

**N**ovel strategies to slow climate change and fight global warming

**N**ew ideas on how to cool Gaïa

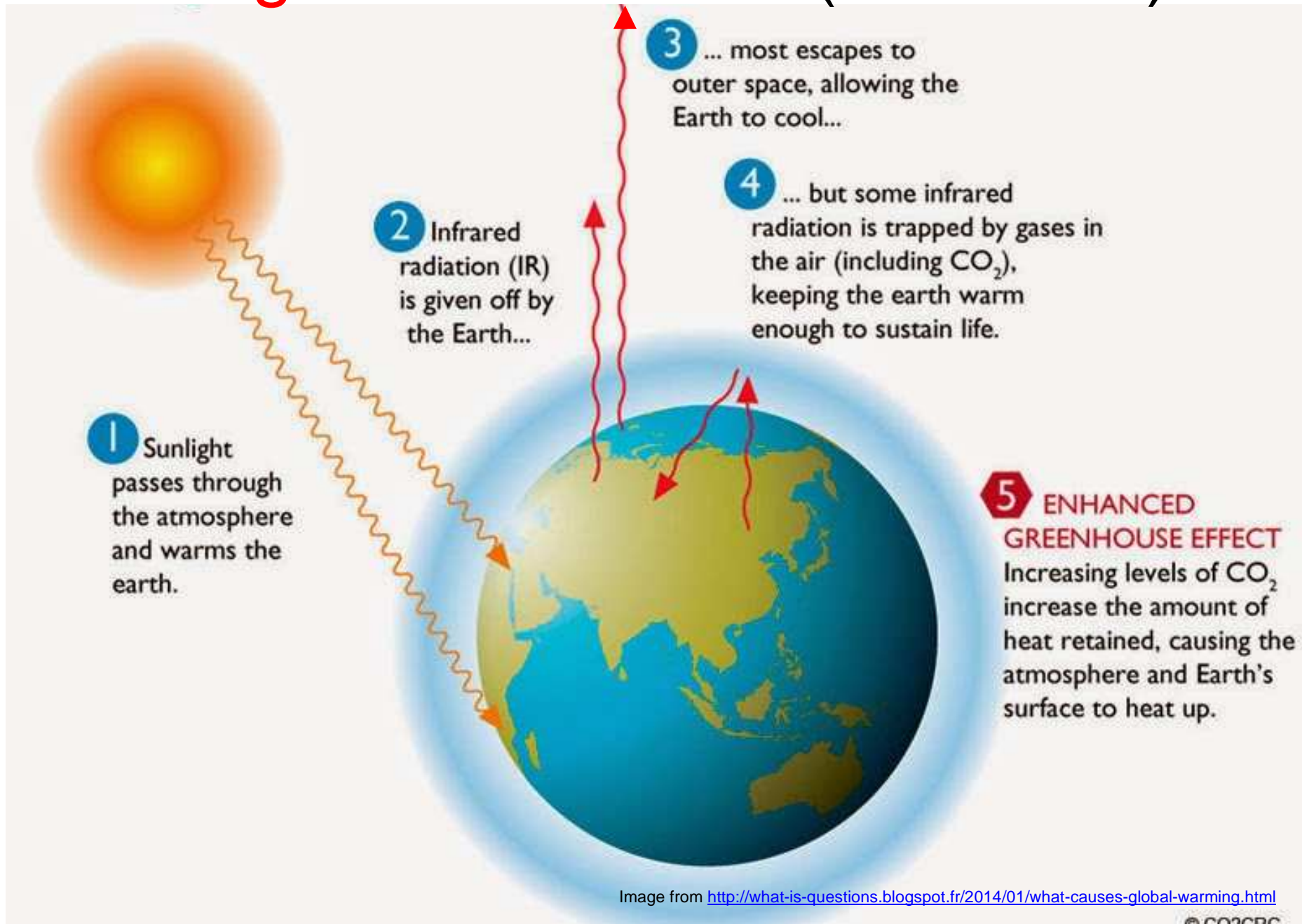
**F**avoring radiative thermal bridges to get cooler temperatures at the Earth surface

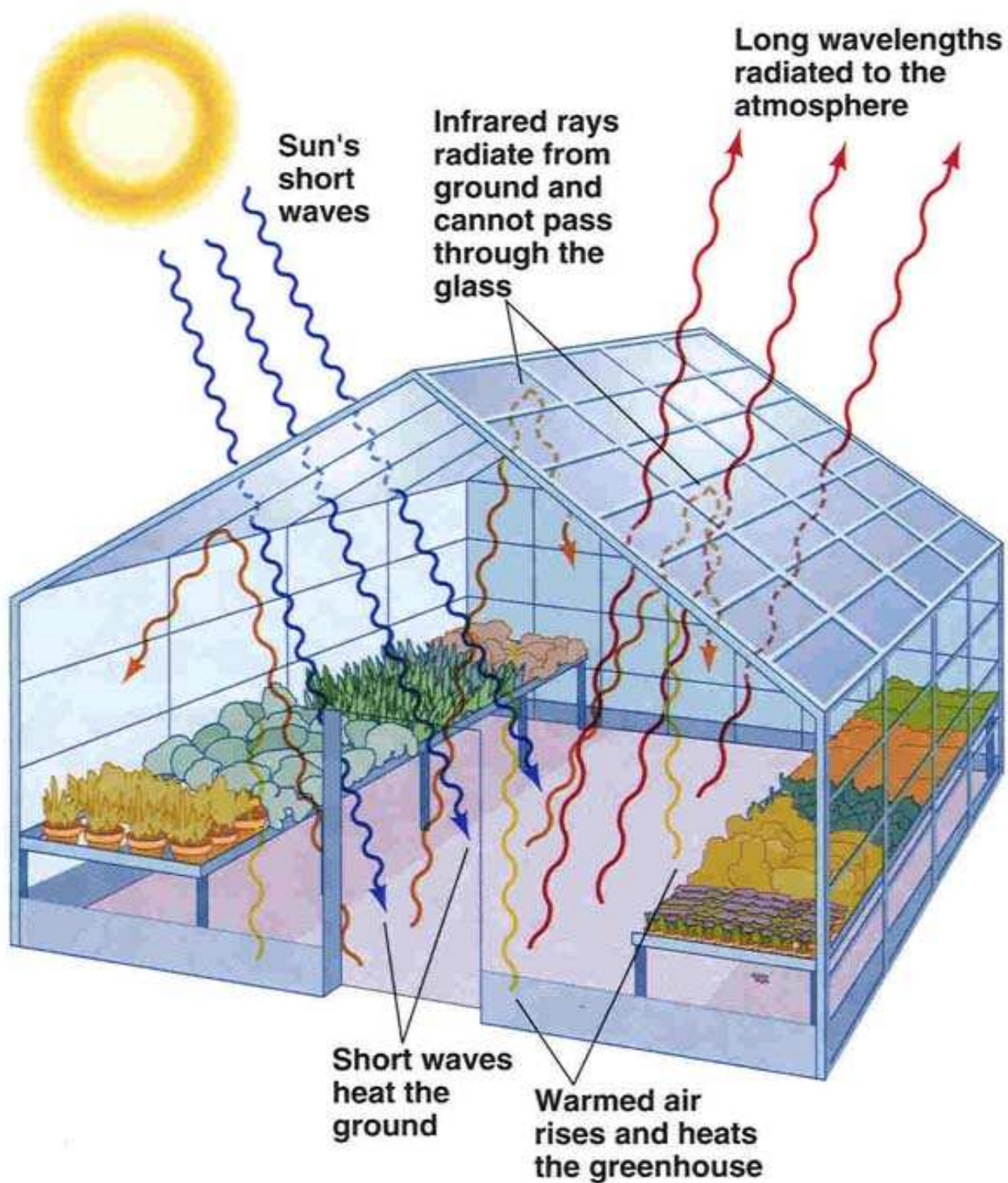
Read the open source paper that can be freely accessed at:

<http://dx.doi.org/10.1016/j.rser.2013.12.032>.

[Fighting global warming by climate engineering: Is the Earth radiation management and the solar radiation management any option for fighting climate change?](http://dx.doi.org/10.1016/j.rser.2013.12.032)

# The greenhouse effect is due to long wave radiation (Infra-Red)

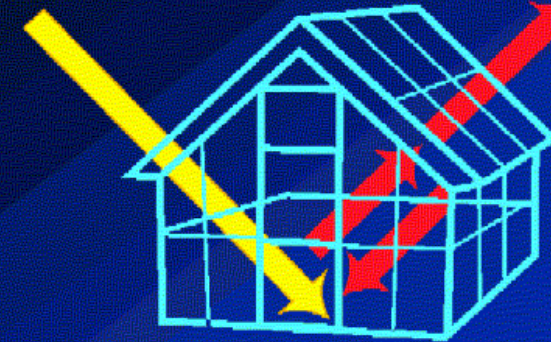




## THE GREENHOUSE EFFECT

Visible energy from the sun passes through the glass and heats the ground

Infra-red heat energy from the ground is partly reflected by the glass, and some is trapped inside the greenhouse



The Met Office

Hadley Centre for Climate Prediction and Research

981951

Image from <http://ozclimatesense.com/category/greenhouse-effect-on-your-health/>



Image from <http://www.realscience.org.uk/science-discussion-climate-change-clouds.html>

# Long and Short wave radiation

Short wavelength heat radiation from the Sun



Re-radiated long wavelength heat radiation

Greenhouse gases (GHGs) are good at absorbing long wave length heat radiation and so the GHGs heat up.

Warm GHGs in the sky re-emit heat radiation in all directions, so some go up to the outer space and some go down back to the Earth's surface.

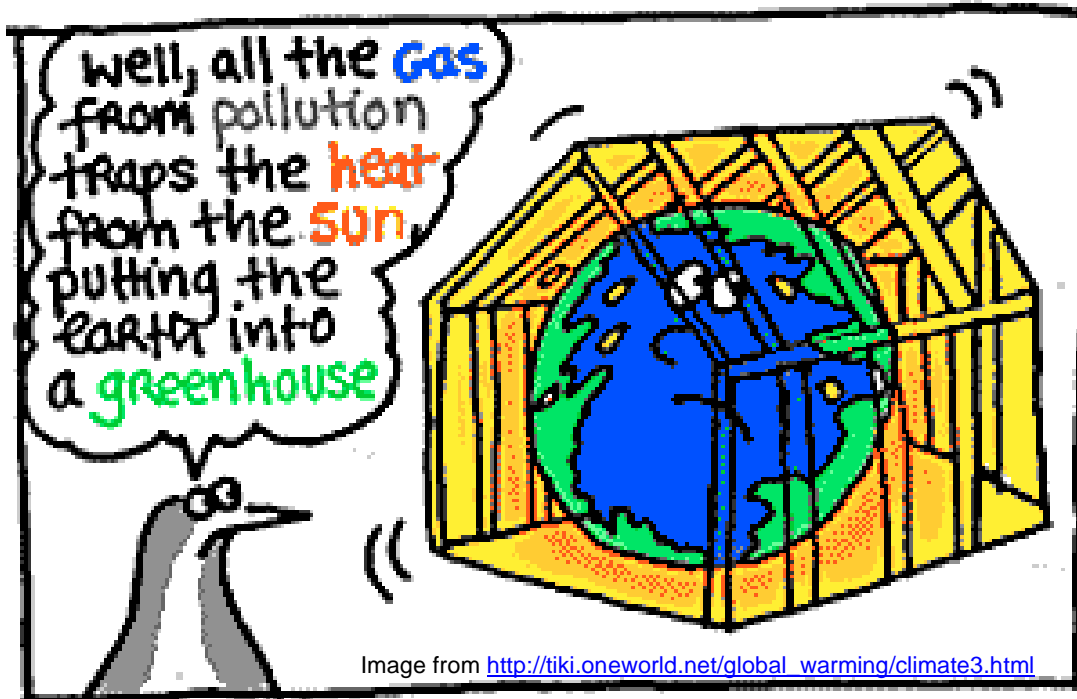
So not all the heat (Infra-Red radiation) leaves the planet. This is how the Earth gets warmer by greenhouse effect.

In an actual greenhouse the glass does not emit much heat into the building – the heating effect is mainly due to the glass trapping the hot air and preventing convection.

On Earth, convection still happens but heat radiation is increased.

Earth radiation management (ERM) aims to favor patterns increasing outgoing long wave radiation (heat release to the outer space).

# Insulation



In a building numerous interruptions of the insulation by the framing members or studs act as direct “thermal bridges” between the inside and the outside.

To better insulate a building a continuous layers of uninterrupted insulation is needed.

**GHGs in the troposphere act on the Earth as a “continuous insulation”.**

Increasing the concentration of GHGs in the atmosphere is **like increasing the insulation** by preventing thermal bridging and replacing the single glass by double and then triple glass

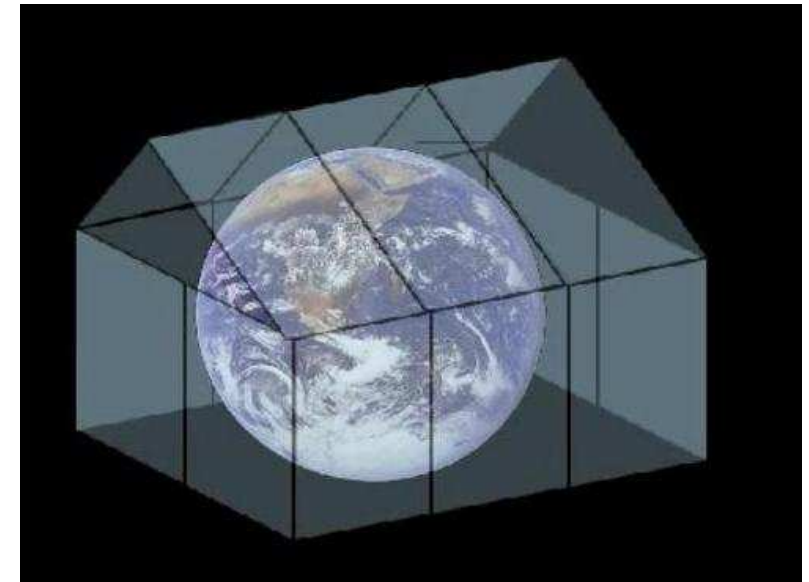


Image from WWF Norway at <http://vimeo.com/40078998>



# Thermal bridges



Photos courtesy of Dryvit Systems, Inc. and The Dow Chemical Company

In a building, placing a good conductor in parallel with good insulation is often referred to as "thermal bridging" because it provides a path for heat flow to bypass the main insulation.

A thermal bridge is an **unwanted** path for **heat flow** (by conduction) that bypasses the main insulation of a building envelope.

Steel studs, framing materials and metal window frames are common thermal bridges. Thus wherever a thermal bridge (by conduction) occurs it is a point where increased heat losses (by IR radiation) will occur.

<http://sustainabilityworkshop.autodesk.com/>

In order to fight global warming we need to « **cool down the Earth** ».

We propose to **voluntarily create wanted paths for heat loss** (by IR = long wave radiation) from the planet surface to the outer space

We call this strategies **Earth Radiation Management**

# The basis of **Earth Radiation Management**

GHGs act as very good insulators that prevent heat to escape from the planet atmosphere to the outer space

Taking the example of a house/building: to have a good insulation, a thick insulator layer is indeed needed, but preventing thermal bridges (conduction process) is mandatory.

In the case of the Earth it is the contrary: Gaïa experiences global warming because the insulation provided by GHGs is **too** good and **too** powerful.

A solution **to cool down the planet** can be to create “**radiative thermal bridges**”, or “**IR thermal shortcuts**” in order to allow the heat to be evacuated.

# Earth Radiation Management

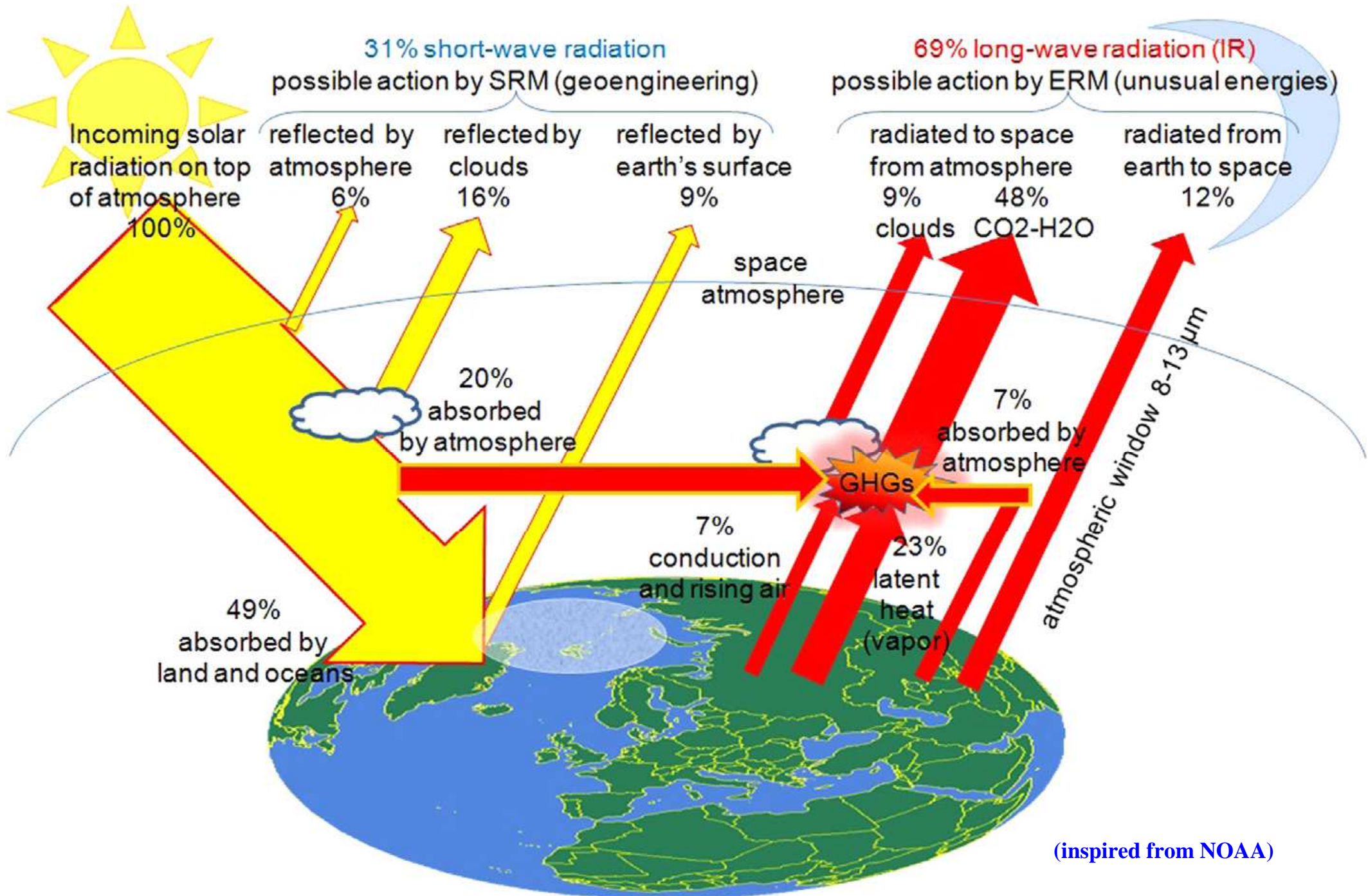
is different from **Solar Radiation Management**

The Meteorological Reactors (MR) described in <http://www.solar-tower.org.uk/> can provide the needed “**thermal shortcuts**” that transfer heat from the Earth surface to higher in the atmosphere, allowing outgoing long-wave (thermal infra-red) heat radiation to escape more easily, and thus enable the humans to perform **ERM**.

**Solar Radiation Management SRM** strategies are part of Geoengineering proposals that aim to intervene in the climate system by deliberately modifying the Earth’s energy balance and is intended to reduce the magnitude of climate change by reducing the global temperature. SRM reduces the net incoming short-wave solar radiation received, by deflecting sunlight, or by increasing the reflectivity (albedo) of the atmosphere, clouds or the Earth’s surface.



# Earth's Annual Global Mean Energy Budget



(inspired from NOAA)

# Targets for ERM and SRM

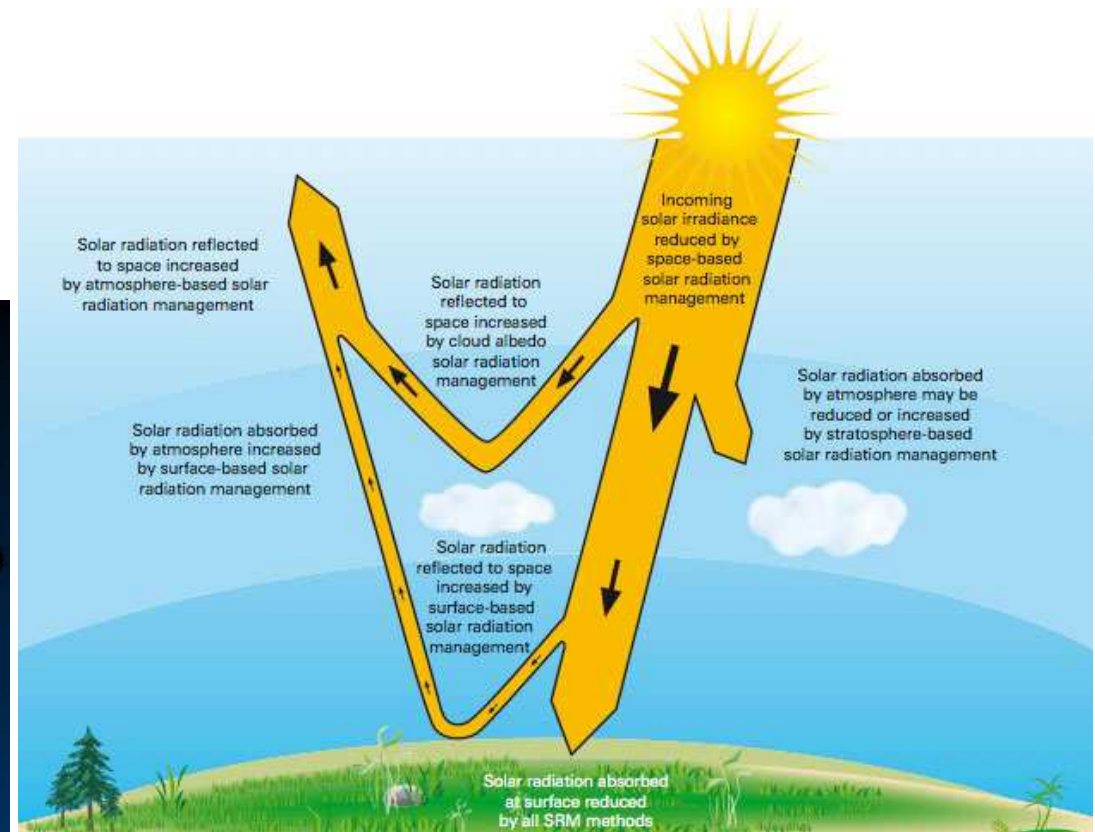
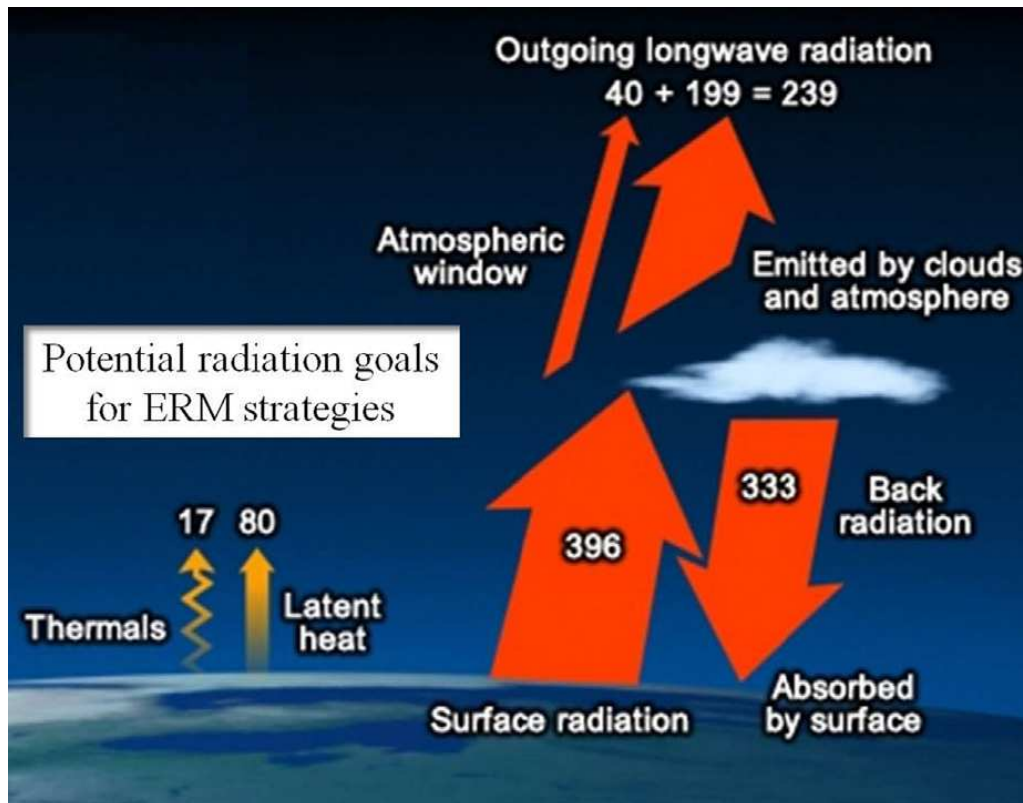
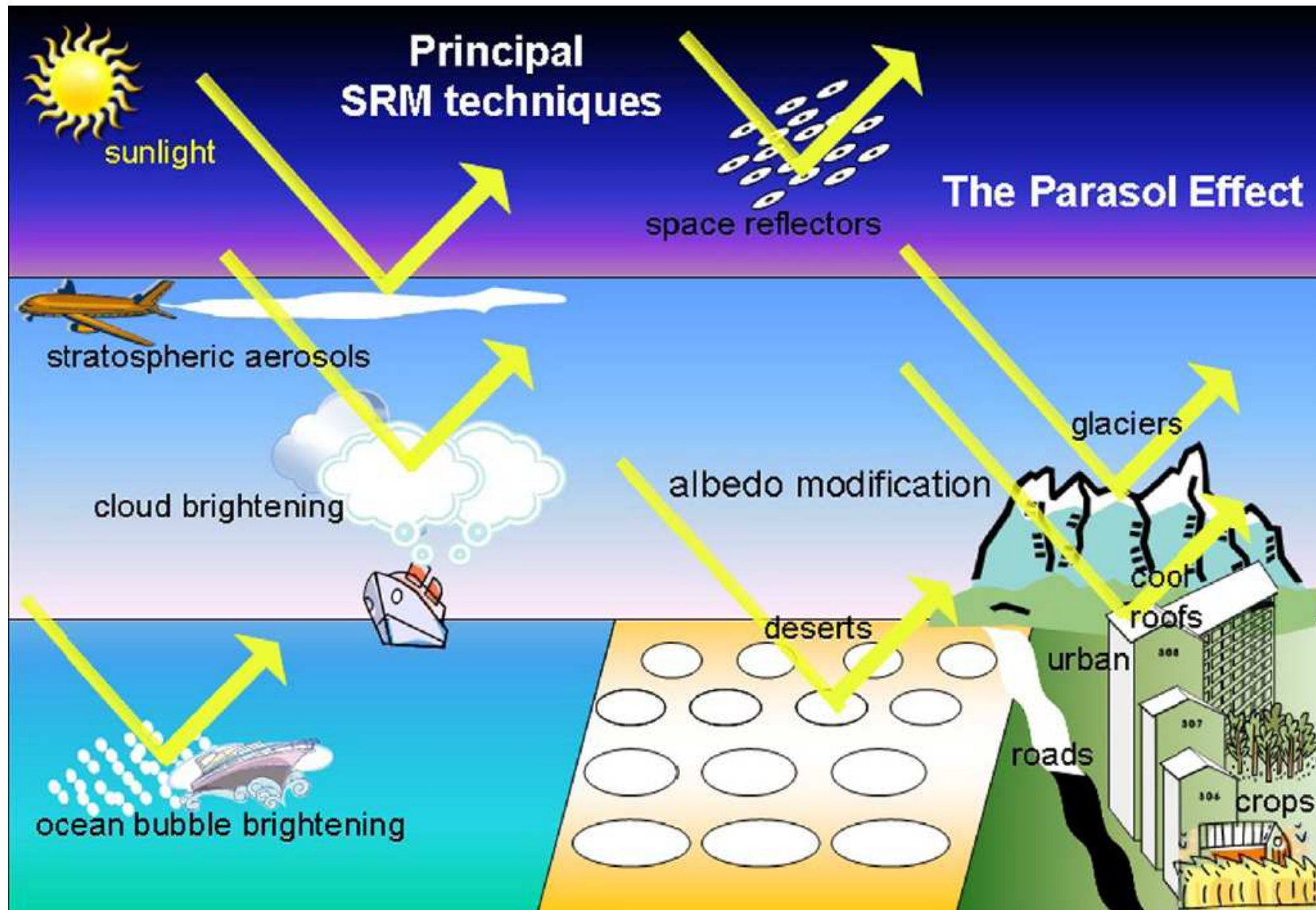


Image from <http://geoengineering.weebly.com/pivotal-article.html>

Incoming Solar **SHORT** wave radiation is targeted by **SRM** also called **Sunlight Reflection Methods**

All the outgoing **EARTH LONG** wave radiation paths are the **ERM** goals

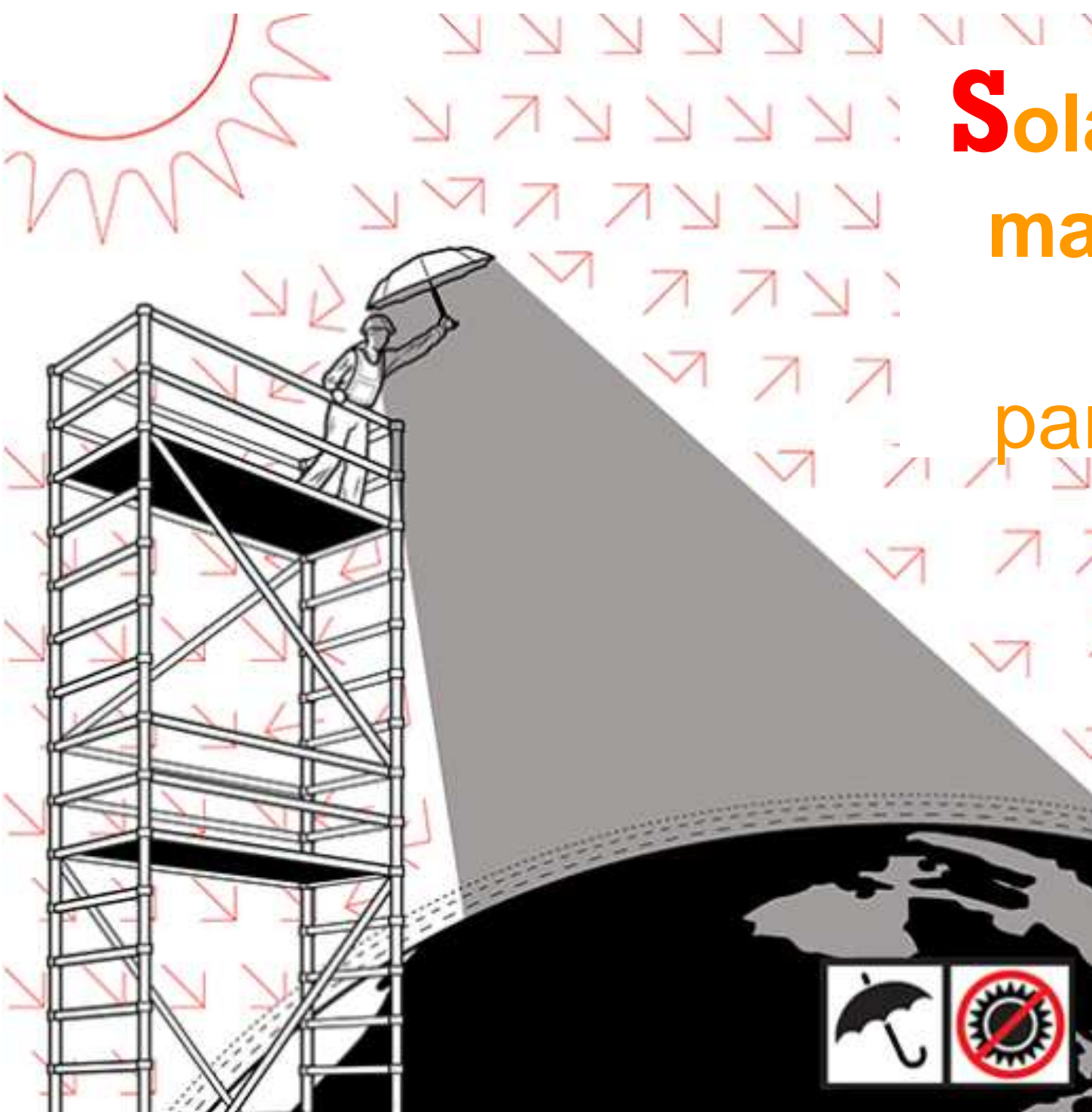
# Solar Radiation Management (SRM)



**SRM targets incoming short wave radiation**

But blocking the sun will not help the humans to stop spewing billions of tons of CO<sub>2</sub> into the atmosphere

# Solar radiation management acts by parasol effect



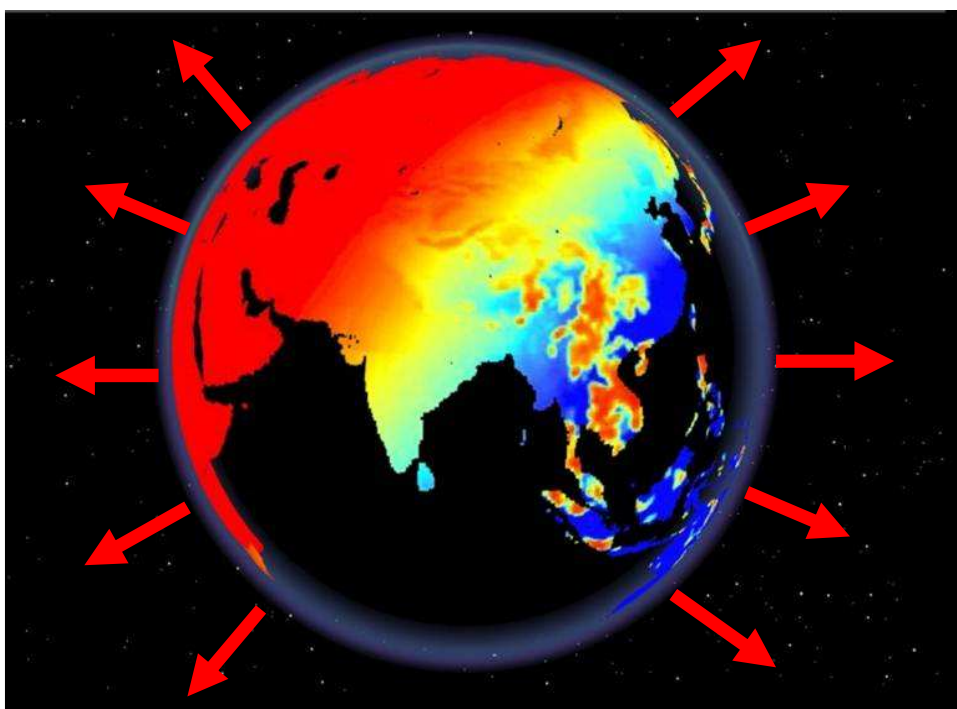


Image from <http://develop.larc.nasa.gov/Summer2012Projects/Nepal%20Agriculture.html>

# Earth Radiation Management

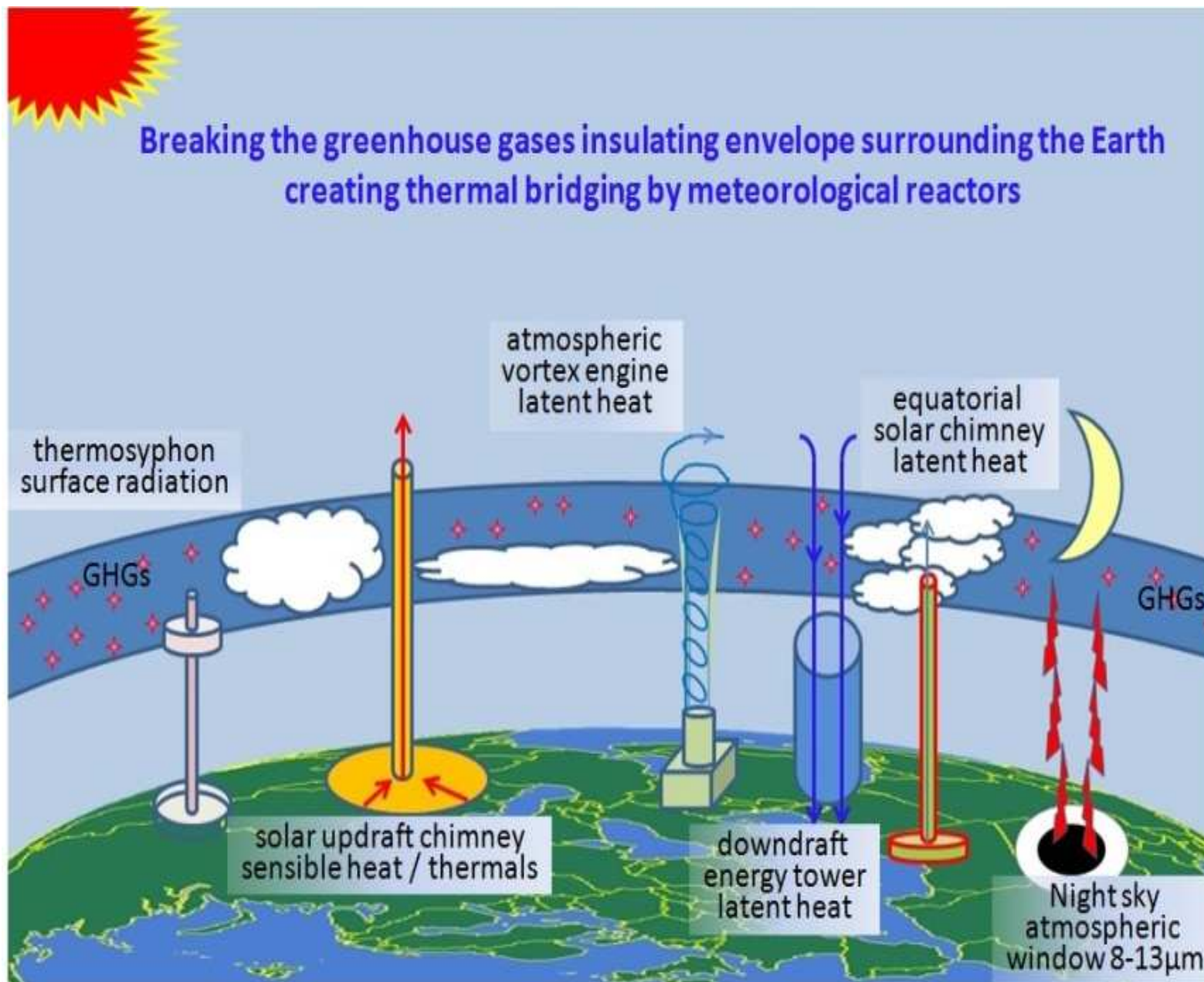
acts by sending **IR** to the space

Among our proposals to perform **long wave ERM**:

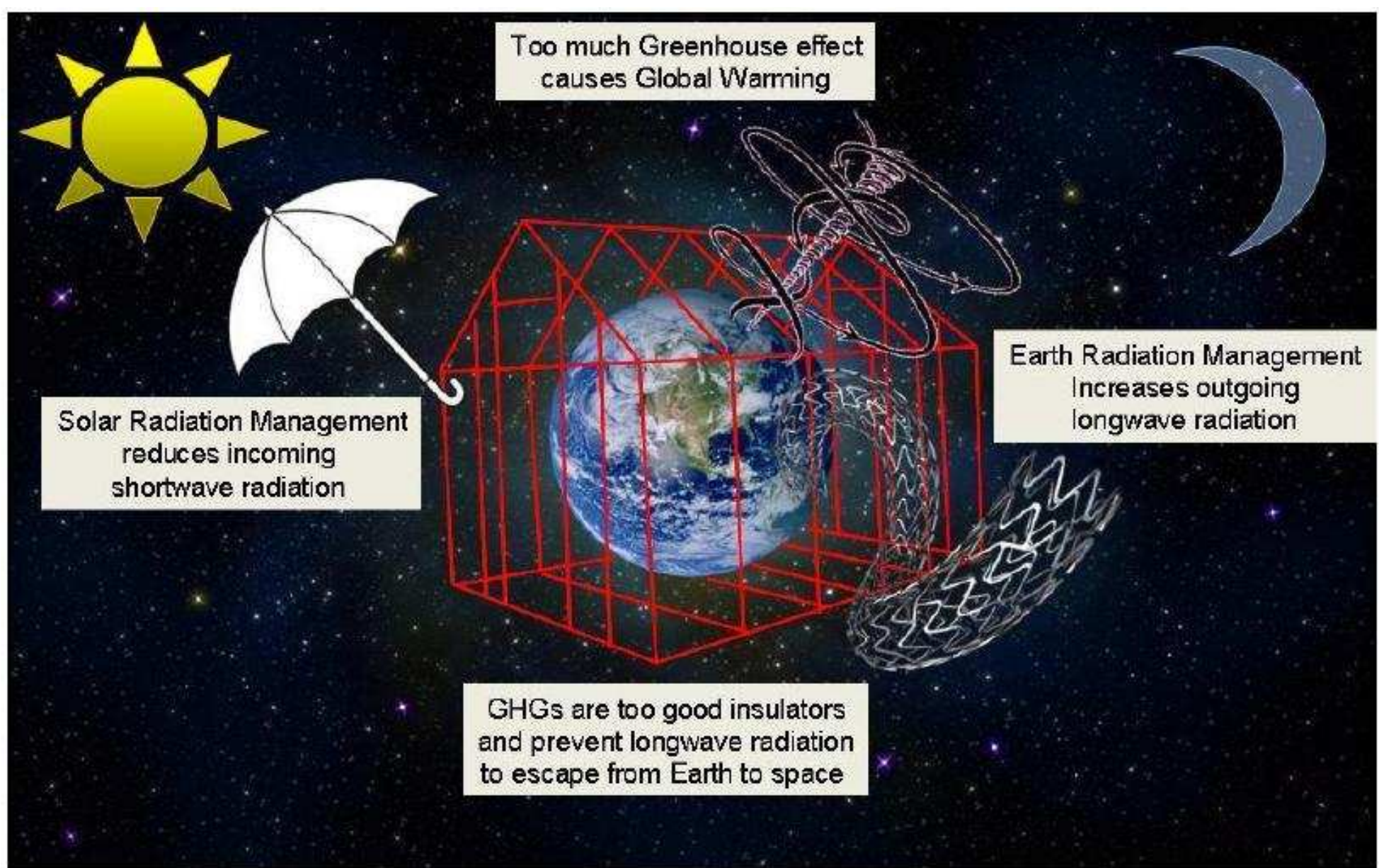
- target the 8-12  $\mu\text{m}$  atmospheric window
- give rise to upward thermals
- create downward cold air currents
- increase altitude latent heat transfer from surface
- facilitate “*thermal shortcuts*” between the surface and the high atmosphere

# Some ERM

## examples



Meteorological Reactors at the same time  
increase outgoing long wave radiation, cool the Earth surface  
and produce the world needs of de-carbonized energy



**Conclusion:** by progressively replacing fossil fuel power plants, unusual renewable energies can produce electricity with no CO<sub>2</sub> emissions and thus are able to reduce global warming, cool the Planet, stop sea level rise, stop ocean acidification...

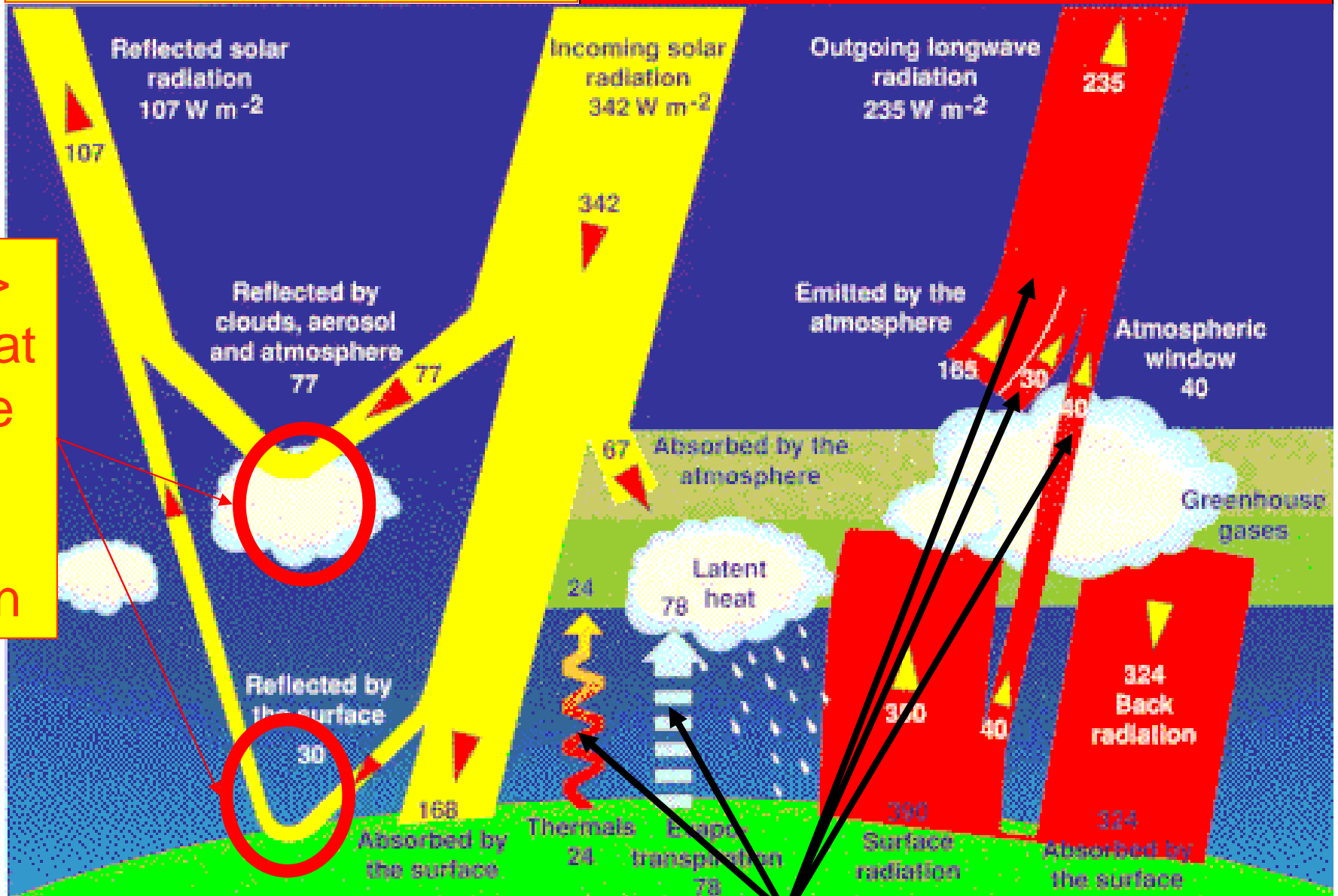
# ERM

## versus SRM

SRM => Sunlight changes

Our Plan C =>  
IR emission changes

SRM =>  
things that  
increase  
short  
wave  
reflection



Our proposal =>  
things that increase outgoing long wave radiation



# Energy Portfolio Diversification with **ERM**

The unusual renewable energies from the Meteorological Reactors family include a set of clean and green alternative energy sources that will enrich our broad energy portfolio mix of de-carbonized renewable energy technologies.

MR include many breakthrough technologies that can increase power generation from renewable sources and create a more diverse and sustainable energy mix portfolio.

By transferring to high altitude heat from the surface, MR **increase outgoing long wave radiation, cool the Earth surface** and at the same time progressively **provide humans with all their energy needs** and **de-carbonize the energy sector**.

Read the open source paper (free access) at:

<http://www.sciencedirect.com/science/article/pii/S1364032113008460>

Listen to the presentation at:

<http://audioslides.elsevier.com//ViewerSmall.aspx?source=1&doi=10.1016/j.rser.2013.12.032>