The future tropospheric and stratospheric ozone radiative forcing

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Outline

1. Motivations

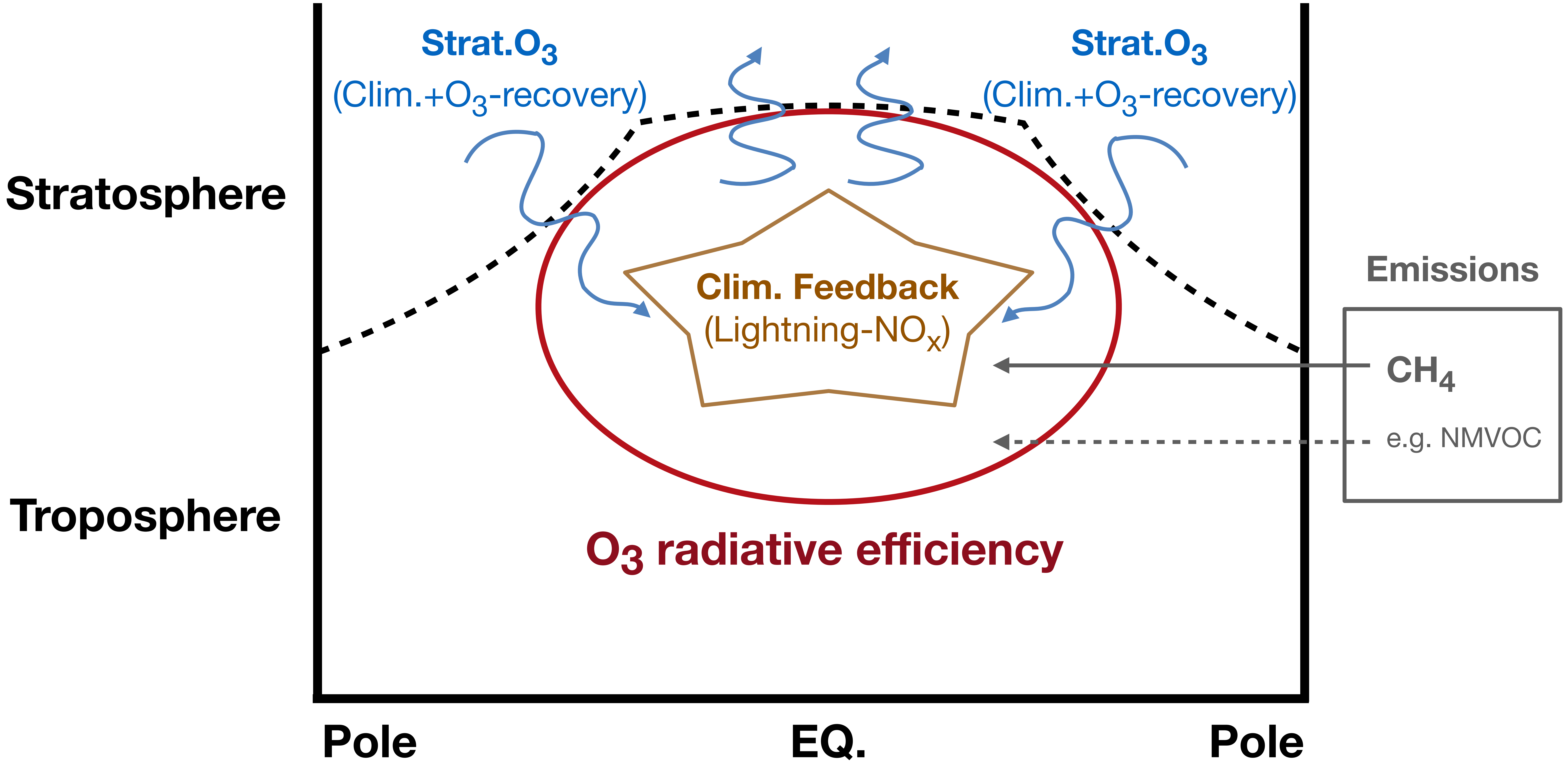
2. Model, experimental setup and radiative effects

3. Present-day and sensitivity experiments

4. Discussion and limitations

5. Summary

Motivations



Model: CESM-WACCM

- Coupled radiation and chemistry (**O_3 chem. troposphere-stratosphere**) schemes.
- Lightning-induced NO_X emissions: cloud top height parameterisation.
- High-top model (140 km); horizontal resolution of 1.9° x 2.5° (latitude by longitude).
  - … equivalent setup as in the Chemistry-Climate Model Initiative (CCMI; further details in Tilmes et al. 2016).

Sensitivity simulations

- **Control** simulation (CNTRL) is for year 2000 boundary conditions.
- **Sensitivity** simulations are used altering one factor of the boundary conditions to year 2100 (RCP8.5 and A1 scenarios) at a time.

Climate	**Lightning-NO_X**
O_3-recovery	**CH_4**

Radiative effects

- Net flux change at tropopause after stratospheric T adjust.
- **Radiative kernel** in Rap et al. (2015).

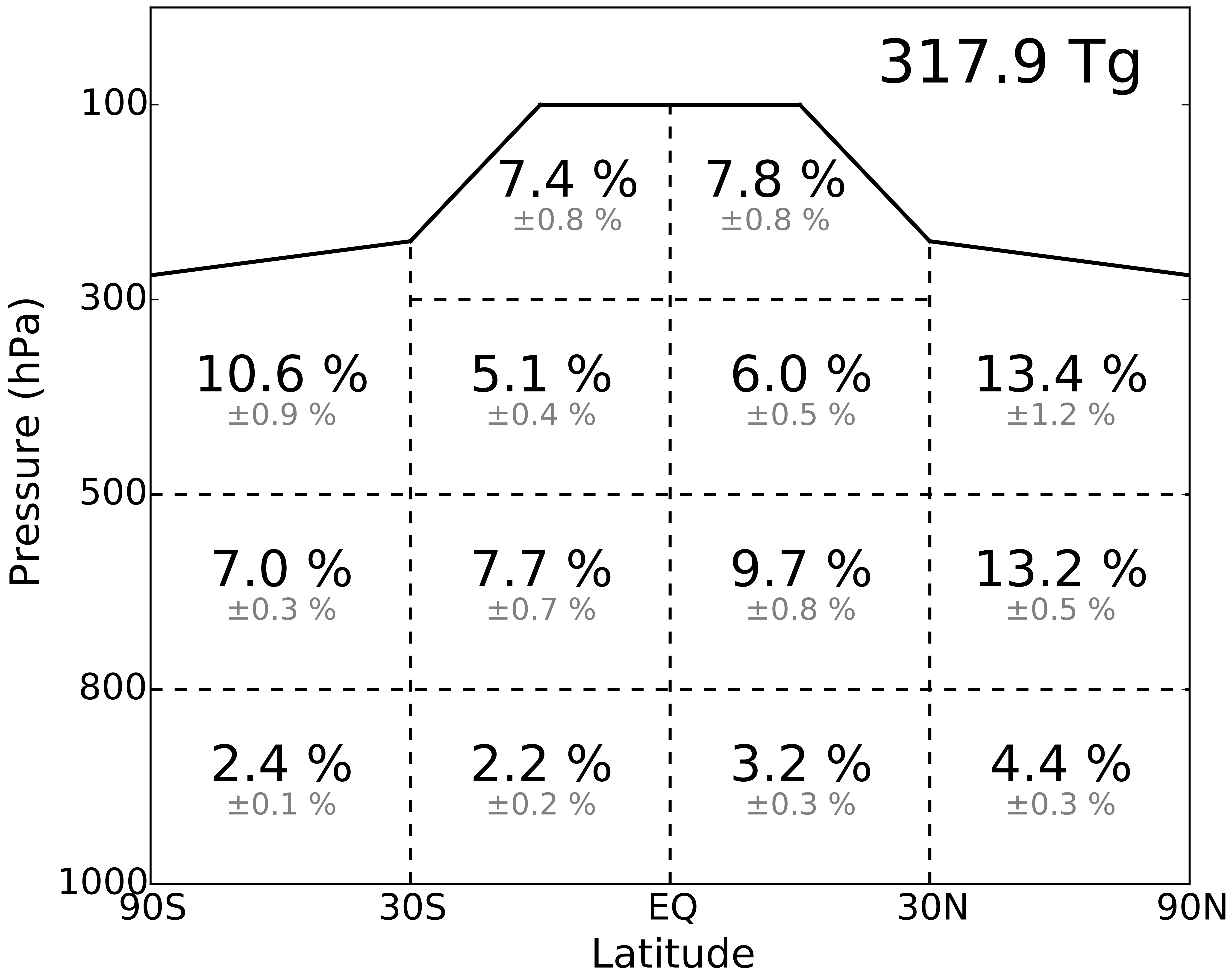
Present-day (yr 2000)

Tropospheric O_3 budget

Simulation	NCP (Tg yr-1)	STE (Tg yr-1)	Burden (Tg)
ACCMIP (2000)	617 ± 242	477 ± 96	337 ± 23
CNTRL	**483**	**398**	**318**

CNTRL

Tropospheric O_3 burden distribution



CLIMATE

Tropospheric O_3 budget

Simulation	NCP (Tg yr-1)	STE (Tg yr-1)	Burden (Tg)
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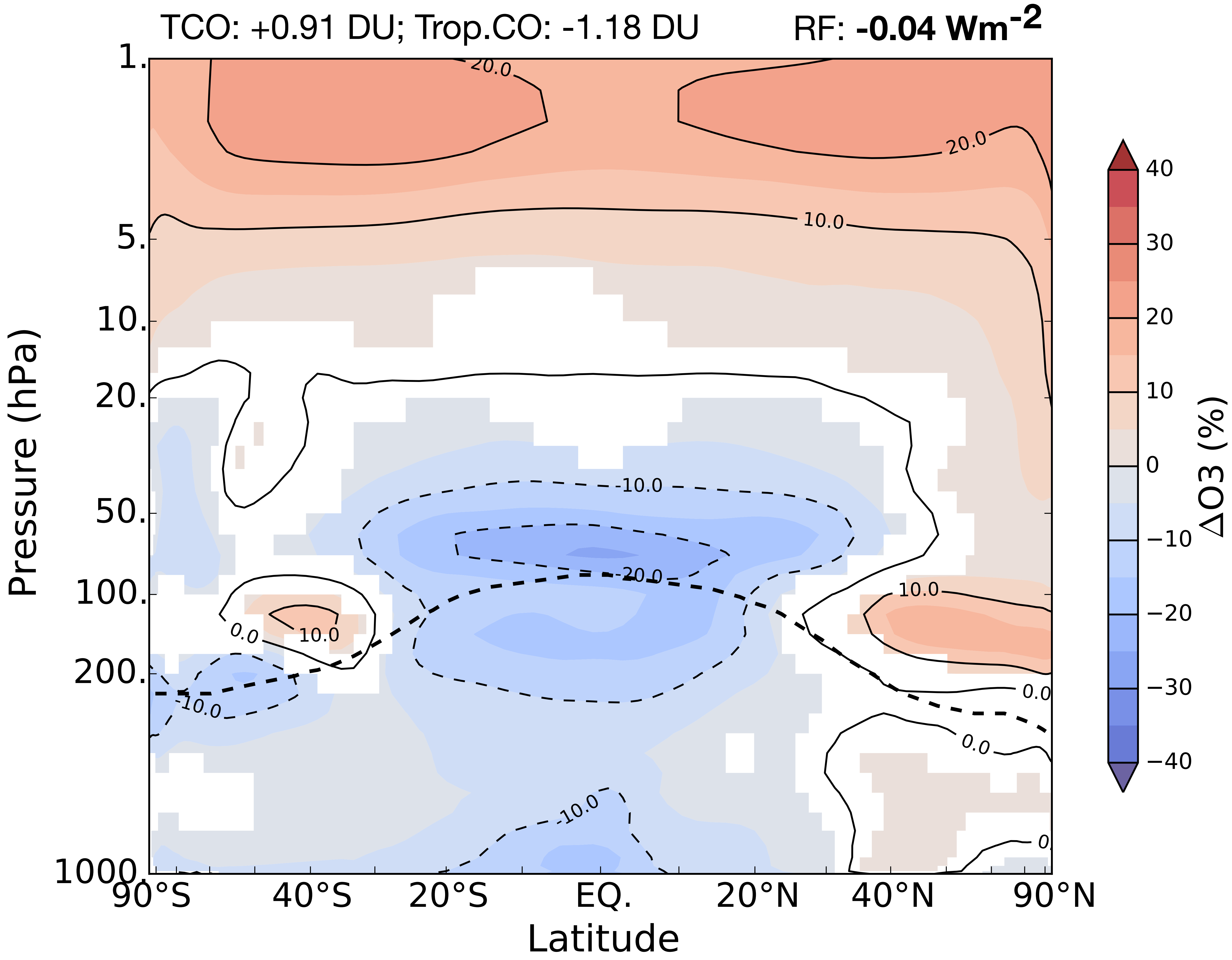
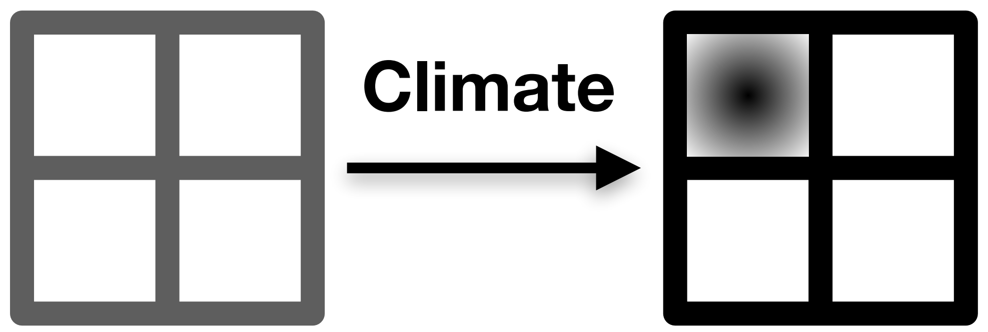
Climate	**302**	**509**	**309**





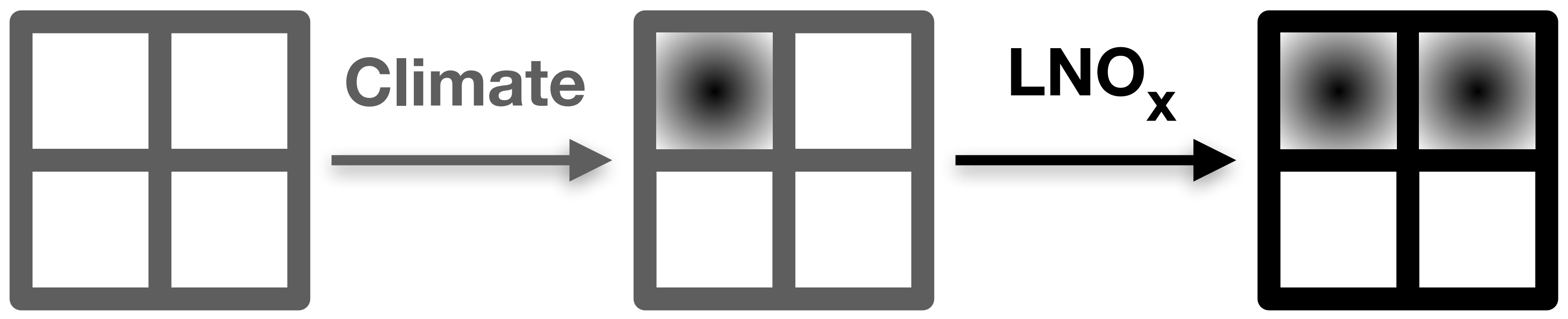
CLIMATE + LNOx

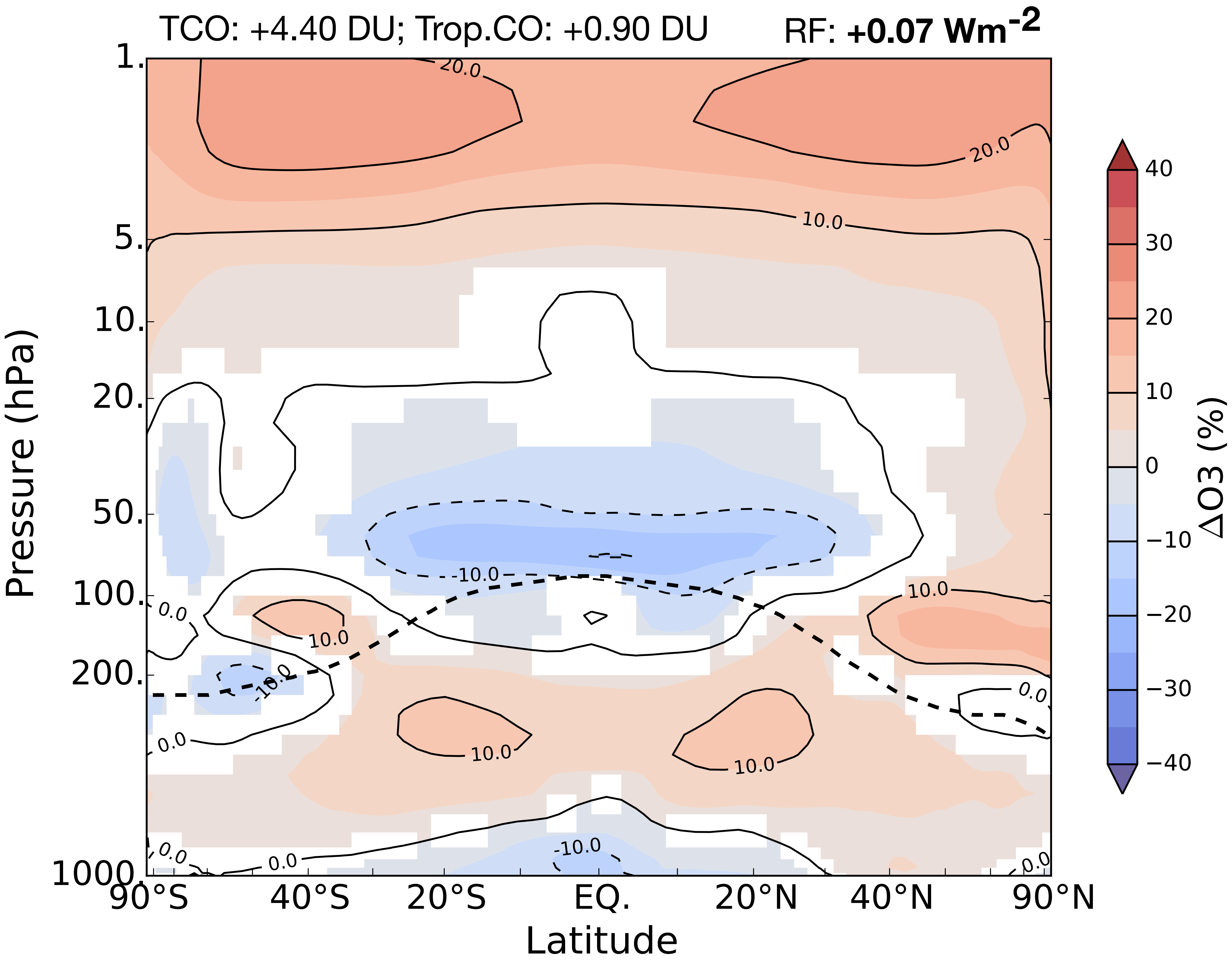
Tropospheric O_3 budget

Simulation	NCP (Tg yr-1)	STE (Tg yr-1)	Burden (Tg)
ACCMIP (2000)	617 ± 242	477 ± 96	337 ± 23
CNTRL	483	398	318
Climate	302	509	309
+ LNO_x	**318**	**517**	**329**

LNO_x **sensitivity** of **10 %K^{-1}.**

LNO_x **contribution** of **3 %** to the increase in **STE and 25 % to the O_3-RF**.





CLIMATE (LNOx) + O3-recovery

Tropospheric O_3 budget

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ACCMIP (2000)	617 ± 242	477 ± 96	337 ± 23
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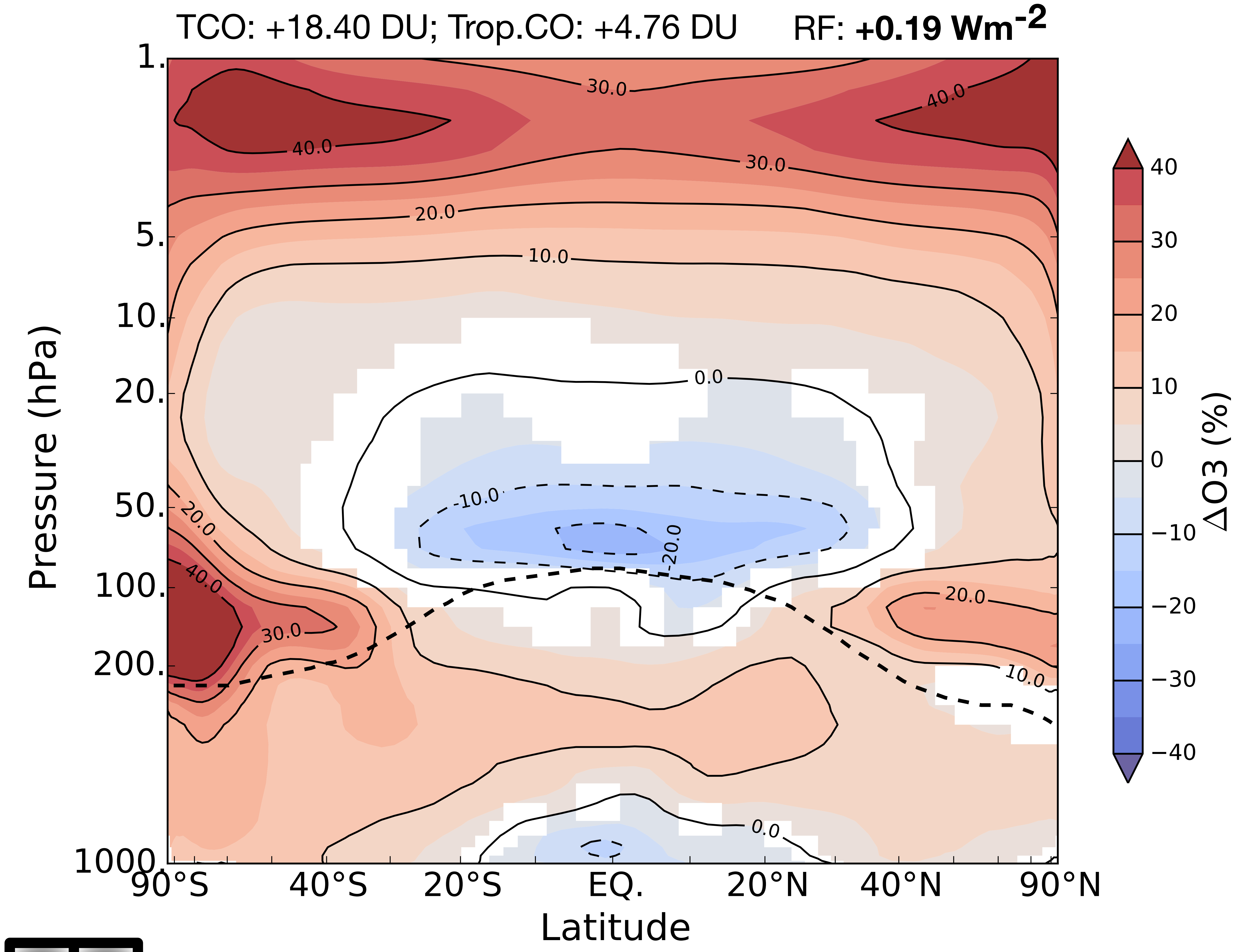
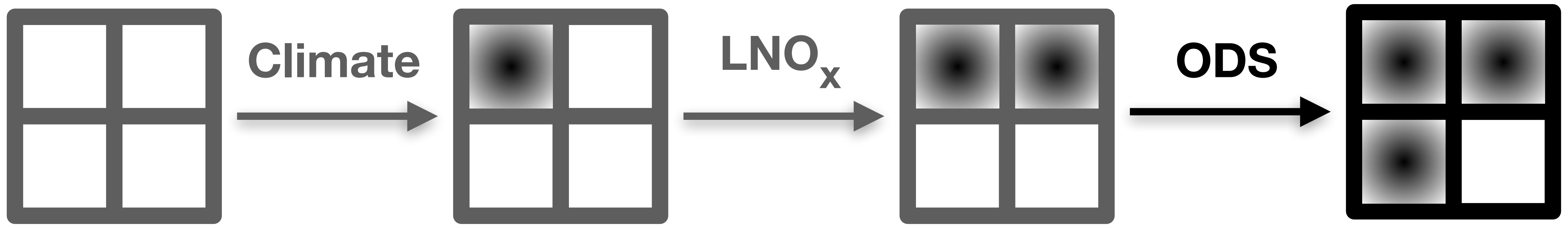
Climate	302	509	309
+ LNO_X	318	517	329
++ O3-recov	245	**610**	**337**

O_3 recovery **contribution** of **35 %** to the increase in **STE. Tropospheric O3 contributes 1/3** its O_3-RF.



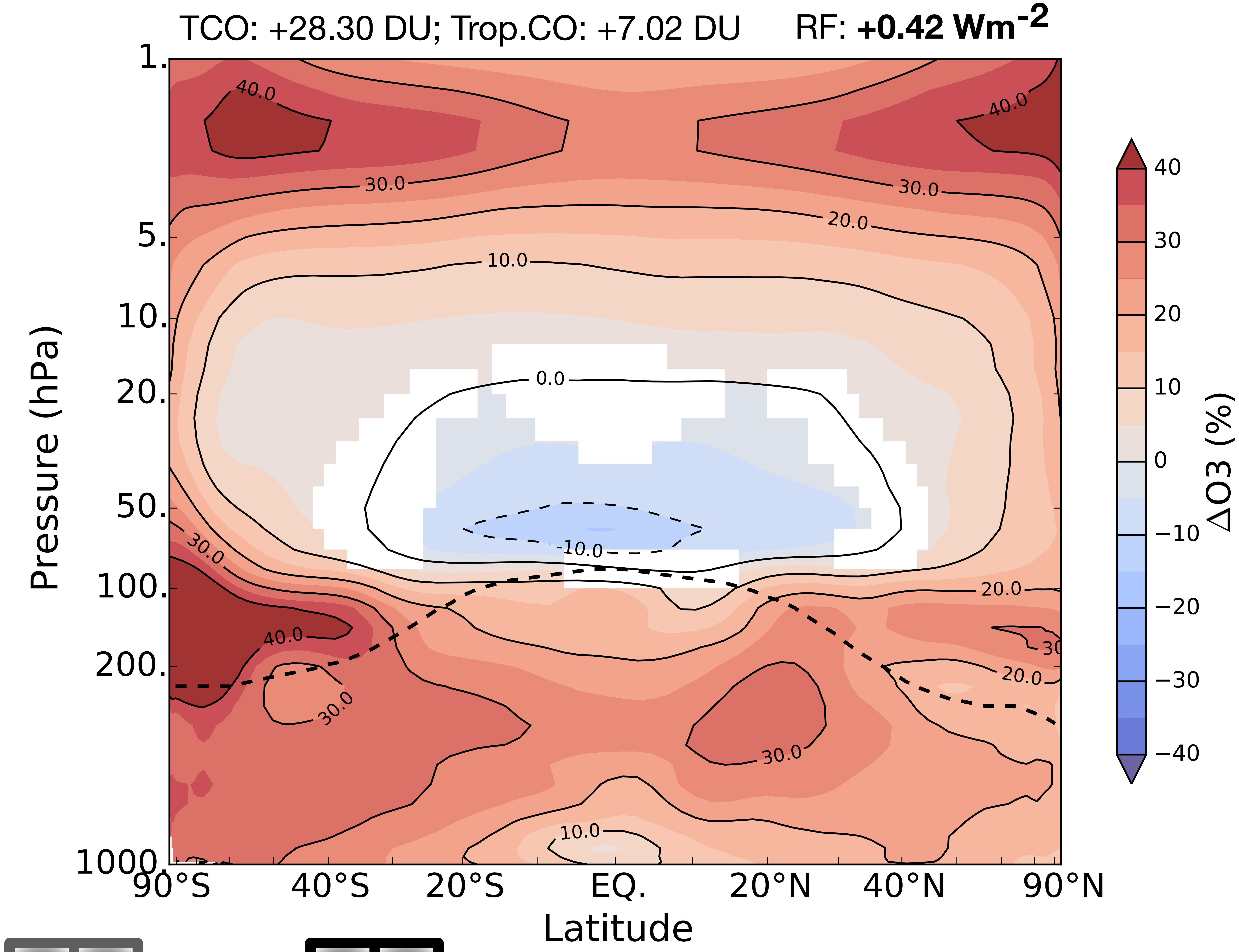


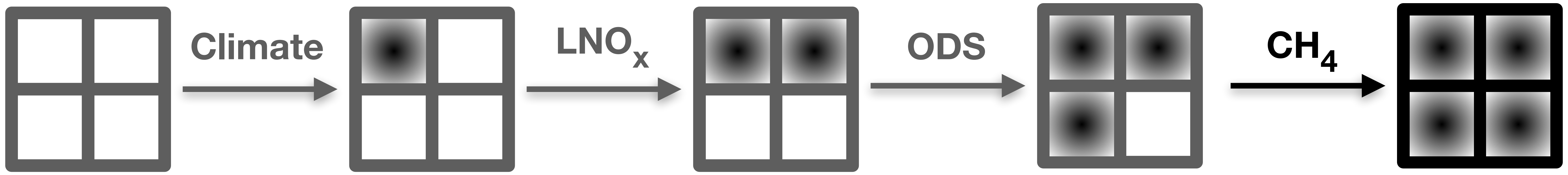
CLIMATE (LNOx) + O3-recovery + CH4

Tropospheric O_3 budget

Simulation	NCP (Tg yr-1)	STE (Tg yr-1)	Burden (Tg)
ACCMIP (2000)	617 ± 242	477 ± 96	337 ± 23
CNTRL	483	398	318
Climate	302	509	309
+ LNO_X	318	517	329
++ O3-recov	245	610	337
+++ CH_4	**313**	**665**	**378**

CH_4 contribution of ~ 50 % to the total O_3-RF, 65 % and 28 % to the trop. O_3-RF & strat.O_3-RF.





Discussion & limitations

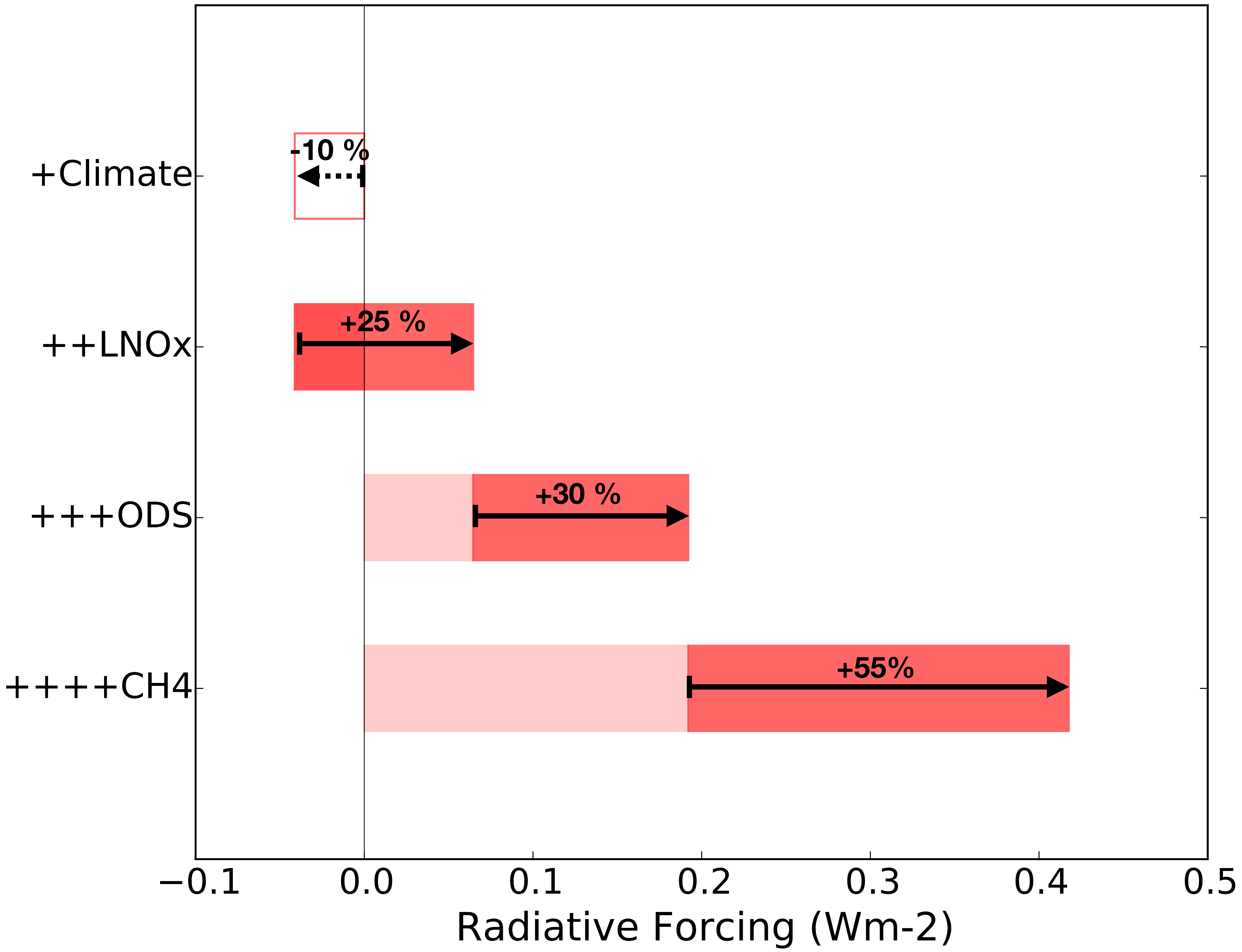
- Radiative kernel method.

- Ozone depletion due to N_2O.

- Feedbacks and CH_4.

- Preliminary results; ongoing work.

Summary and conclusions



-**Climate** drives small negative O_3-RF.

-Similar O_3-RF results from **lightning-NO_x** emissions and **O_3 recovery**.

-**CH_4** dominates the total O3-RF.