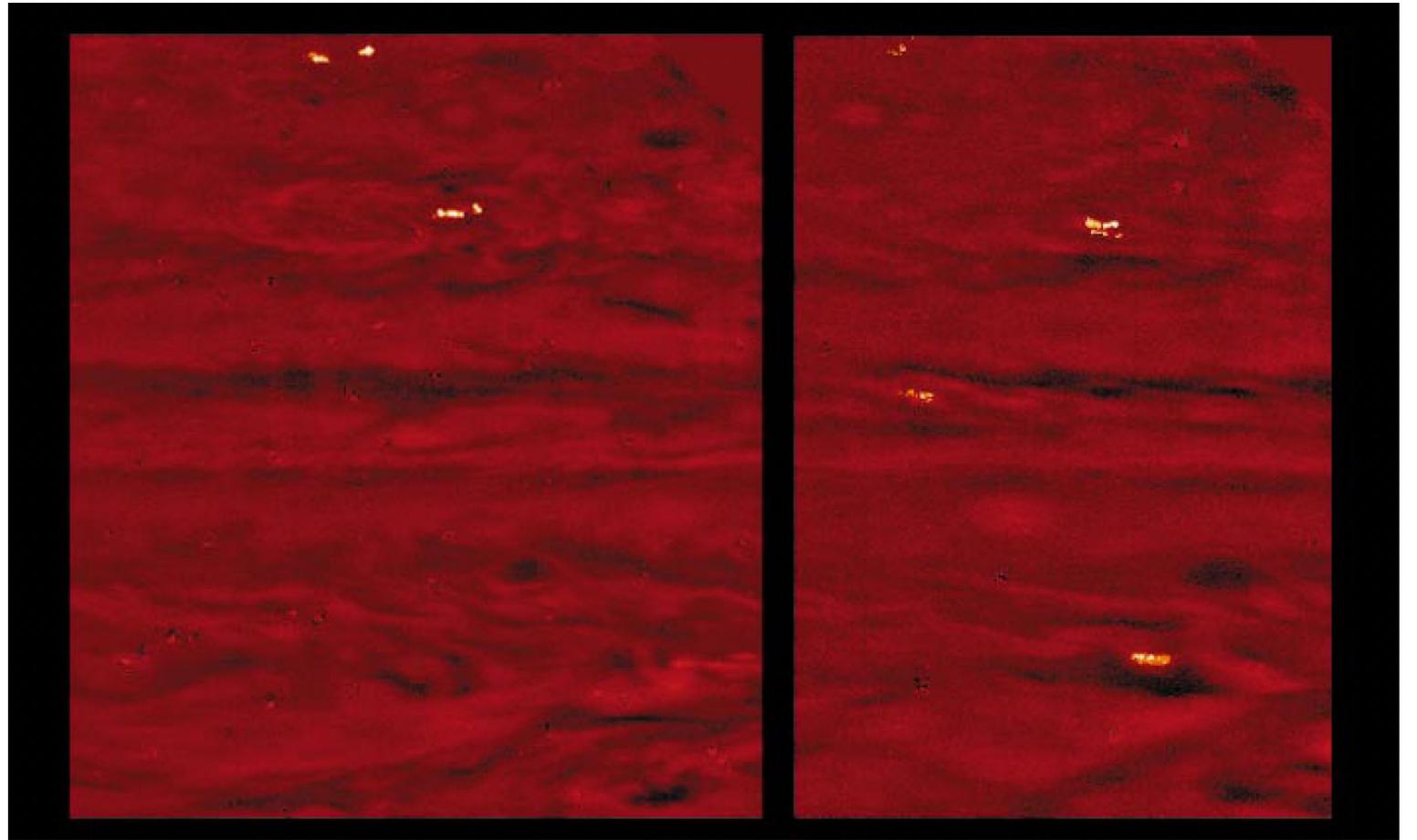
Vasavada et al 1998

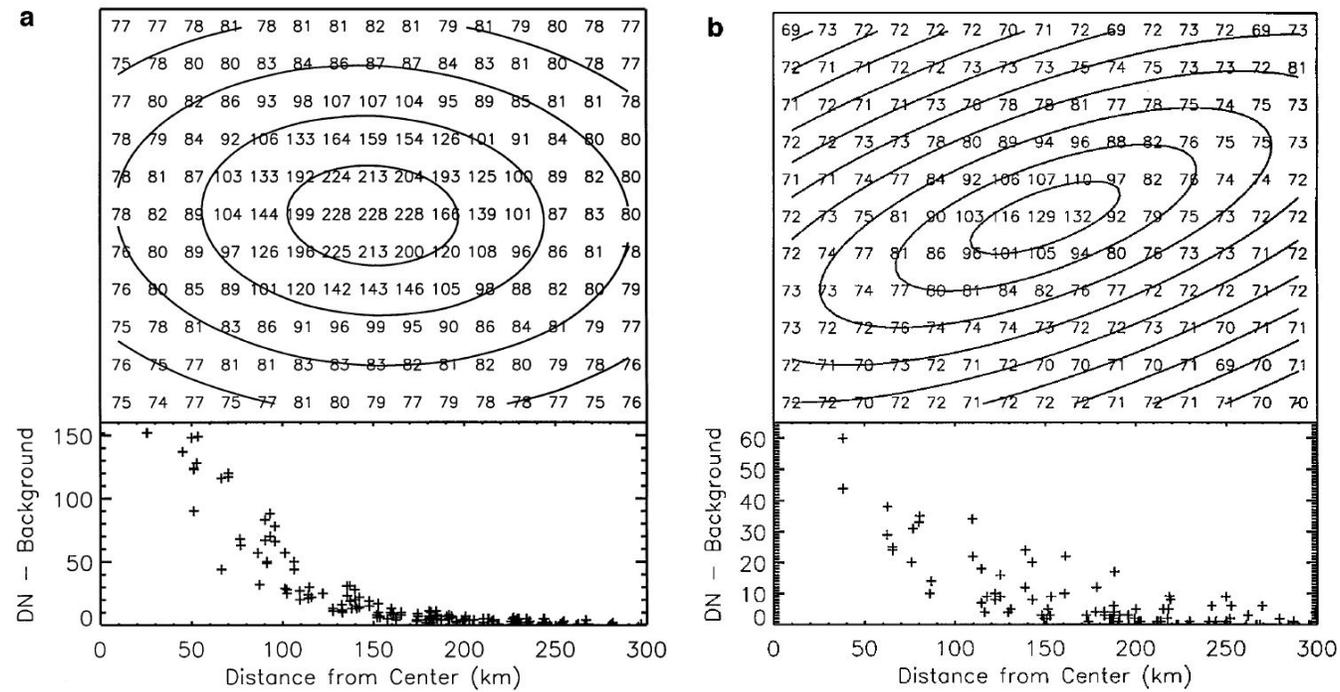


Galileo orbiter

Lightning in the moonlight

Little, B., et al., 1999



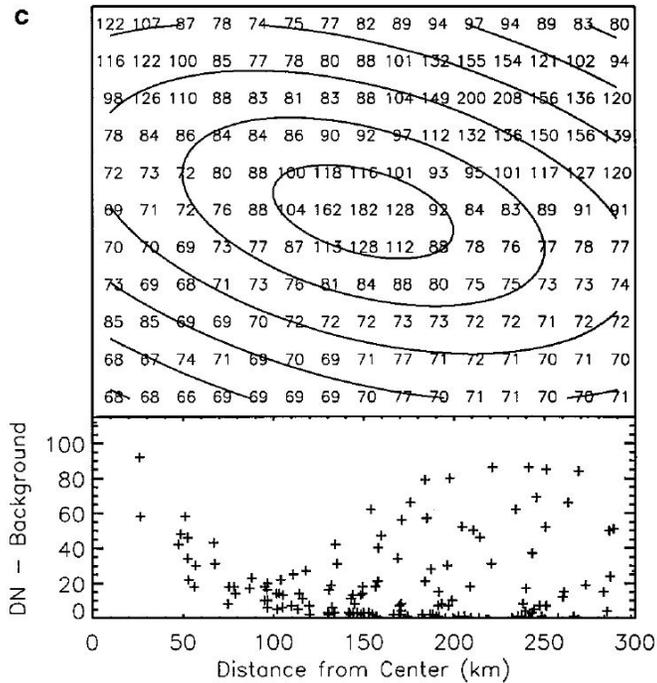


## Galileo imaging

Width of the lightning  
 flashes  $\approx$  depth of the  
 water cloud

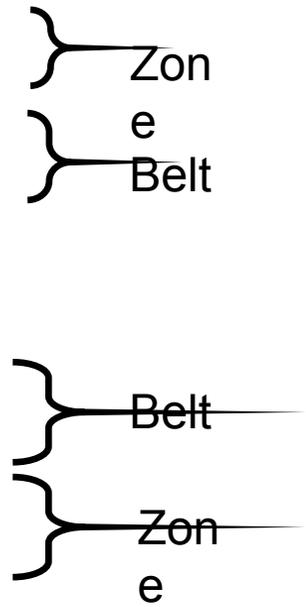
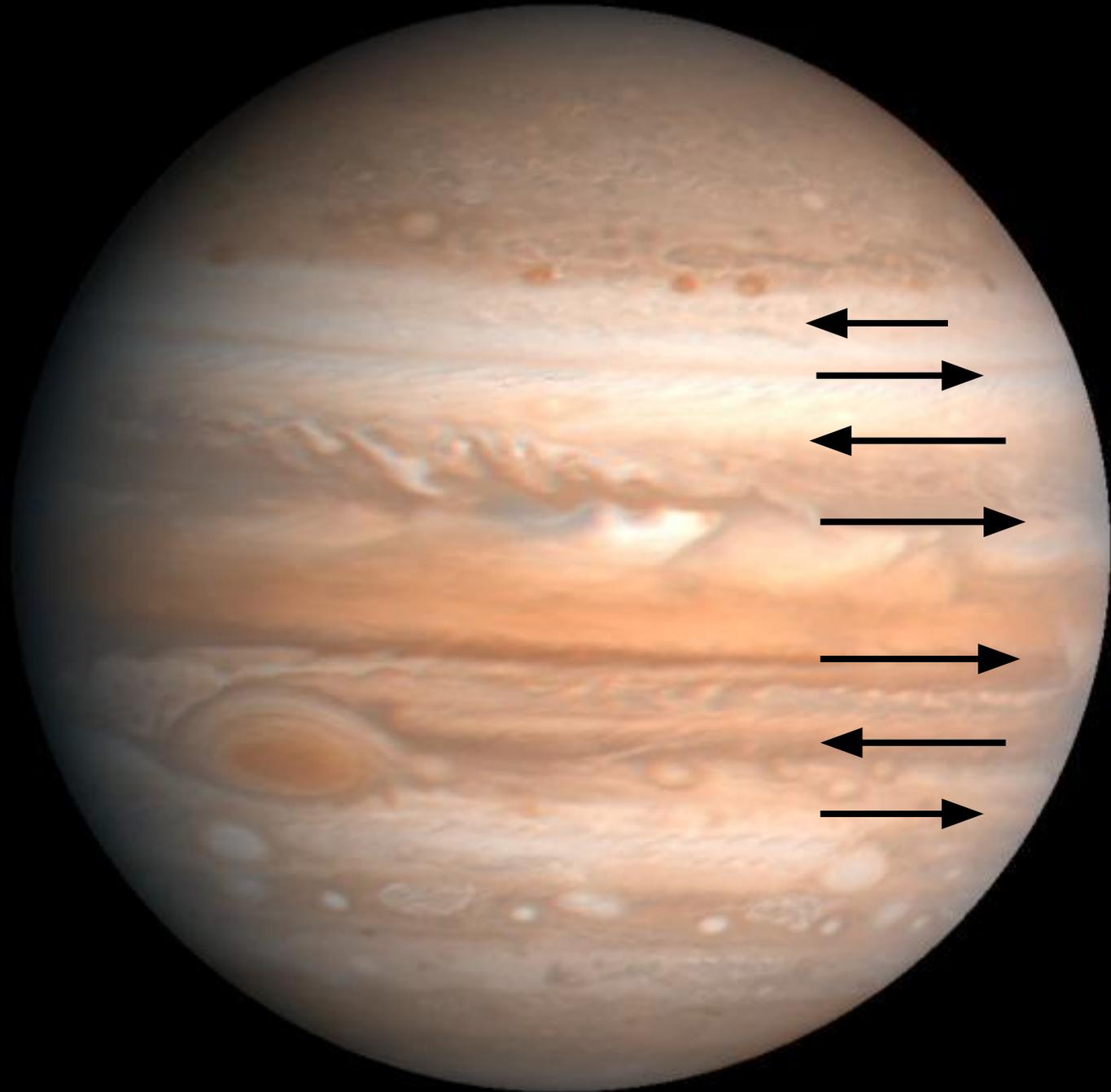
Little, B., et al 1999

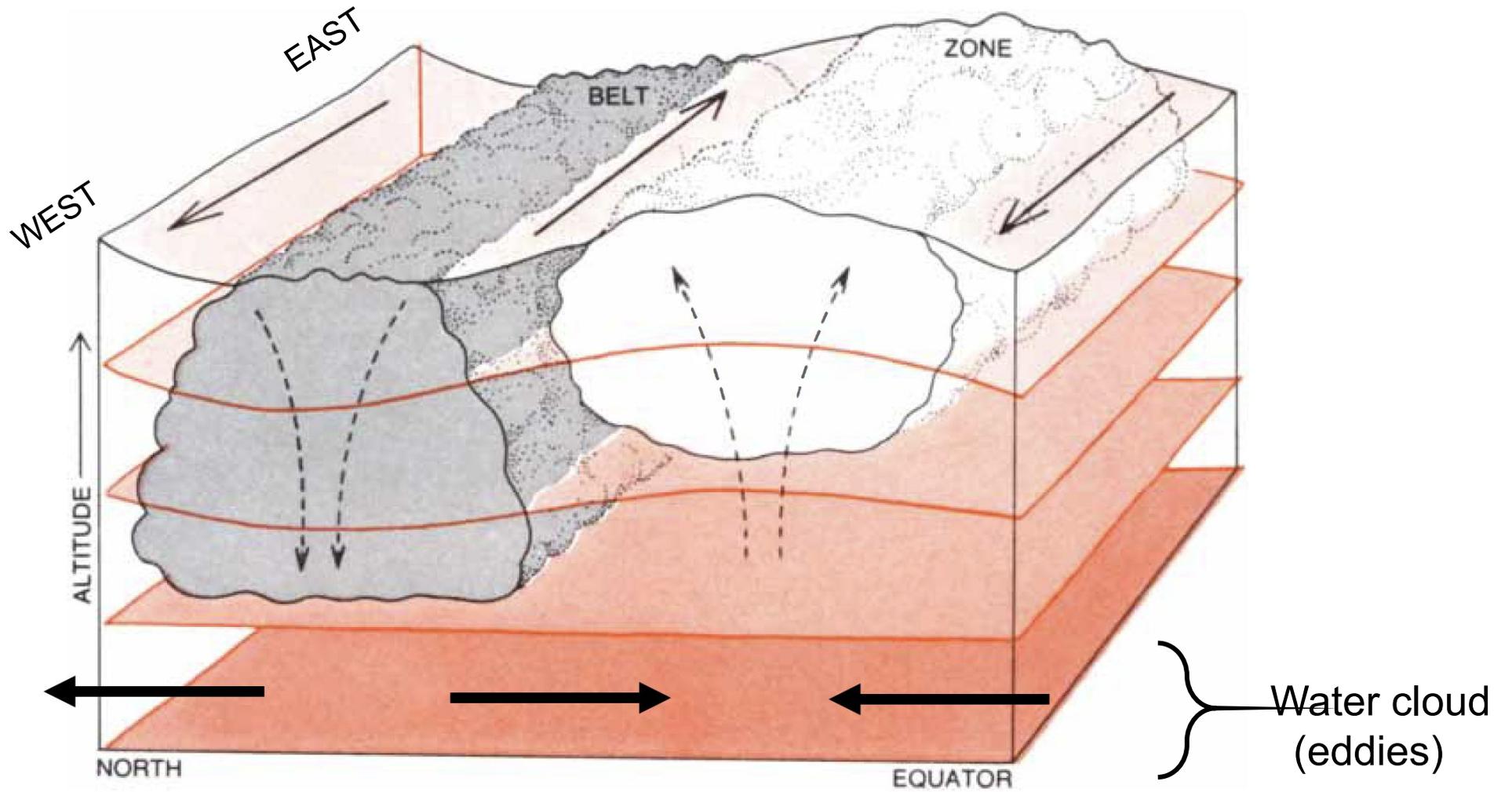
Dyudina, U., et al., 2002



Voyagers 1 and 2  
Eddies drive the  
zonal jets and the  
updraft/downrafts  
in between

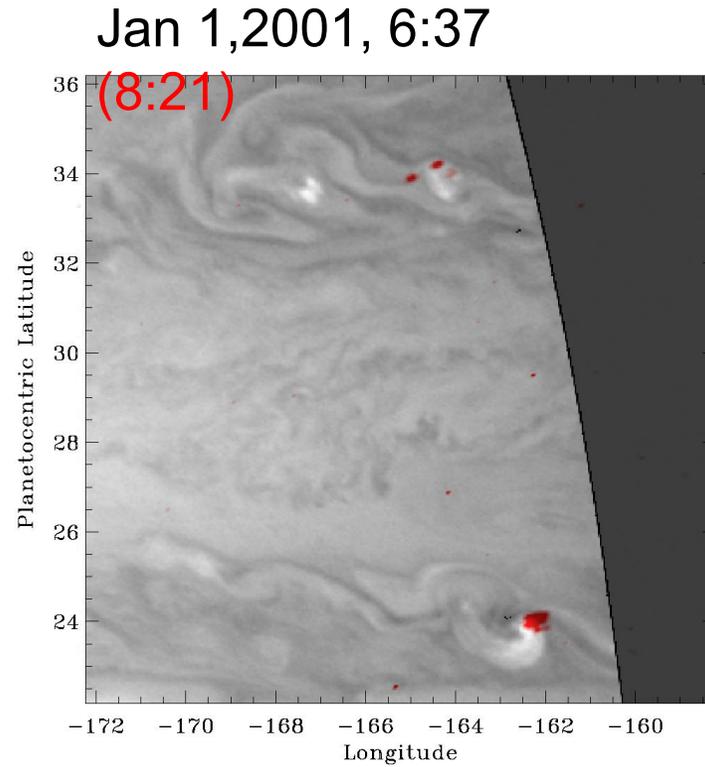
Beebe et al., 1981  
Ingersoll et al., 1982



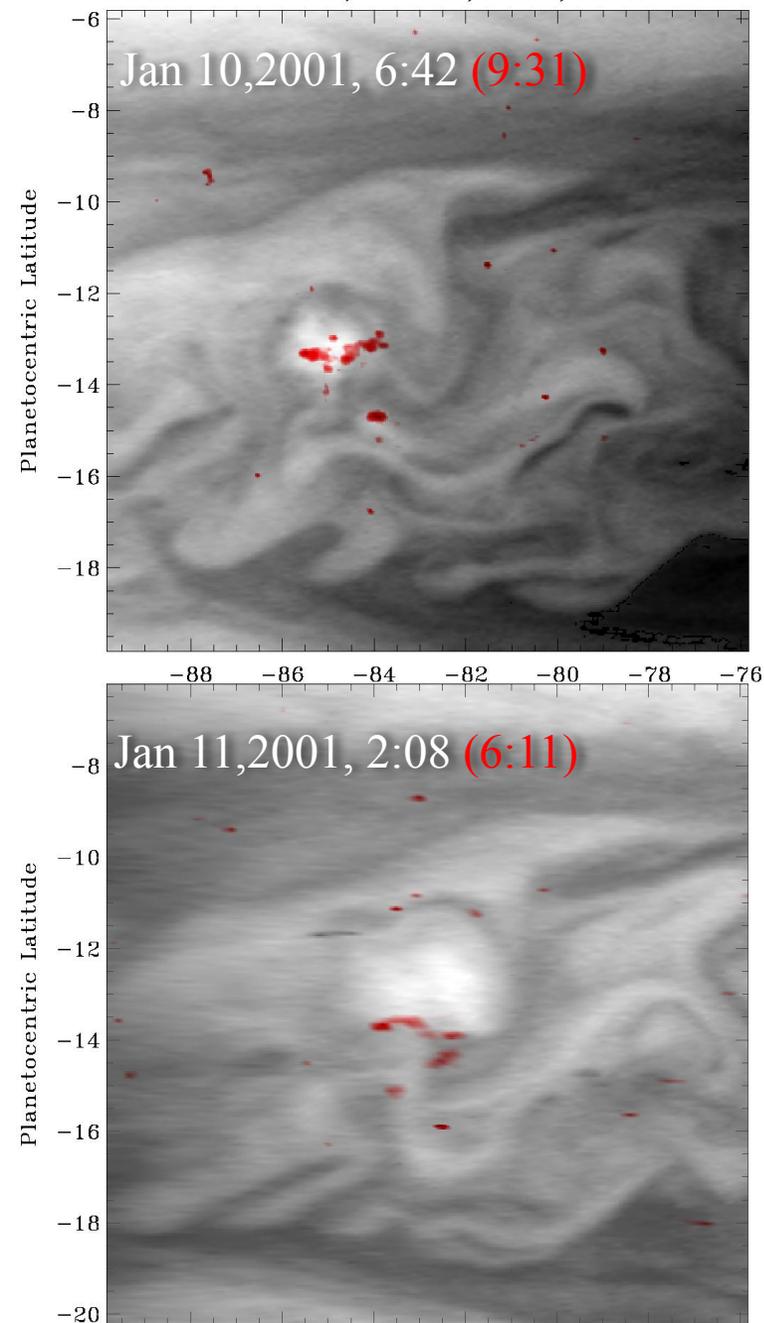


Ingersoll, Scientific American, 1976. Heavy arrows from Voyager analysis. Implies upwelling in the zones, downwelling in the belts. Gierasch et al., 1986

Lightning in the belts at 24N and 34N  
Puffy white clouds in the zone at 22-32N



Implies upwelling in the belts  
Dyudina et al., 2004



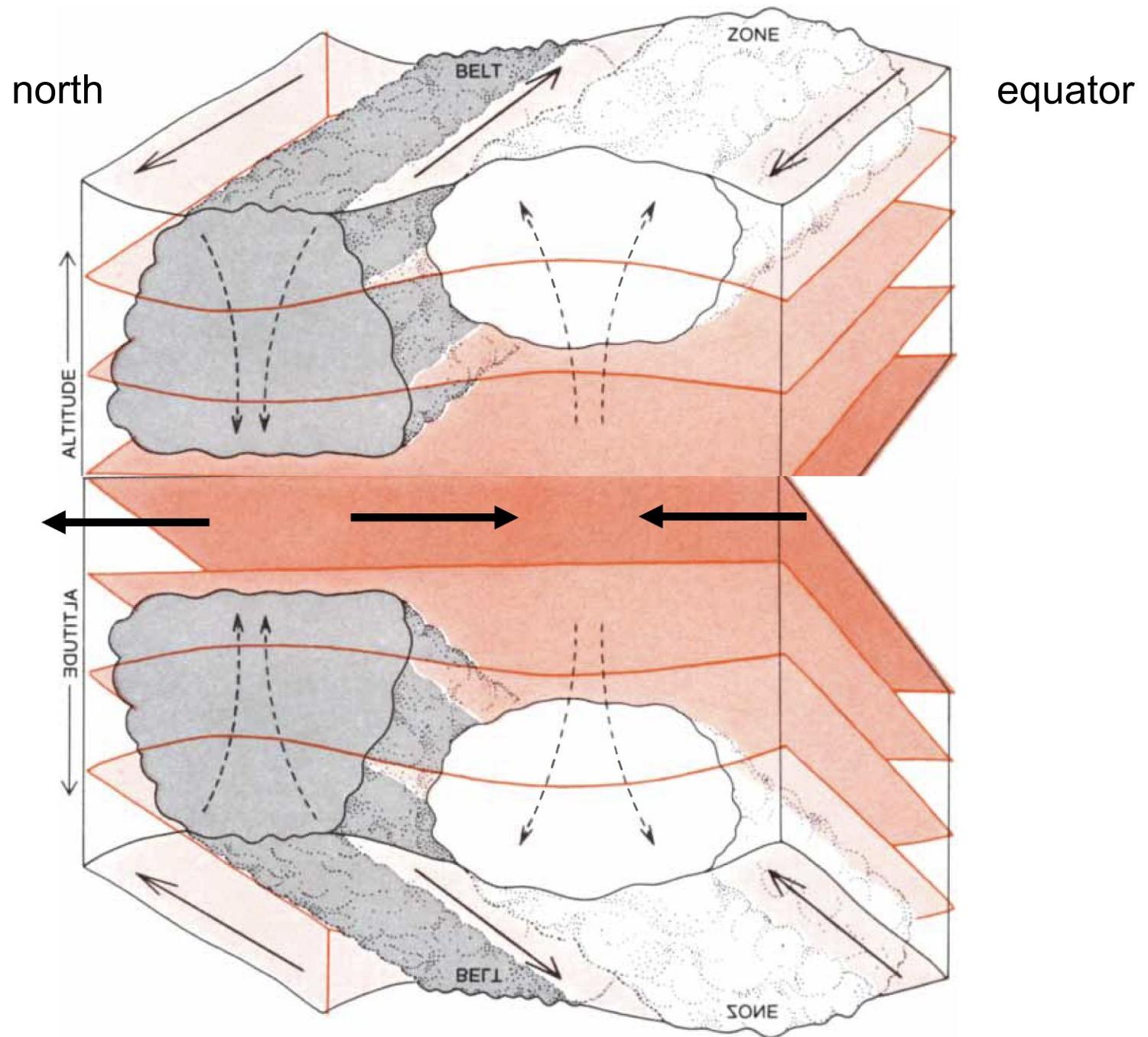
Galileo

Lightning in the belts  
implies upwelling

Gierasch et al., 2000  
Ingersoll et al., 2000

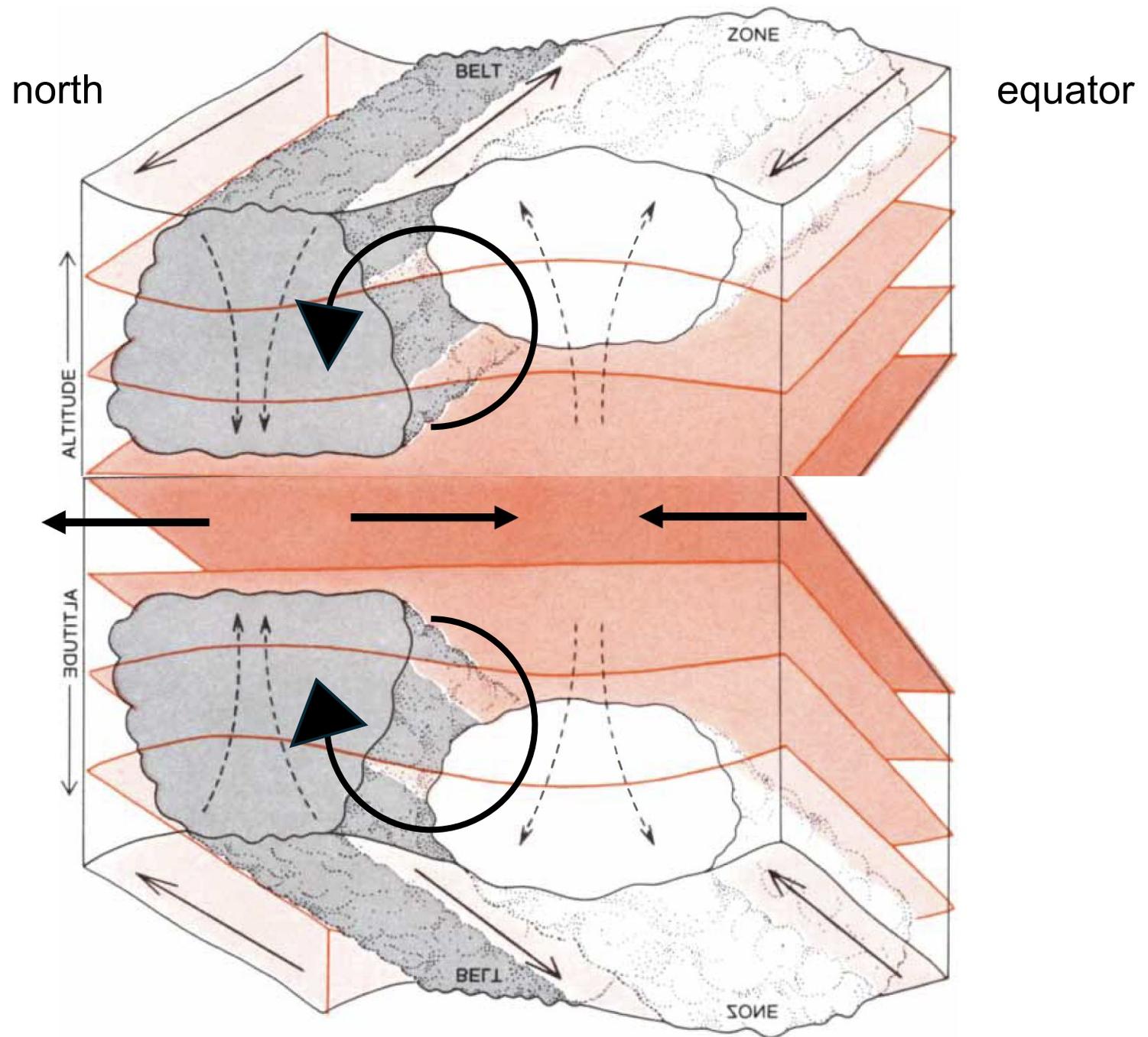
Ammonia deficit in  
belts implies  
downwelling

Showman and  
de Pater, 2005



Galileo and VLA:  
Counter-rotating stacked  
Hadley cells

Gierasch et al., 2000  
Ingersoll et al., 2000  
Showman and  
de Pater, 2005

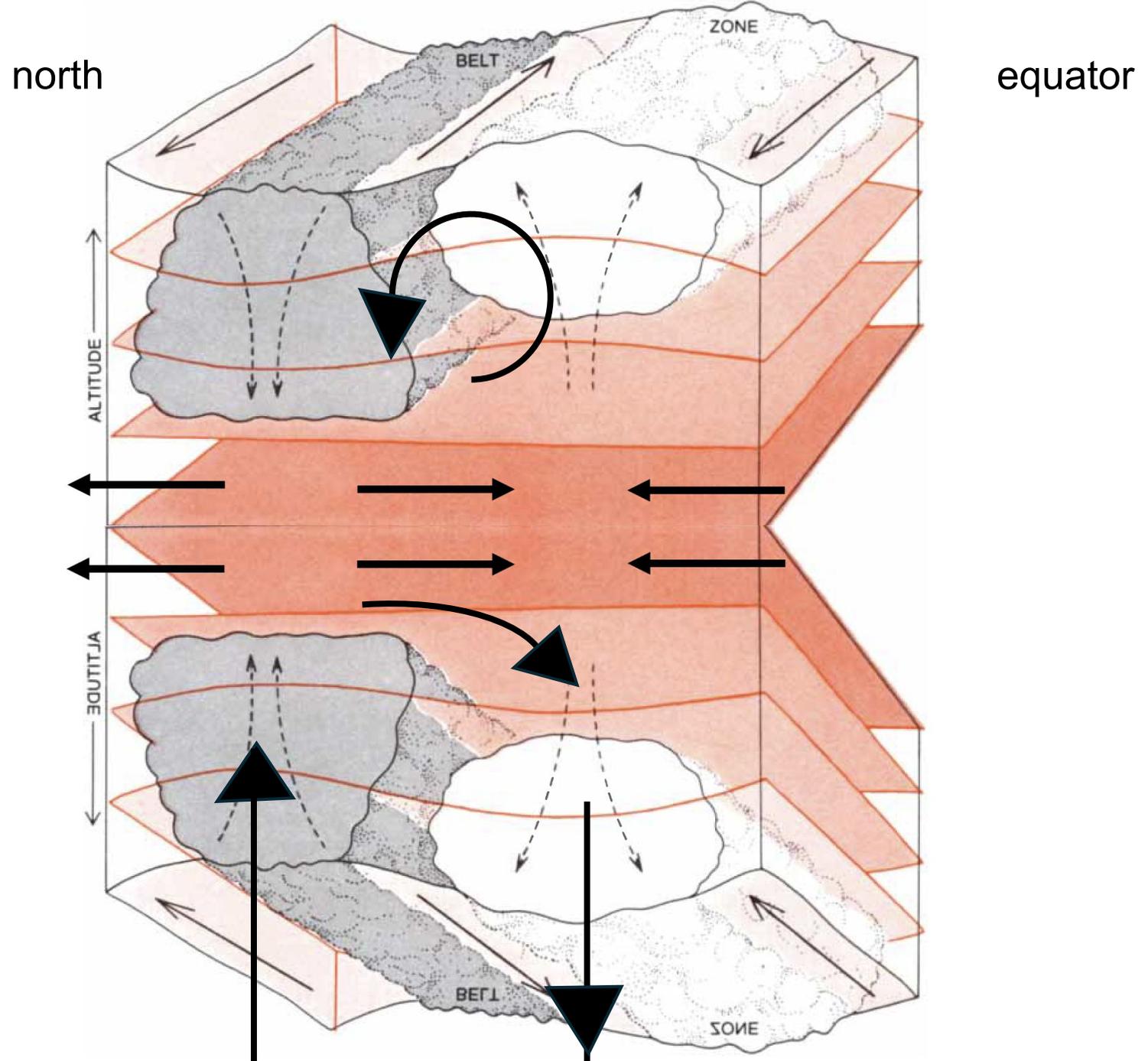


Galileo and VLA:  
Counter-rotating stacked  
Hadley cells

Gierasch et al., 2000  
Ingersoll et al., 2000  
Showman and  
de Pater, 2005

Juno gravity: Zonal  
jets extend at least  
3000 km into the interior

Kaspi et al., 2018  
Galanti et al., 2021



Galileo and VLA:  
Counter-rotating stacked  
Hadley cells

Gierasch et al., 2000  
Ingersoll et al., 2000  
Showman and  
de Pater, 2005

The  
End

Juno gravity: Zona  
jets extend at least  
3000 km into the interior

Kaspi et al., 2018  
Galanti et al., 2021

