

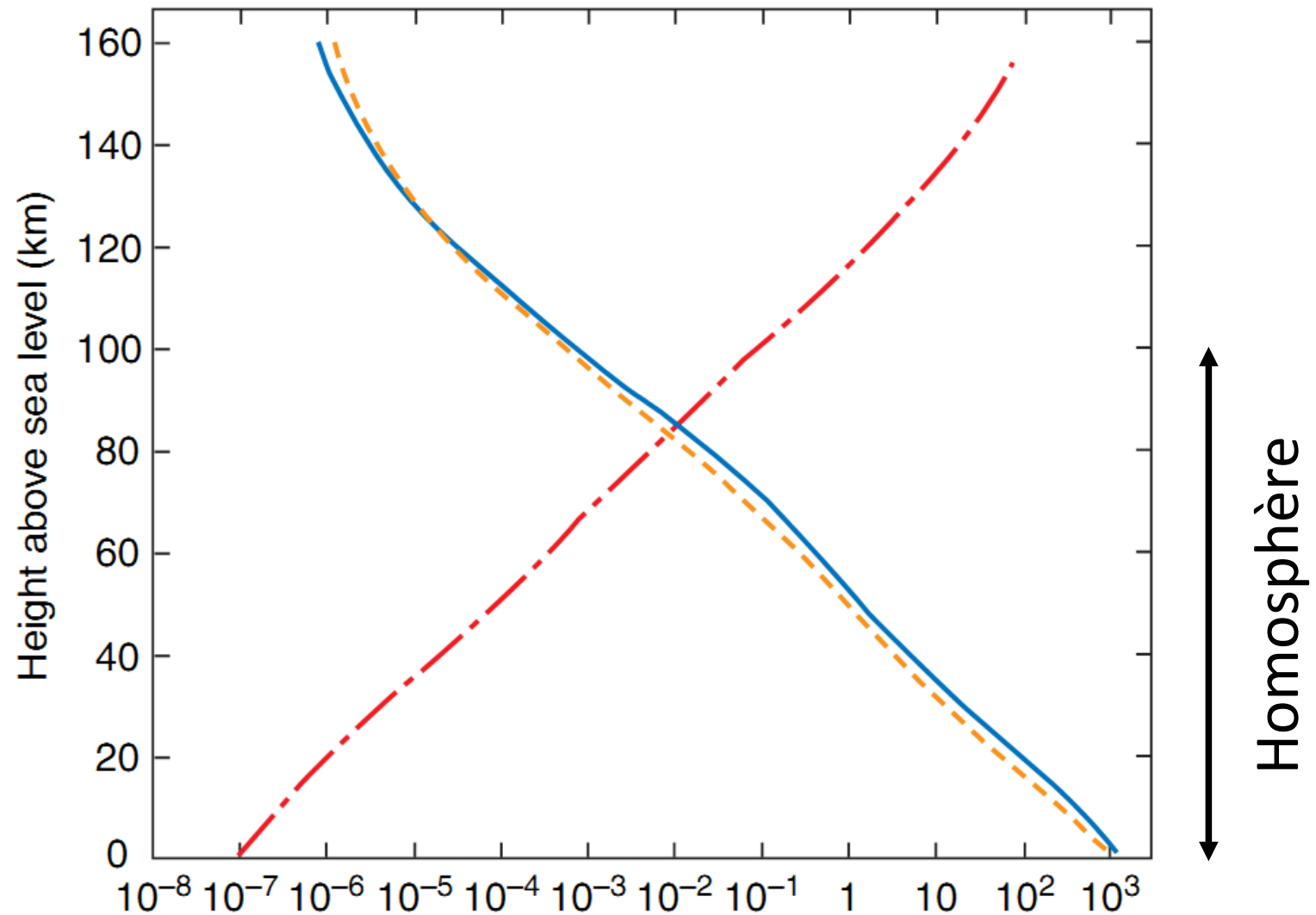
Introduction à la météorologie et l'océanographie



Composition de l'atmosphère

Absorbants IR		N ₂	Azote	78 %	
		O ₂	Oxygène	21 %	
		A	Argon	0,93 %	
		H ₂ O	Vapeur d'eau	0-3 %	
		CO ₂	Dioxyde de carbone	0,033 %	
		O ₃	Ozone	10 ⁻⁶ %	
		CH ₄	Méthane	0.0002%	
					Absorbant UV (proche)

Structure Verticale

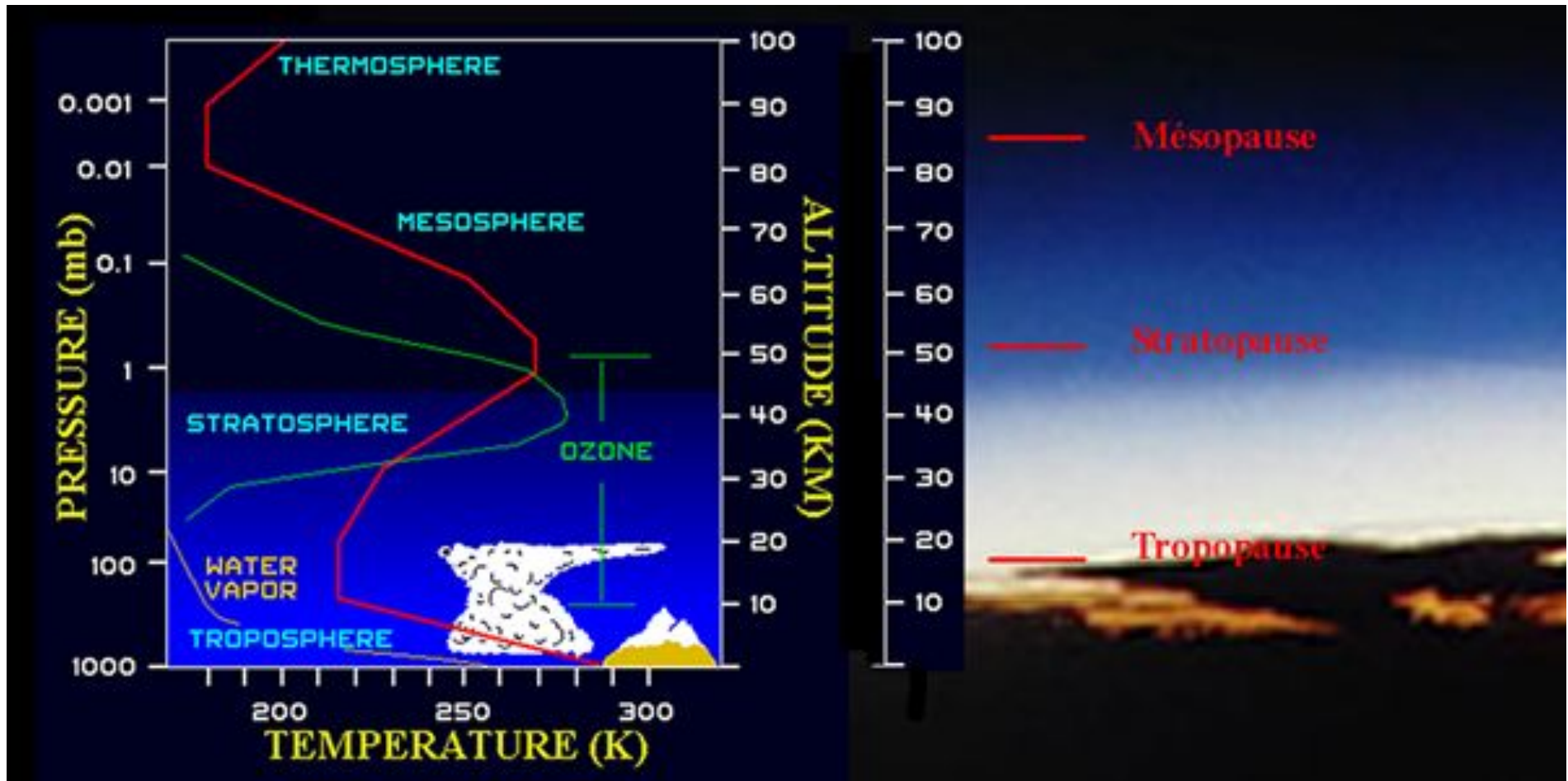


Échelle logarithmique:

Décroissance exponentielle

- Pressure (hPa)
- Density (g m^{-3})
- · - Mean free path (m)

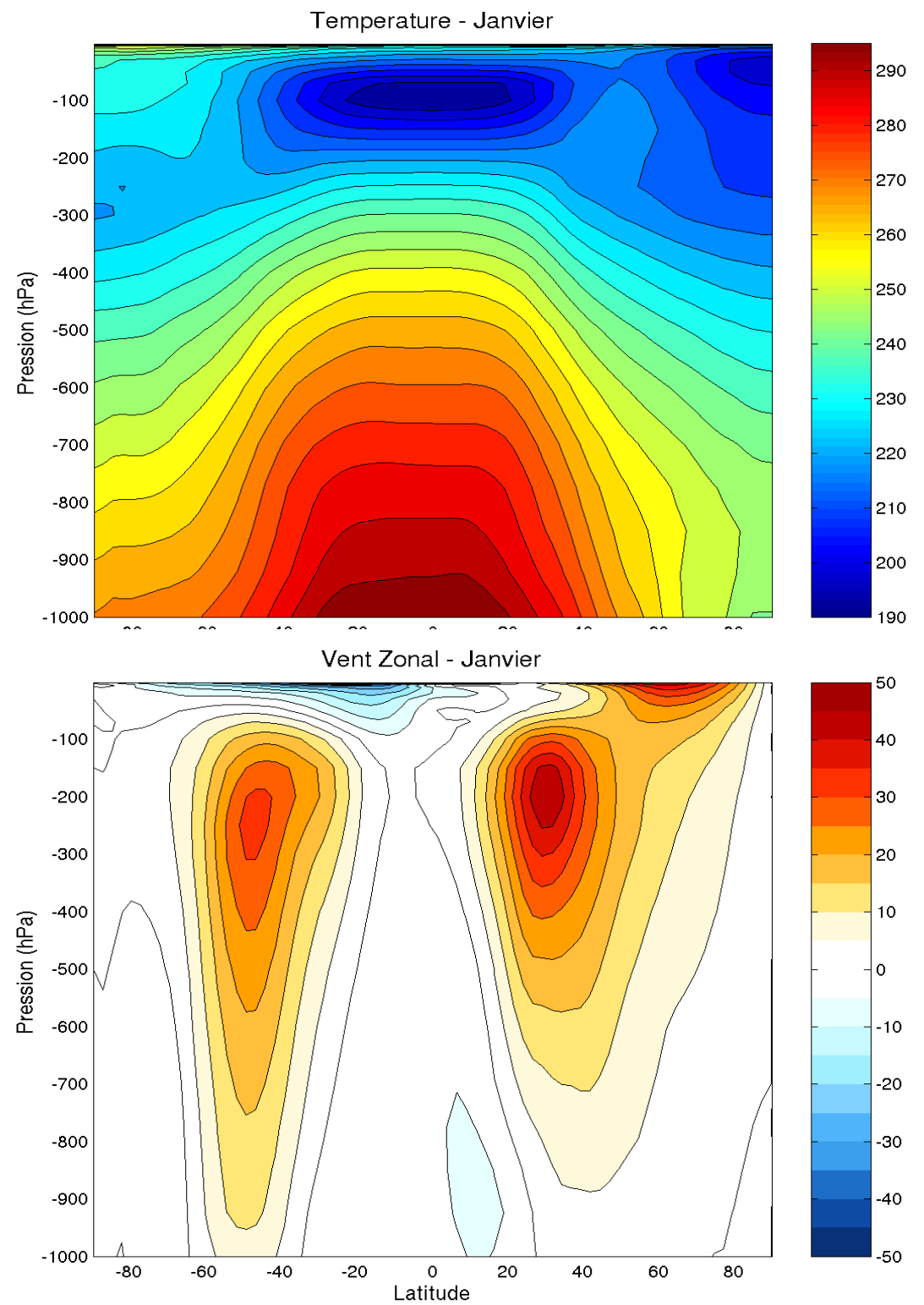
Profil vertical de température: Couches de l'atmosphère



Température

Coupe latitude/hauteur
Janvier

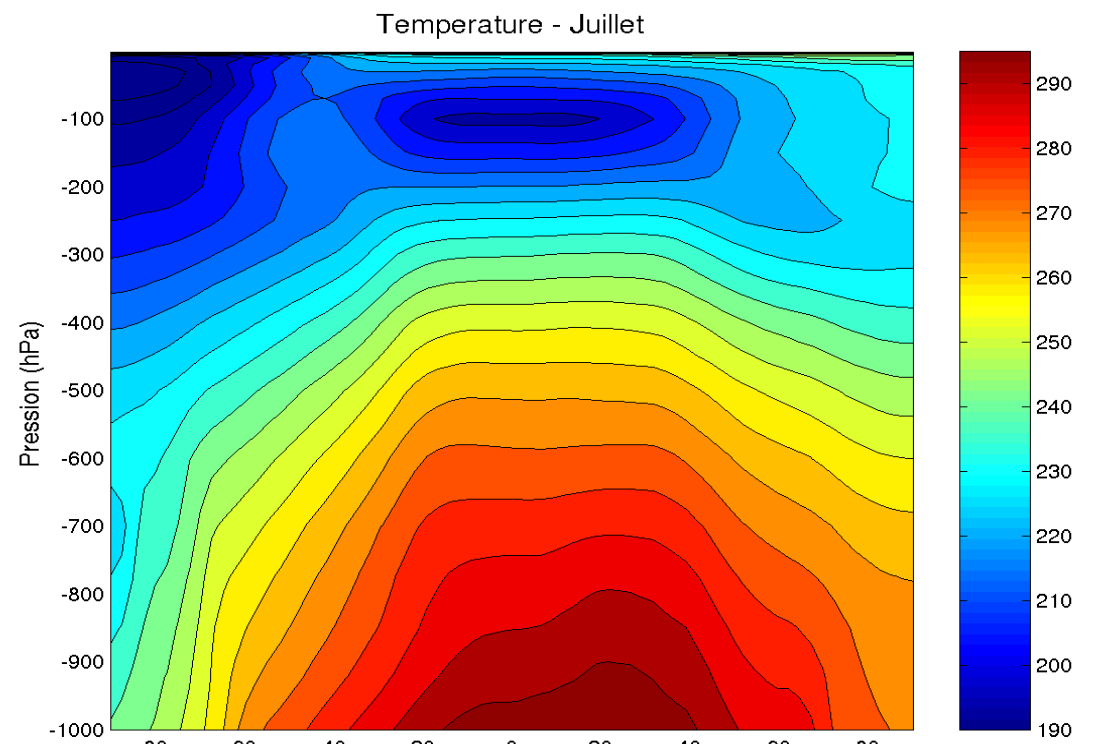
Vent zonal
(ouest-est)



Température

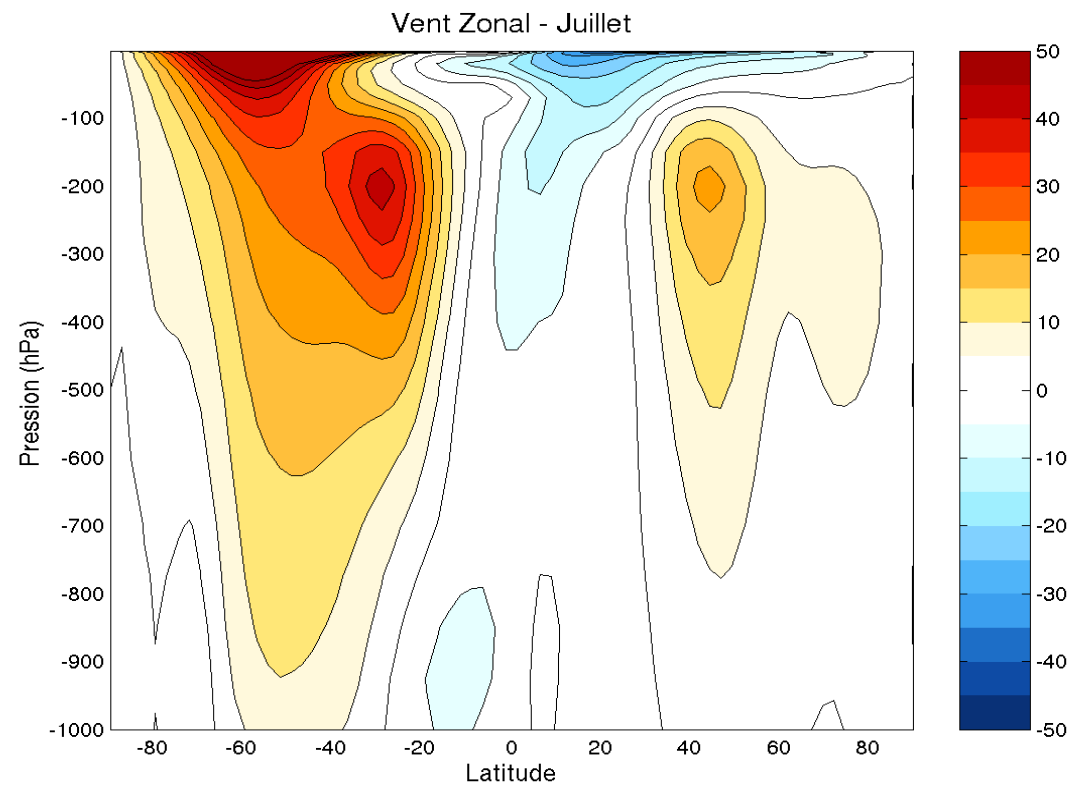
Coupe latitude/hauteur

Juillet

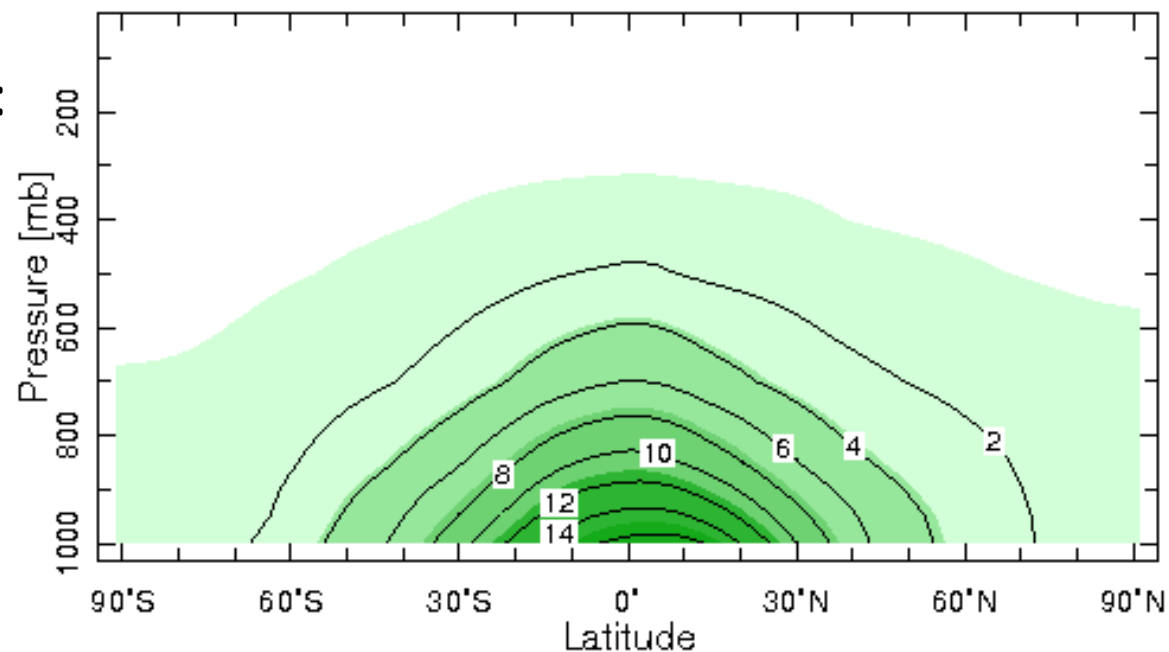


Vent zonal

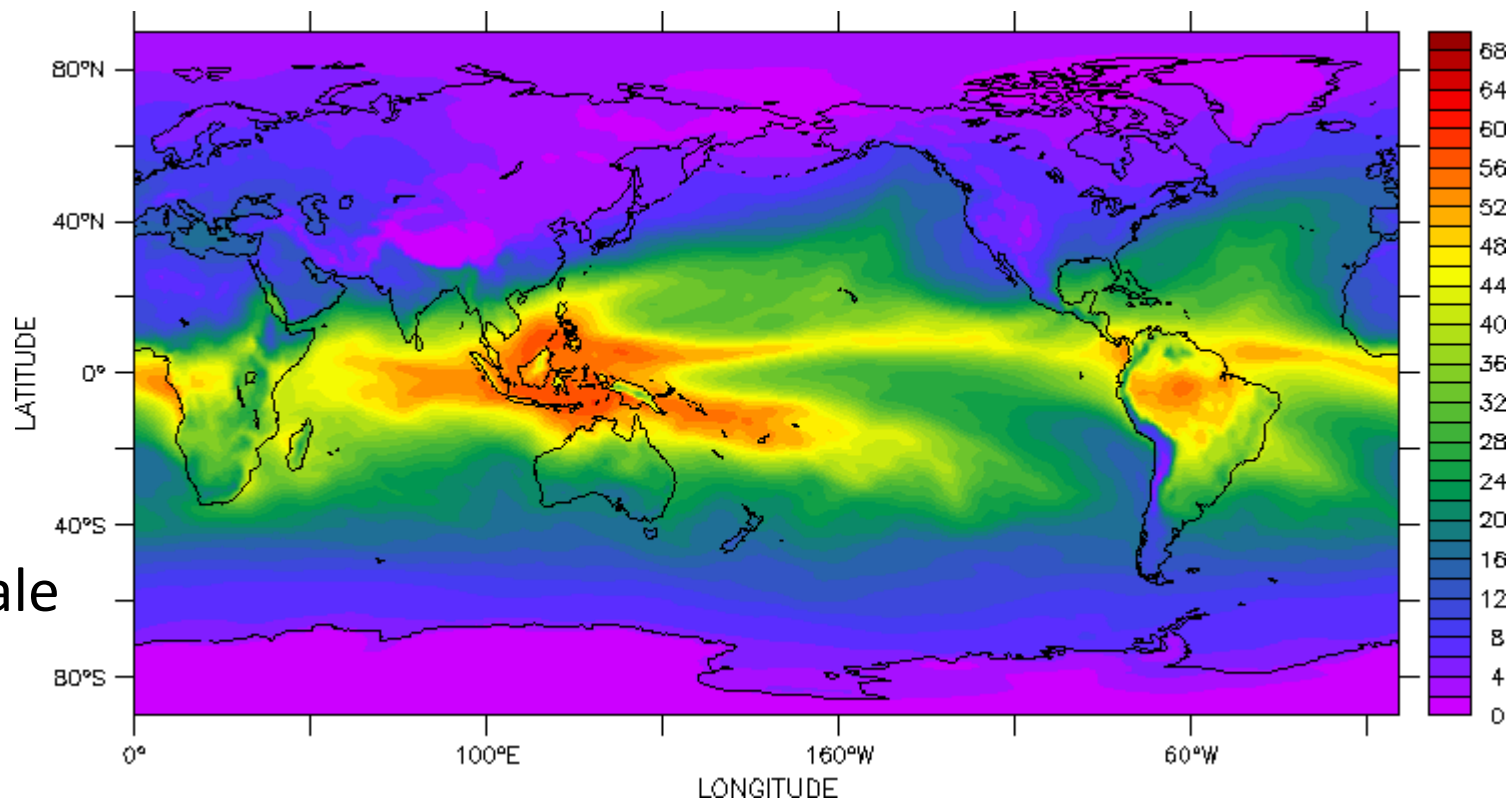
(ouest-est)



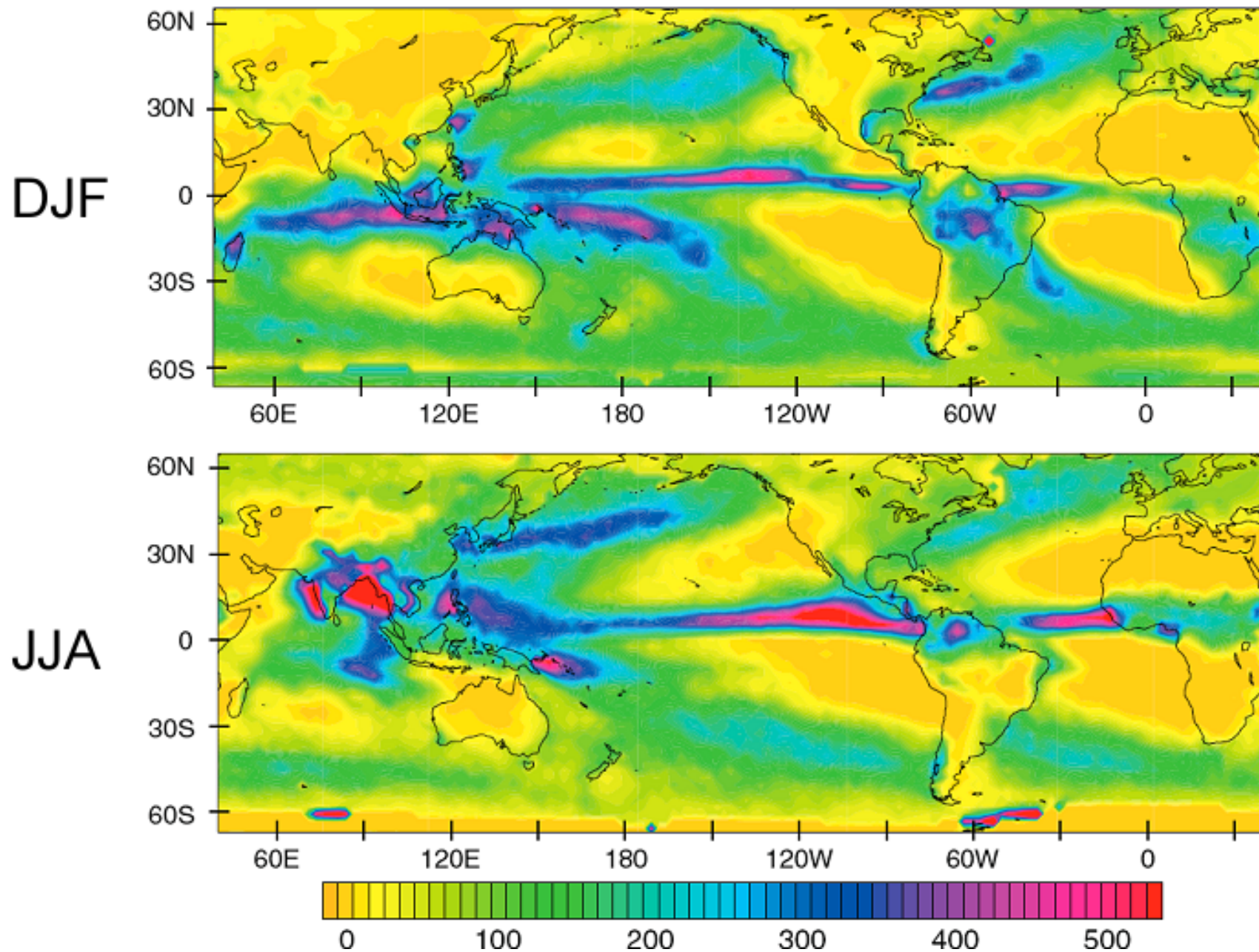
Contenu en vapeur d'eau:
Structure verticale
(g/kg)



Vapeur d'eau
Intégrée sur verticale

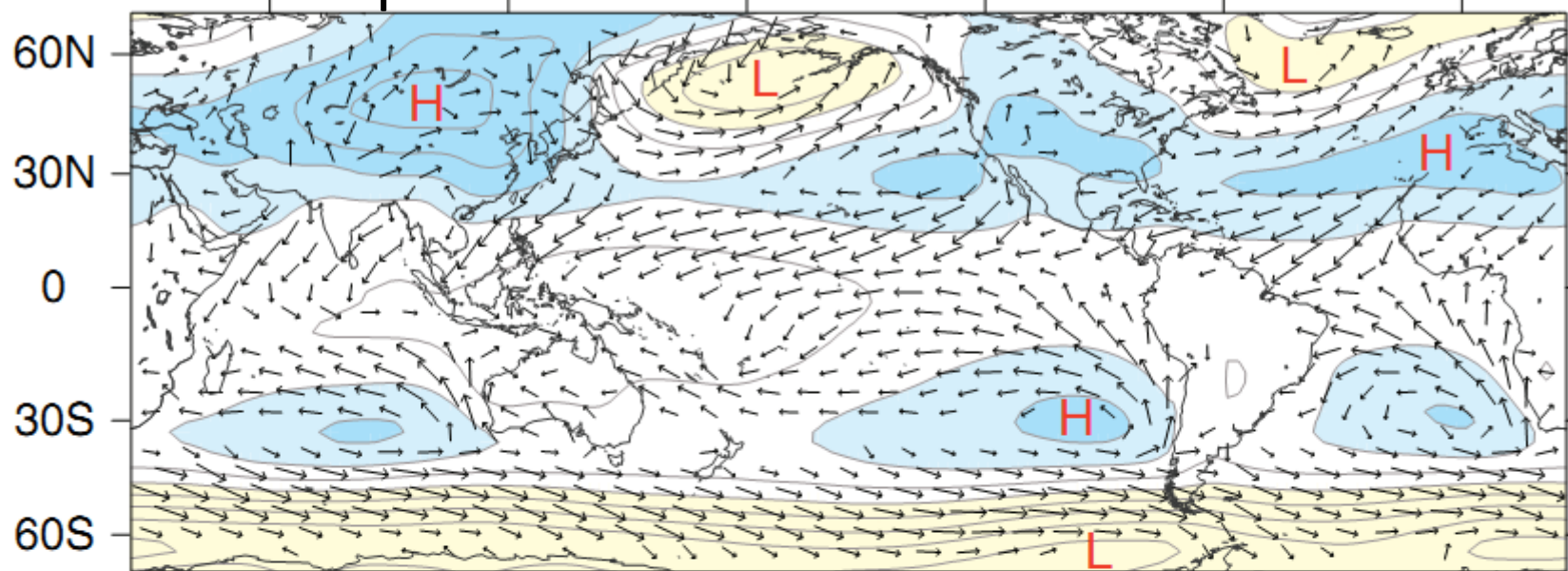


Seasonal rainfall

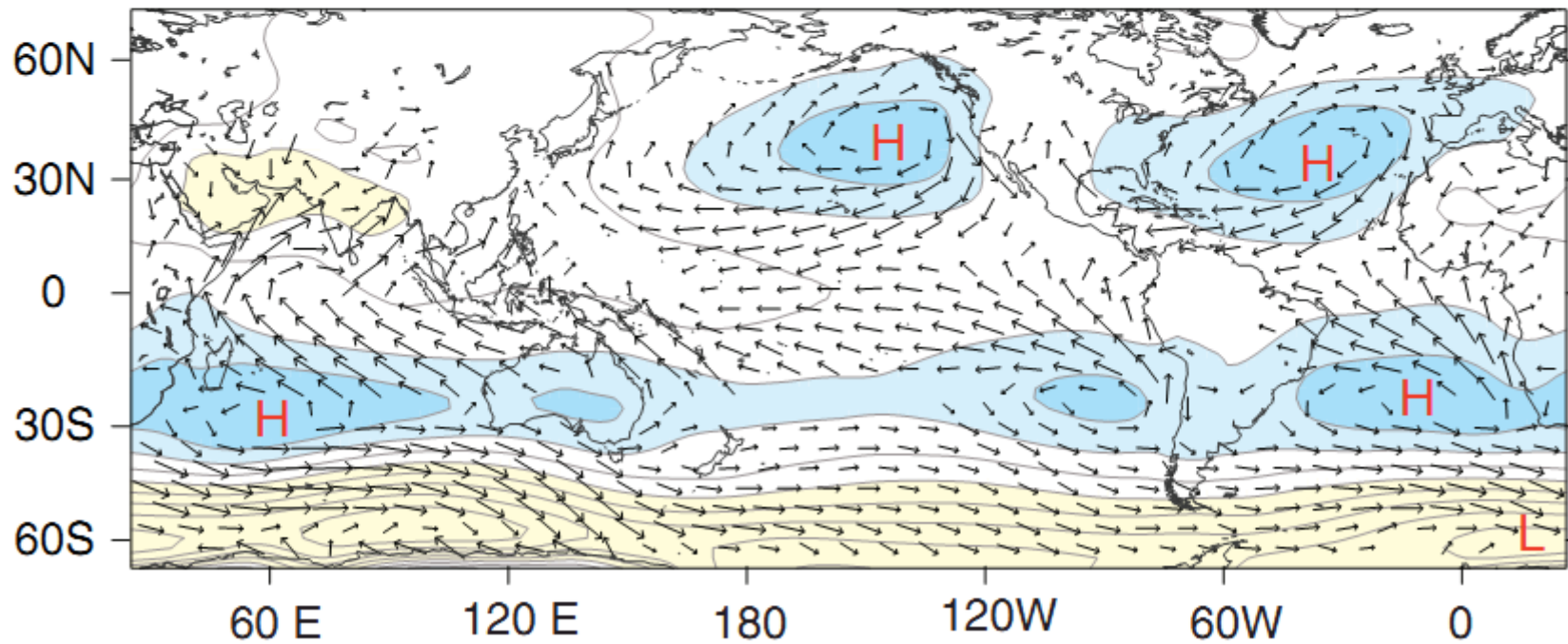


Vents de surface et pression au niveau de la mer

DJF



JJA



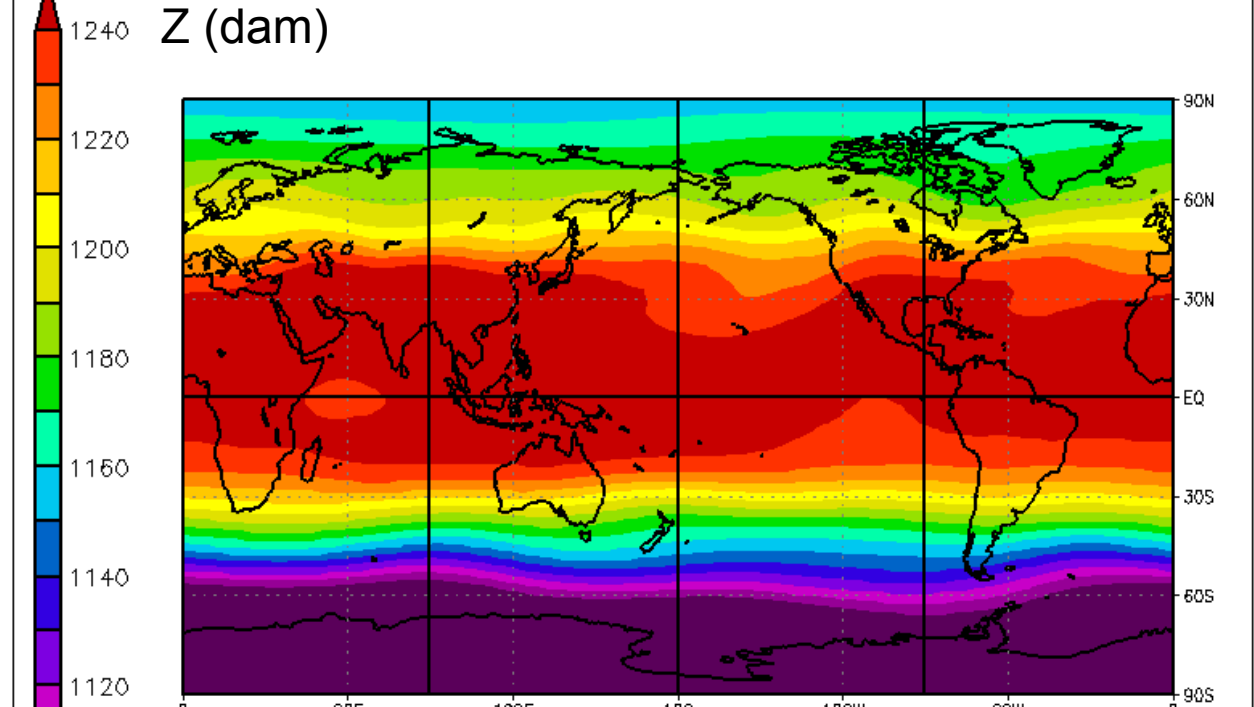
→ 20 m s⁻¹

Circulation à 200 hPa:

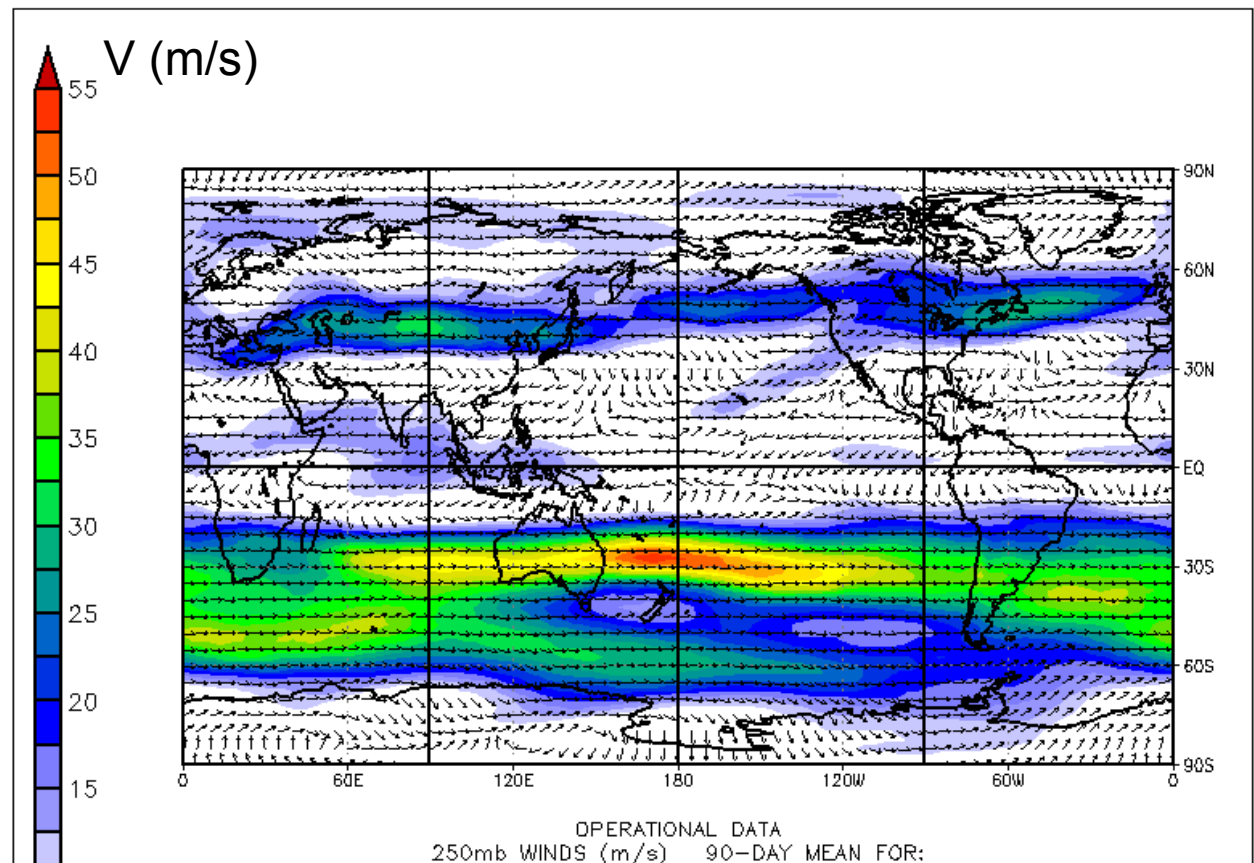
Moyenne été 2006

Altitude à 200hPa

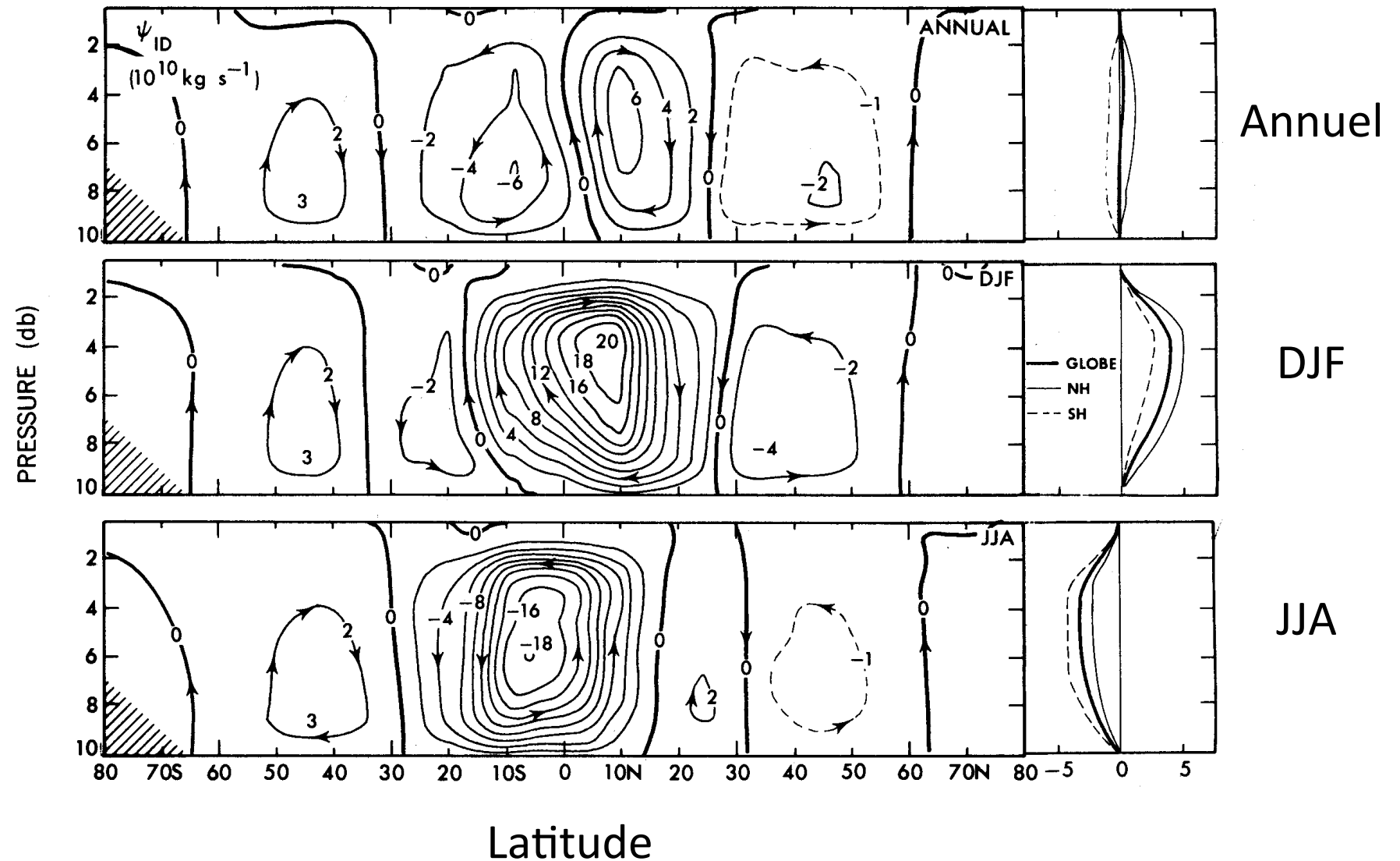
(altitude élevée=
haute pression)



Vent
(direction et vitesse)

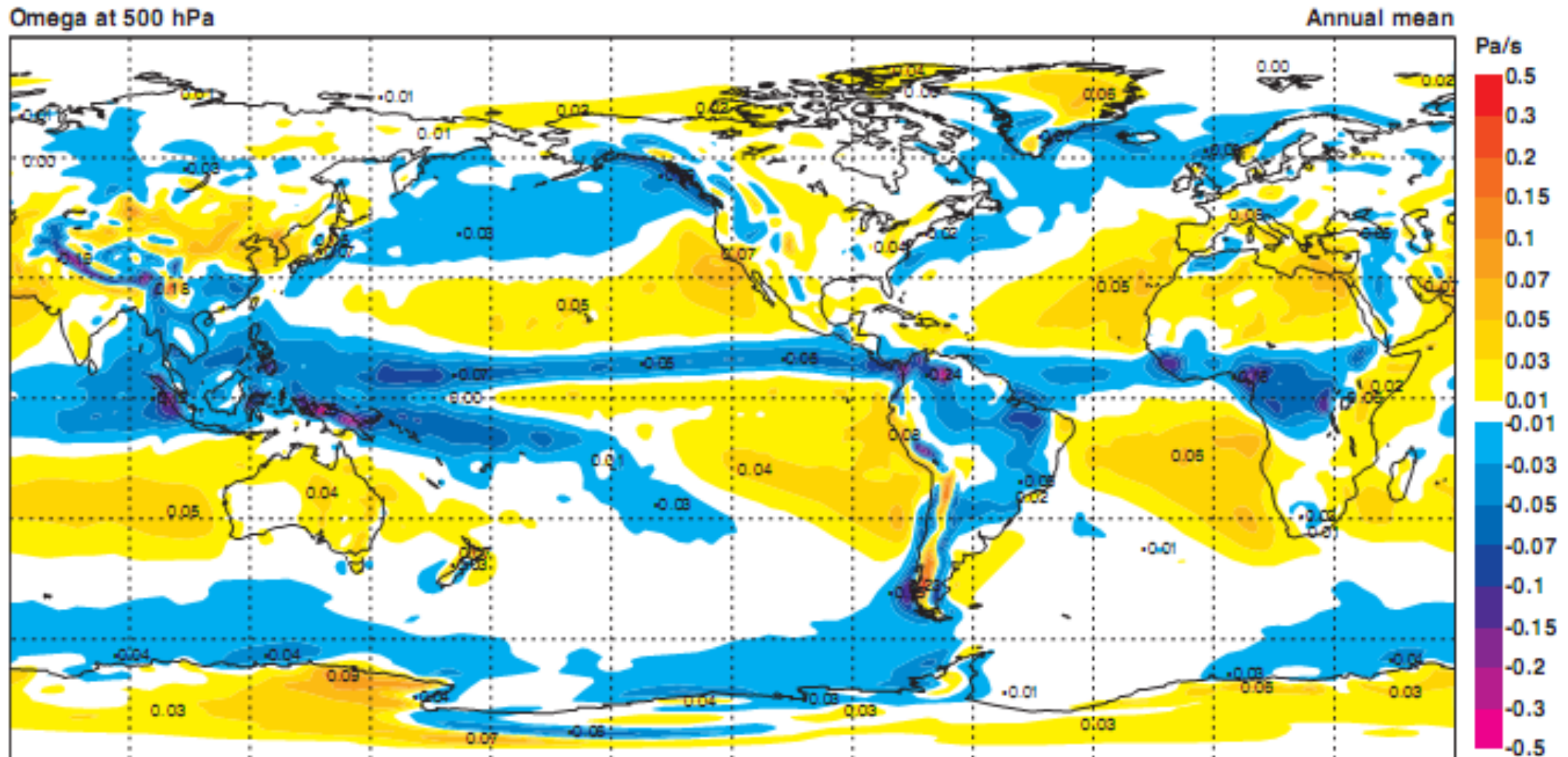


Cellules de Hadley (circulation en moyenne zonale)

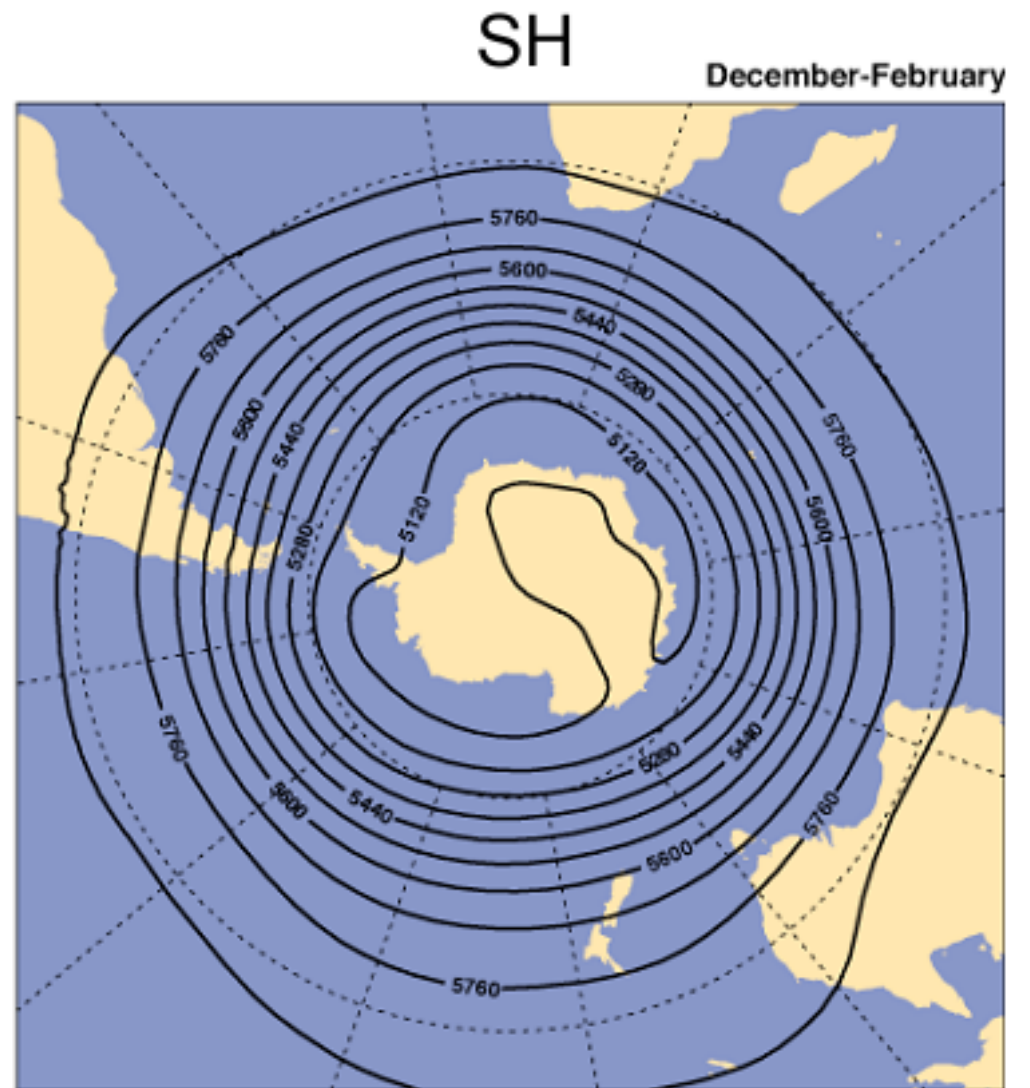
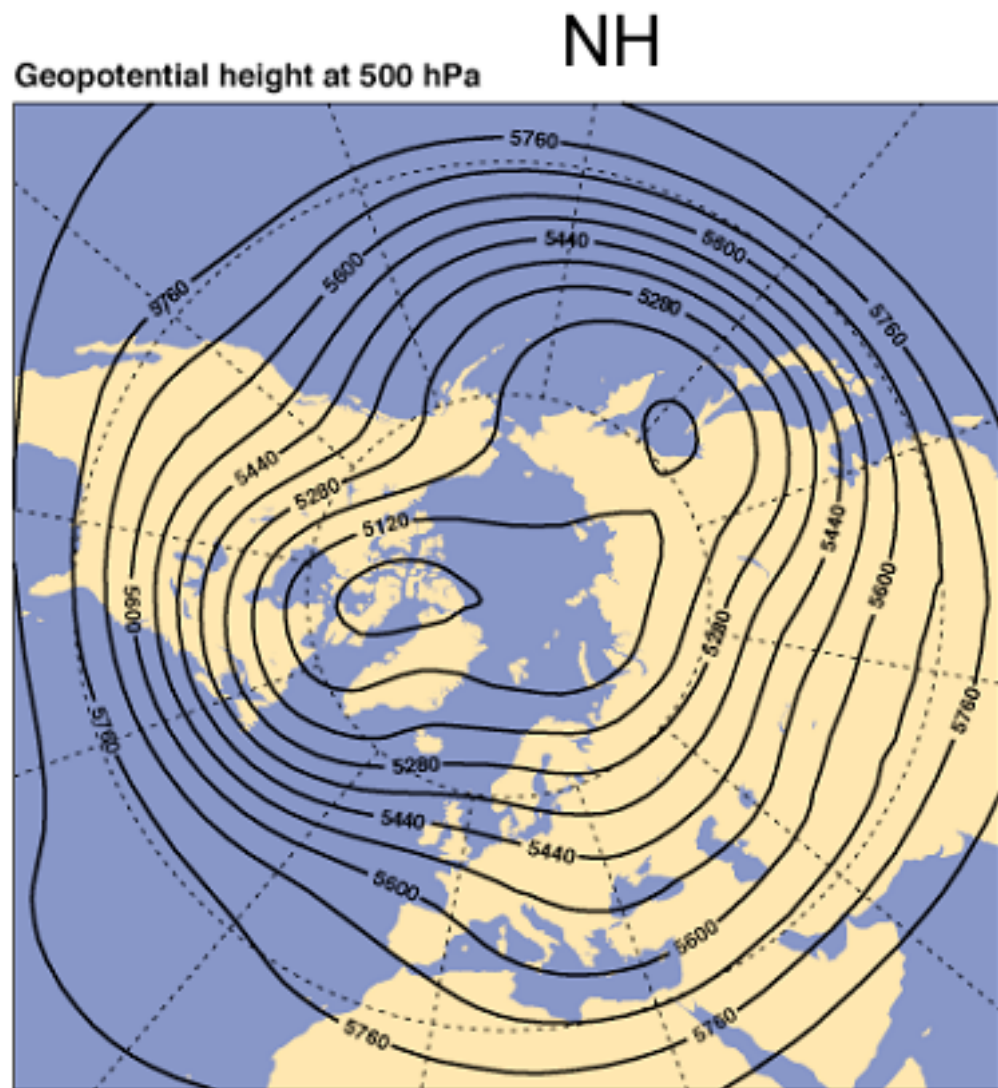


Vitesse verticale à 500 hPa
($\omega = dP/dt$, $\omega < 0$ ascension)

moyenne annuelle



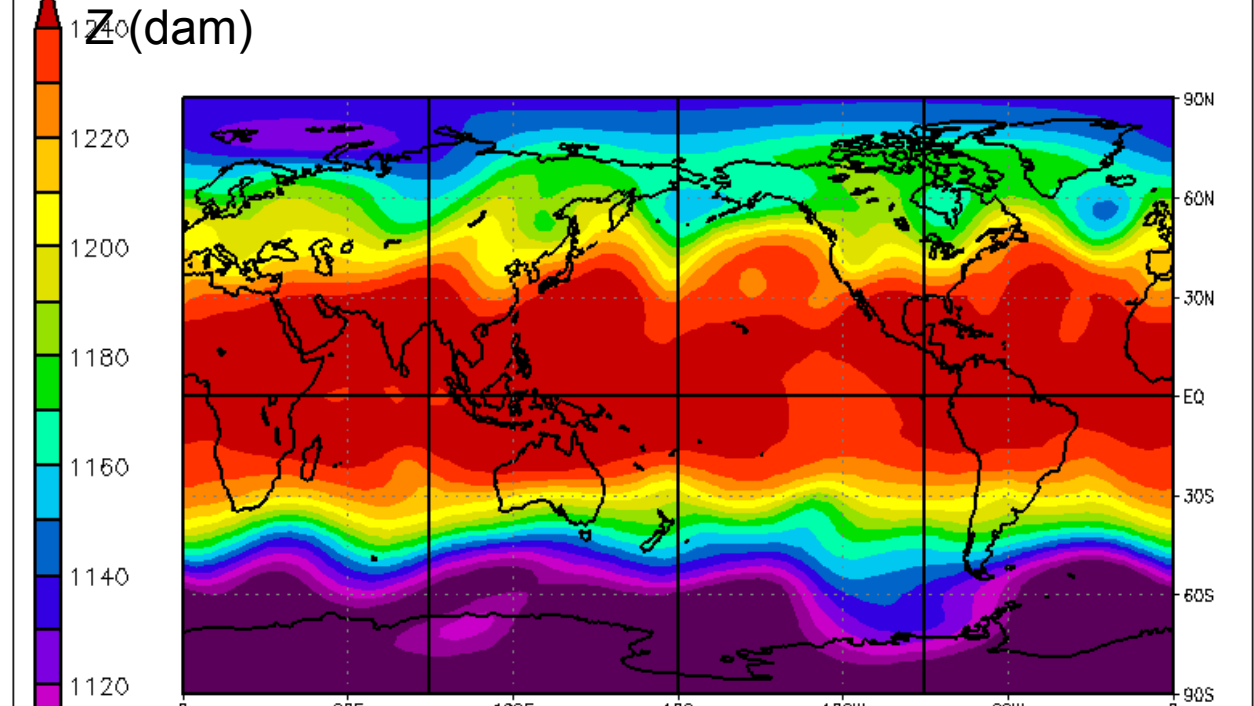
Géopotentiel moyen à 500 hPa (DJF)



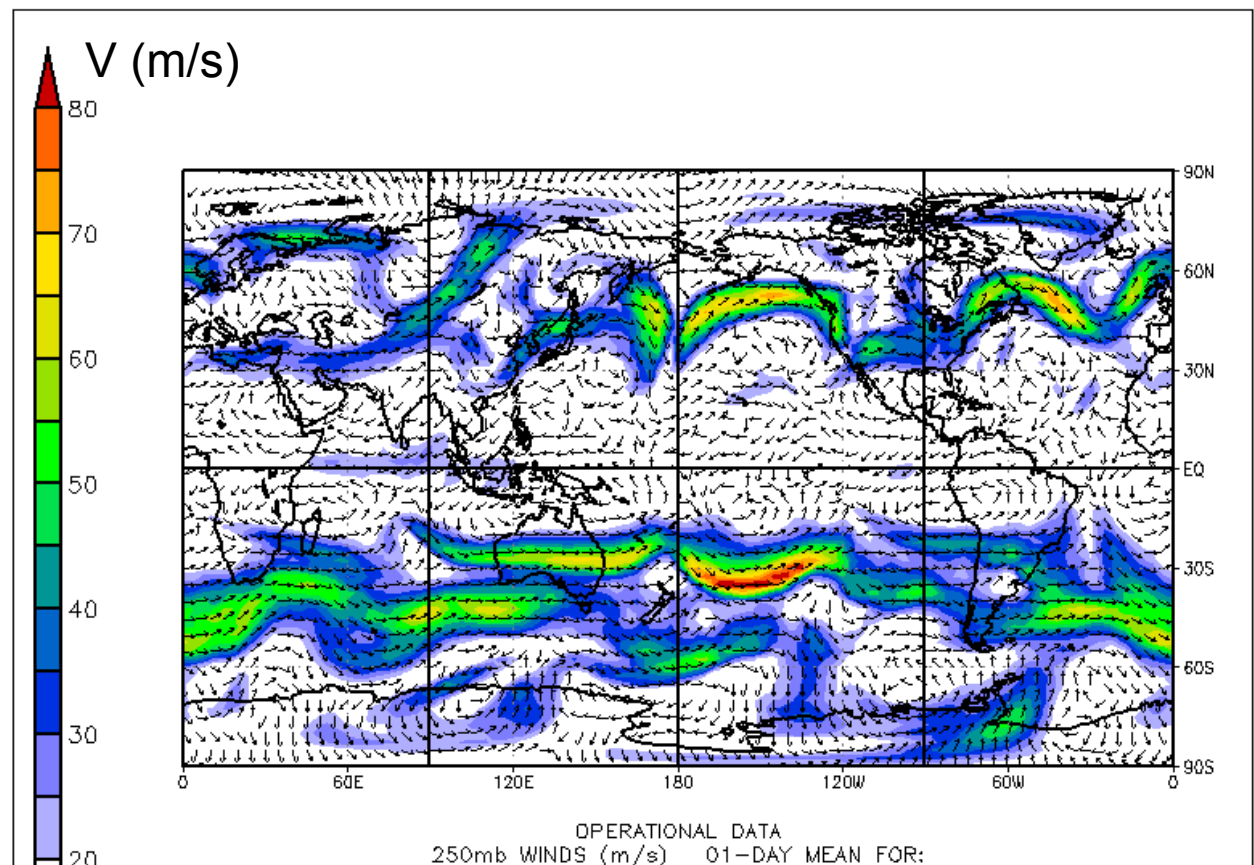
20 septembre 2006:

Altitude à 200hPa

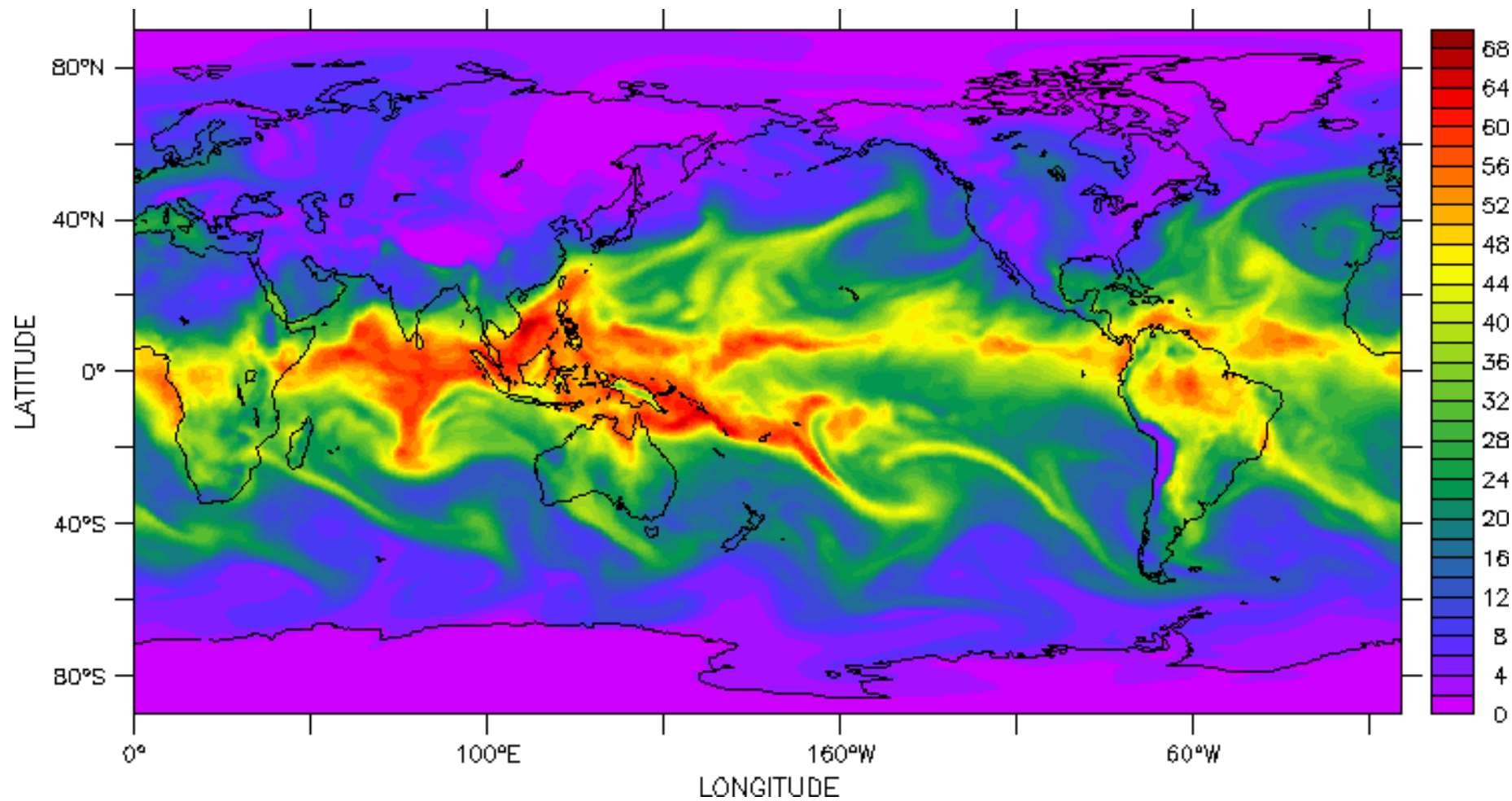
(altitude élevée=
haute pression)



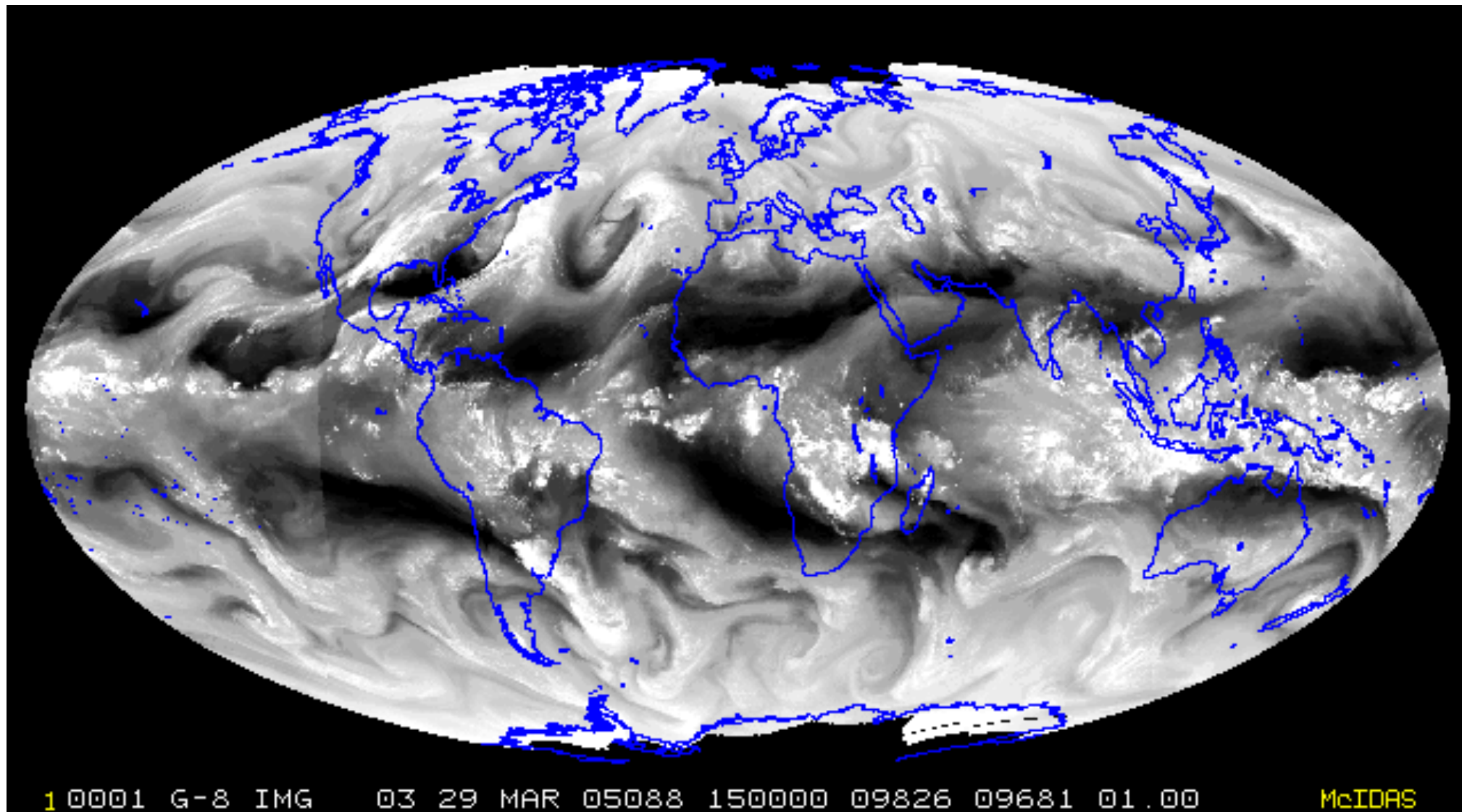
Vent
(direction et vitesse)



Vapeur d'eau intégrée sur la verticale: Image instantanée



Météosat canal vapeur d'eau 29 Mars



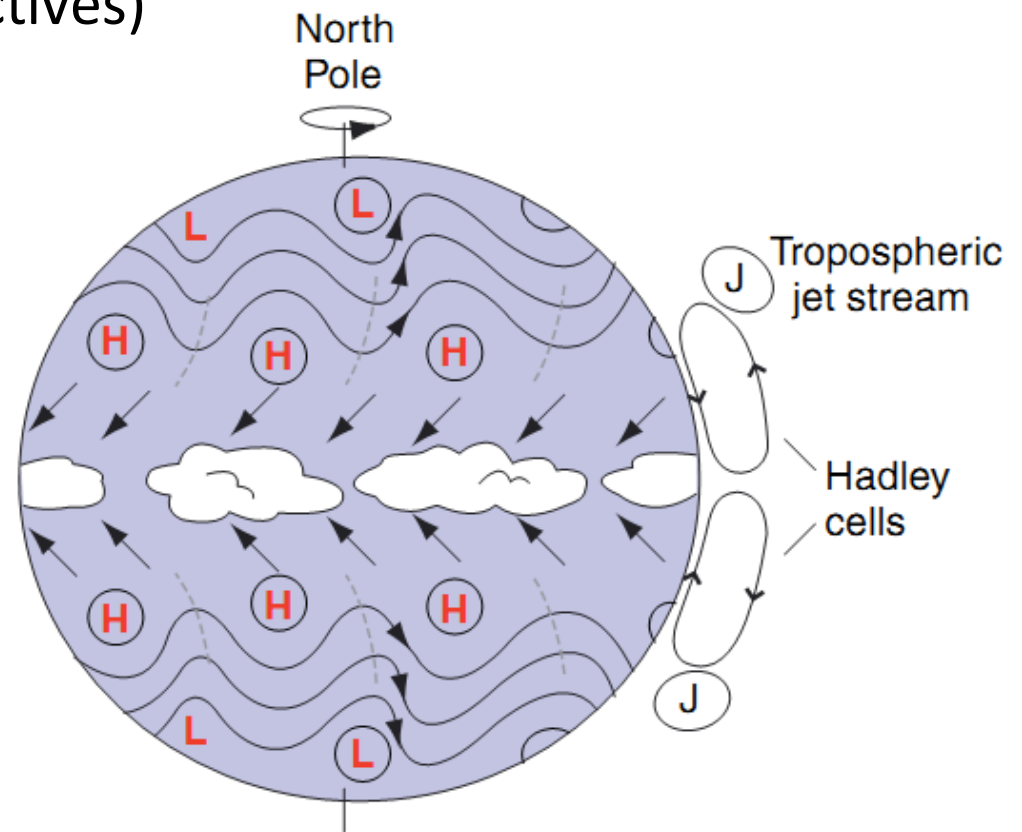
Caractéristiques de la circulation générale:

- **Tropiques:**

- Faibles variations horizontales de température et pression
- Zones sèches ou humides (et convectives)
- Circulation en cellules verticales, ascendance dans zones humides.

- **Moyennes latitudes:**

- Forts contrastes de température et pression
- Vent zonal fort (jet) // aux isobares
- Circulation horizontale turbulente.

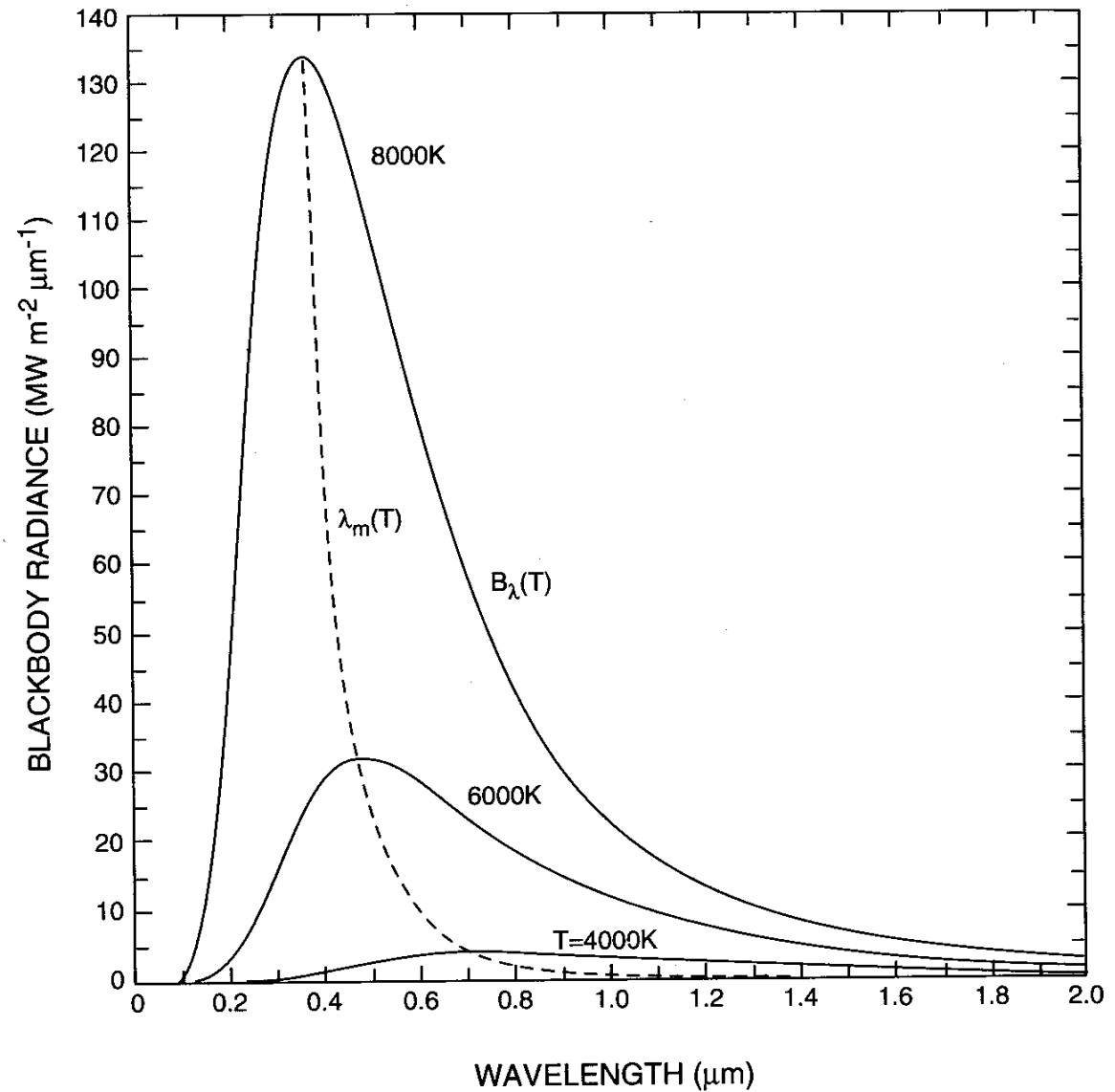


Émission du corps noir

$$\text{Flux total} = \sigma T^4$$

$$\lambda_{\text{max}} \propto T^{-1}$$

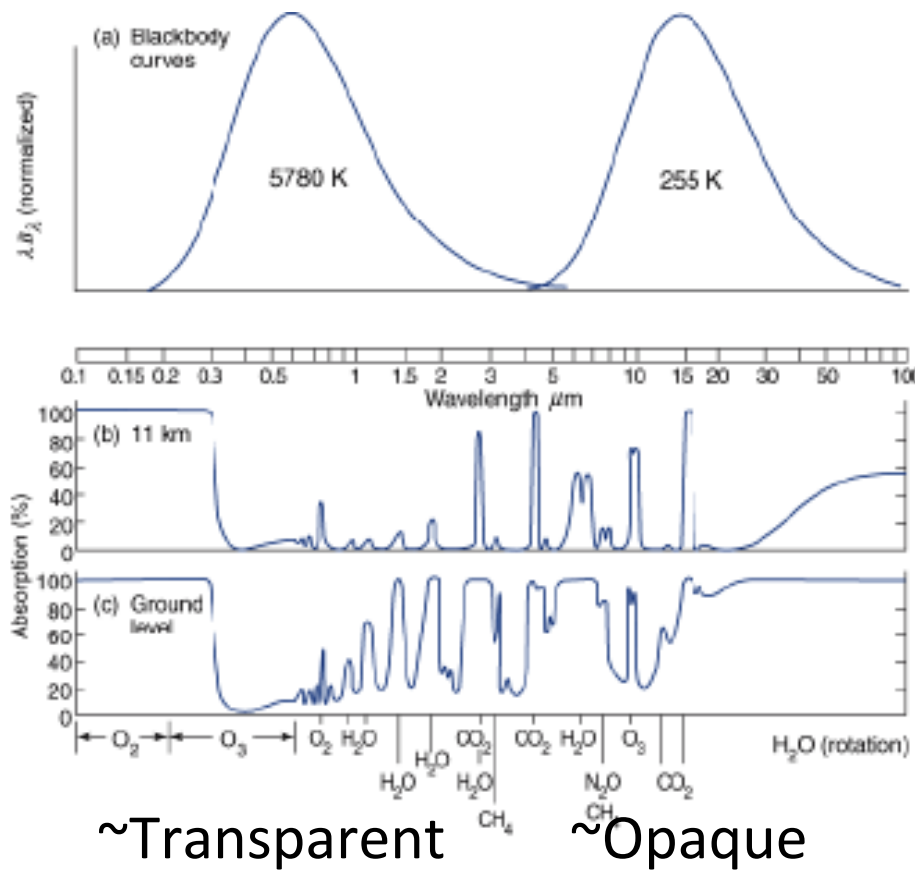
S_I



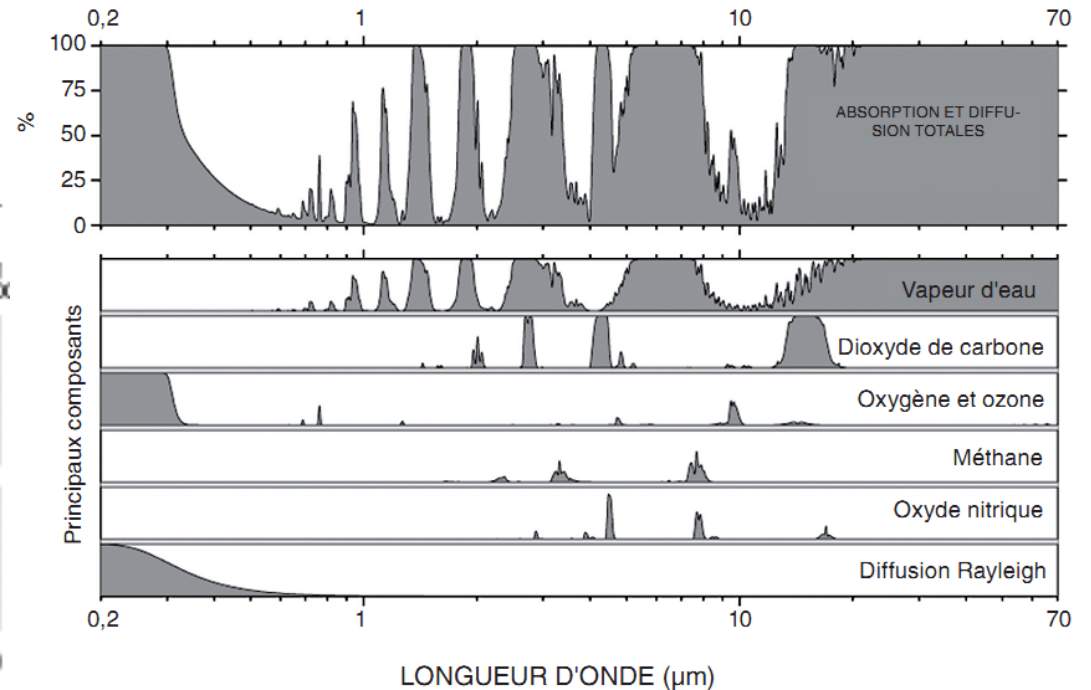
Absorption: spectre atmosphérique

Rayonnement
solaire (vis.)

Rayonnement
Terrestre (IR)

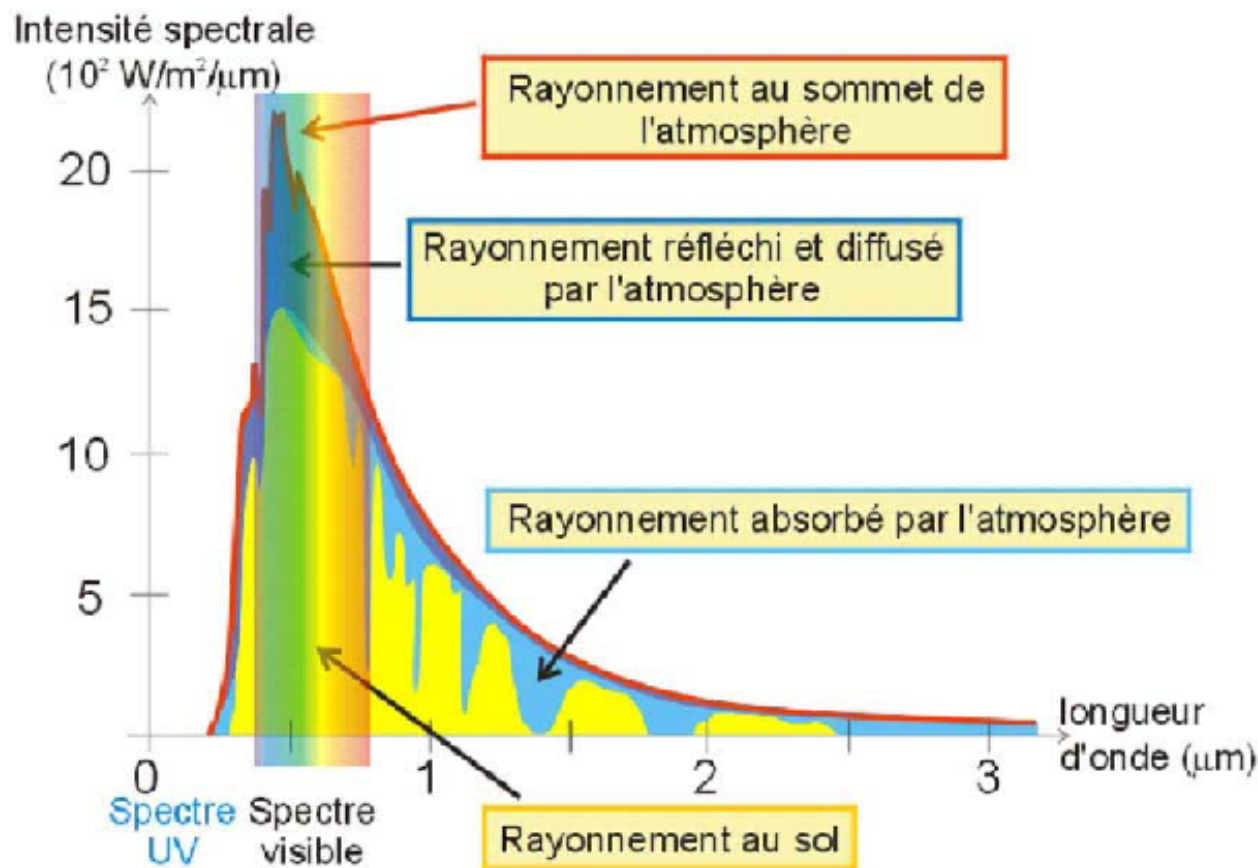


Détail par composant



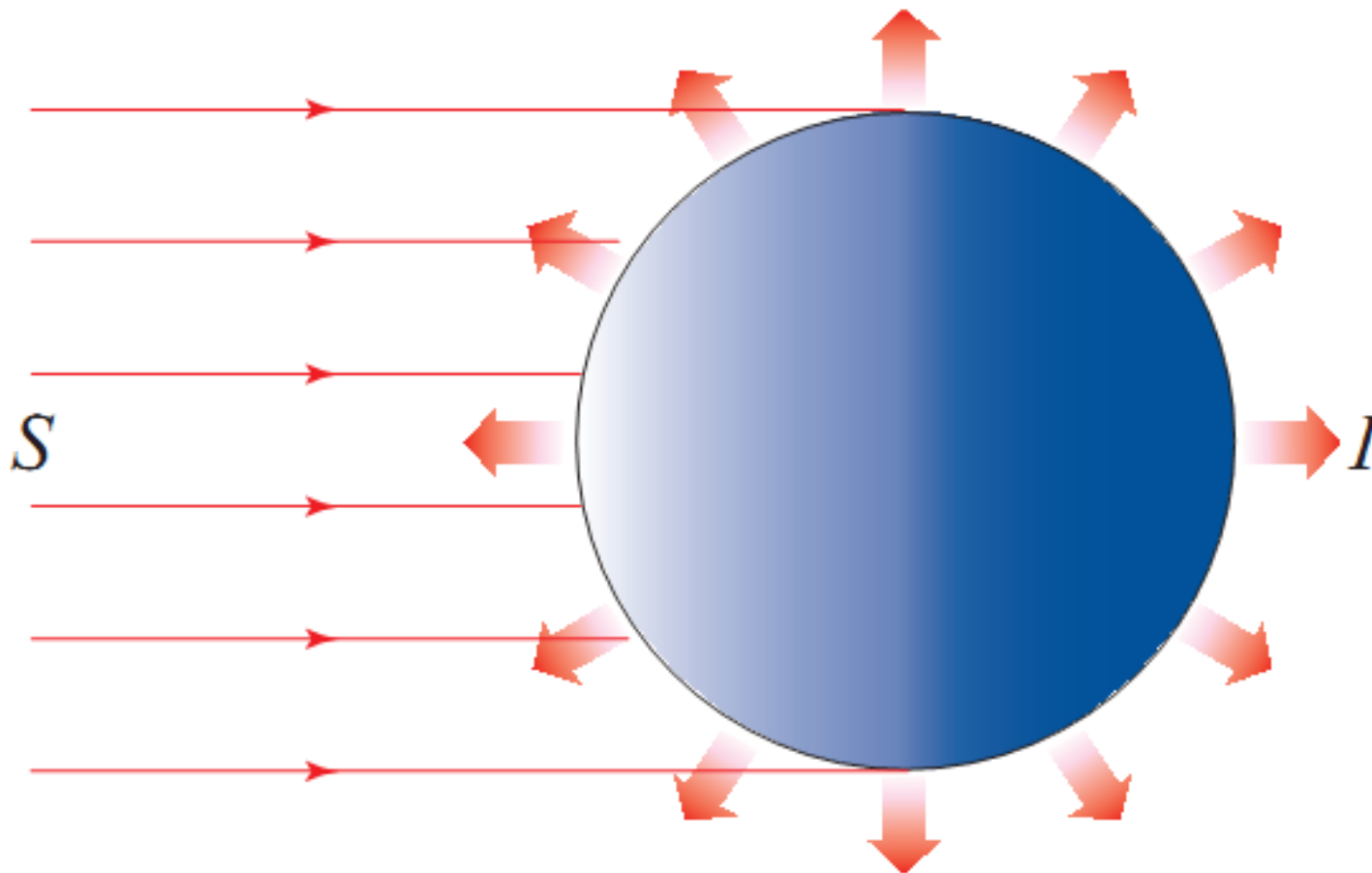
Transfert radiatif dans le visible

- Absorption
- Diffusion et rétrodiffusion (albédo)



Type de Surface	Albédo (%)
<i>Sol nu</i>	
Roches sombres, humus	10
Sol sec, désert	30
Sable mouillé	25
Sable clair, sec	35
Asphalte	7
Béton	20
<i>Végétation</i>	
Végétation basse, verte	17
Végétation sèche	25
Forêt conifères	12
Forêt décidue	17
<i>Neige et glace</i>	
Forêt avec neige au sol	25
Banquise sans neige	30
Neige fondante	50
Neige fraîche	80

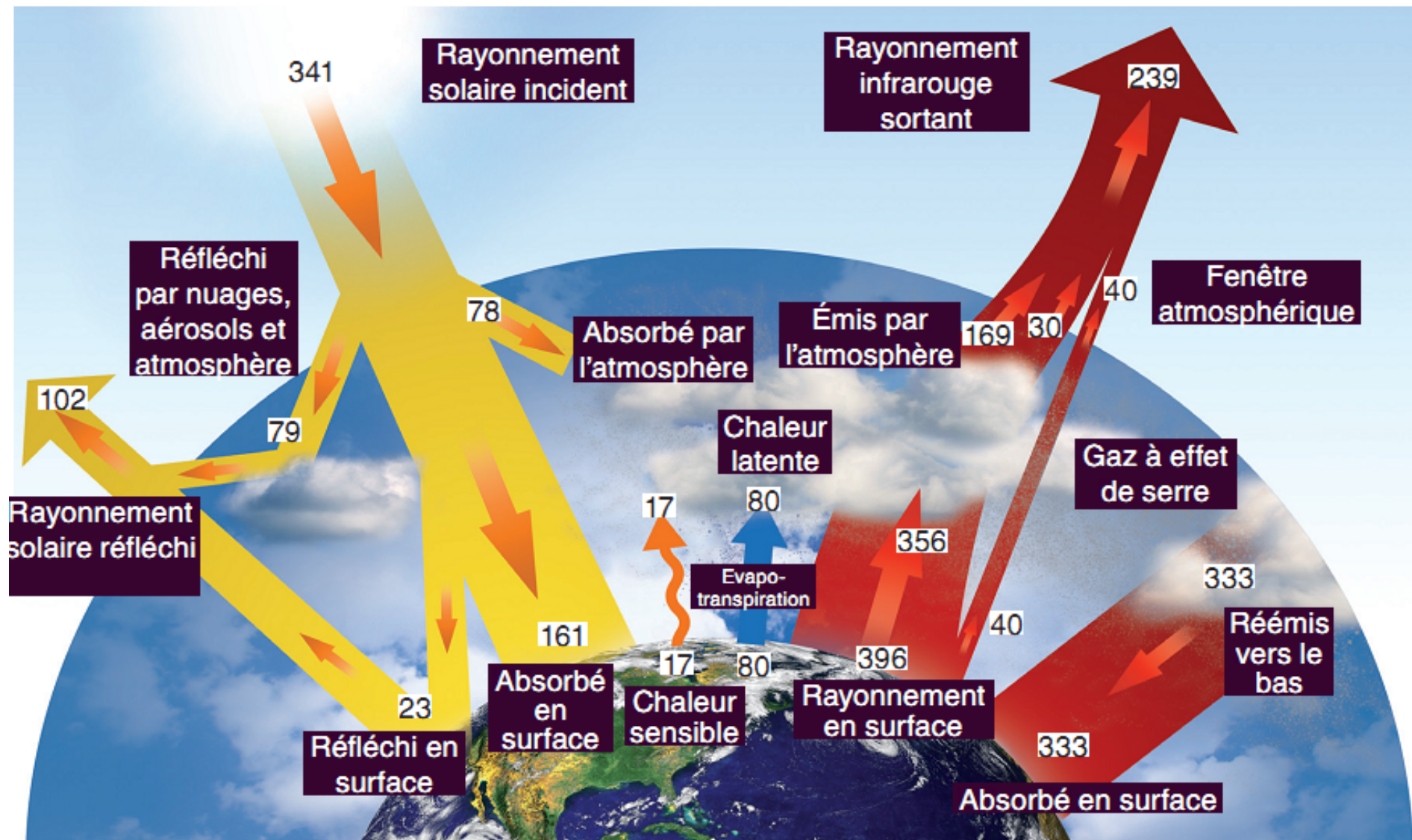
Rayonnement solaire:
Éclairement $E=S/4$



Flux solaire intercepté:
 $S\pi R_T^2$

Surface de la Terre:
 $4\pi R_T^2$

Bilan énergétique global (flux en W m^{-2})

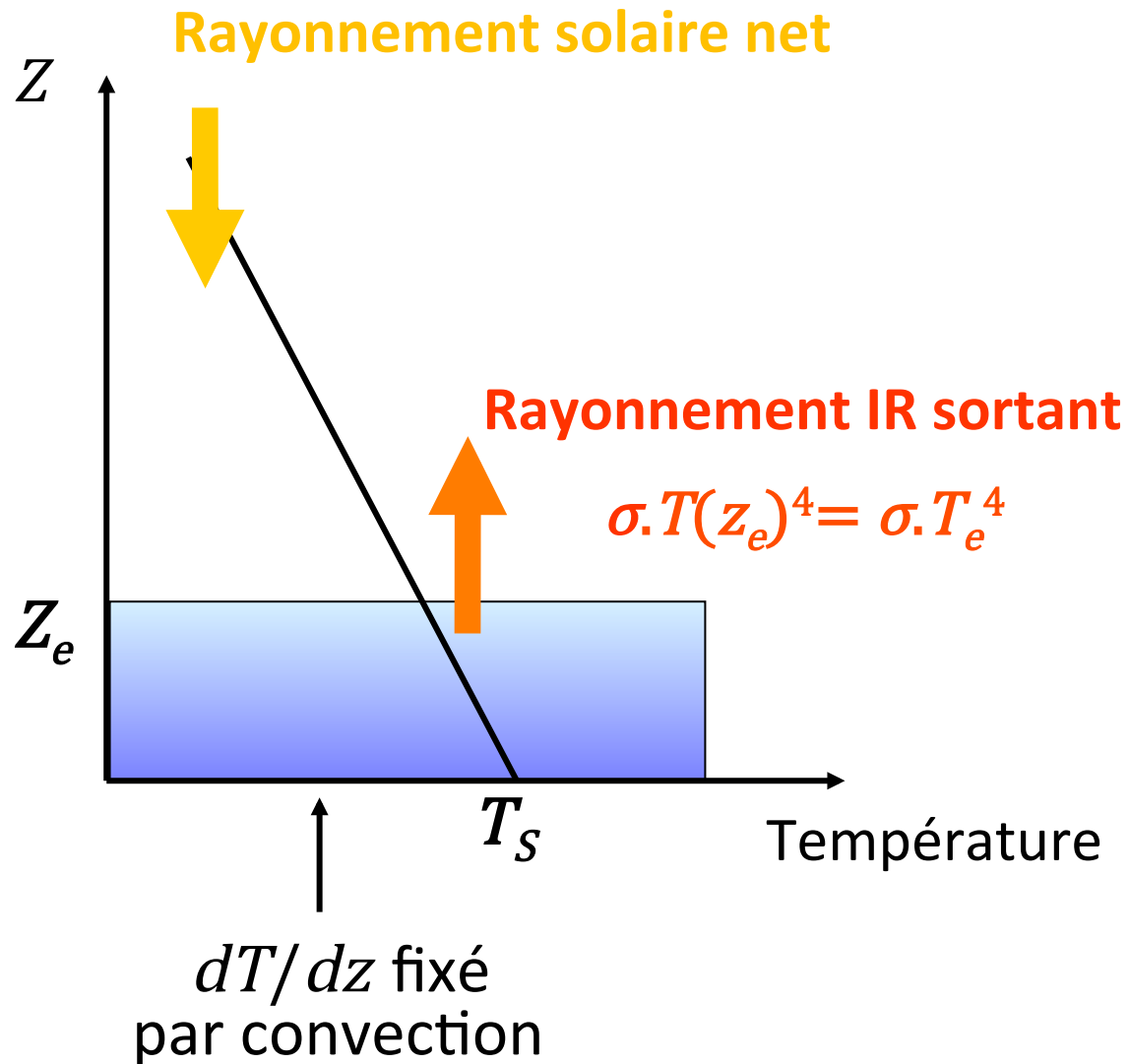


Rayonnement solaire

Rayonnement IR terrestre

Équilibre radiatif global

Profil de température fixé par convection

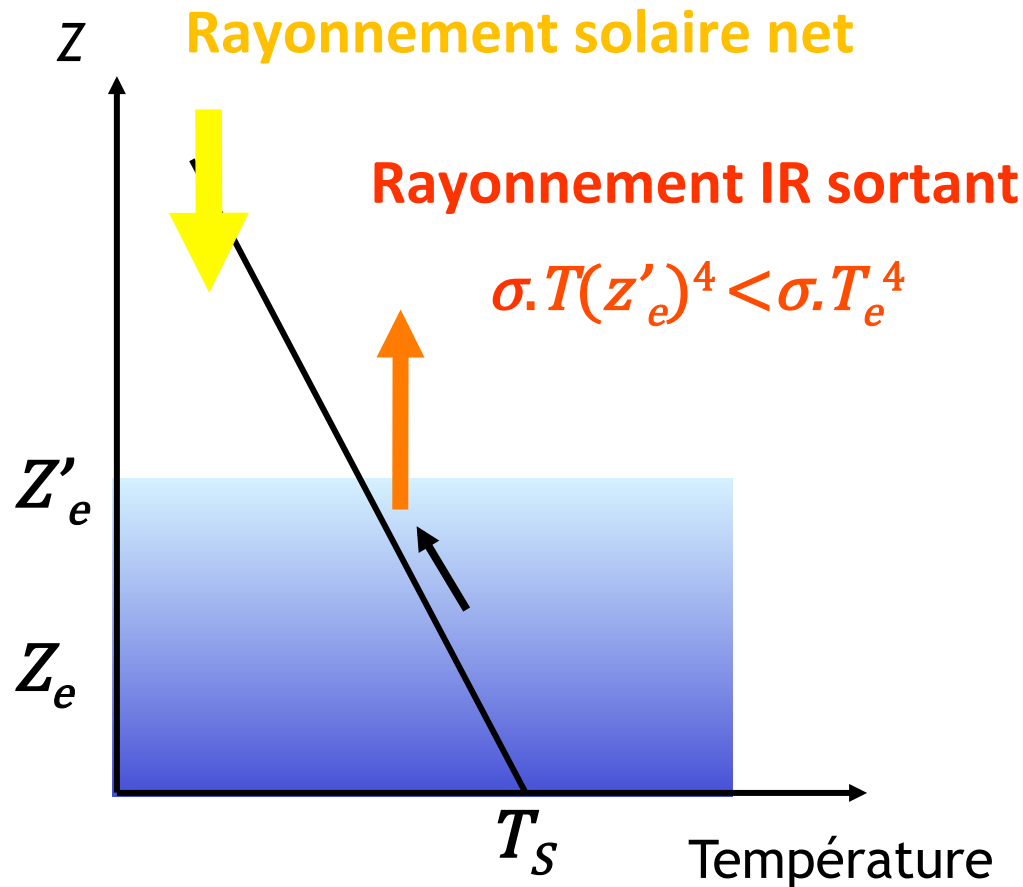


Atmosphère transparente:
ni émission ni absorption

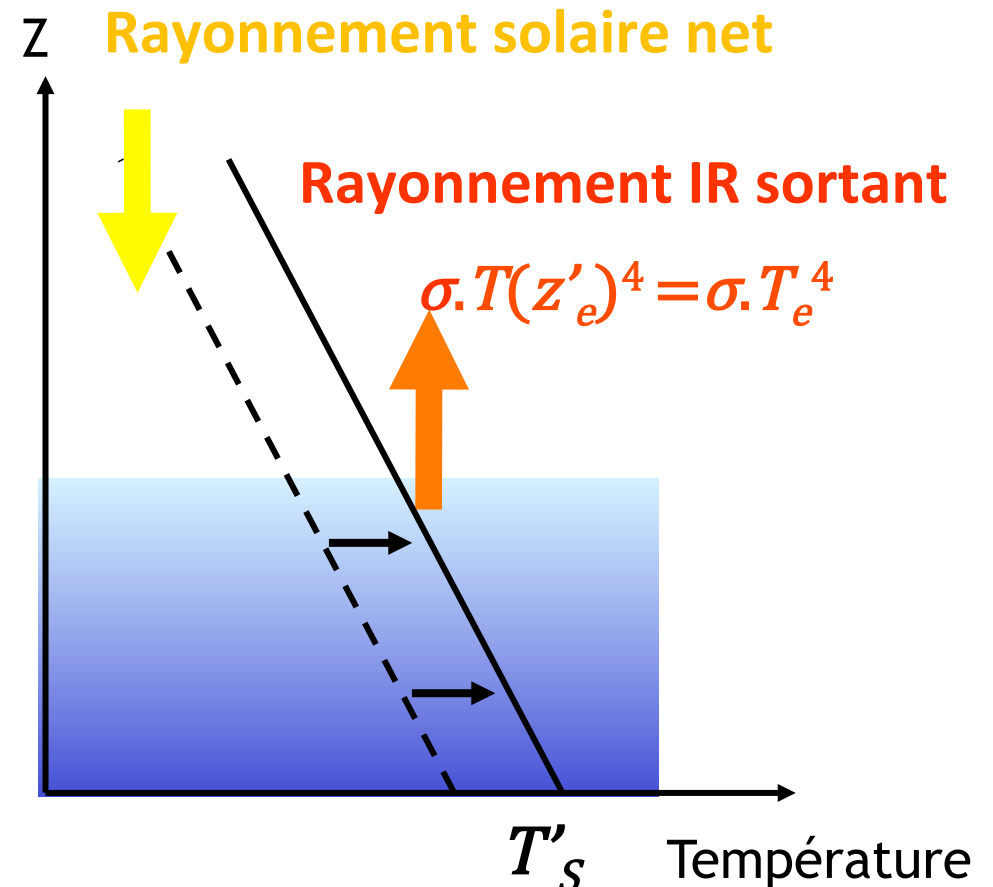
Z_e : altitude d'émission
vers l'espace

Atmosphère opaque:
Rayonnement absorbé

Augmentation de gaz à effet de serre:
 Altitude d'émission vers l'espace plus élevée
 Augmentation de la température.

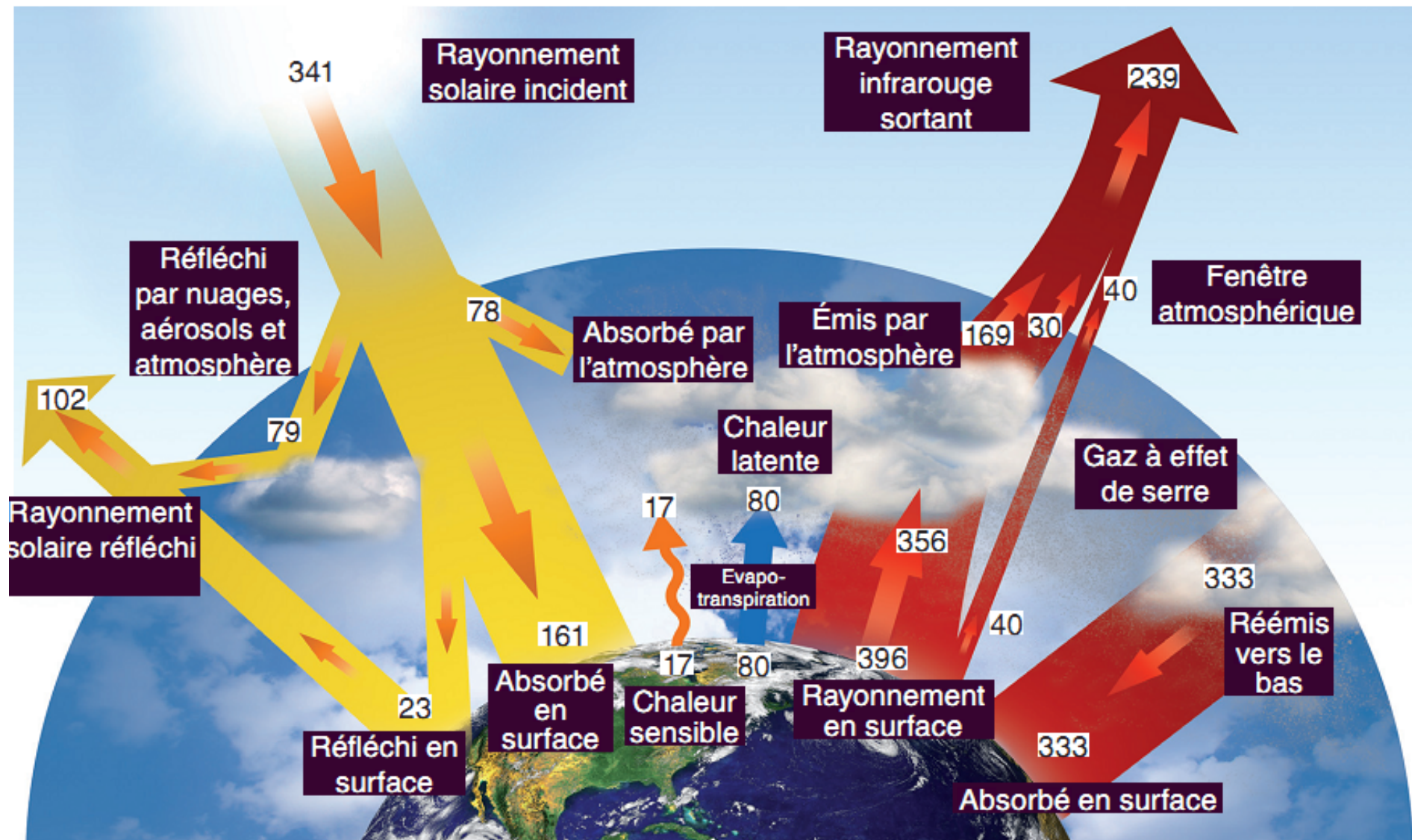


1. $T_{\text{émission}}$ diminue (z_e plus élevée):
 Rayonnement sortant plus faible.



2. $T(z)$ augmente:
 Retour à l'équilibre

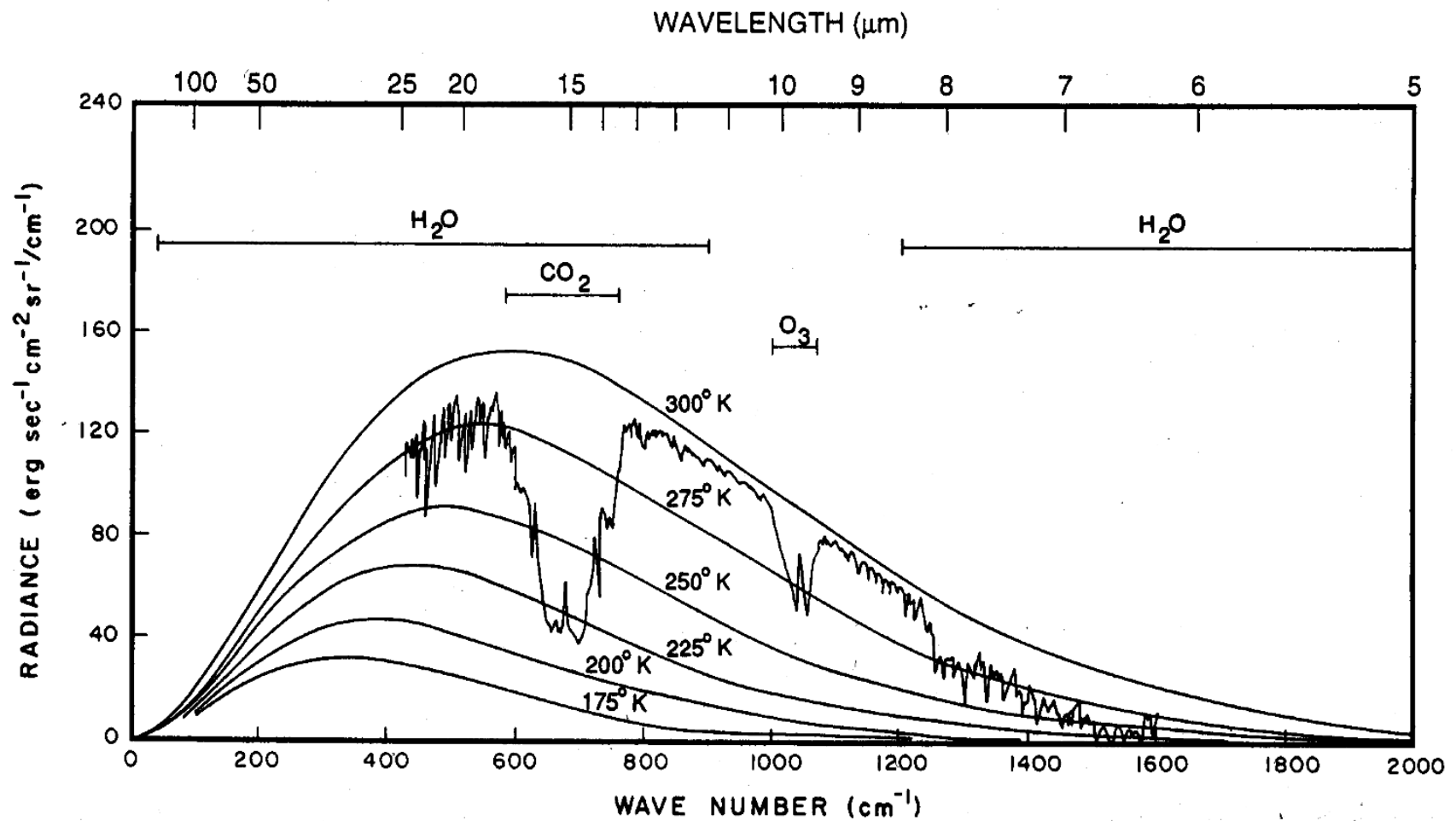
Bilan énergétique global (flux en W m^{-2})



Rayonnement solaire

Rayonnement IR terrestre

Dépendance spectrale

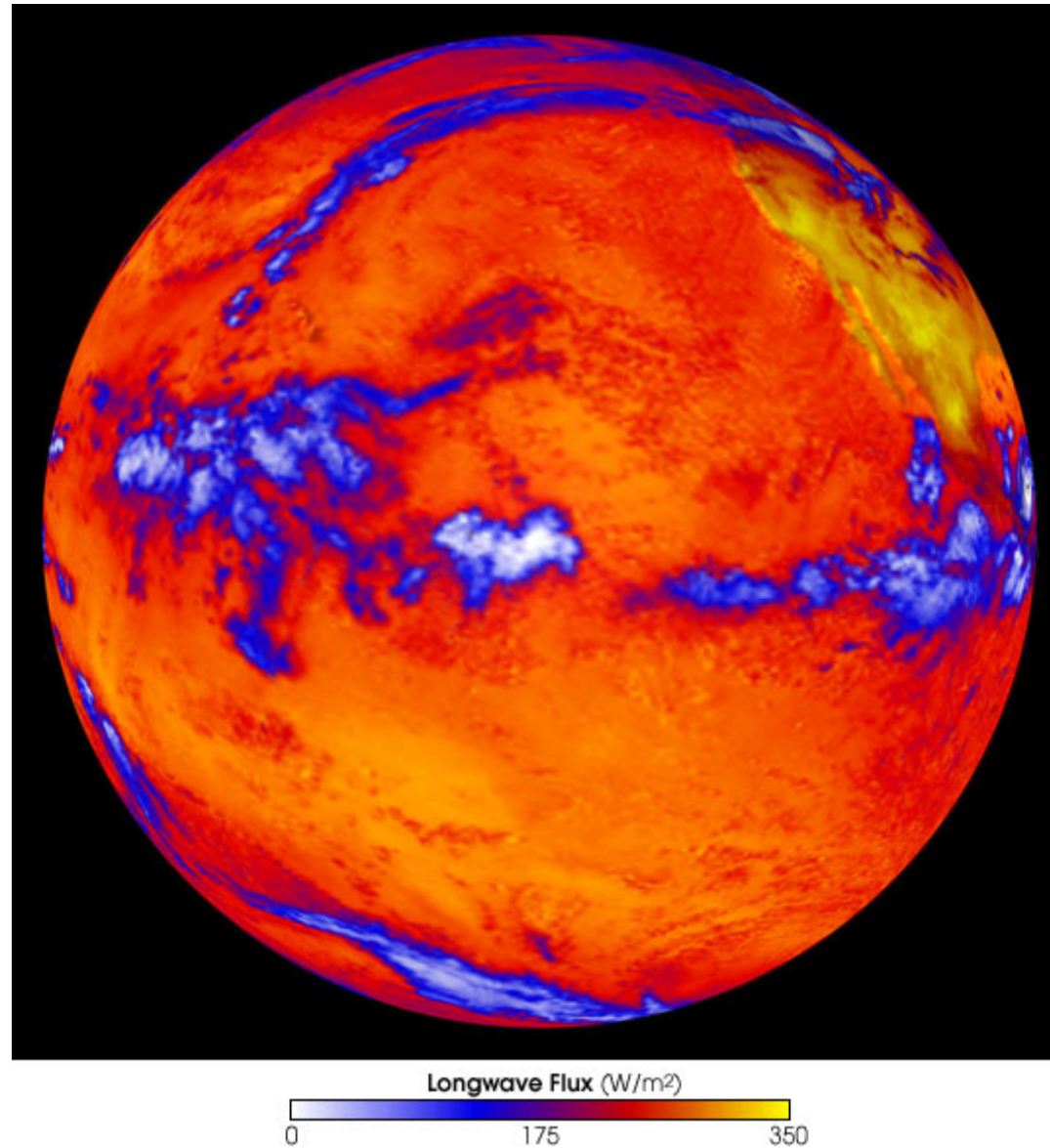


Flux infrarouge sortant

Dépendance géographique

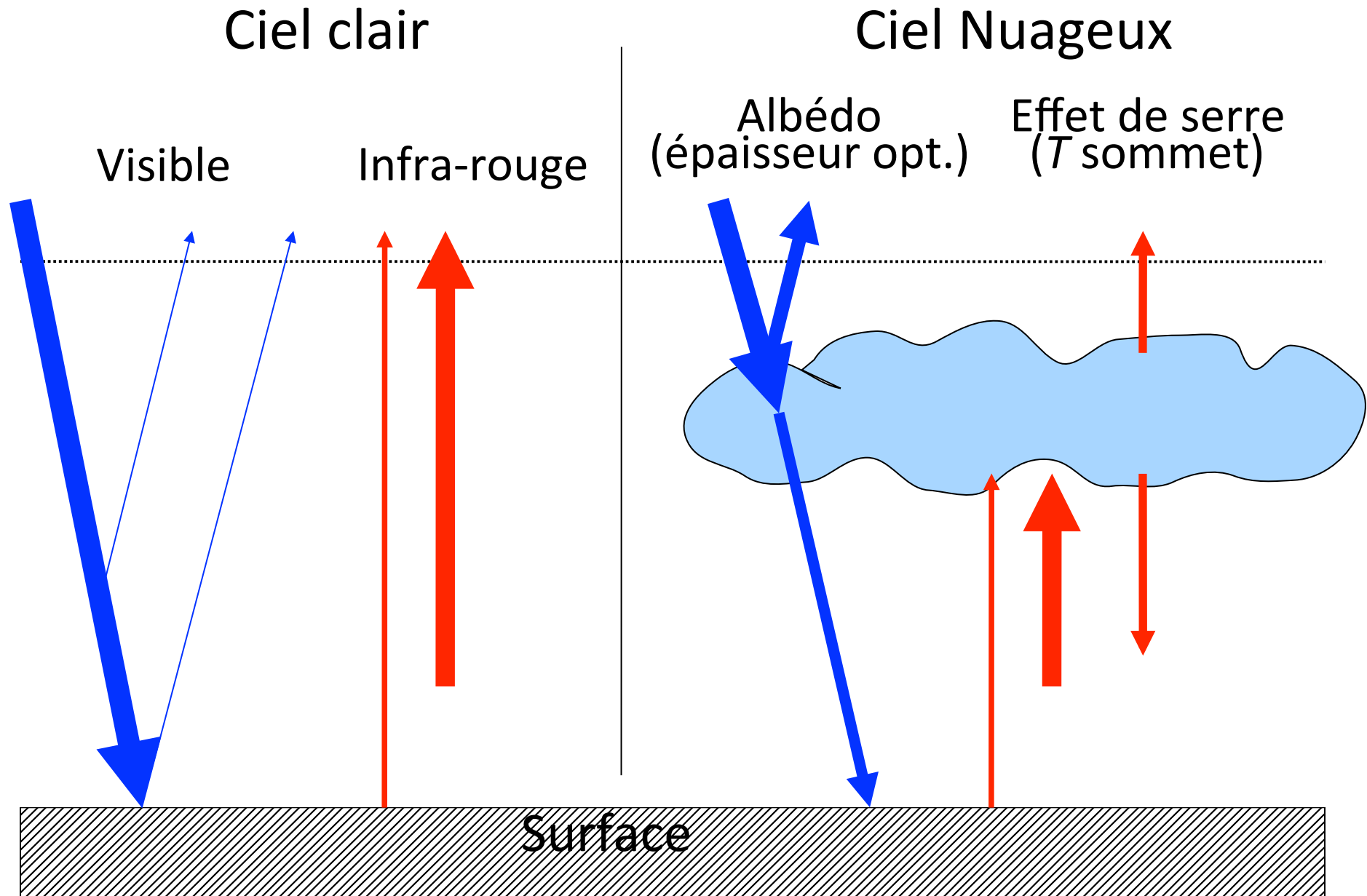
$$\text{Flux} = \sigma T^4$$

T émission

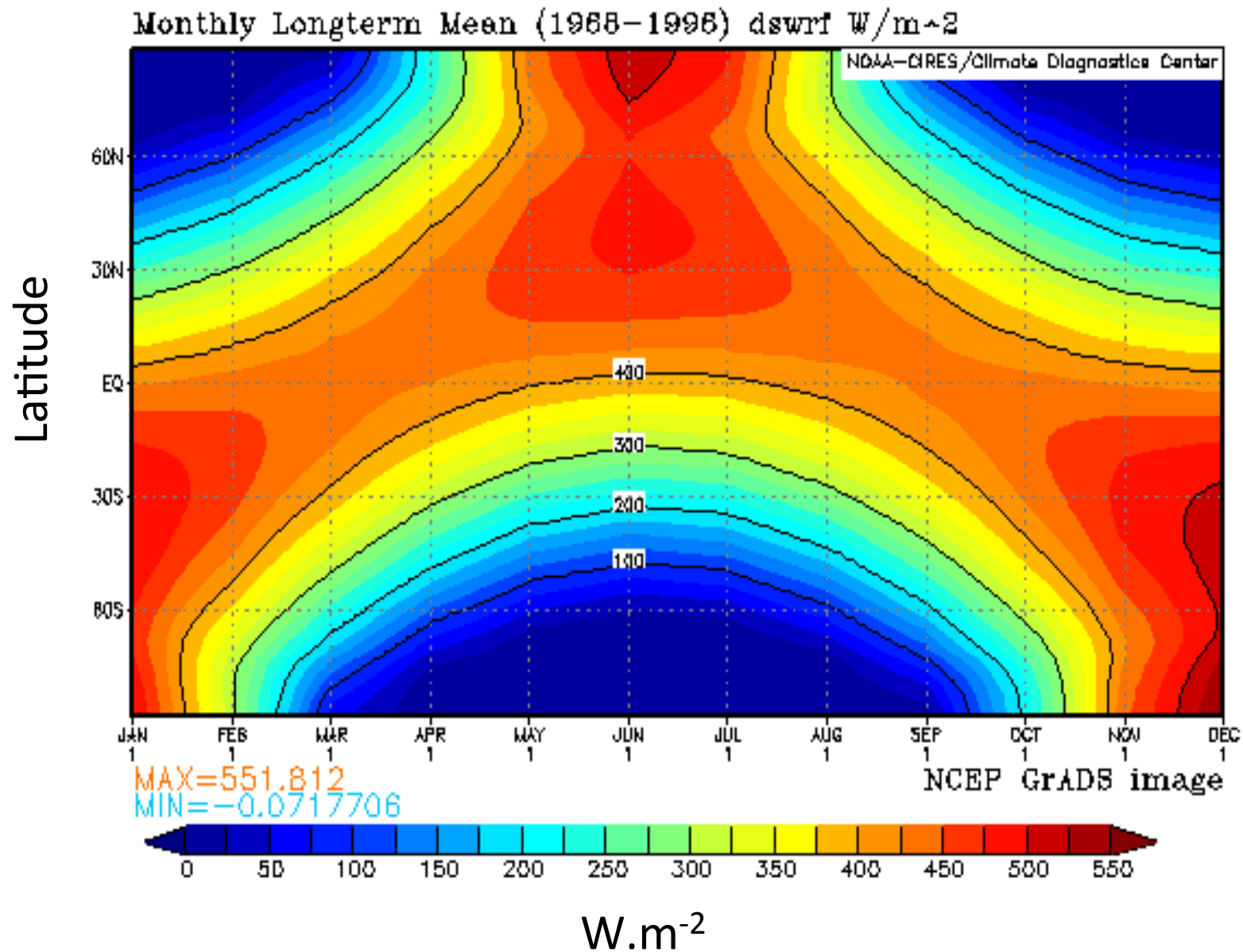


Flux infrarouge sortant
sommet de l'atmosphère

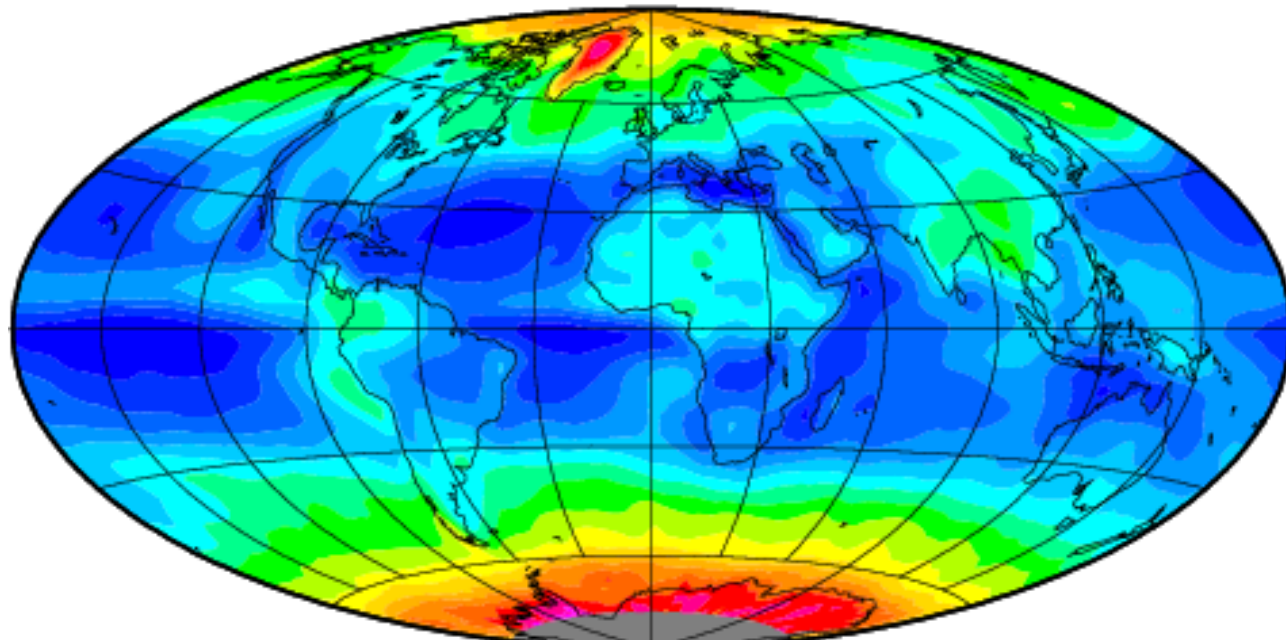
Forçage radiatif des nuages



Flux solaire sommet de l'atmosphère



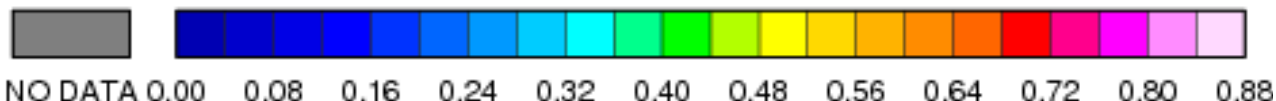
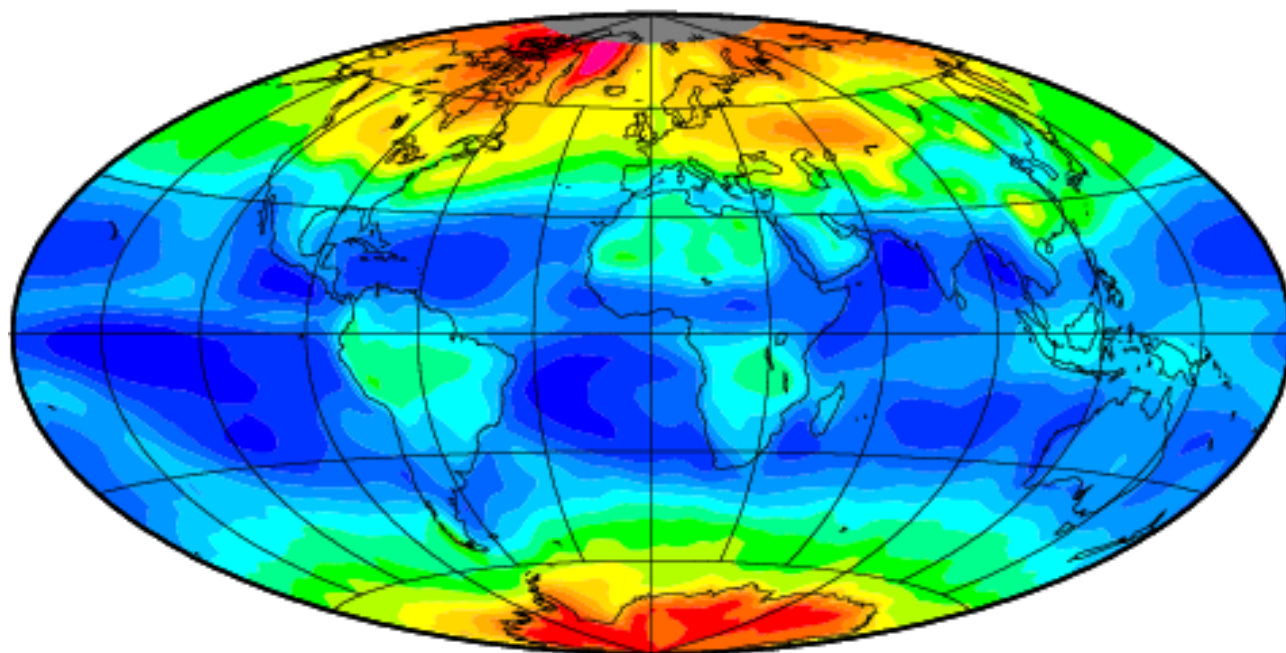
Dec-Jan-Fev



Albedo

DJF 1985-1986

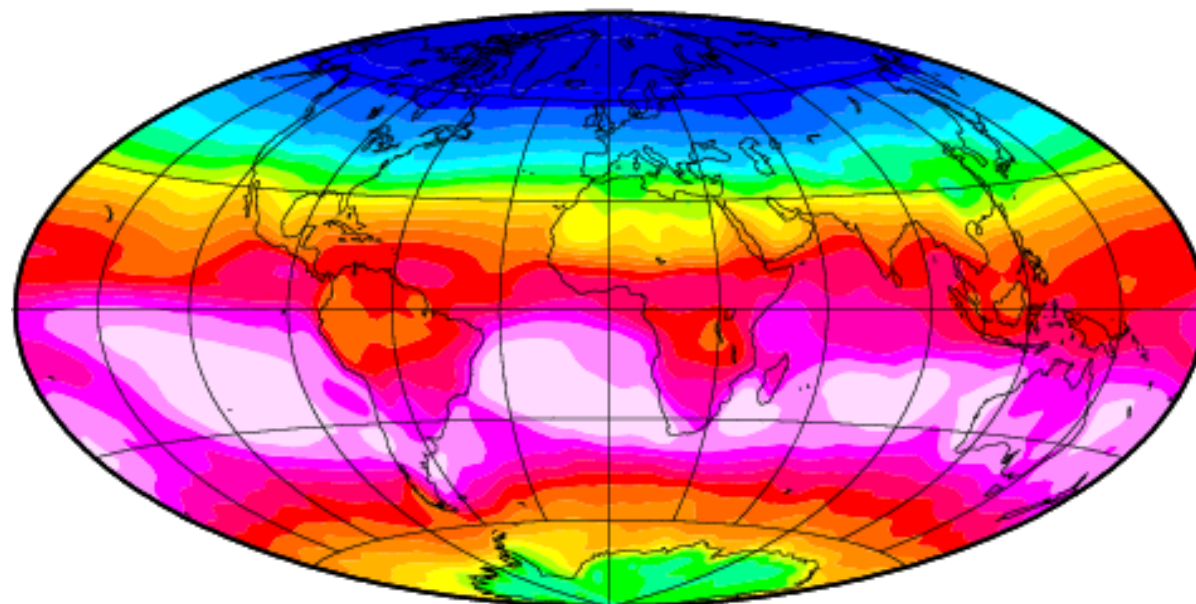
Juin-Juil-Août



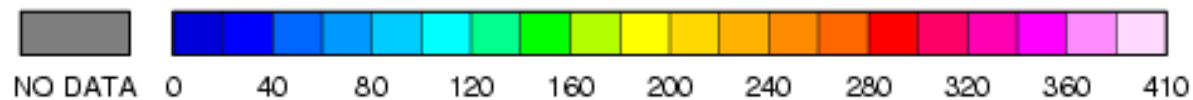
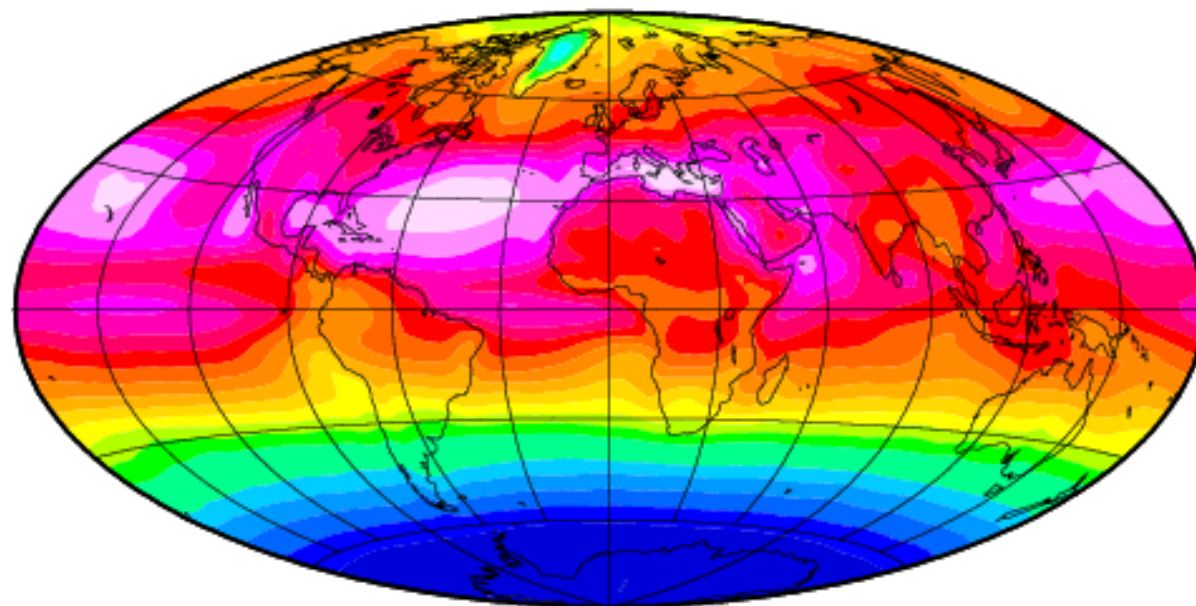
Dec-Jan-Fév

Rayonnement Visible absorbé

Juin-Juil-Août



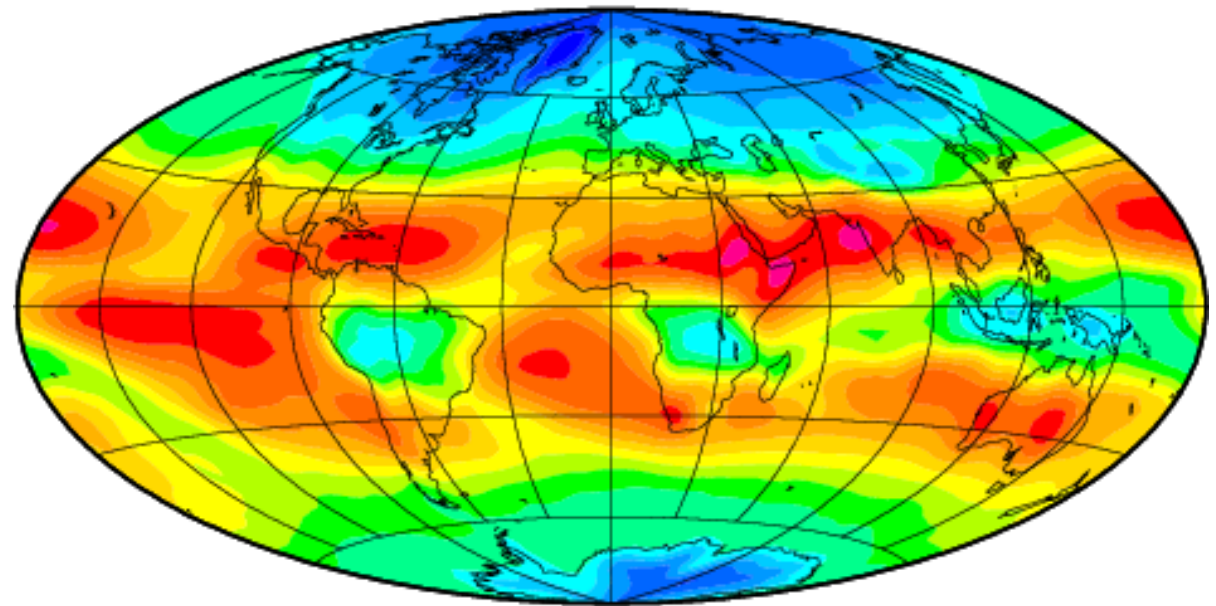
Absorbed Shortwave Radiation
JJA 1985-1986



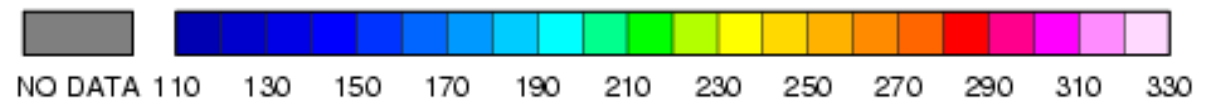
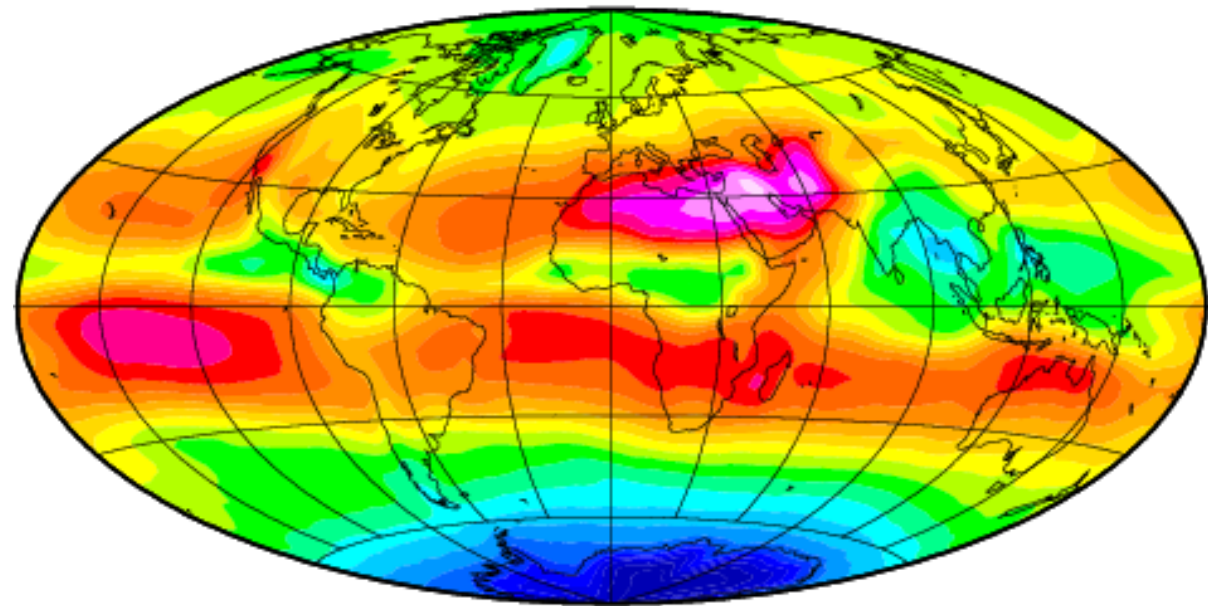
Dec-Jan-Fév

Rayonnement Infrarouge sortant

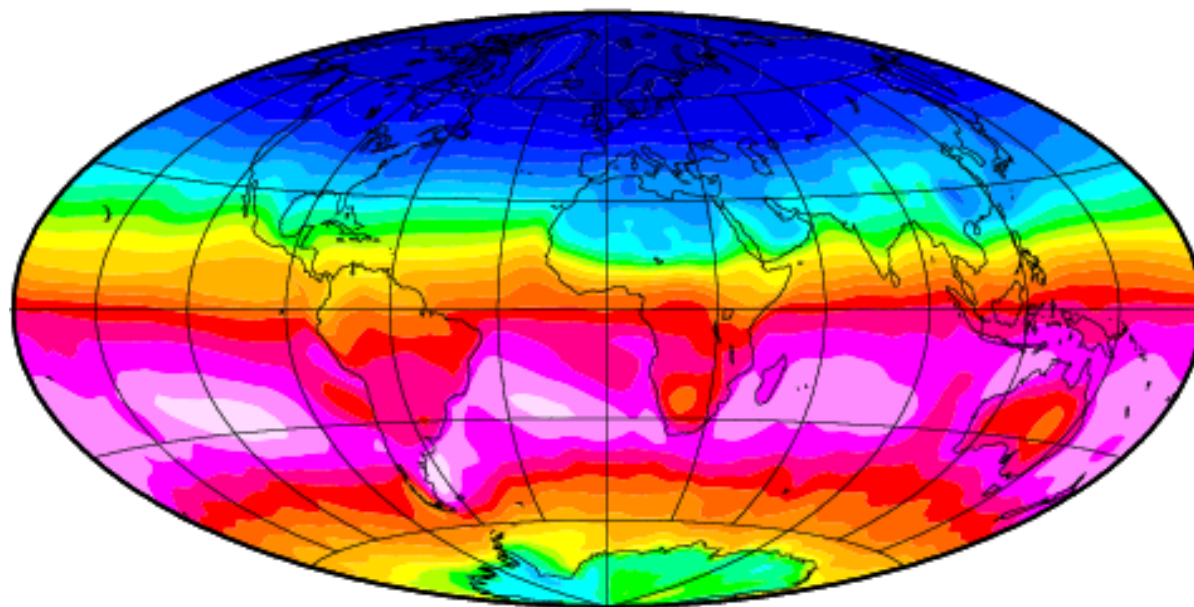
Juin-Juil-Août



Outgoing Longwave Radiation
JJA 1985-1986



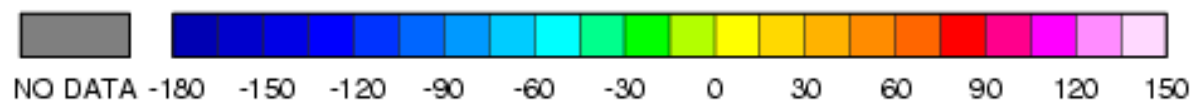
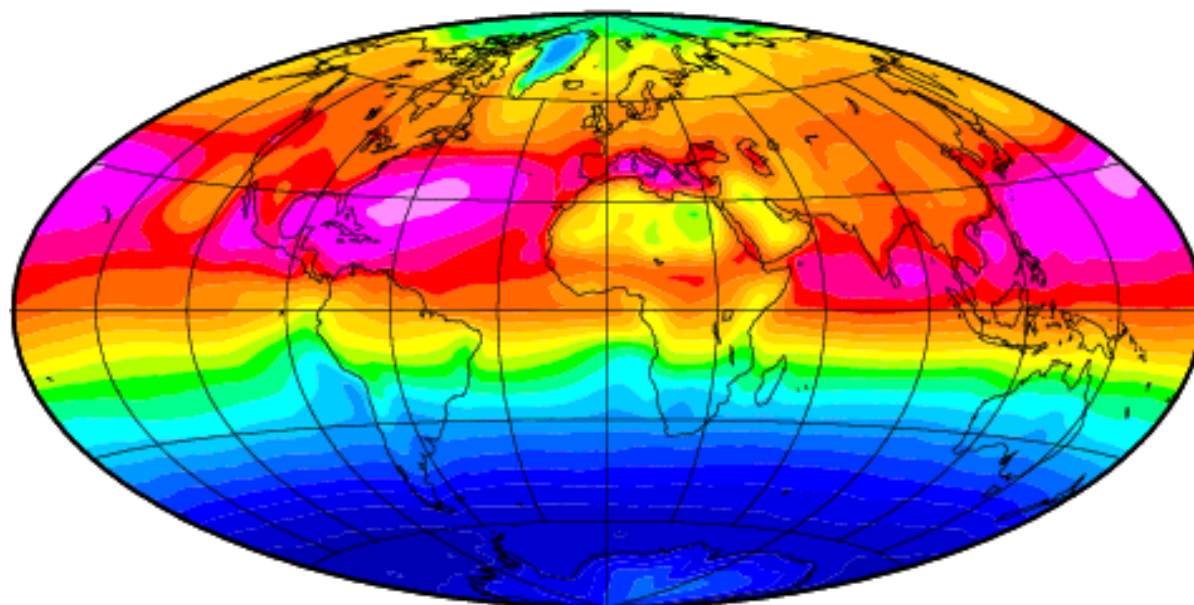
Dec-Jan-Fév



Rayonnement Net

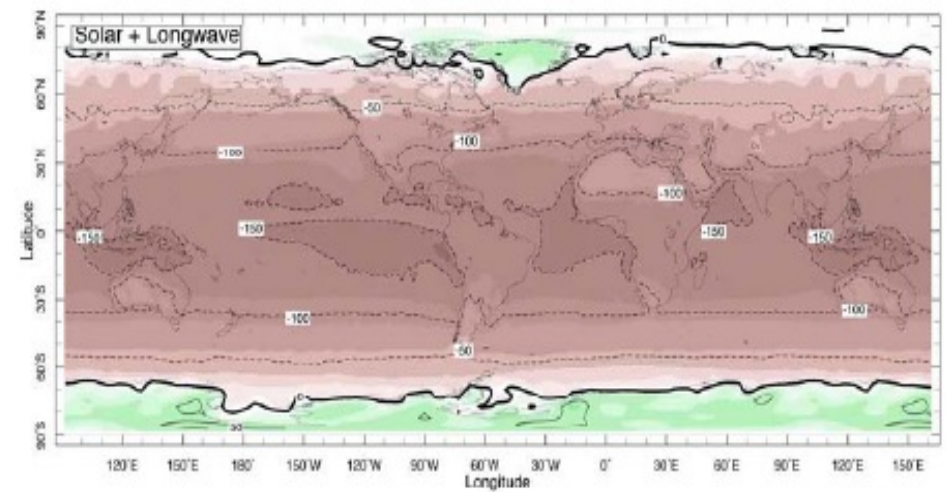
Net Radiation
JJA 1985-1986

Juin-Juil-Août

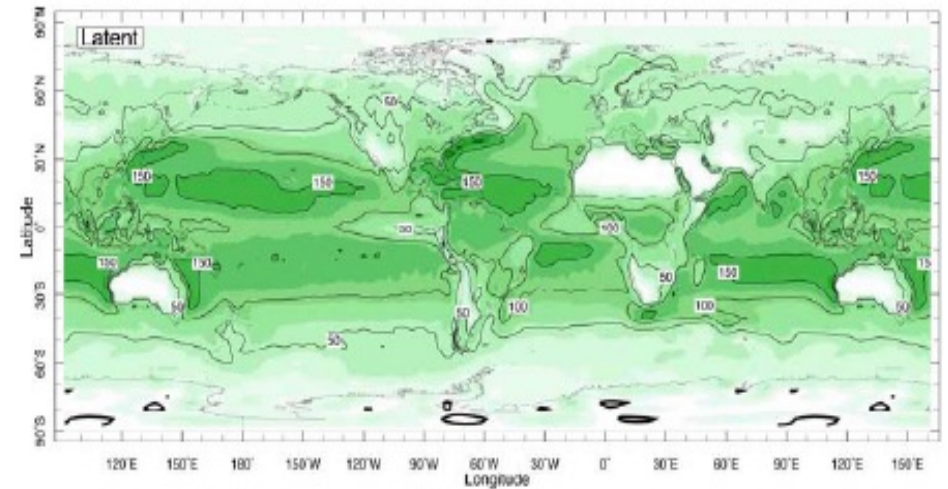


Flux de chaleur Surface->atmosphère

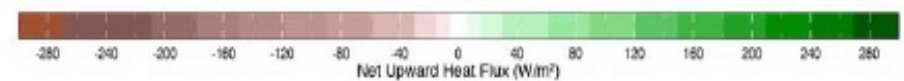
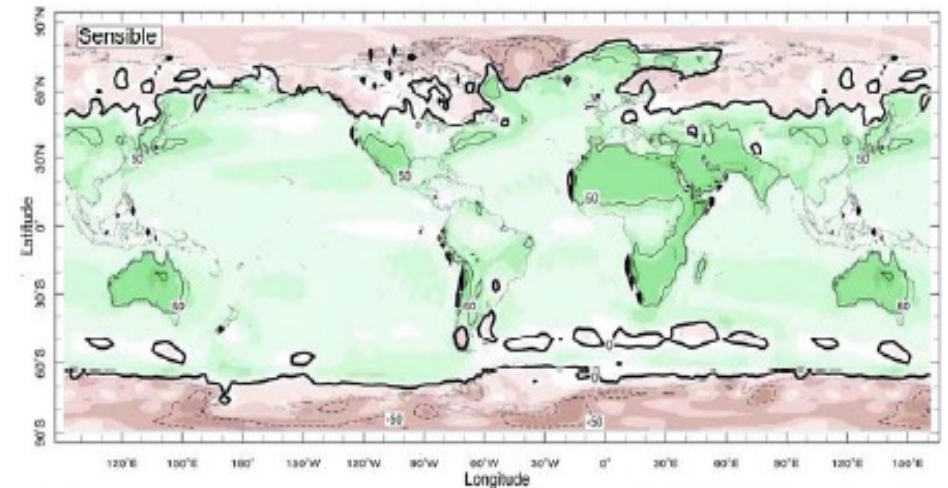
Radiatif

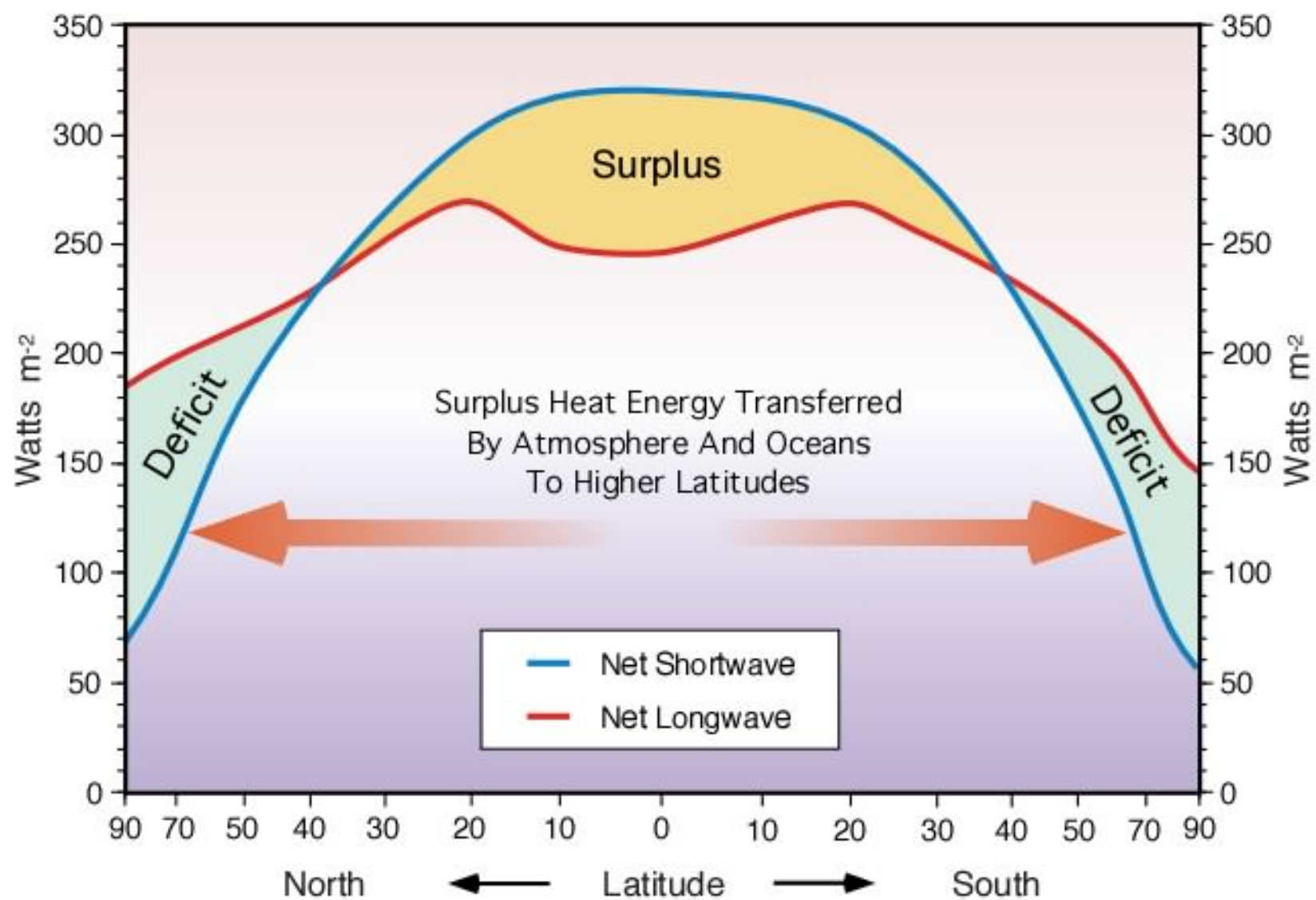


Latent

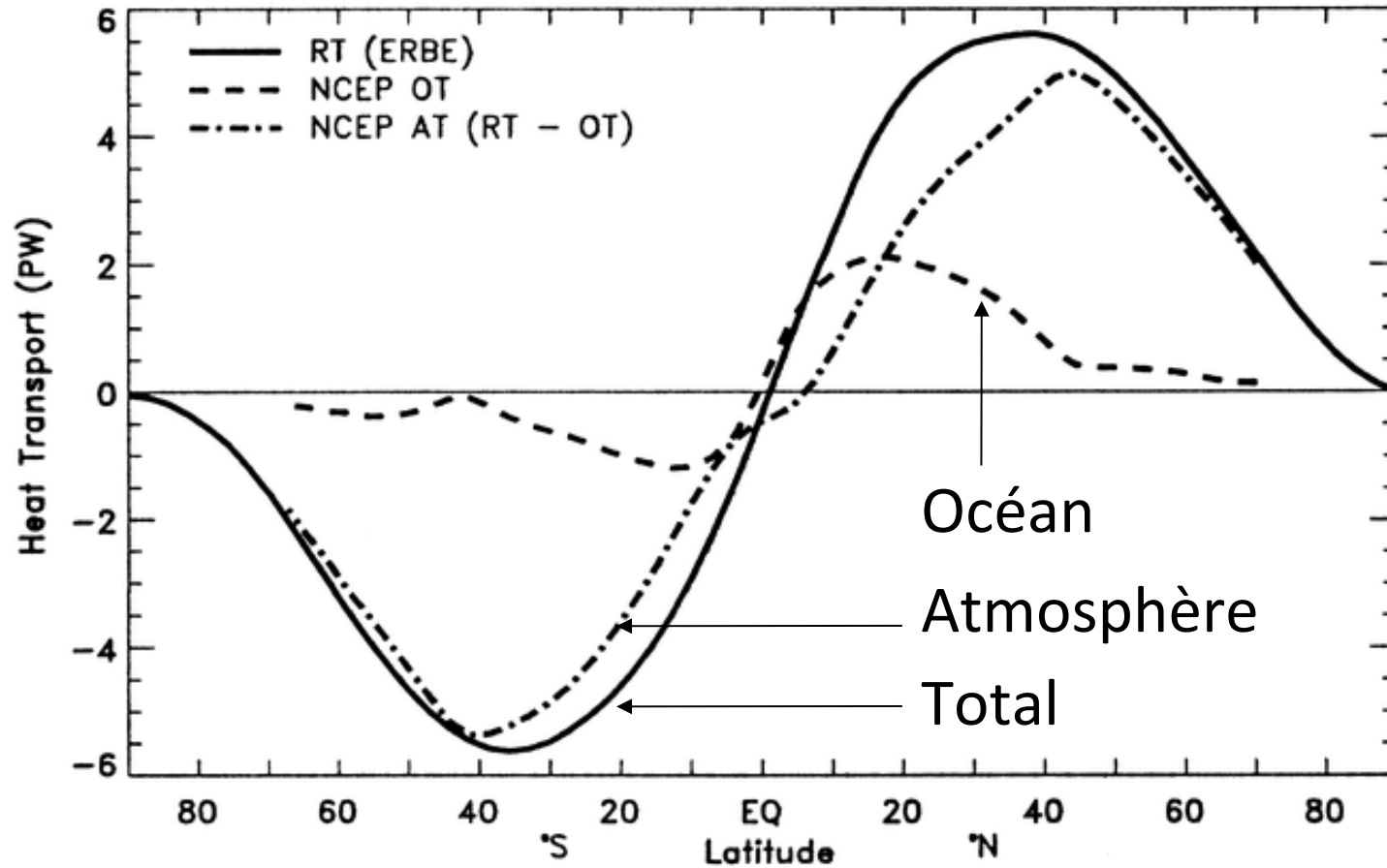


Sensible





Transport de chaleur méridien



Transport positif = vers le nord

Transport de Chaleur
Océanique

