

Les atmosphères planétaires vues comme des fluides

Aymeric Spiga



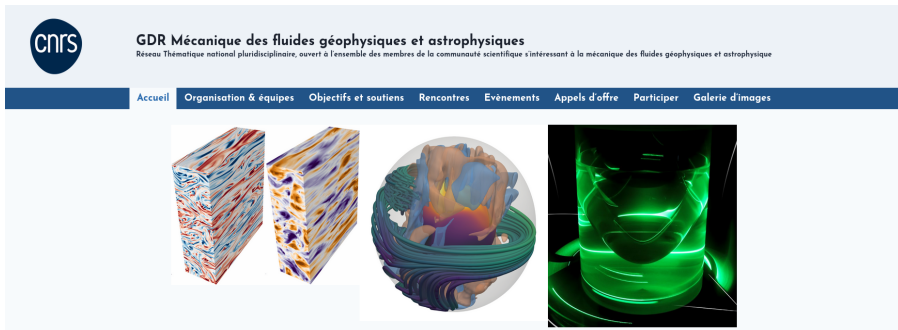
**SORBONNE
UNIVERSITÉ**
CRÉATEURS DE FUTURS
DEPUIS 1257



Journée inter-UFR
October 20, 2025

Contexte

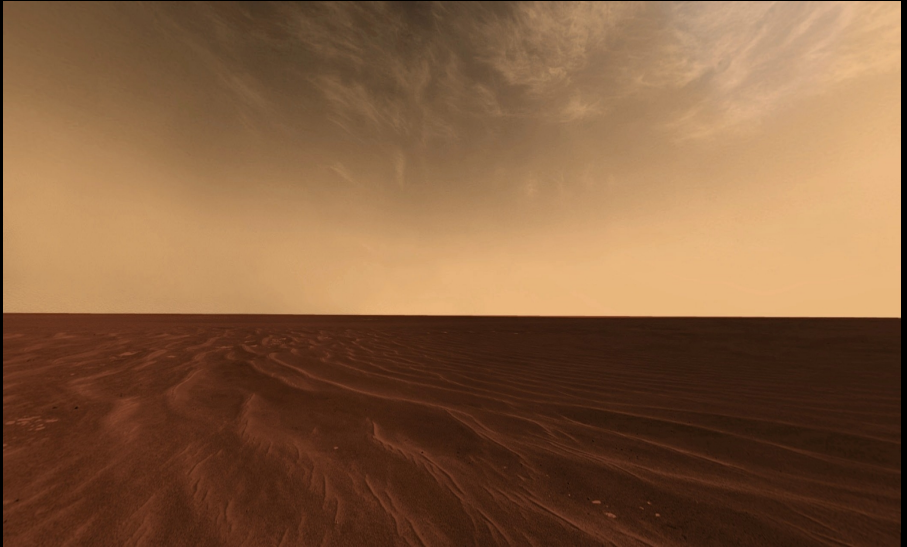
discussion avec S. Popinet et le GDR MFGA



+ précédemment contacts étudiants M2 Mécanique des Fluides

Exemple 1 : couche limite planétaire stable sur Mars

L'environnement martien

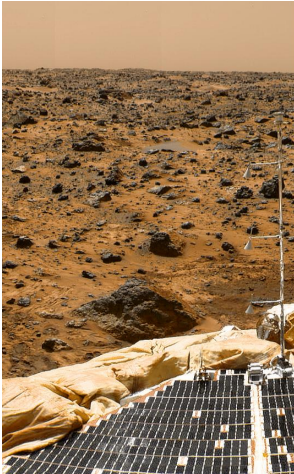


[Pancam on Opportunity Rover]

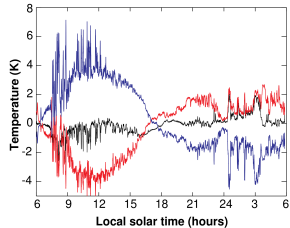
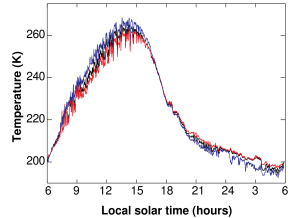
Near-surface temperature on Mars

Monitored by Mars Pathfinder (1997), summer latitude 20°

Meteorological mast



Measured at 100, 50, 25 cm

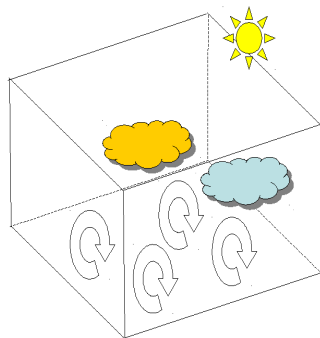
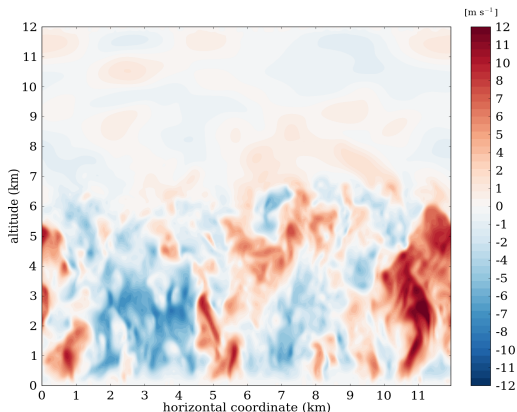


[Schofield et al., 1997]

Turbulent convection in daytime boundary layer

Simulated through Large-Eddy Simulations [LES] for Mars

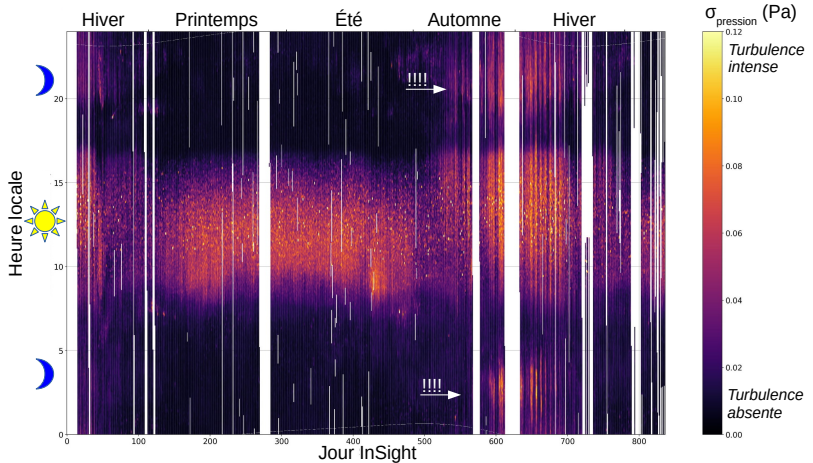
Vertical velocity: updraft (red) downdraft (blue)



[Spiga et al. QJRM 2010; Colaitis et al. JGR 2013]

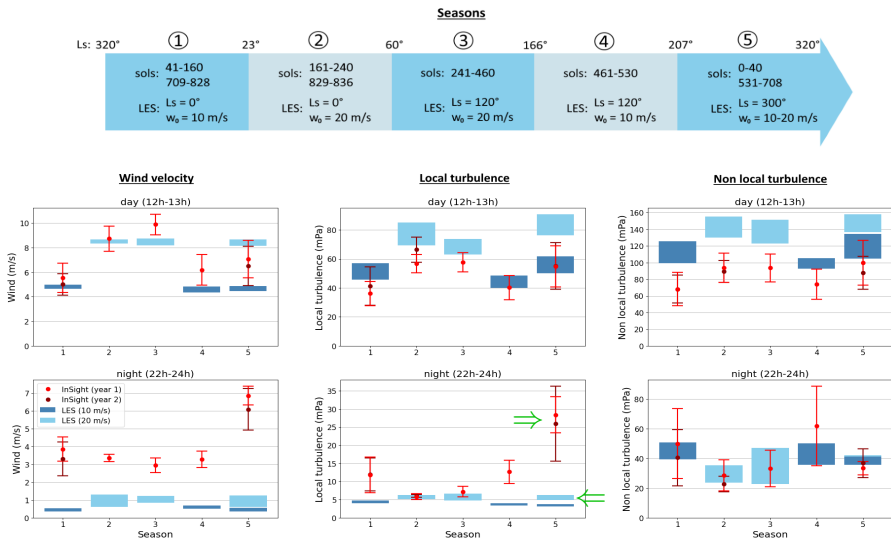
Un an martien de turbulence au site InSight

Standard deviation of pressure for periods below 100 s (vortices aside)



[Chatain et al. Geophysical Research Letters 2021]

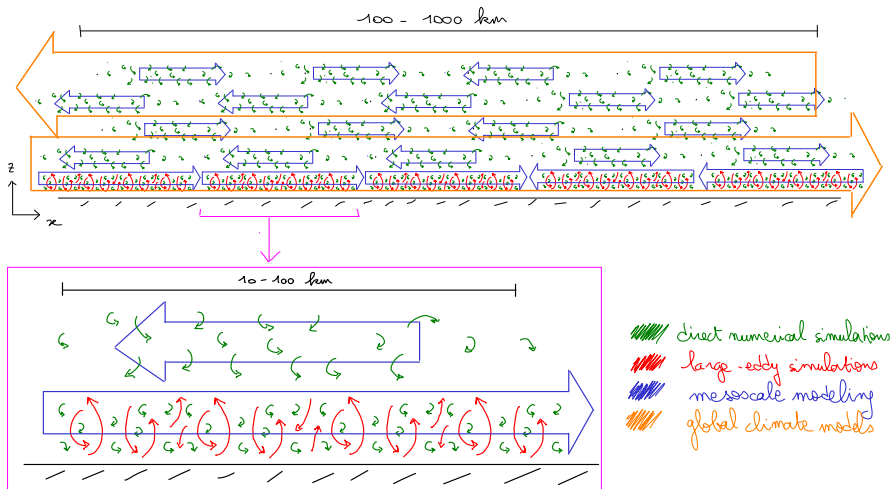
The difficulty of nighttime LES



[Figure by A. Chatain]

Multiscale circulations in planetary atmospheres

... and various modeling tools to resolve and characterize those circulations



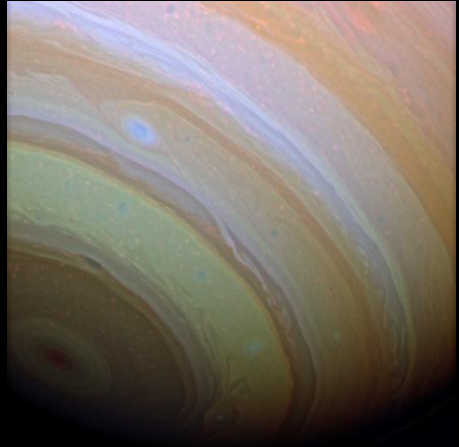
Exemple 2 : “mers” de tourbillons sur les planètes géantes

Gas giants: jets & eddies

Jupiter



Saturn



Les nuages chaotiques de Jupiter

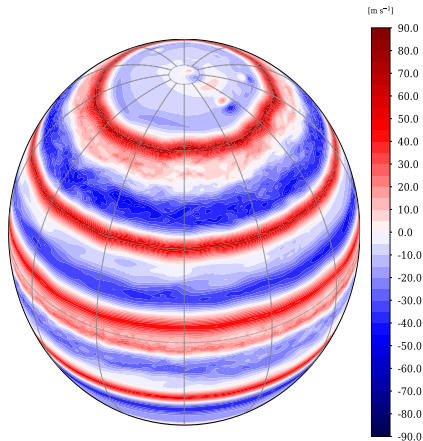


[Junocam image P13 (05-2018) NASA/JPL-Caltech/SwRI/MSSS/Gerald Eichstad/Sean Doran PIA22424]

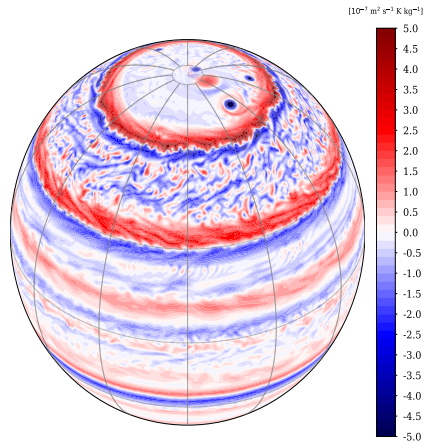
Jets, eddies and vortices in a $1/2^\circ$ Saturn GCM

Beginning of the seventh simulated year (171 thousands simulated Saturn days)

Zonal velocity ($P = 1.5$ bar)

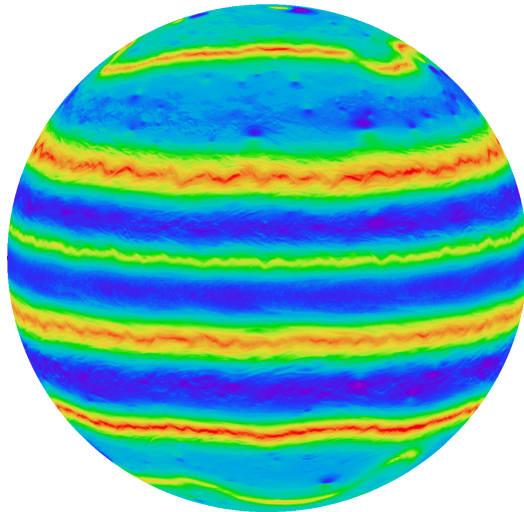


Potential Vorticity ($\theta = 205$ K)

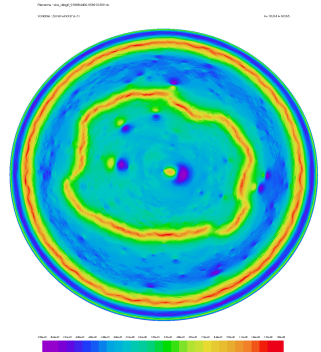


[Spiga et al. Icarus 2020, arxiv 1811.01250]

Simuler les vents des géantes par calcul numérique



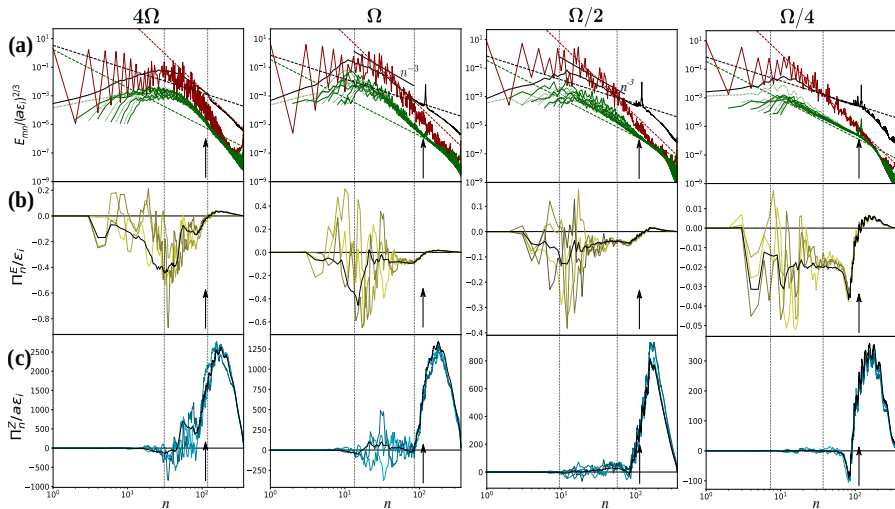
-100 m/s -50 m/s 0 m/s 50 m/s 100 m/s 150 m/s



Movie by Y. Meurdesoif

Energy spectra, energy & enstrophy transfers

Idealized simulations (varying Ω) with Taylor-Green vortex forcings



[Cabanes, Spiga and Young Icarus 2020]

Mécanique des fluides fondamentale

Avec des exemples environnementaux

Couches limites stables et turbulence

☞ problématique sur Terre notamment en Antarctique

Grappes de tourbillons et cascades

☞ problématique sur Terre notamment dans l'océan