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Ministerie van Infrastructuur en Milieu

Methane changes after the Pinatubo eruption

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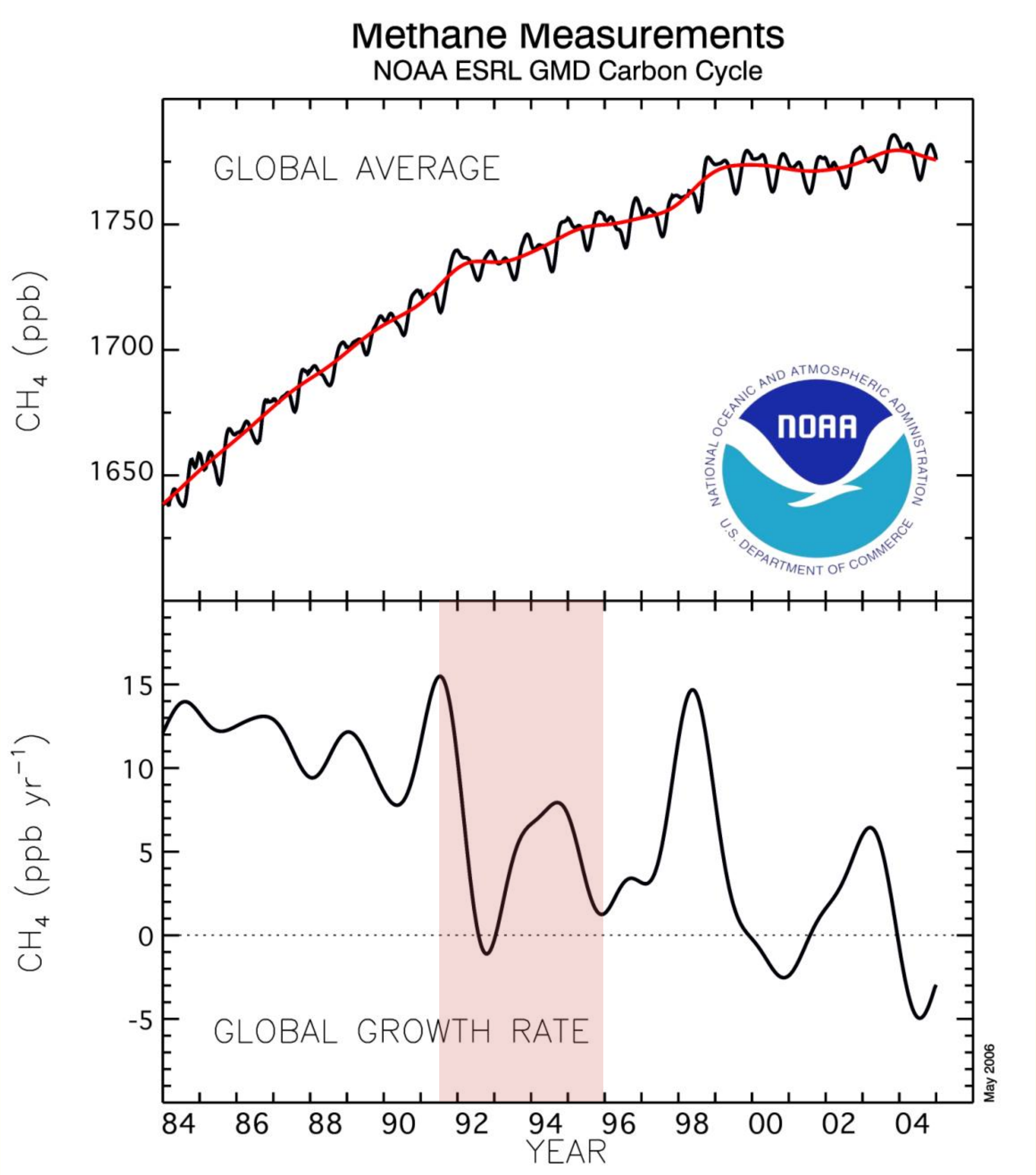
Outline

- Motivation
- The processes
- The model
- Results
- Conclusions

Methane evolution



A bit of tropospheric chemistry

CH_4

- Source – Emissions (natural, anthropogenic)
- Sink – reaction with OH

A bit of tropospheric chemistry

CH_4 → Source – Emissions (natural, anthropogenic)

CH_4 → Sink – reaction with OH

$$dCH_4 / dt = E_{CH4} - k \times OH \times CH_4$$

A bit of tropospheric chemistry

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OH
- Source – ozone photolysis ($O_3 + h\nu \xrightarrow{+H_2O} 2OH$)
- Sink – reaction with CH4, CO, etc

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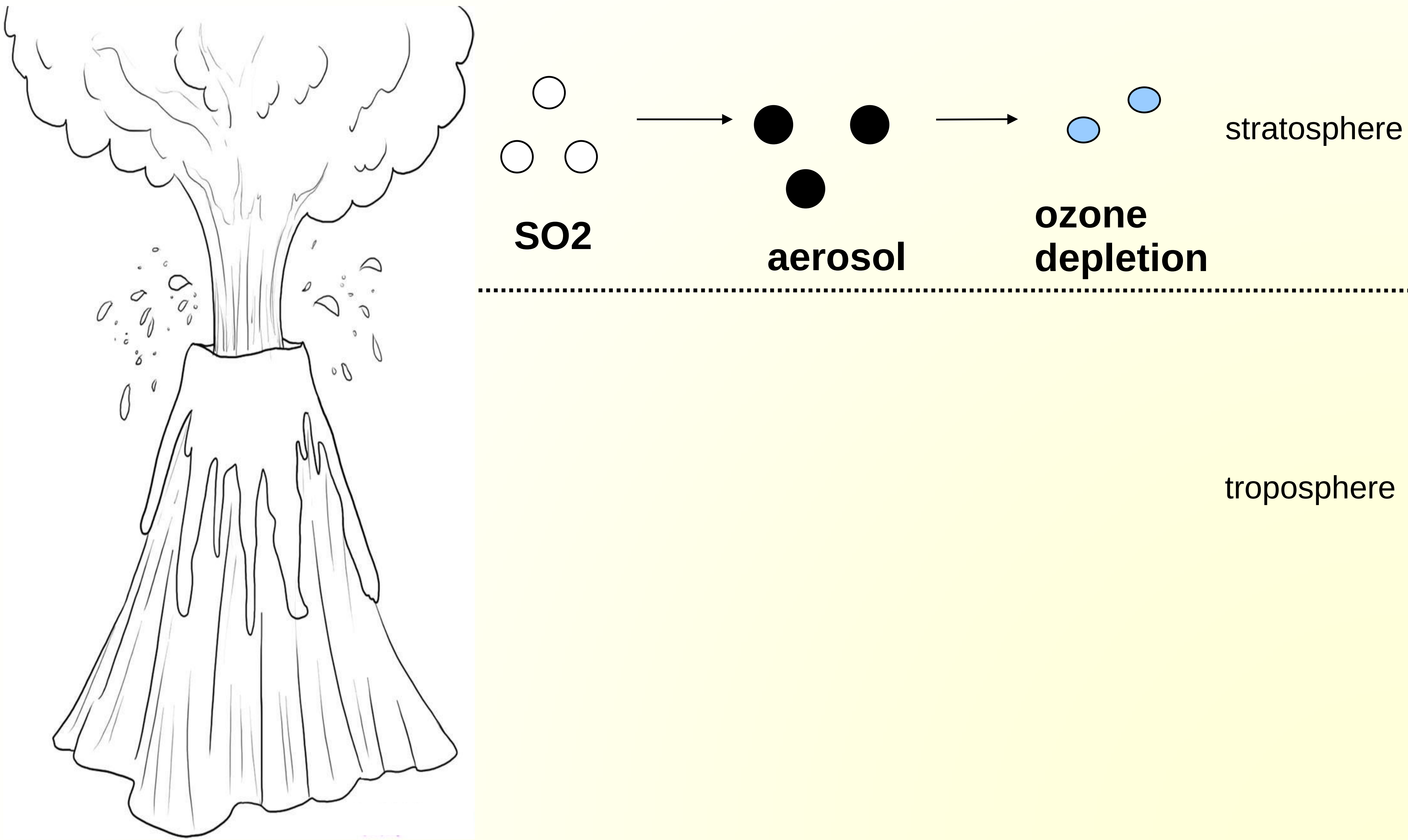
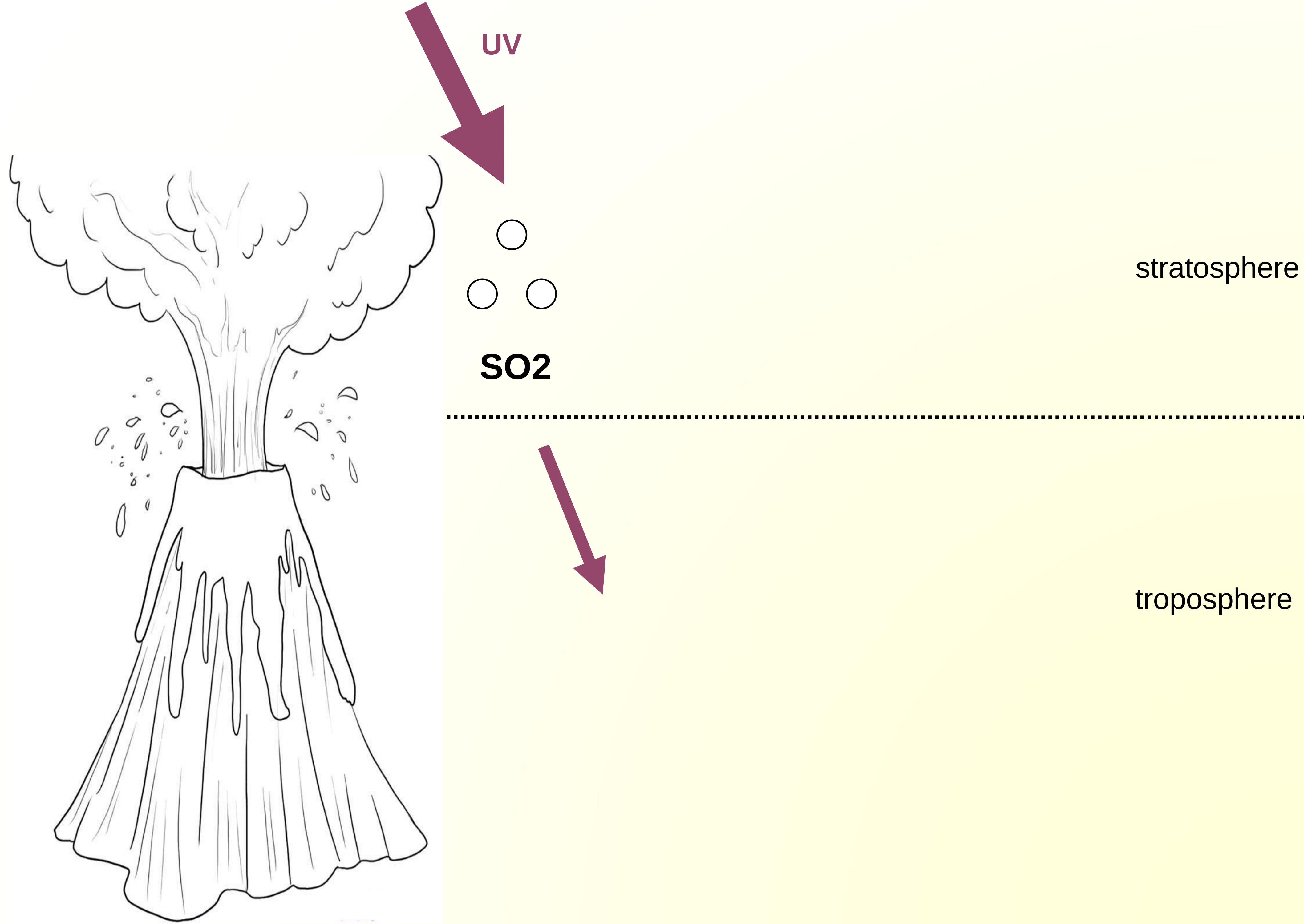
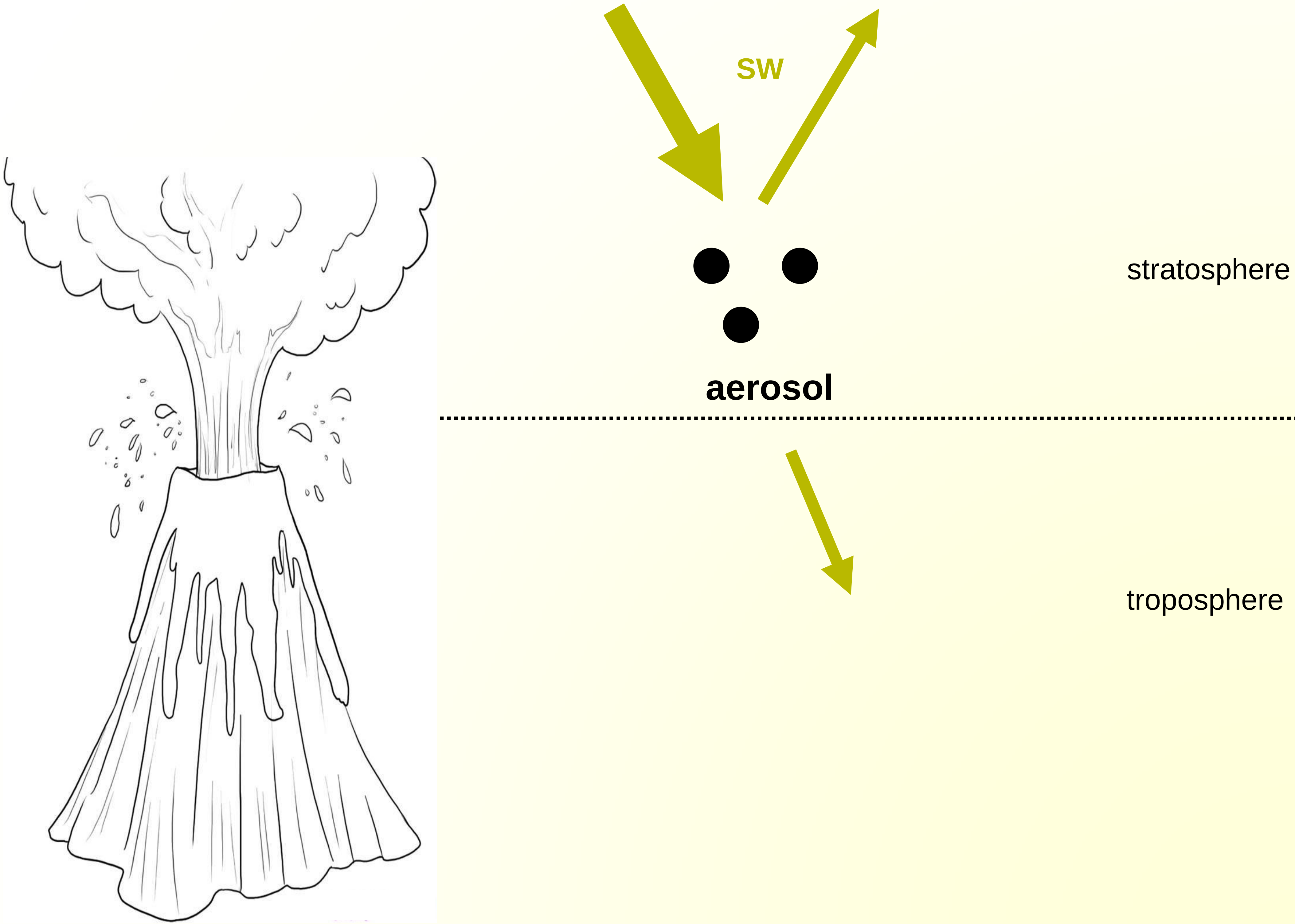
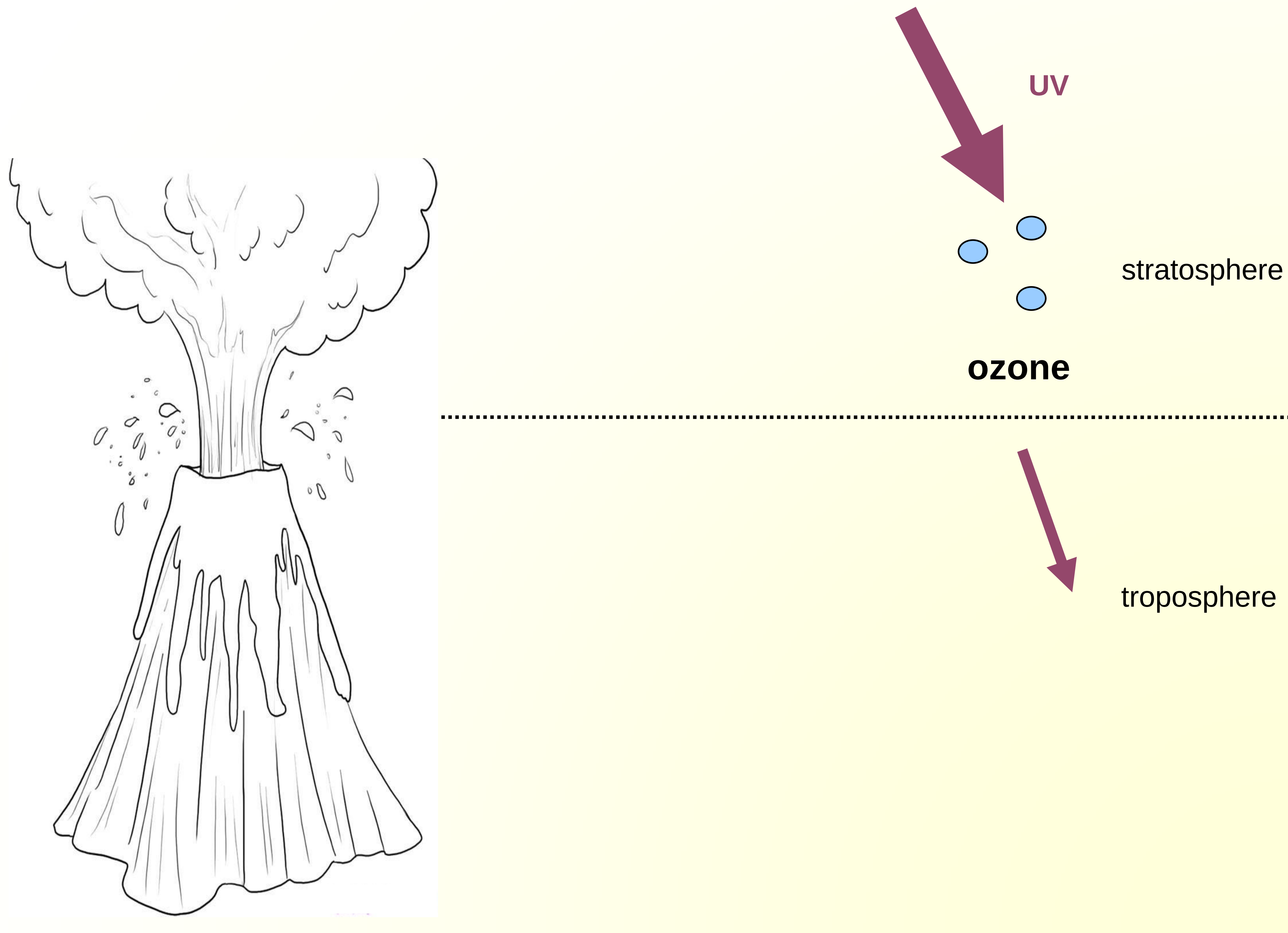
Recycling by NO_X ($NO_2 + h\nu \longrightarrow NO + O_3$
$NO + O_3 \longrightarrow NO_2 + O_2$)

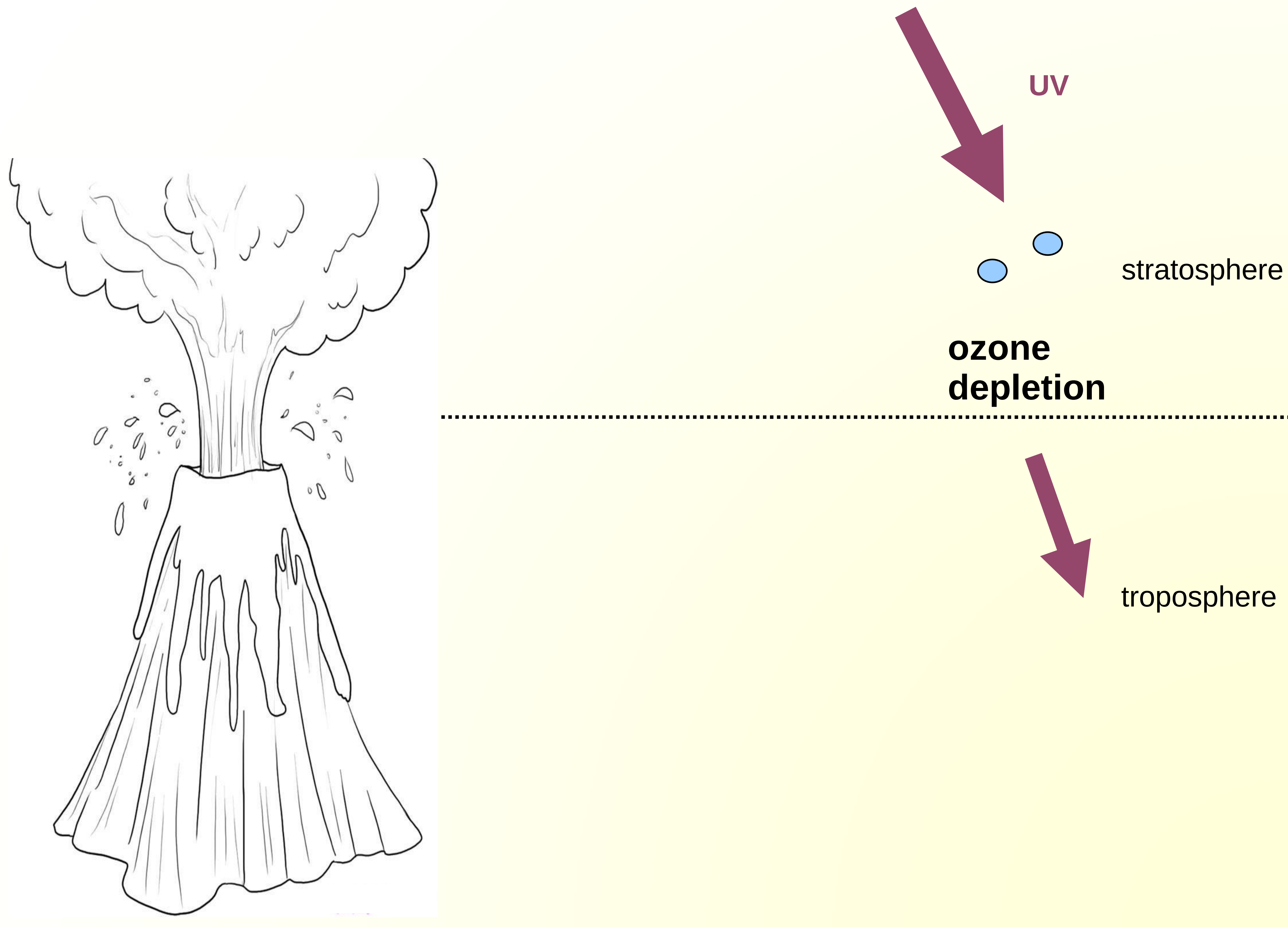

SO2
aerosol
ozone
depletion
stratosphere
troposphere

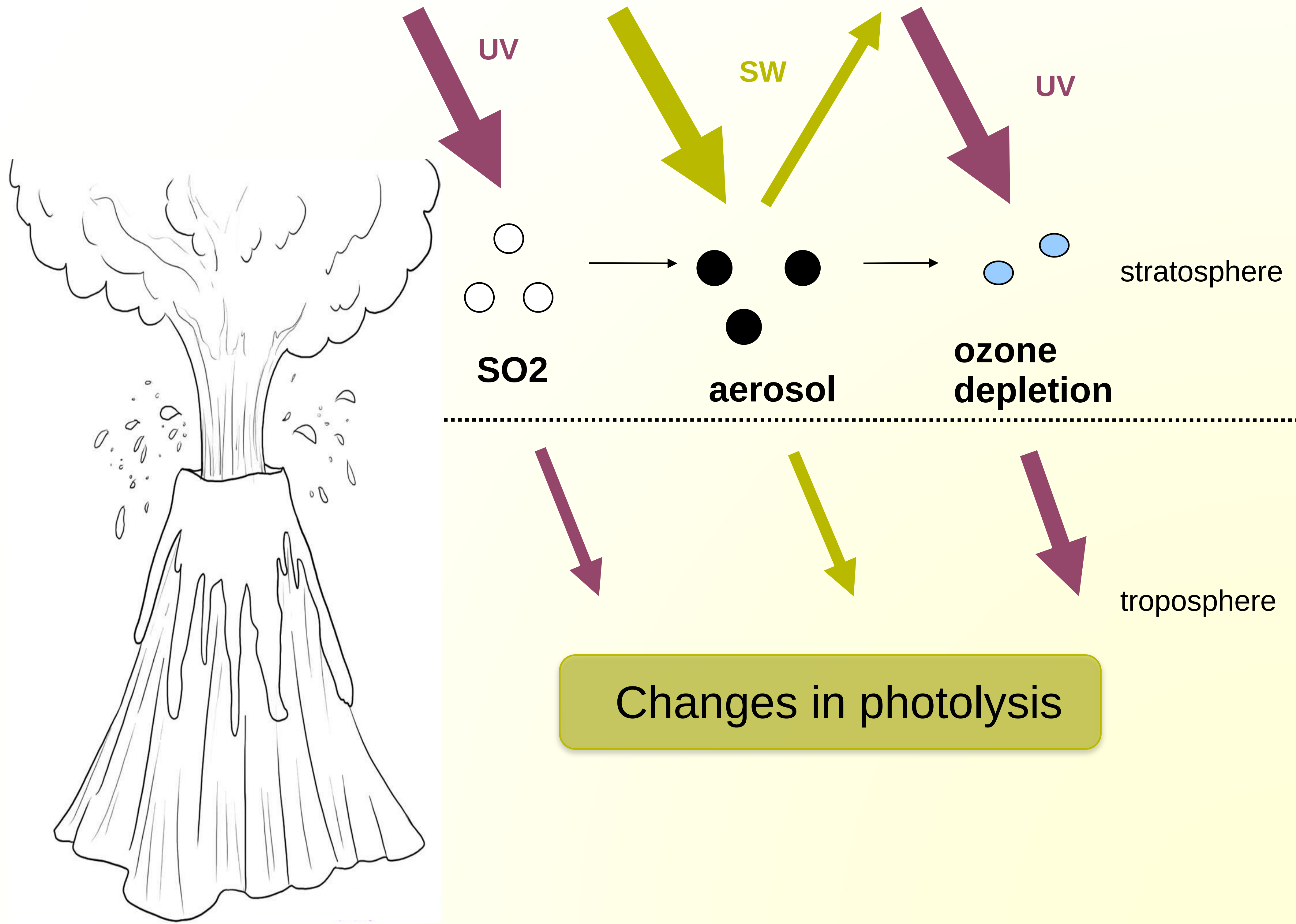

UV
SO2
stratosphere
troposphere



SW
aerosol
stratosphere
troposphere


UV
stratosphere
ozone
troposphere


UV
stratosphere
ozone depletion
troposphere


UV
SW
UV
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Changes in photolysis

CH_4

Source – Emissions (natural, anthropogenic)

Sink – reaction with OH

OH

Source – ozone photolysis ($O_3 + hv \xrightarrow{+H_2O} 2OH$)

Sink – reaction with CH4, CO, etc

CH_4

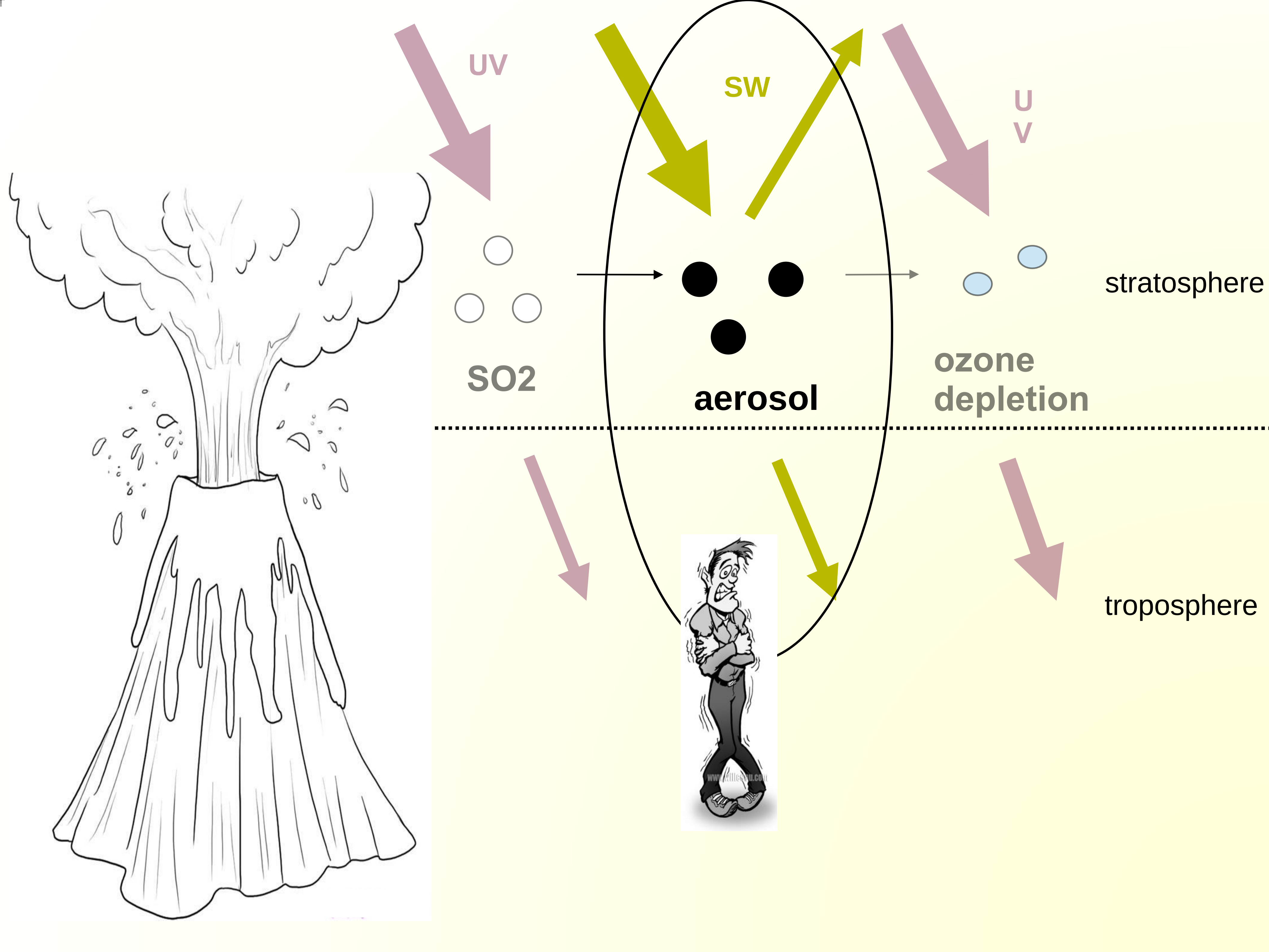
Source – Emissions (natural, anthropogenic)

Sink – reaction with OH

Changes in UV => changes in OH production through photolysis

OH

Sink – reaction with CH4, CO, etc


UV
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CH_4

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- Source – ozone photolysis ($O_3 + h\nu \xrightarrow{+H_2O} 2OH$)
- Sink – reaction with CH4, CO, isoprene, etc

CH_4

Decrease in CH4 emissions from wetlands

Sink – reaction with OH

OH

Source – ozone photolysis ($O_3 + hv \xrightarrow{+H_2O} 2OH$)

Sink – reaction with CH4, CO, isoprene, etc

CH_4

- Decrease in CH4 emissions from wetlands
- Slower reaction with OH

OH

- Source – ozone photolysis ($O_3 + hv \xrightarrow{+ H_2O} 2OH$)
- Sink – reaction with CH4, CO, isoprene, etc

CH_4

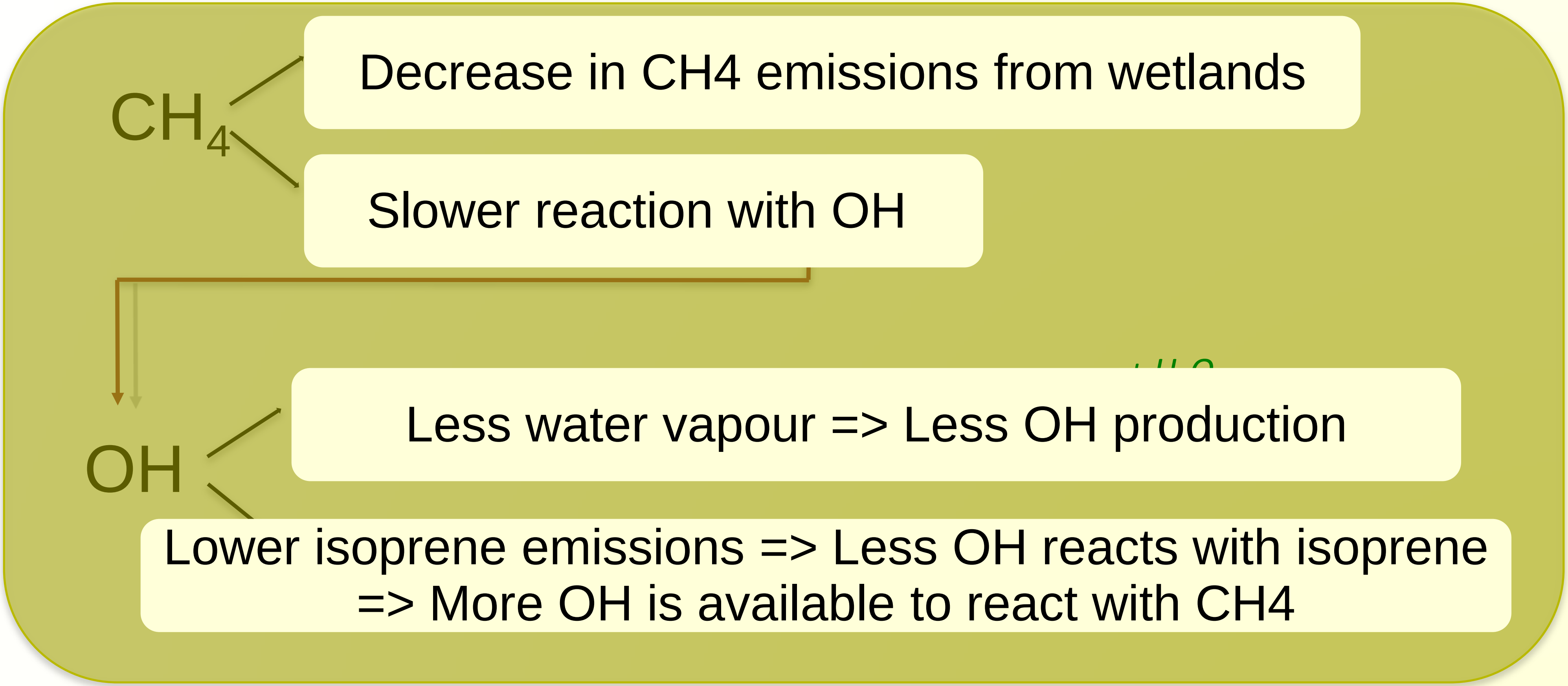
Decrease in CH4 emissions from wetlands

Slower reaction with OH

OH

Less water vapour => Less OH production

Sink – reaction with CH4, CO, isoprene, etc

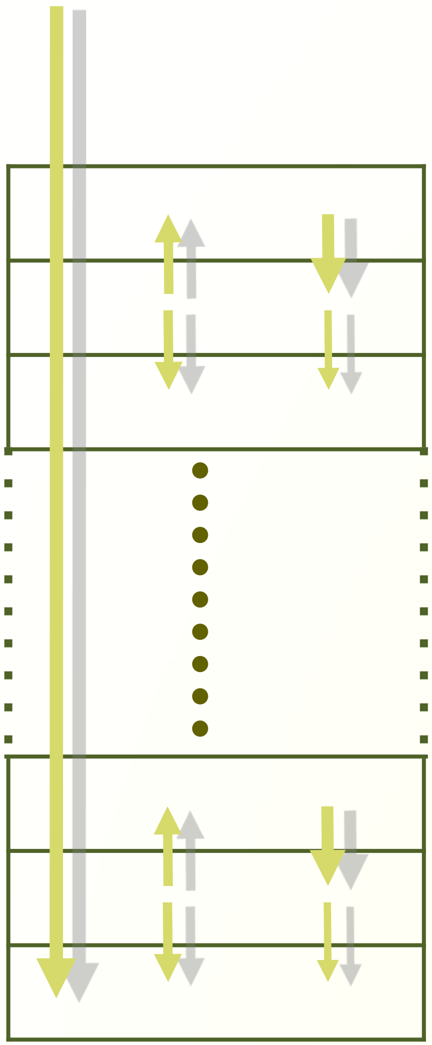


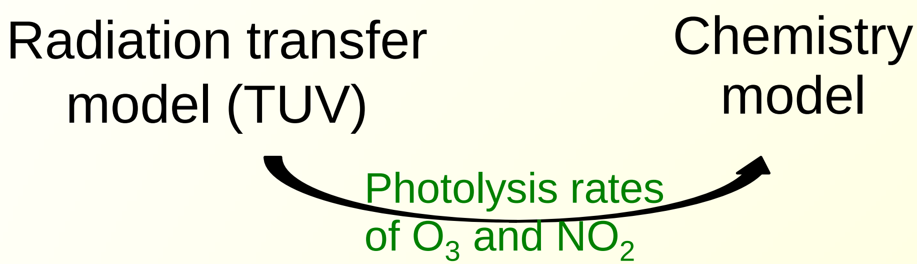
CH_4
Decrease in CH4 emissions from wetlands
Slower reaction with OH
OH
Less water vapour => Less OH production
Lower isoprene emissions => Less OH reacts with isoprene
=> More OH is available to react with CH4

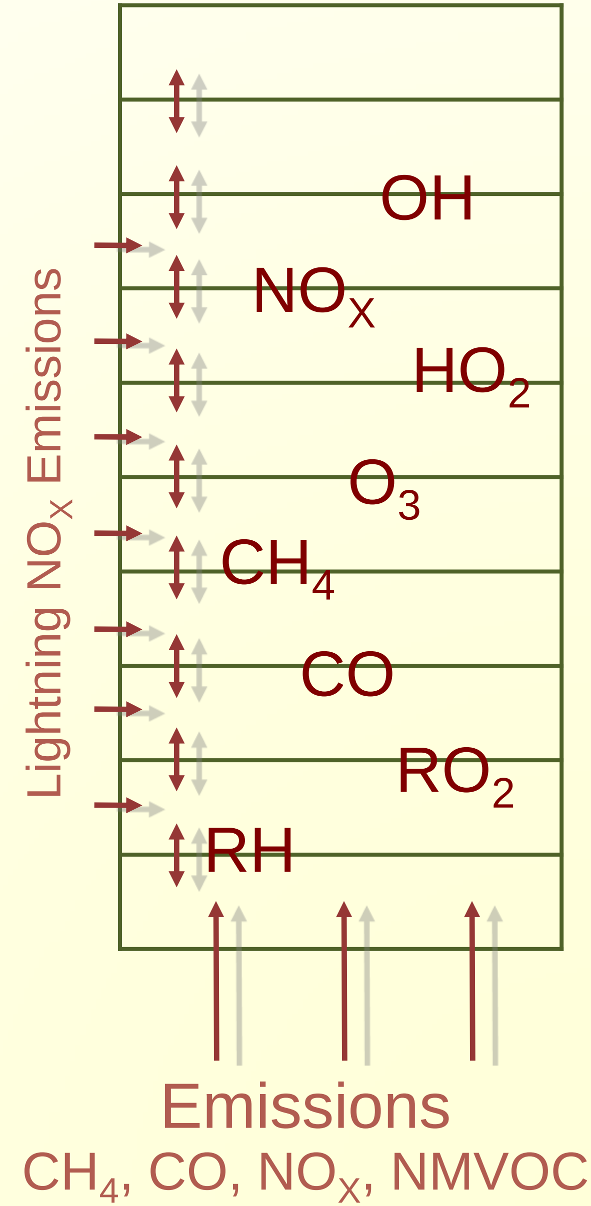
Process	E_{CH4}	k	UV	OH	CH4
UV absorption by SO_2			↘	↘	↗
Aerosol scattering of radiation			↘	↘	↗
Ozone depletion			↗	↗	↘
Reduced CH_4 wetland emissions	↘				↘
Slower reaction with OH		↘			↗
Reduced isoprene emissions				↗	↘
Less water vapour				↘	↗

$$dCH_4 / dt = E_{CH4} - k \times OH \times CH_4$$

A simple model



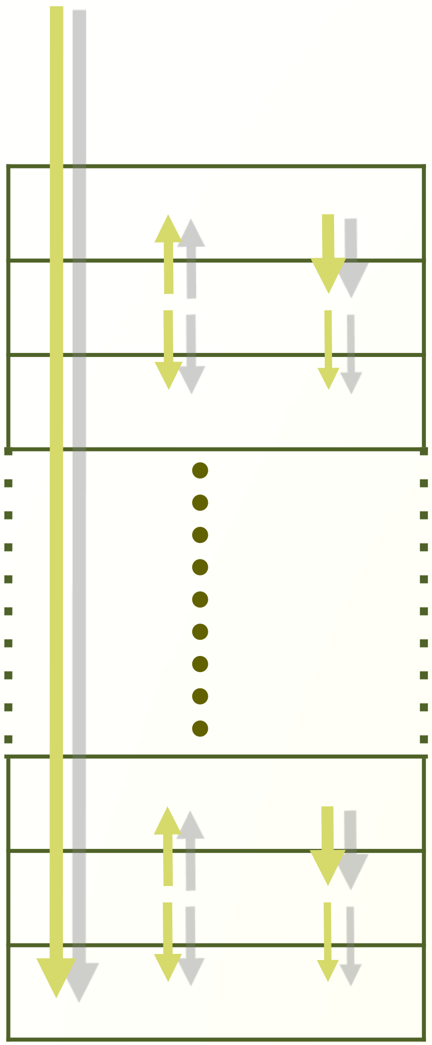


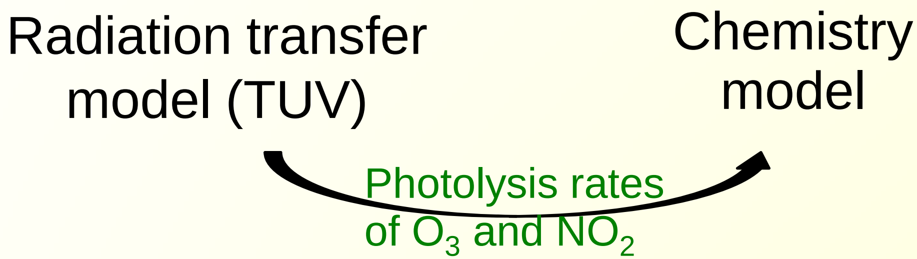


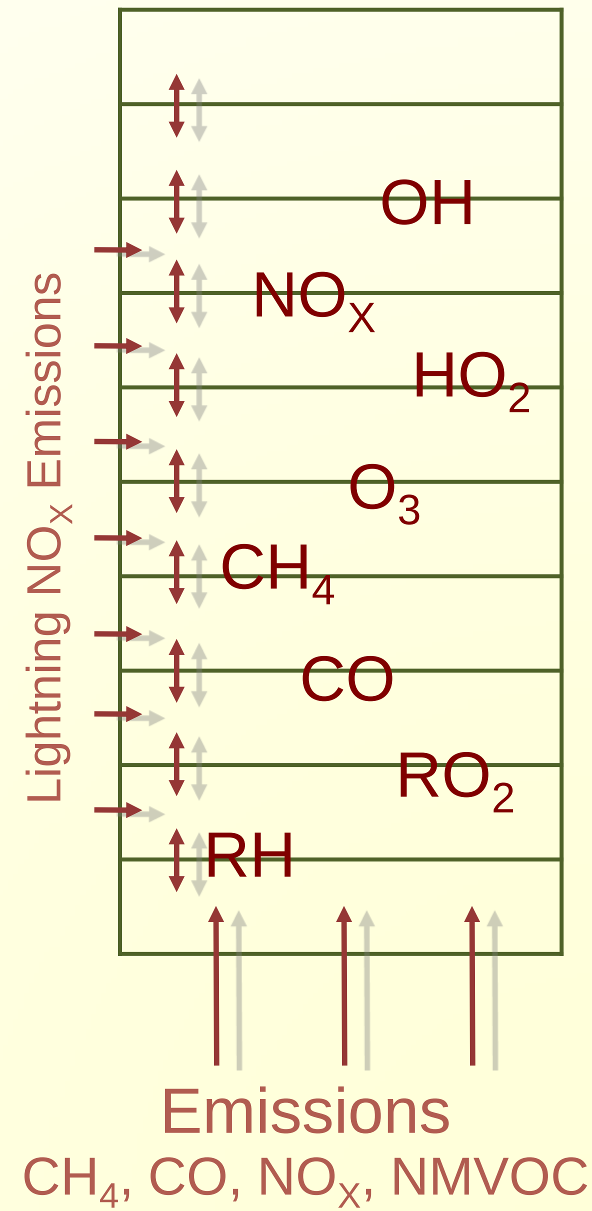
Versions:

- Steady state
- Transient

A simple model

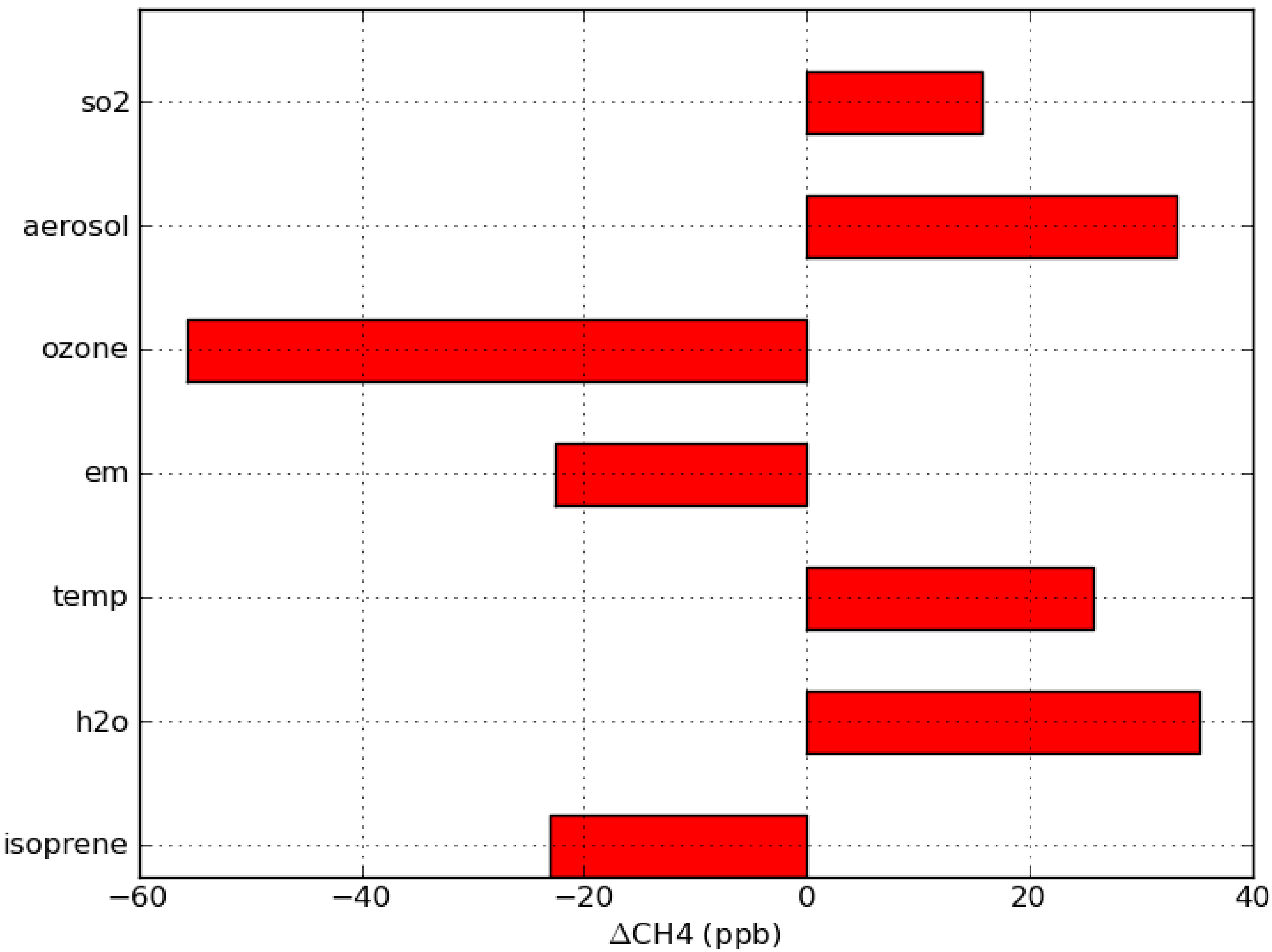






- Initial condition: equilibrium state obtained with Edgar-Hyde 1990 emissions

Effects on methane steady state



1 DU SO2 in the stratosphere

0.15 additional stratospheric AOT

3% ozone column decrease

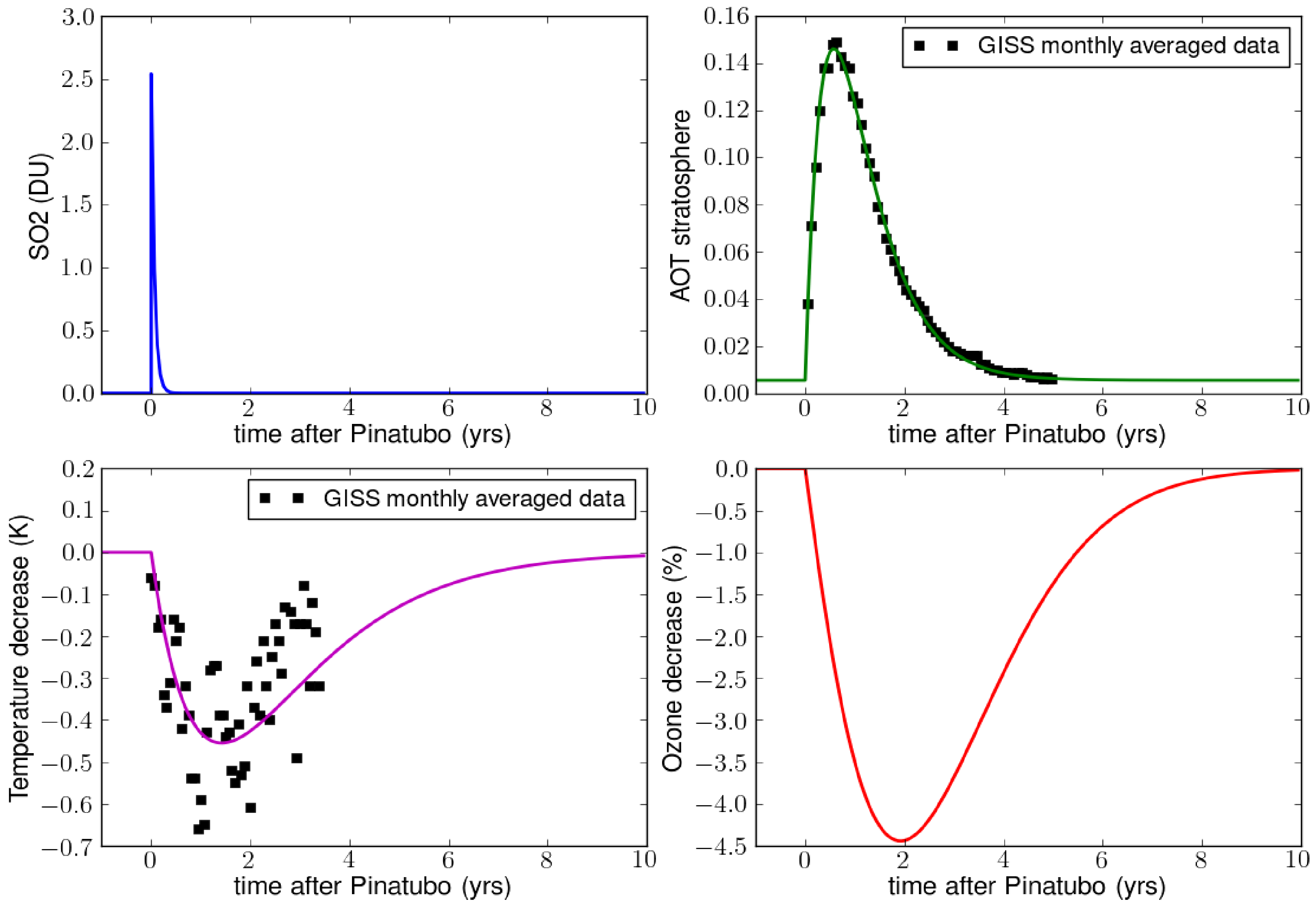
CH4 wetland emissions for temperature -0.5C

Changed reaction rates due to temperature

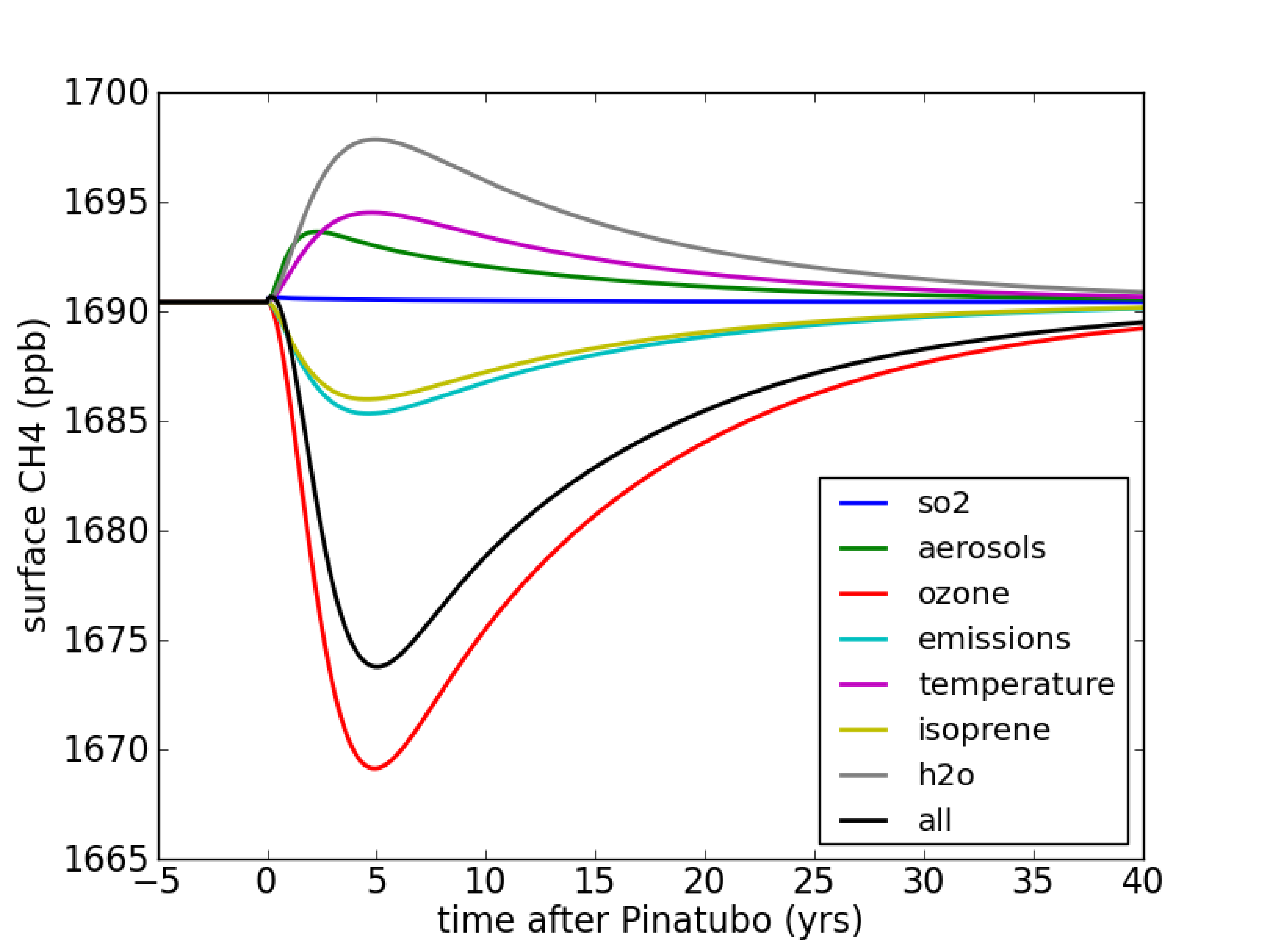
Water vapour effect of temperature -0.5

Effect of 0.15 AOT and -0.5 temperature on isoprene emissions

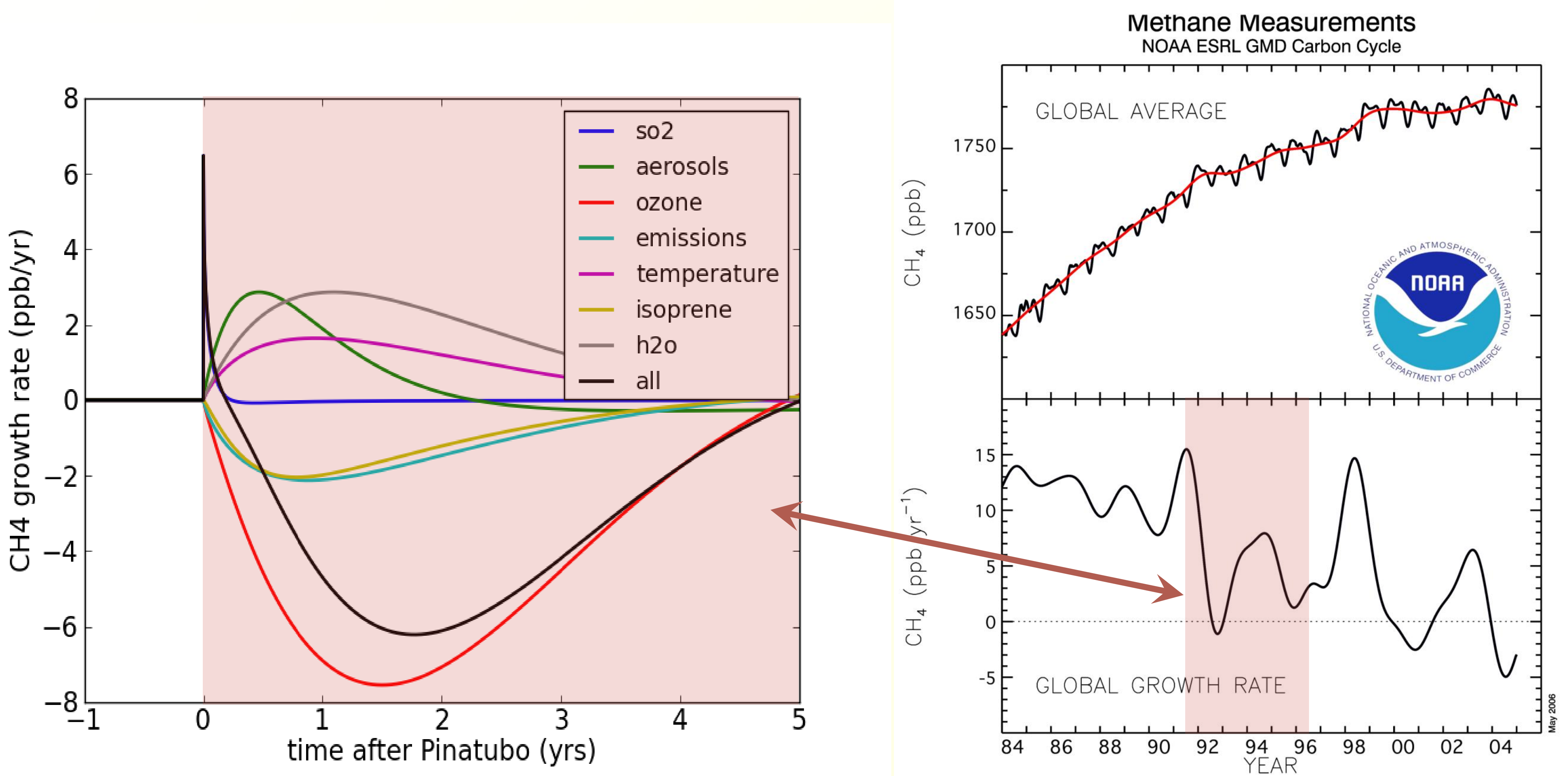
Time evolution of the forcings



Methane transient concentrations



Methane growth rate



Conclusions

- Effect of the eruption is dominated by the SO_2 forcing in the first few months after the eruption, then by the ozone forcing
- Other effects are in the same order of magnitude but compensate each other
- Results for growth rate show remarkably good agreement with measurements, considering the simplicity of the model
- Spatial distributions also important => 3D simulations

Thank you!

Questions?