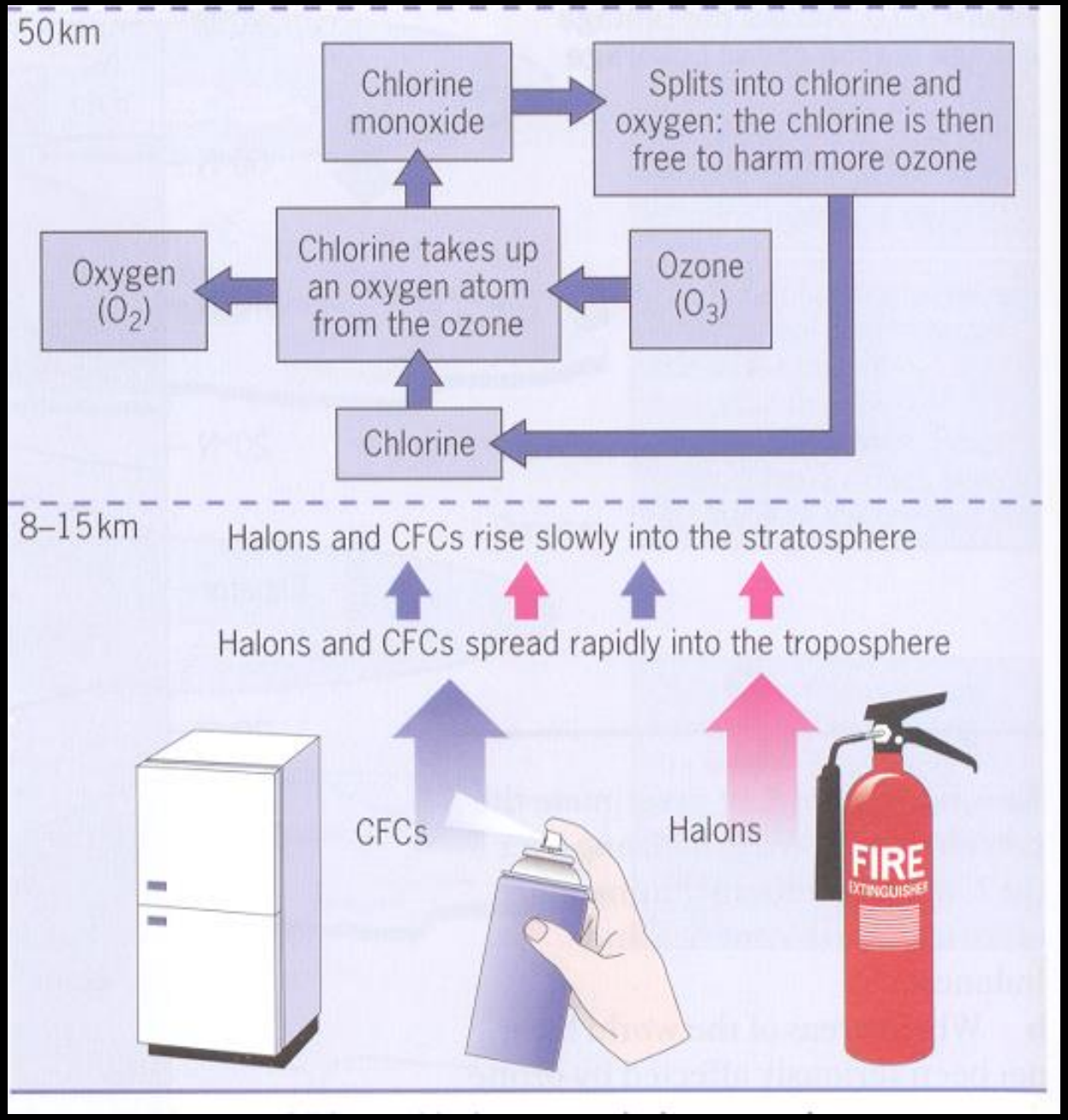
فیزیک جو

درس دهم

صحرایی

گروه فیزیک دانشگاه رازی

http://www.razi.ac.ir/sahraei


50 km
Chlorine monoxide
Splits into chlorine and oxygen: the chlorine is then free to harm more ozone
Oxygen (O_2)
Chlorine takes up an oxygen atom from the ozone
Ozone (O_3)
Chlorine
8–15 km
Halons and CFCs rise slowly into the stratosphere
Halons and CFCs spread rapidly into the troposphere
CFCs
Halons
FIRE
EXTINGUISHER

Ozone Destruction

Ozone is destroyed by reactions with chlorine, bromine, nitrogen, hydrogen, and oxygen gases.

Reactions with these gases typically occurs through catalytic processes.


Sources That Harm the Protective Ozone Layer
Solvent Cleaning Products 36.1%
Sterilization 3.0%
Refrigeration and Air Conditioning 29.6%
Foam Products 14.3%
Aerosols 5.0%
Other Products Including Halons 12.0%

Reservoir Molecules

Molecules in the atmosphere that bind with atoms or other molecules and prevent them from participating in chemical reactions.

One Cl atom can catalyze the destruction of about 100000 ozone molecules.

Some Cl atoms can be temporarily trapped in "reservoir molecules" by reacting with methane (CH_4) or nitrogen dioxide (NO_2)

$$Cl + CH_4 \rightarrow \mathbf{HCl} + CH_3$$

$$ClO + NO_2 \rightarrow \mathbf{ClONO_2}$$

HCl and **$ClONO_2$** are "reservoir"molecules as the serve as a "reservoir" of Cl atoms (for future use!)

At any given time in the stratosphere:

Active chlorine (**ClOx = Cl** + **ClO**) is about 1%

Chlorine reservoirs (**HCl** and **ClONO2**) are about 99%

Why has caused the depletion Stratospheric Ozone over some regions of the Earth?

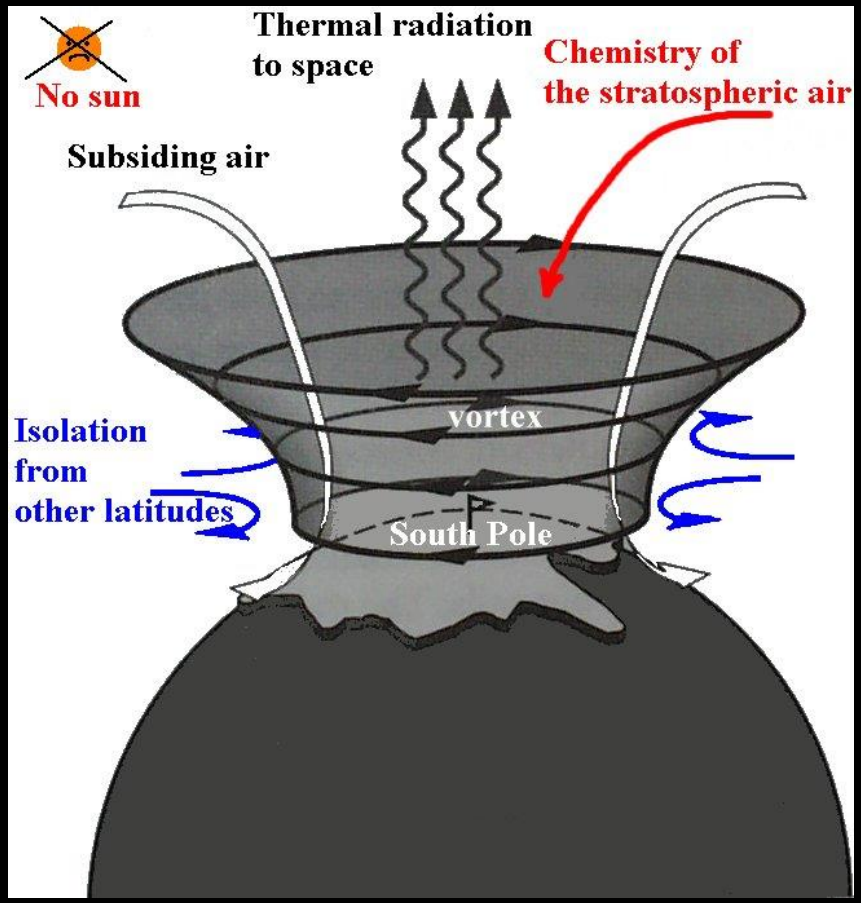
Mechanism of ozone destruction in the polar stratosphere:

two ingredients are necessary:

cold temperature and **sunlight**.

Antarctic Ozone Hole

As winter arrives, a vortex of winds develops around the pole which isolates the air within it.



Polar stratospheric clouds (PSCs).

Clouds can be formed in the stratosphere in the Antarctic because of **VERY LOW** temperatures (as low as -90 ^{o}C) reached during the long polar night (no sun light).

thin clouds form of ice, nitric acid mixtures.

The lowest temperatures are common in the Antarctic, where the polar vortex is more stable than in the Arctic.

NOTE: The stratosphere is very dry and generally cloudless.
Therefore, the temperature should be extremely low to condense the small amount of water vapor present.

PSCs provide a reaction surface for the ozone destruction reactions involving chlorine and bromine.

Many of the chemical reactions require sunlight, so the ozone destruction does not begin until the polar night ends in the late winter or early spring.

Frozen particles in these clouds allow "chlorine reservoir" molecules to react to form Cl_2

$$ClONO_2\ (g) + HCl\ (s) \rightarrow \mathbf{Cl_2\ (g)} + HNO_3\ (s)$$

$$ClONO_2 + H_2O \rightarrow HO\mathbf{Cl}\ \mathbf{(g)} + HNO_3\ (g)$$

Cl_2 & HOCl accumulates during winter when the first light of spring arrives Cl_2 & HOCl are cleaved into Cl & ClO atoms

Inert chlorine reservoir species, HCl and $ClONO_2$, are transformed into active chlorine species, Cl and ClO, via heterogeneous reactions on PSCs surfaces.

Two major processes:

1) via Cl_2 photolysis:

$$Cl_2 + light \rightarrow Cl + Cl$$

$$2[Cl + O_3 \rightarrow ClO + O_2]$$

2) dimer mechanism

$$2[Cl + O_3 \rightarrow \mathbf{ClO} + O_2]$$

$$\mathbf{ClO} + \mathbf{ClO} + M \rightarrow \mathbf{Cl_2O_2} + M$$

$$\mathbf{Cl_2O_2} + h\nu \rightarrow Cl + Cl + O_2$$

Net reaction: $2\ O_3 + hn \rightarrow 3\ O_2$

In the warmer Arctic a large proportion of the loss may be driven by:

$$ClO + BrO \rightarrow Br + Cl + O_2$$

$$\mathbf{Cl + O_3 \rightarrow ClO + O_2}$$

$$\mathbf{Br + O_3 \rightarrow BrO + O_2}$$

Net reactio: $\mathbf{2\ O_3 \rightarrow 3\ O_2}$

This sudden release of large amounts of Cl atoms results in a rapid decrease in ozone levels

Ozone's Problem with Polar Stratospheric Clouds

2. ozone depletion. Global

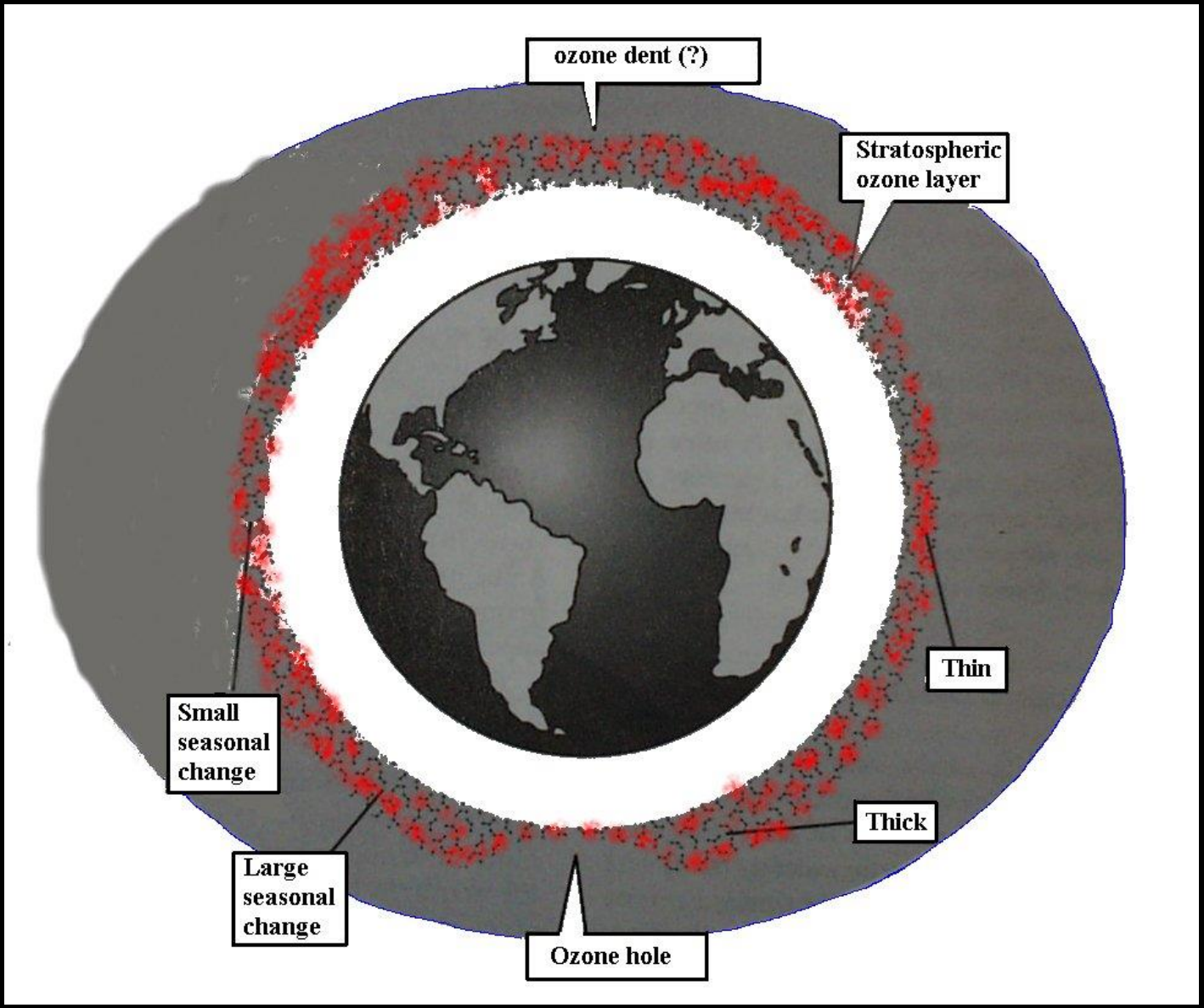
Ozone depletion over different regions;

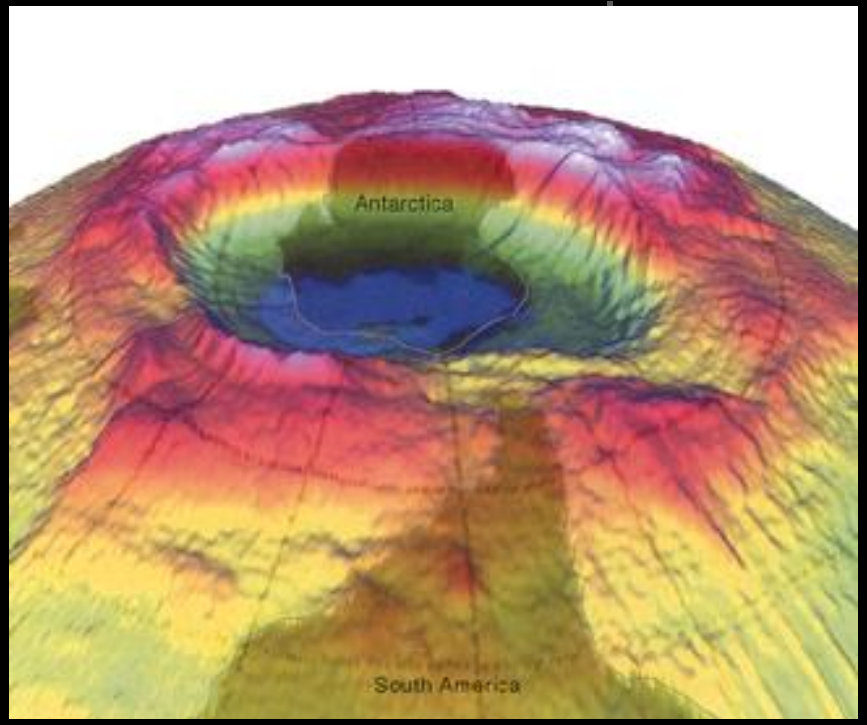
Arctic: local ozone reductions are up to 15% only (because the vortex is not very stable, and PSCs are not common).

Tropical latitudes: no ozone reduction was observed so far;

Mid-latitudes (30º-60ºN): ozone depletion is detected (winter ozone depletion of 6-8%) (exact cause is unknown; probably, due to stratospheric aerosols);

Global variation in the thickness of the ozone layer




Antarctica
South America

از توجه شما متشکرم