Meteorologia

LEEA
LMOG

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Composição.
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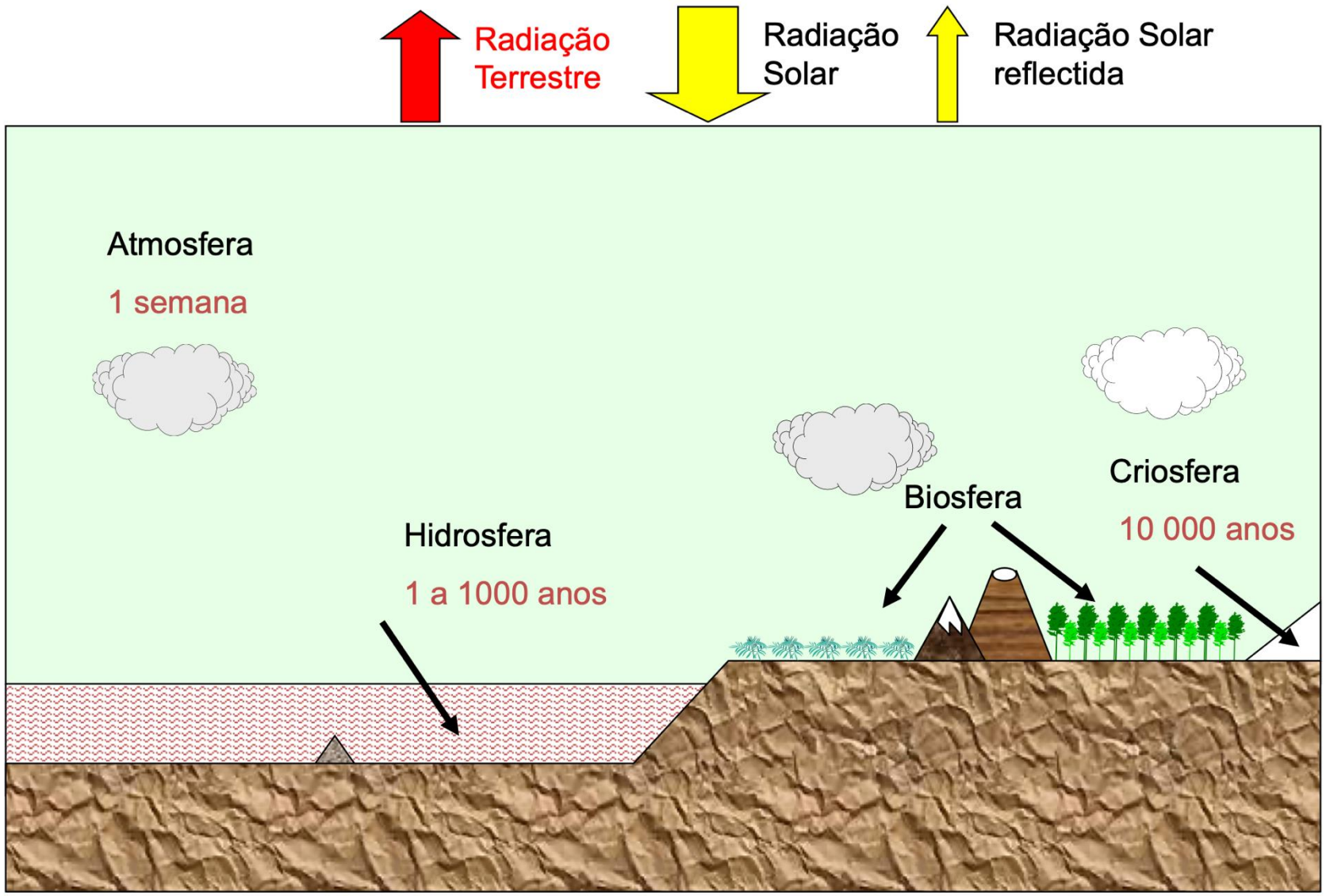
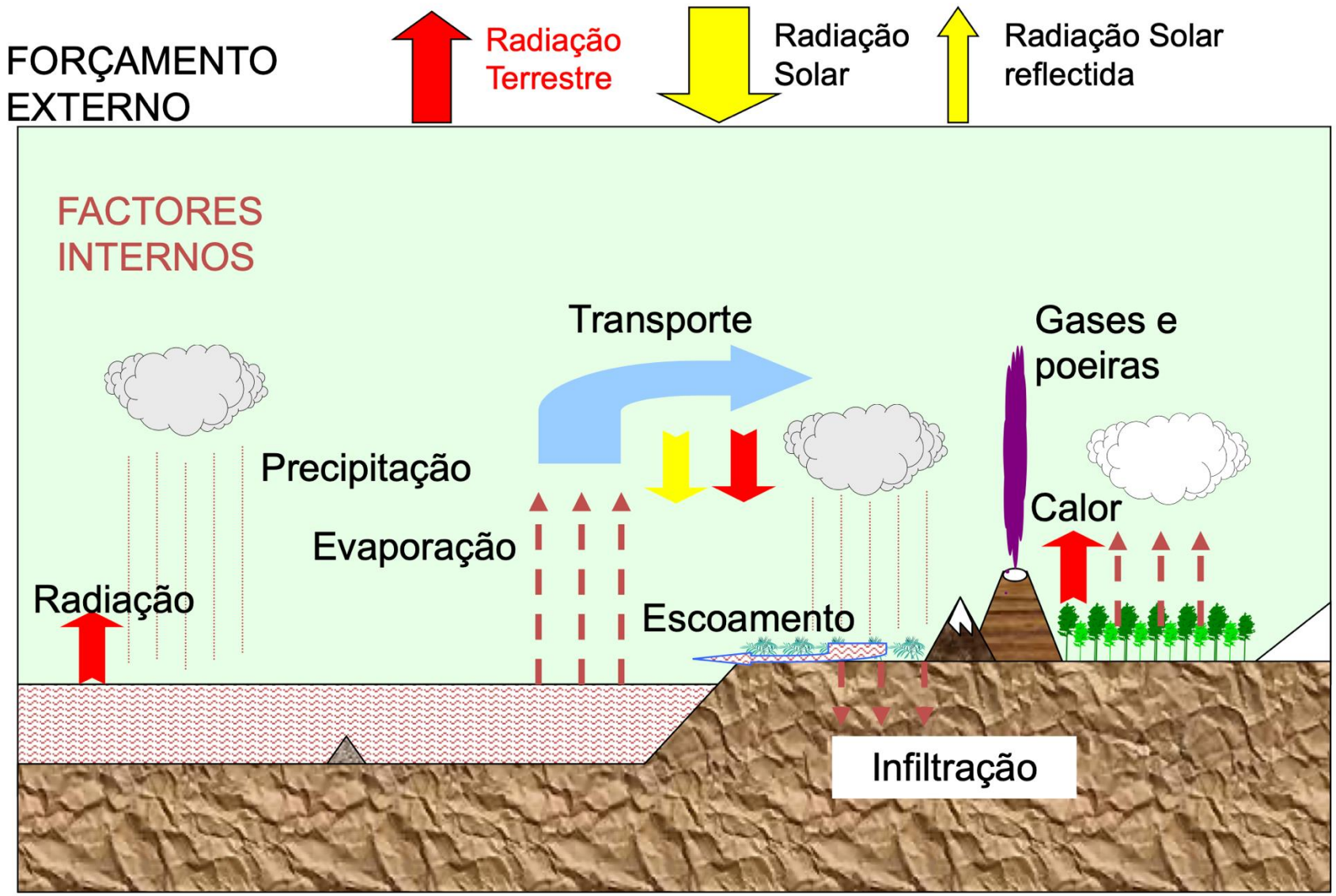
Sistema Climático

Componentes

Escalas de Tempo




FORÇAMENTO EXTERNO
Radiação Terrestre
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FACTORES INTERNOS
Transporte
Gases e poeiras
Precipitação
Calor
Evaporação
Radiação
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Massa da Terra $\approx 6\times10^{24}$ kg

Massa da atmosfera $\approx5\times10^{18}$ kg (1/1 000 000)

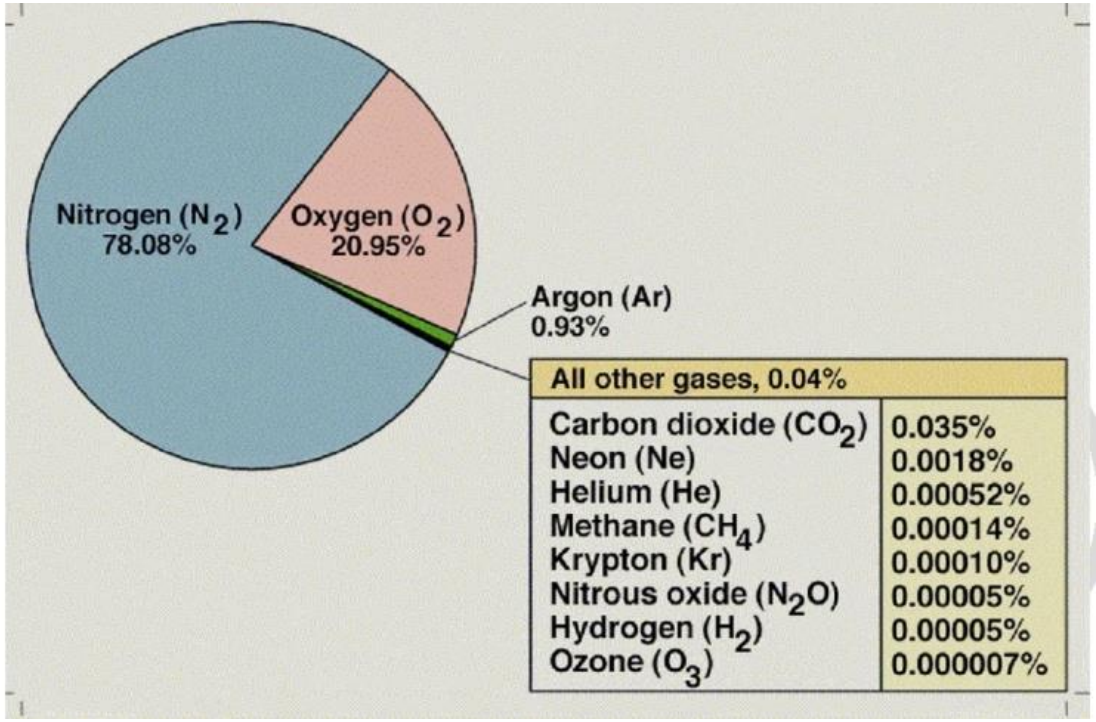
Massa do oceano $\approx1.4\times10^{21}$ kg (1/4 000)

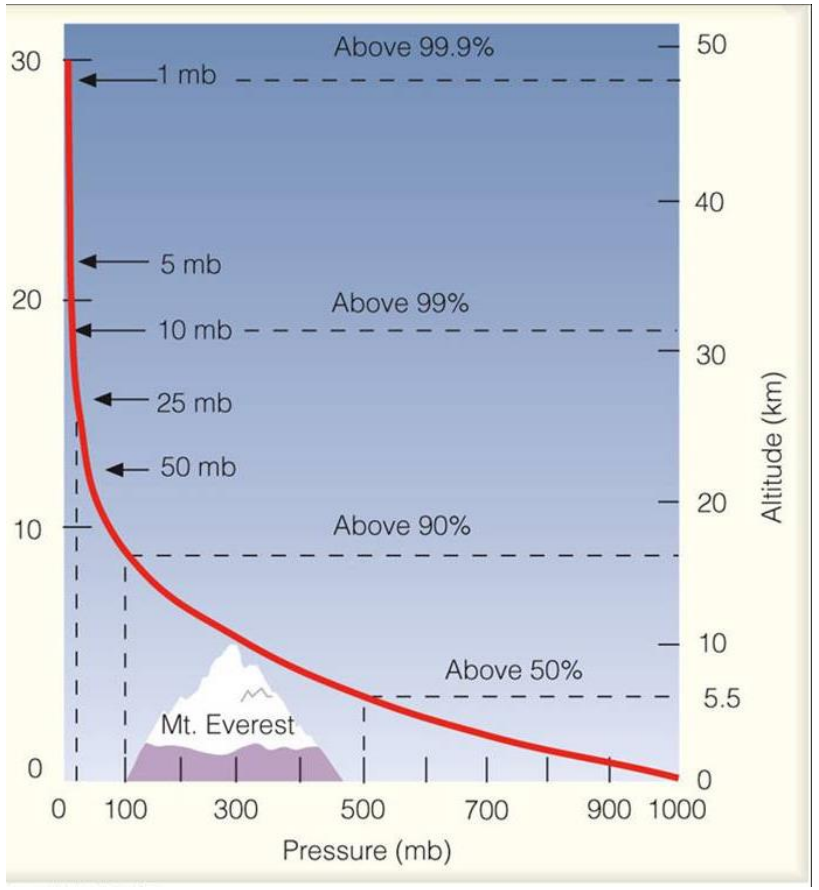
No entanto, o ambiente físico junto da superfície é determinado pela a atmosfera e (em menor grau) pelo oceano

Composição da Atmosfera

A composição da Atmosfera é praticamente uniforme até à mesopausa no que respeita os gases permanentes e de CO_2. A **densidade** e a **pressão** diminuem exponencialmente com a altura seguindo o equilíbrio hidrostático

Composição da Atmosfera seca na troposfera





Atmospheric Chemistry

The chemistry of the Earth's atmosphere plays a major role in determining the balance of energy in the Earth system.

Knowledge of its constituents is thus important for understanding energy in the climate system.

Species	Molecular Mass (g/mol)	Proportion by volume

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Atmospheric Chemistry

Together, nitrogen gas (N_2) and oxygen gas (O_2) represent approximately 99% of the total gaseous composition of the atmosphere.

Species	Molecular Mass (g/mol)	Proportion by volume
N_2	28.01	78%
O_2	32.00	21%

Species	Molecular Mass (g/mol)	Proportion by volume

Atmospheric Chemistry

Argon (Ar) is the oft-forgotten third most abundant component of the Earth's atmosphere. It is generally forgotten since it is largely unreactive and unimportant to climate.

Species	Molecular Mass (g/mol)	Proportion by volume
N_2	28.01	78%
O_2	32.00	21%
Ar	39.95	0.93%

Species	Molecular Mass (g/mol)	Proportion by volume

Atmospheric Chemistry

Water vapor (H_2O) concentration varies significantly throughout the atmosphere.

Practically all water vapor is confined to the lower 10km of the atmosphere.

Whereas the warmest tropical air is almost 4% water vapor by volume, in polar regions water vapor may be as low as 0.2%.

Species	Molecular Mass (g/mol)	Proportion by volume
N_2	28.01	78%
O_2	32.00	21%
Ar	39.95	0.93%
H_2O	18.02	~ 0.5%

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Atmospheric Chemistry

Carbon dioxide (CO_2) is the next most abundant gas, presently making up 410 parts per million (ppm) of the atmosphere (1 ppm = 0.0001%). This means for every one million air molecules, approximately 410 are carbon dioxide.

CO_2 levels continue to rise from preindustrial levels of 280ppm as a result of human activity.

Species	Molecular Mass (g/mol)	Proportion by volume
N_2	28.01	78%
O_2	32.00	21%
Ar	39.95	0.93%
H_2O	18.02	~ 0.5%
CO_2	44.01	~ 410 ppm

Species	Molecular Mass (g/mol)	Proportion by volume

Atmospheric Chemistry

Of the next five most abundant gases, neon (Ne), Helium (He), and Krypton (Kr) are unreactive.

Only methane (CH_4) is relevant to energy balance. Its concentration in the Earth's atmosphere has also been increasing because of human activity (approximately 1800ppb in 2020, compared with 720ppb in preindustrial).

Species	Molecular Mass (g/mol)	Proportion by volume
N_2	28.01	78%
O_2	32.00	21%
Ar	39.95	0.93%
H_2O	18.02	~ 0.5%
CO_2	44.01	~ 410 ppm
Ne	20.18	19 ppm
He	4.00	5.2 ppm
CH_4	16.04	1.8 ppm
Kr	83.8	1.1 ppm
H_2	2.02	~ 500 ppb

Species	Molecular Mass (g/mol)	Proportion by volume

Atmospheric Chemistry

Excluding trace species, the remaining gases include:

ozone (O_3)
nitrous oxide (N_2O)
carbon monoxide (CO)
ammonia (NH3)
nitrogen dioxide (NO_2)
chlorofluorocarbons*
sulphur dioxide (SO_2)
hydrogen sulfide (H_2S)

* no natural sources

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Species	Molecular Mass (g/mol)	Proportion by volume
O_3	48.00	~ 500 ppb
N_2O	44.01	310 ppb
CO	28.01	120 ppb
NH_3	17.03	~ 100 ppb
NO_2	46.00	~ 1 ppb
CCl_2F_2	120.91	480 ppt
CCl_3F	137.37	280 ppt
SO_2	64.06	~ 200 ppt
H_2S	34.08	~ 200 ppt
AIR	28.97	

Atmospheric Chemistry

The gases highlighted in **red** are the infamous **greenhouse gases**, which are particularly important for understanding the energetics of the Earth's atmosphere.

They include **water vapor**, **carbon dioxide**, **methane**, **ozone**, **nitrous oxide**, and the **chlorofluorocarbons**.

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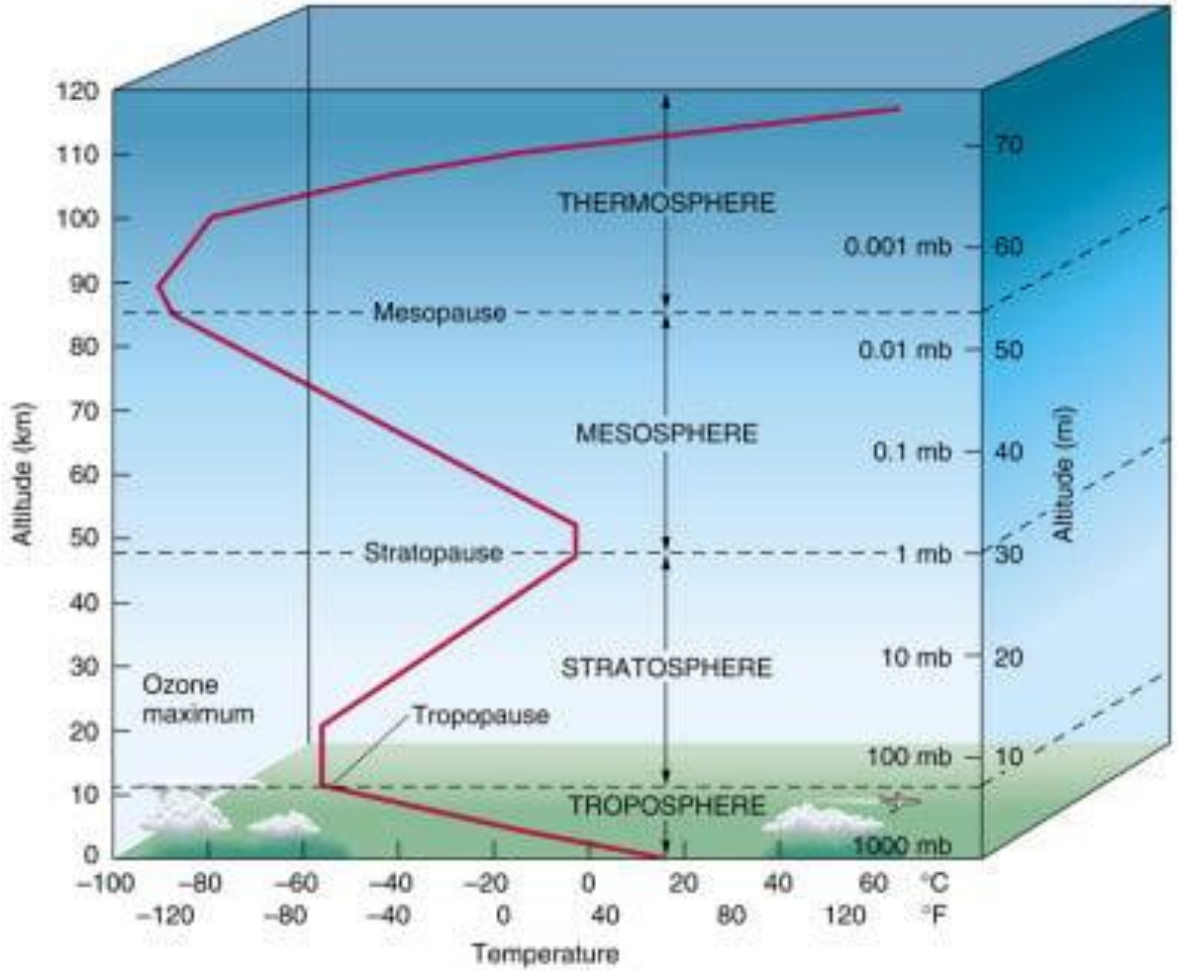
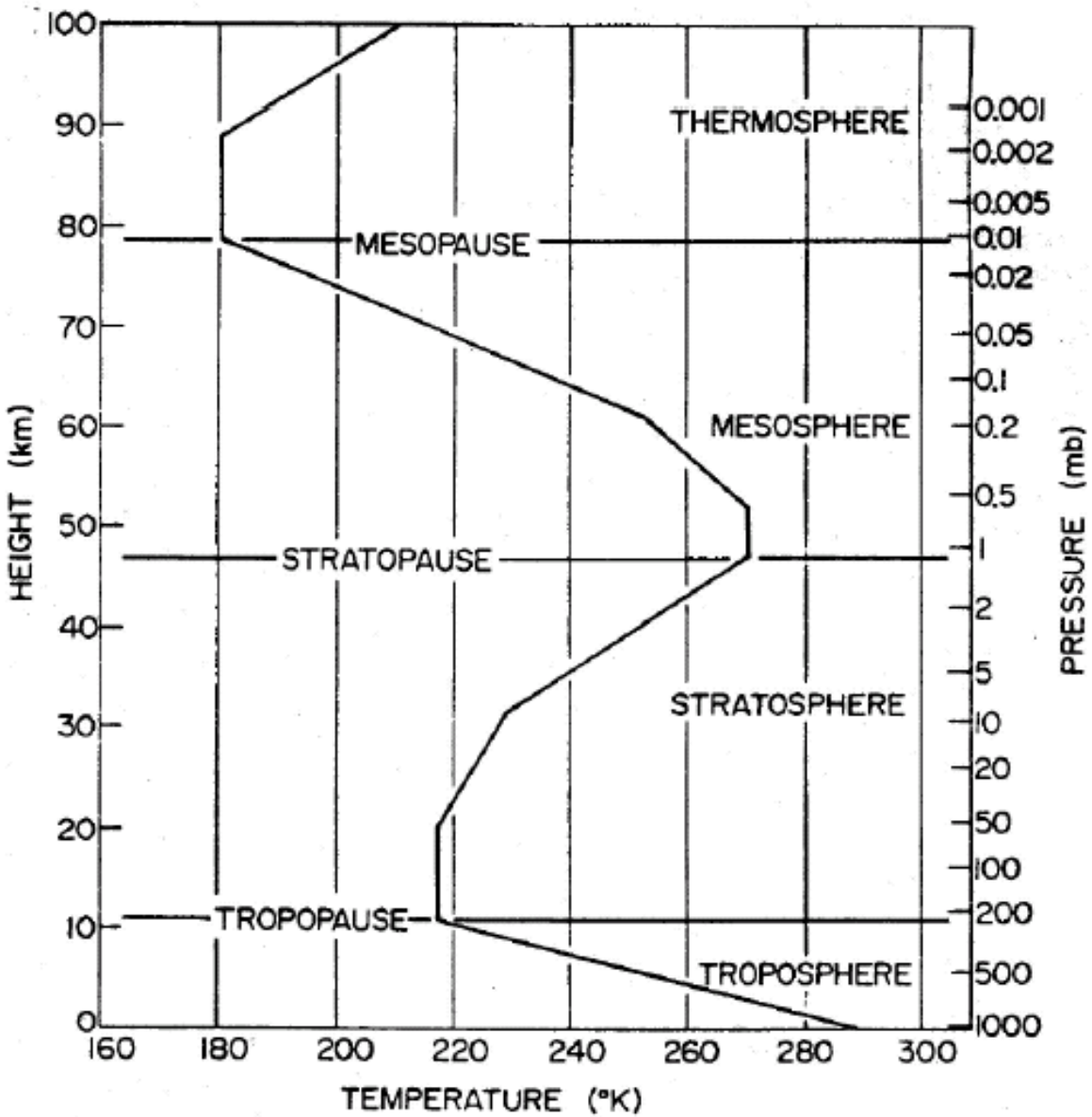
Estrutura vertical média da Atmosfera

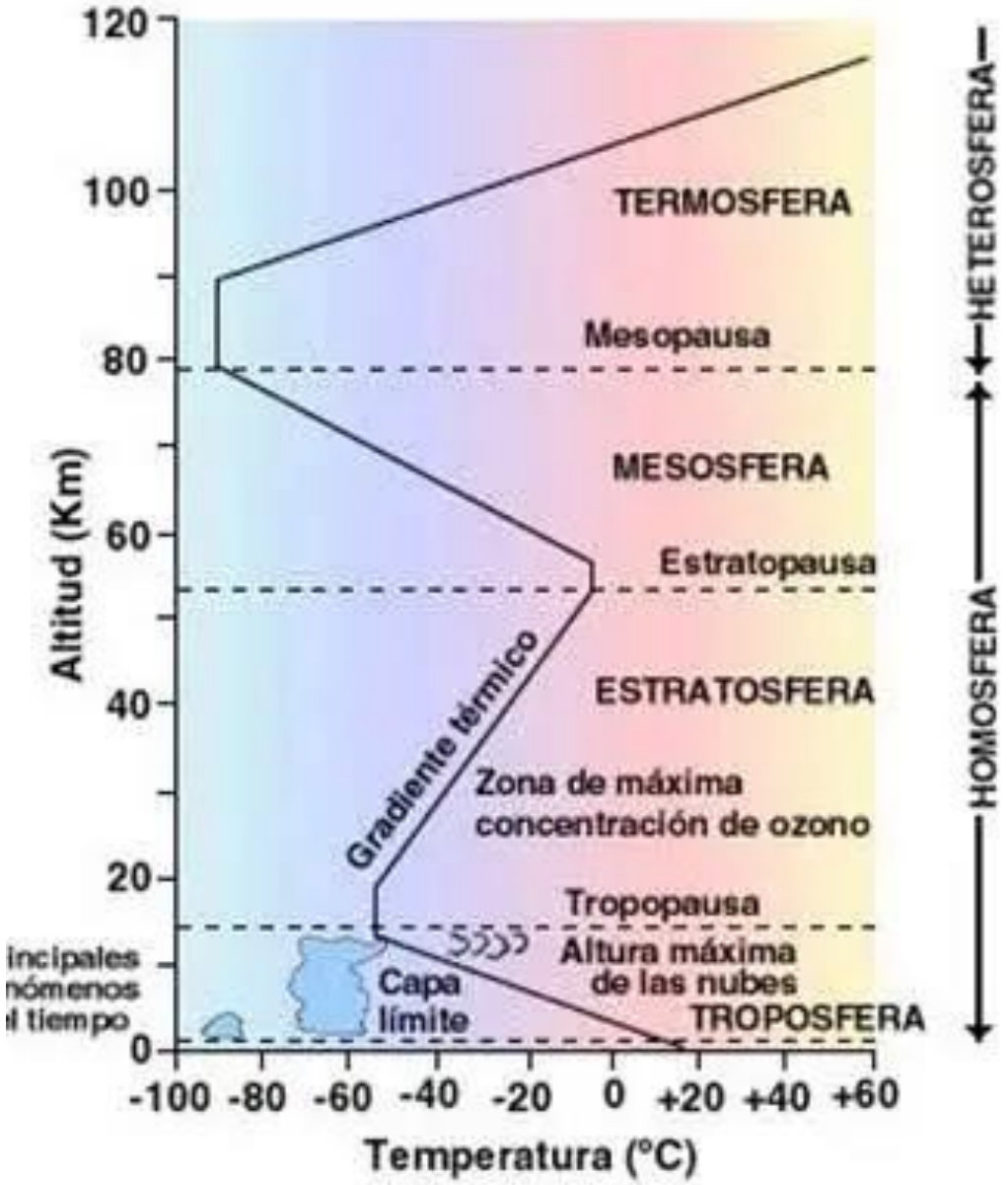




Homosfera e Heterosfera

Homosfera – Região da atmosfera abaixo da mesopausa (incluindo, portanto, a troposfera, a estratosfera e a mesosfera) em que a composição de gases é mais ou menos uniforme.

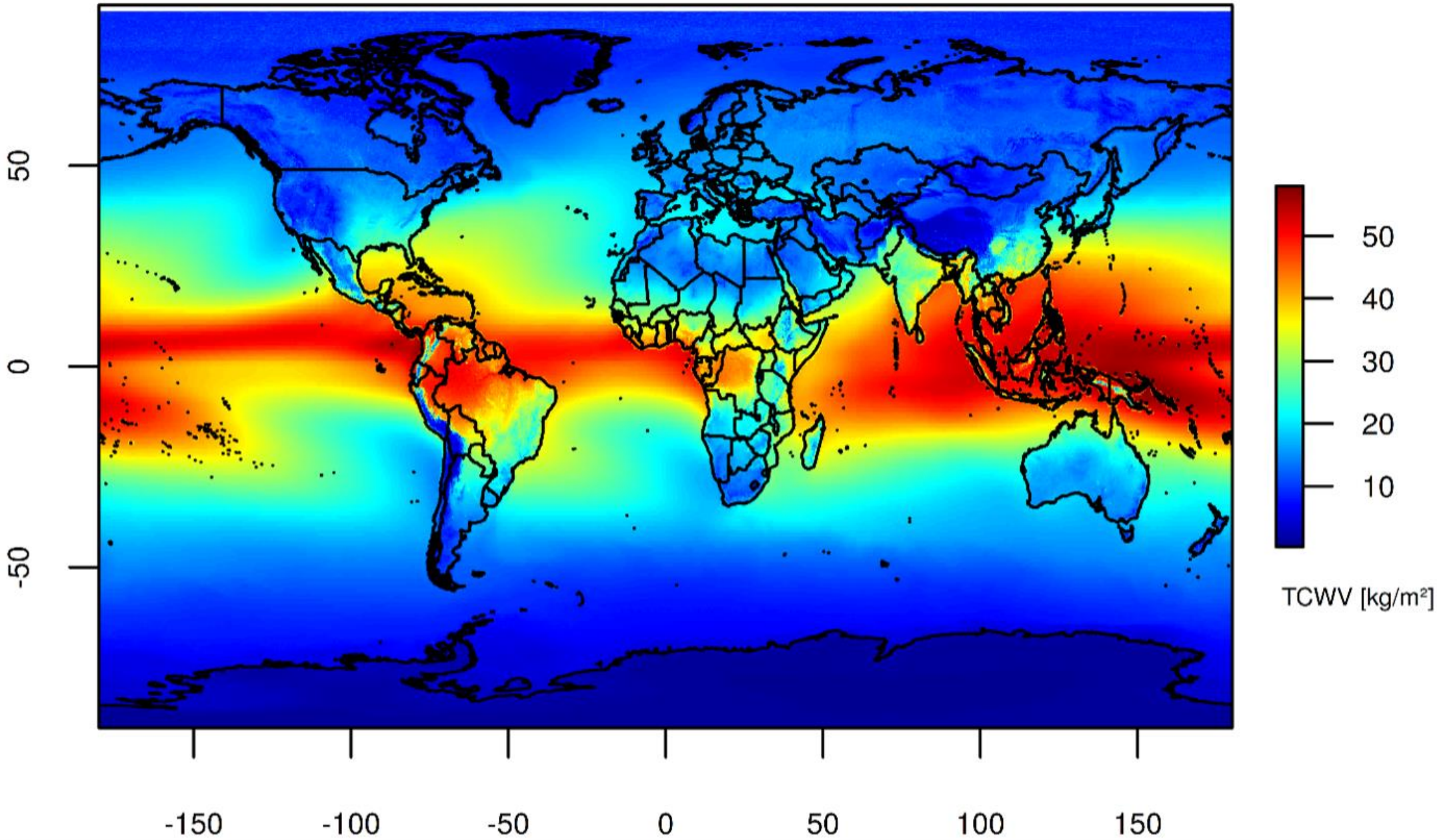
Heterosfera – Região da atmosfera acima da mesopausa, em que a composição de gases é variável. Acima desta região existe a exosfera.



Composição da Homosfera (z<100 km)

Componente		Concentração Volúmica (%)	Partes por Milhão em vol. (ppmv)
Azoto	N_2	78.08[(1)]	
Oxigénio	O_2	20.95[(1)]	
Árgon	Ar	0.93[(1)]	
Néon	Ne	0.0018	
Hélio	He	0.0005	
Hidrogénio	H_2	0.00006	
Xénon	Xe	0.000009	
Vapor de água	H_2O	0. a 4	
Dióxido de carbono	CO_2	0.036[a]	360
Metano	CH_4	0.00017[b]	1.7
Óxido nitroso	N_2O	0.00003[b]	0.3
Ozono	O_3	0.000004[b]	0.04
Ozono (Estratosfera)		0.001[b]	10
Partículas		0.000001[b]	0.01
Clorofluorcarbonetos	CFCs	0.00000001[b]	0.00001

Monthly Mean Total Column Water Vapour 2002 - 2017
based on the combined microwave and near-infrared product (0.05°)



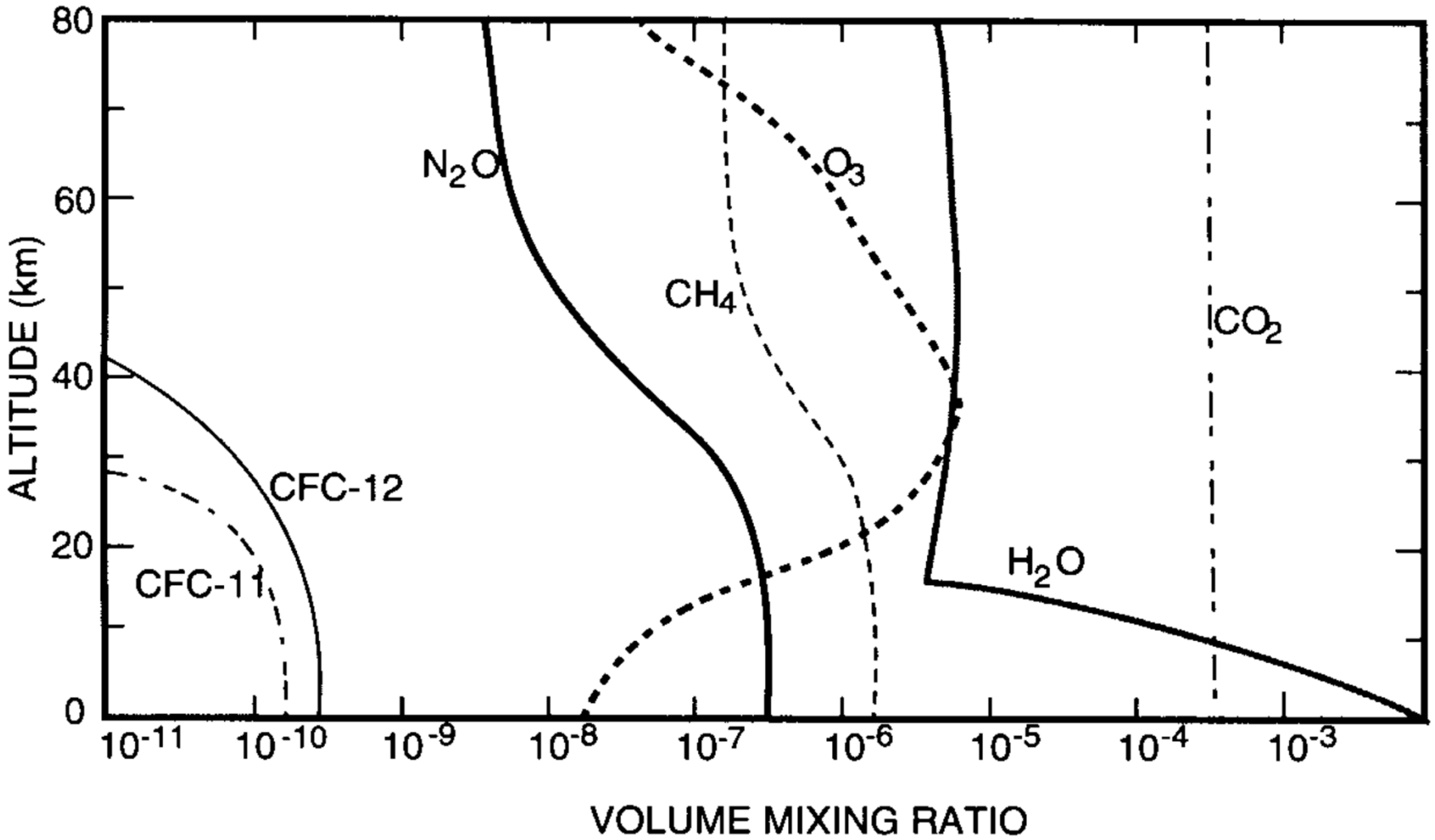
Ar

Na homosfera as proporções de N_2, O_2, Ar são aproximadamente constantes. As concentrações de H_2O são muito variáveis. Os outros compostos contribuem com muito pouca massa.

Vamos chamar AR SECO à mistura em proporções constantes que se observa na Homosfera.

Vamos chamar AR HÚMIDO à mistura em proporções variáveis de ar seco e água. O ar húmido pode ser monofásico (só contém vapor) ou pode ser uma mistura heterogénea (vapor+líquido+sólido)

Gases de estufa



O que explica a composição observada?

História: origem dos constituintes

Gravidade:

- Retenção de gases: Problema do escape
- Estratificação vertical: separação por densidades (porque existe uma Homosfera?)

Ambiente cósmico

- Radiação
- Propriedades conservativas (Massa, momento angular)