



Royal Netherlands  
Meteorological Institute  
*Ministry of Infrastructure and the  
Environment*

# **TM5-MP: tropopause, ERA-5, aquabug,...**

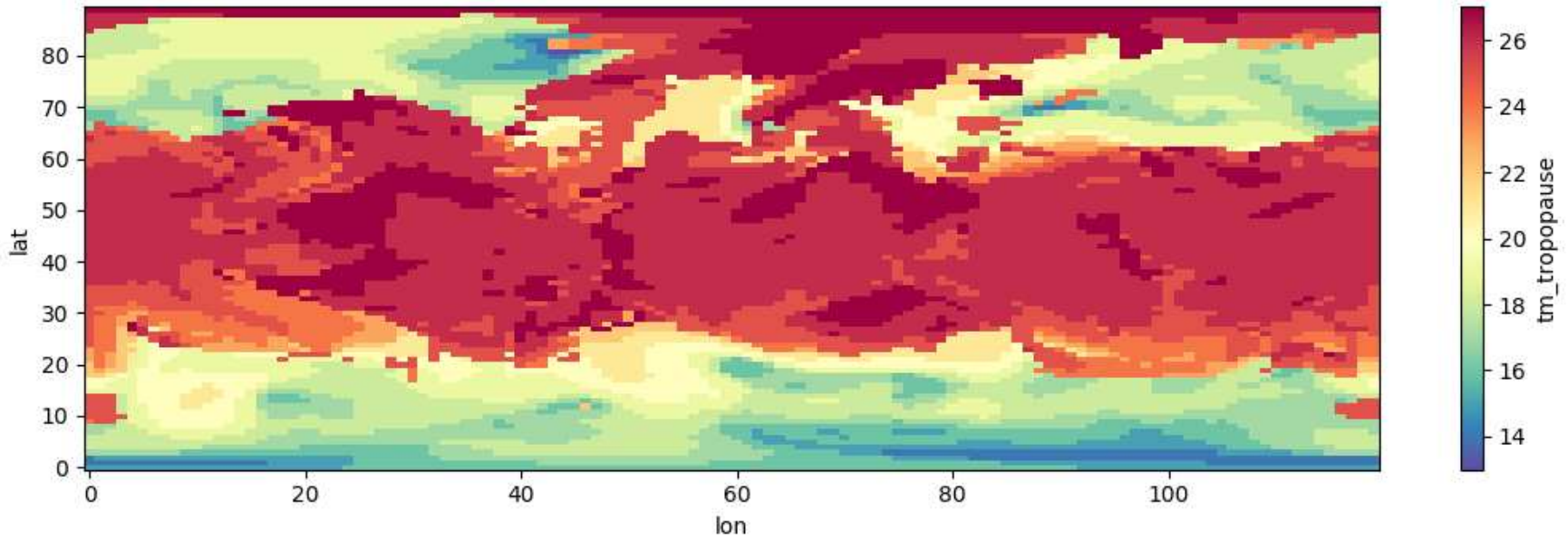
Philippe Le Sager (KNMI)



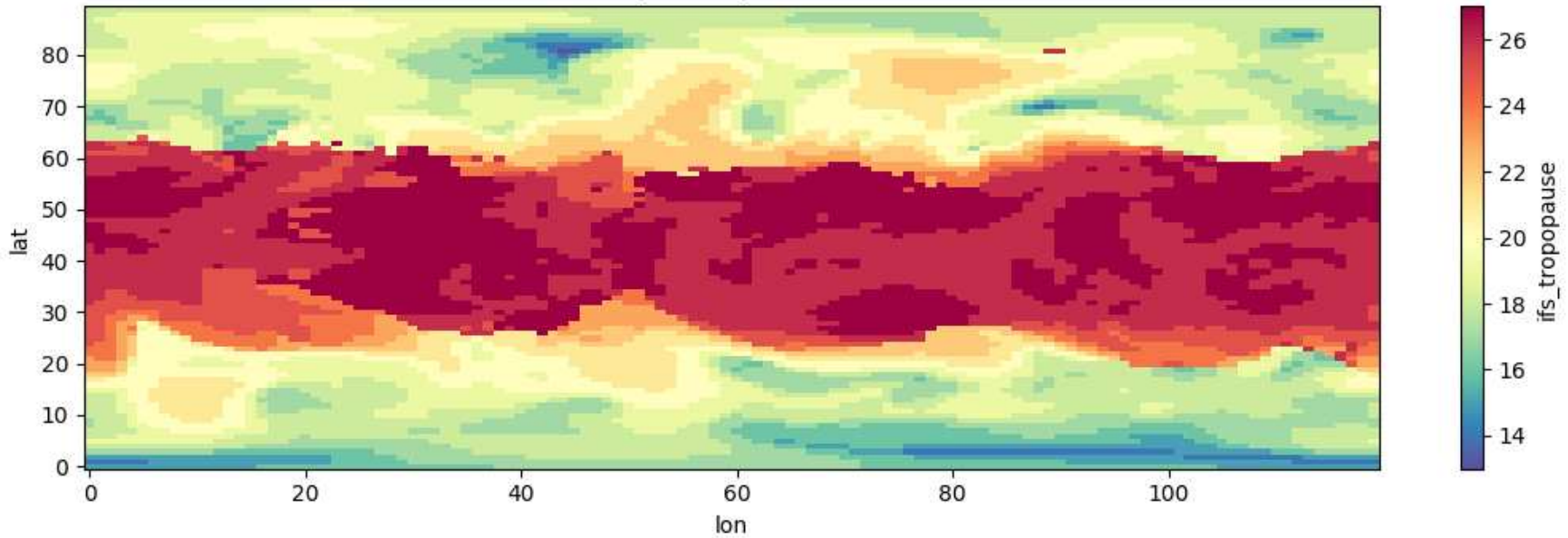
Still thermal tropopause (WMO) based on lapse rate ( $dT/dz$ )

- now follows the IFS implementation
- better search algorithm:
  - previous: "**highest** level where  $dT/dz > 2 \text{ K/km}$ "
  - now: "**lowest** level where  $dT/dz < 2 \text{ K/km}$ "
  - not necessary the same (eg double minimum)
- now check that  $dT/dz < 2 \text{ K/km}$  for at least 2 km

OLD TM at 01-01-2006



NEW TM (a la IFS) at 01-01-2006





# METEO PRE-PROCESSING

## **switch from ERA-INTERIM to ERA-5**

- mentioned last meeting
- status
  - NRT is up and running
  - back log: stuck at 2008, issues?
- they/we must be ready by EOY



# METEO PRE-PROCESSING

## switch from GRIB\_API to EC-CODE

- to read original meteo
- EC-CODE already loaded by default at ECMWF
- GRIB\_API will not be available in Bologna
  
- code should work with both libs
  - similar calls, but few exceptions
    - GRIB\_NEW\_FROM\_TEMPLATE →  
GRIB\_NEW\_FROM\_SAMPLES
  - can use directives
    - `#ifdef ECCODES`



**who:** TM5-MP using netCDF

**when:** between july 2016 (r359) and june 2018 (r792)

**what:** no land

- diffusion is too small in the PBL (base code)
- non-base code
  - dry deposition
  - latest DMS, seasalt (m7), and dust emissions (m7)

→ chemistry is so badly affected that anybody who used it would have noticed it



**who:** chemistry (cb05, cbm4) that do not have the aquabug

- EC-Earth () or
- driven by HDF (*Williams et al.*, 2017; TROPOMI retrievals)

**when:** since april 2012 (r4385). Fixed now in TM5-MP (r788)

**what:**

- aerosol optical properties (without M7 only)
  - cloud optical properties
  - effective radius is underestimated over land only, but constraint by the code between 4 and 16
- you need clouds, and land grid to see the effect
- 3% of grid boxes affected



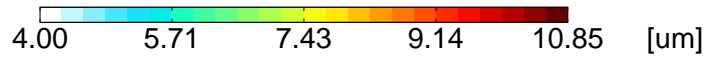
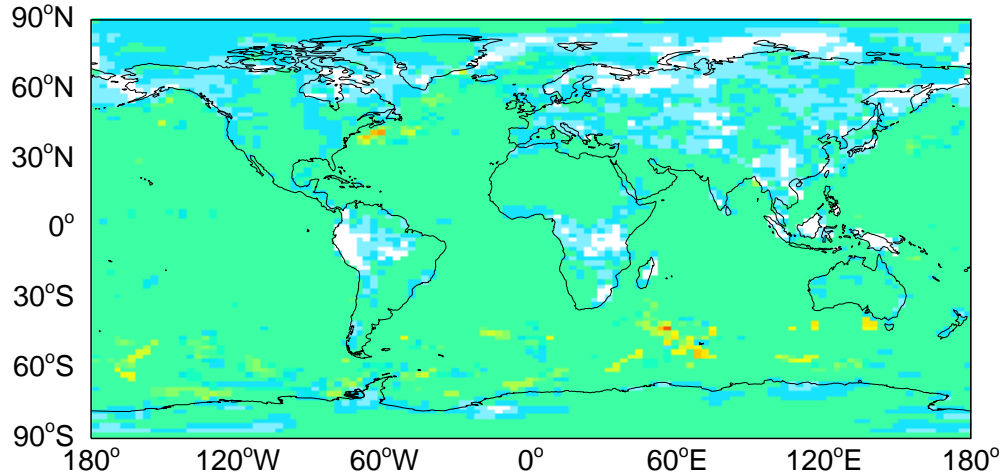
## OZONE BUDGET over one year

			Global	
		Small Reff	Normal Reff	
			Diff.	
O3	drydep (Tg)	954.6327	955.9718	1.3391
trop O3	change (Tg)	-5.0599	-5.0124	0.0475
tropO3	burden (Tg)	383.7306	383.6648	-0.0659
N0 + H02	tropo (Tg)	3522.6277	3517.6655	-4.9618
N0 + M02	tropo (Tg)	1402.8879	1400.7755	-2.1125
N0 + X02	tropo (Tg)	565.8805	565.9839	0.1034
Total p03	tropo (Tg)	5491.3960	5484.4258	-6.9709
O3 + H02	tropo (Tg)	1579.7694	1578.7927	-0.9769
O3 + OH	tropo (Tg)	713.0034	710.7439	-2.2593
O3 + OLE	tropo (Tg)	1.1824	1.1773	-0.0050
O3 + ETH	tropo (Tg)	5.9769	5.9754	-0.0015
O3 + ISOP	tropo (Tg)	69.8380	69.4913	-0.3467
N2O5 loss	tropo (Tg)	28.9368	28.6723	-0.2645
Total l03	tropo (Tg)	2398.7068	2394.8528	-3.8541
O3 + hv	tropo (Tg)	2755.7822	2750.8074	-4.9745
O3s loss	tropo (Tg)	-429.7528	-429.8434	-0.0906

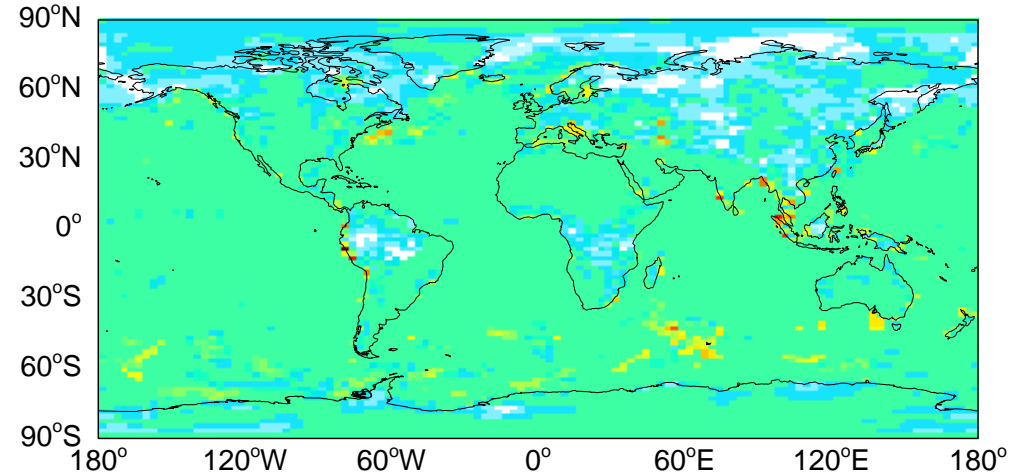


Surface REFF\_AV (winter)

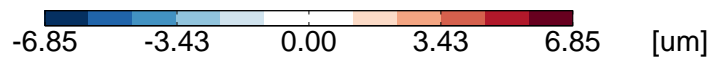
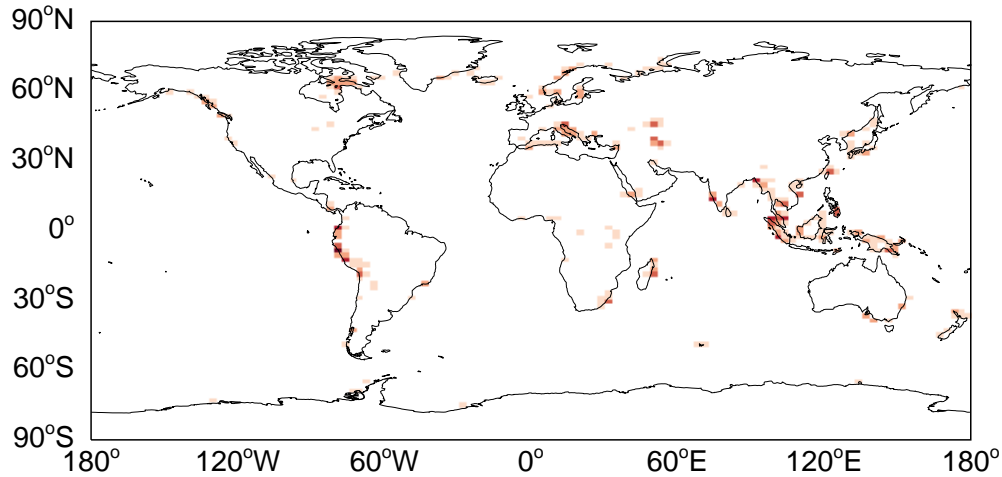
Small Reff



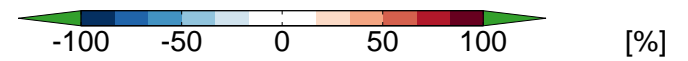
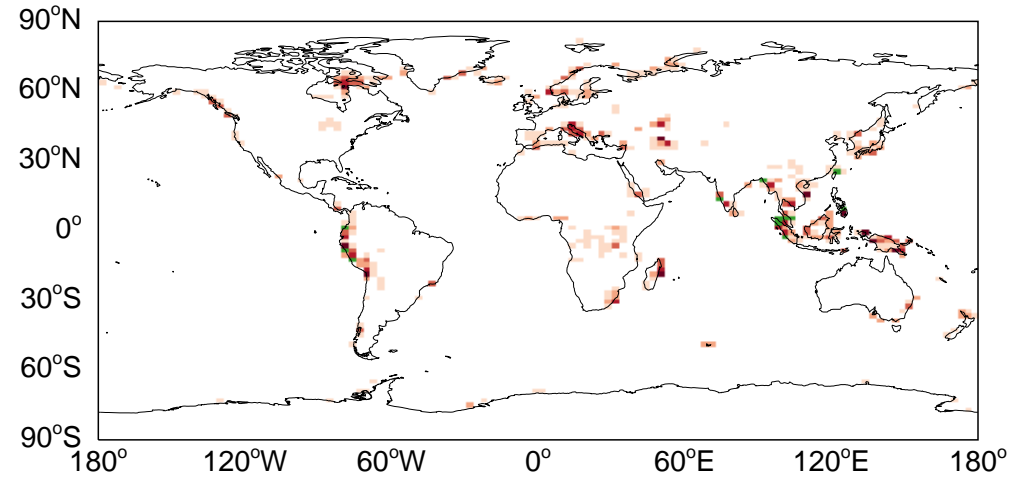
Normal Reff



Difference (#2-#1)

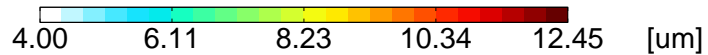
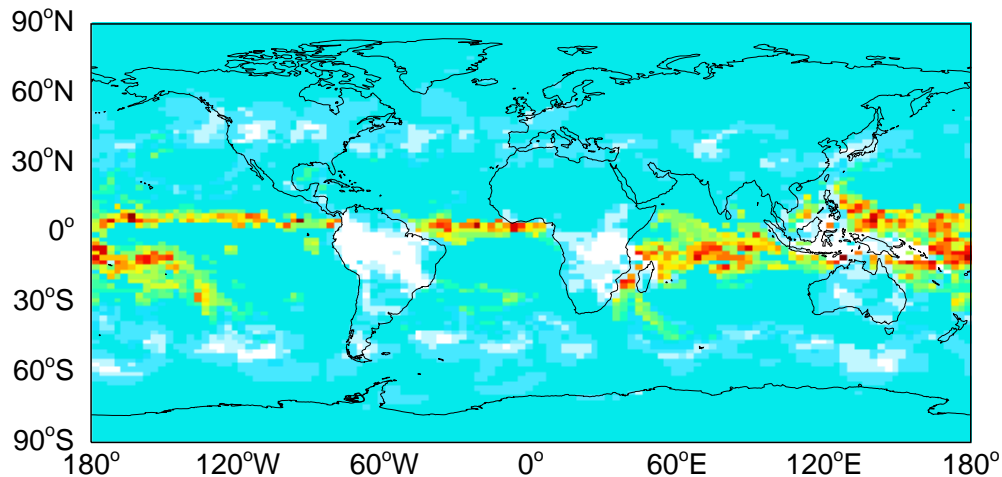


Rel. Diff. [%]

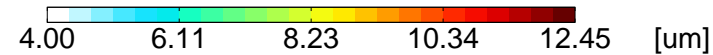
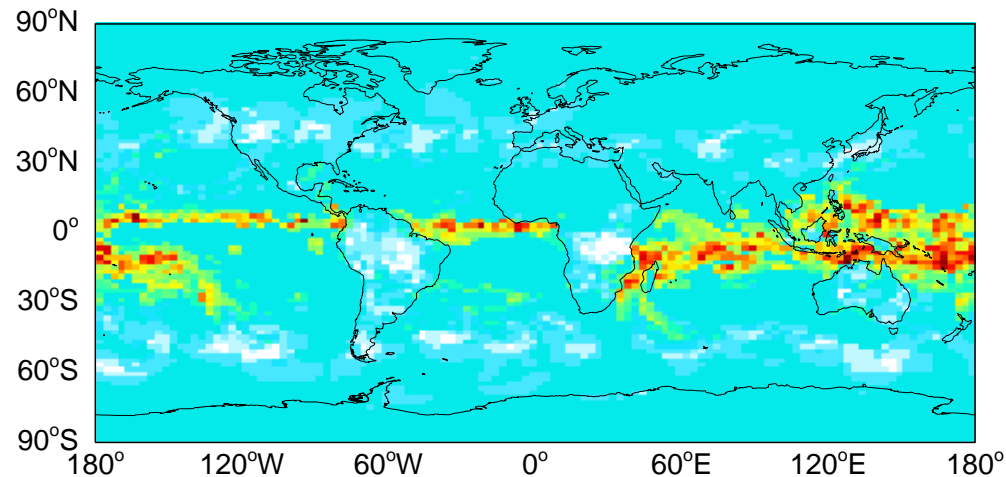


REFF\_AV @ 500 hPa (winter)

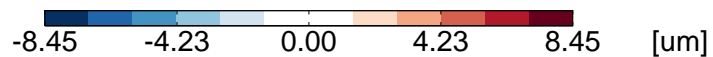
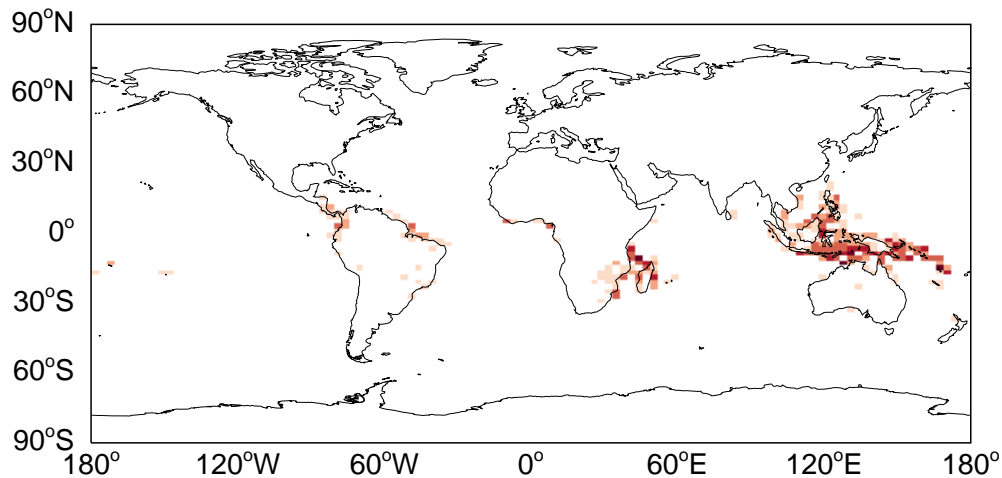
Small Reff



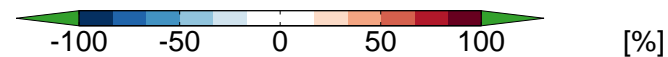
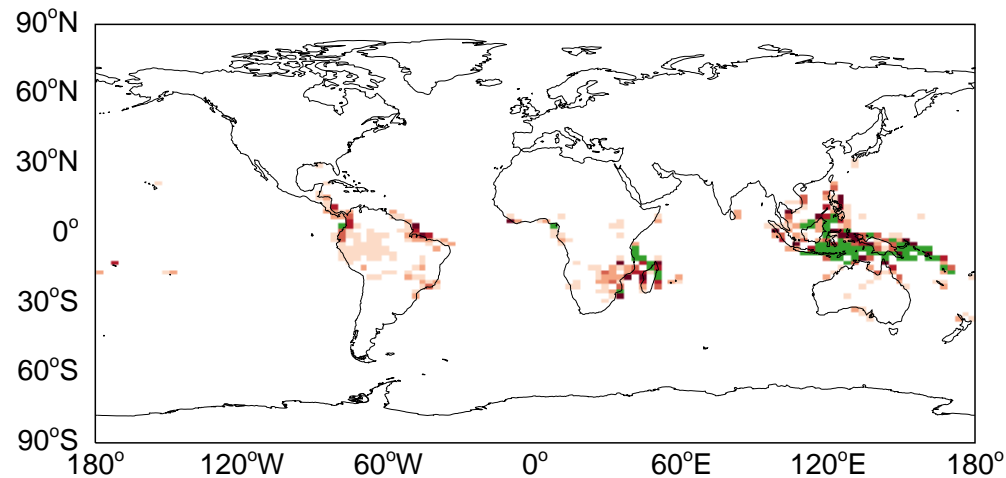
Normal Reff



Difference (#2-#1)

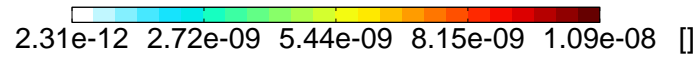
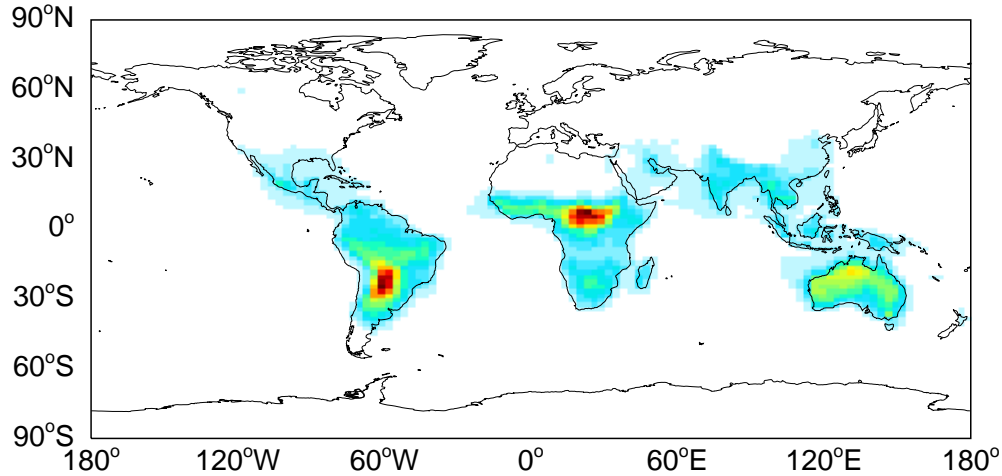


Rel. Diff. [%]

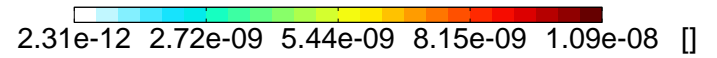
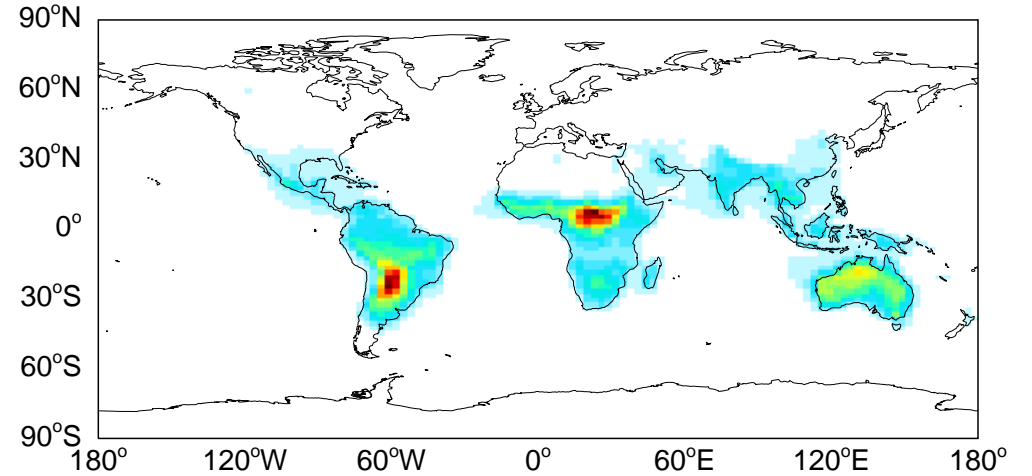


Surface CH<sub>2</sub>O (winter)

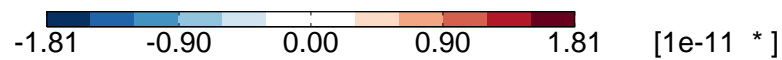
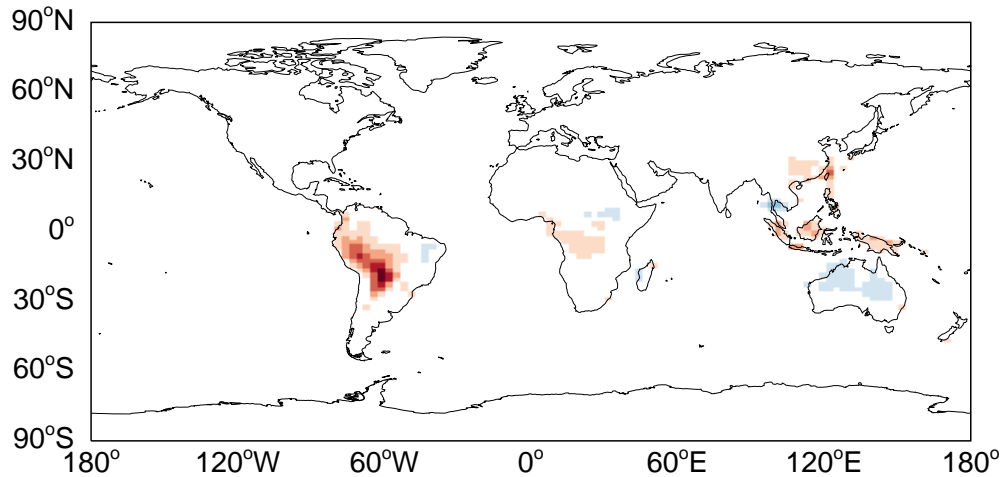
Small Reff



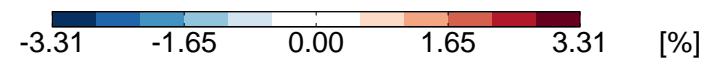
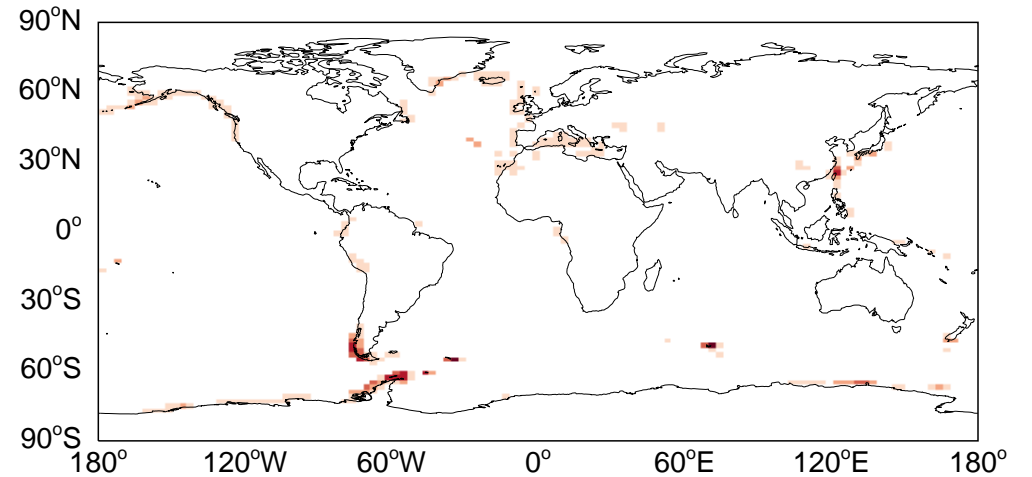
Normal Reff



Difference (#2-#1)

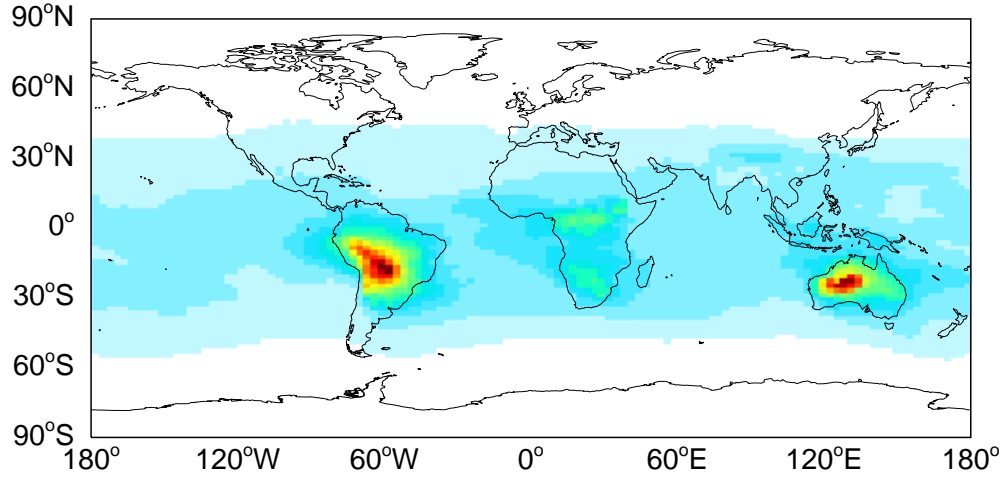


Rel. Diff. [%]



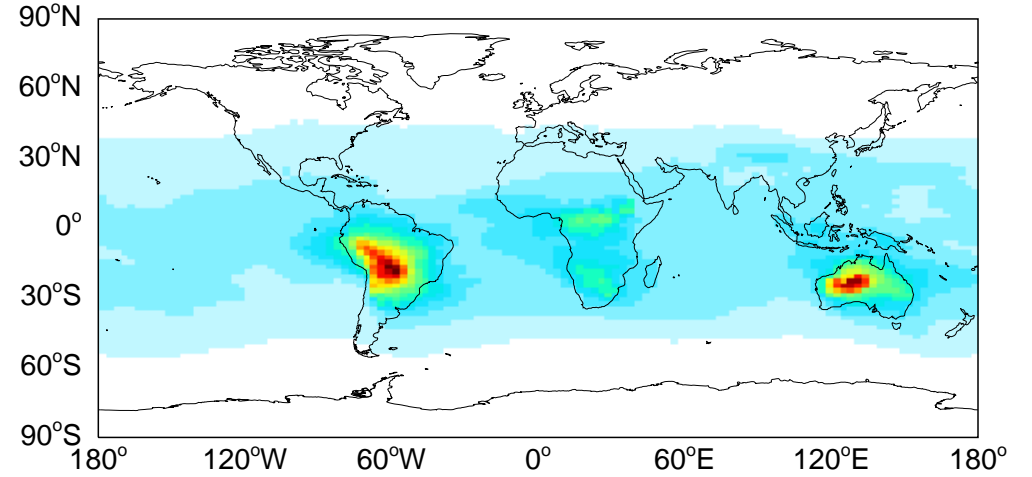
CH<sub>2</sub>O @ 500 hPa (winter)

Small Reff



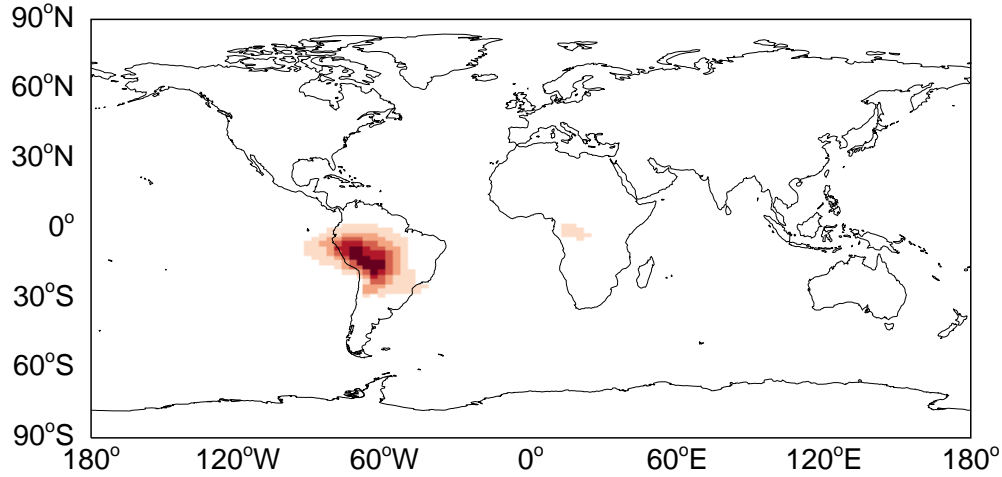
3.29e-12 2.81e-10 5.58e-10 8.36e-10 1.11e-09 [ ]

Normal Reff



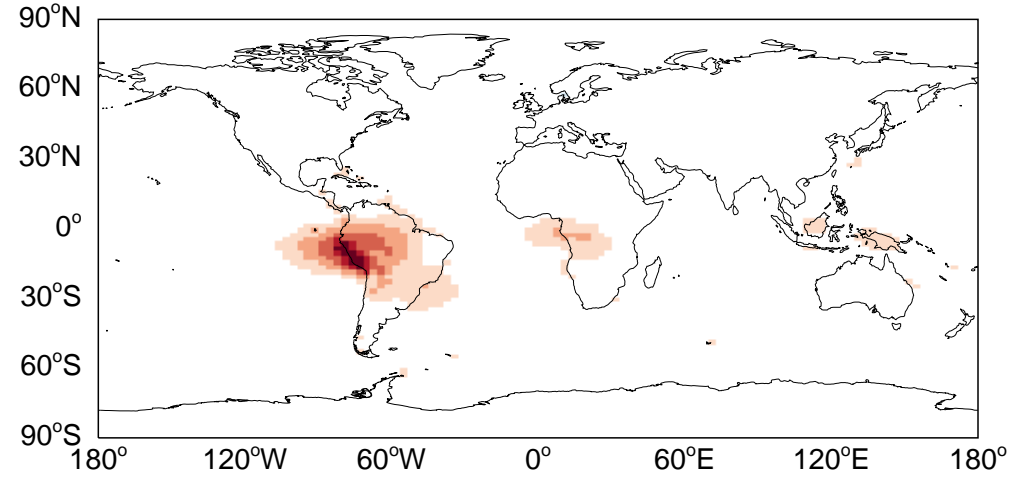
3.29e-12 2.81e-10 5.58e-10 8.36e-10 1.11e-09 [ ]

Difference (#2-#1)



-8.15 -4.08 0.00 4.08 8.15 [1e-12 \*]

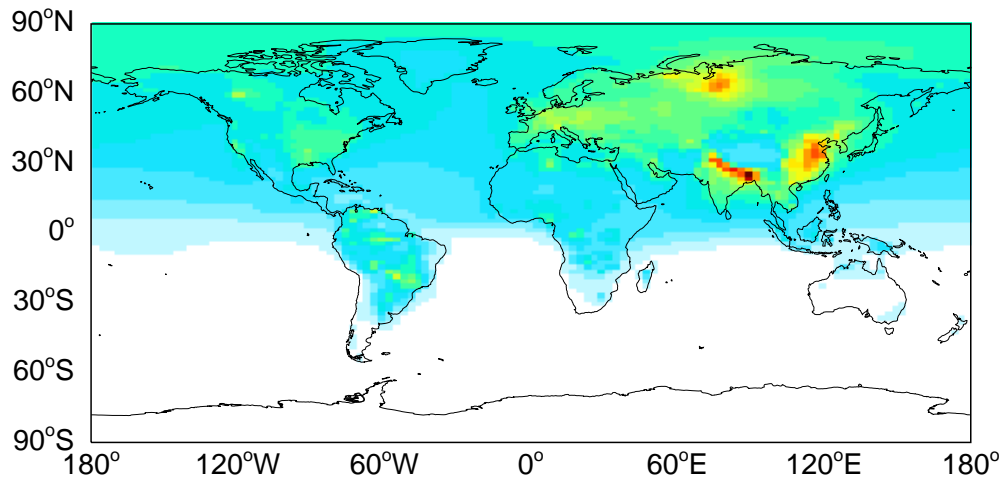
Rel. Diff. [%]



-1.64 -0.82 0.00 0.82 1.64 [%]

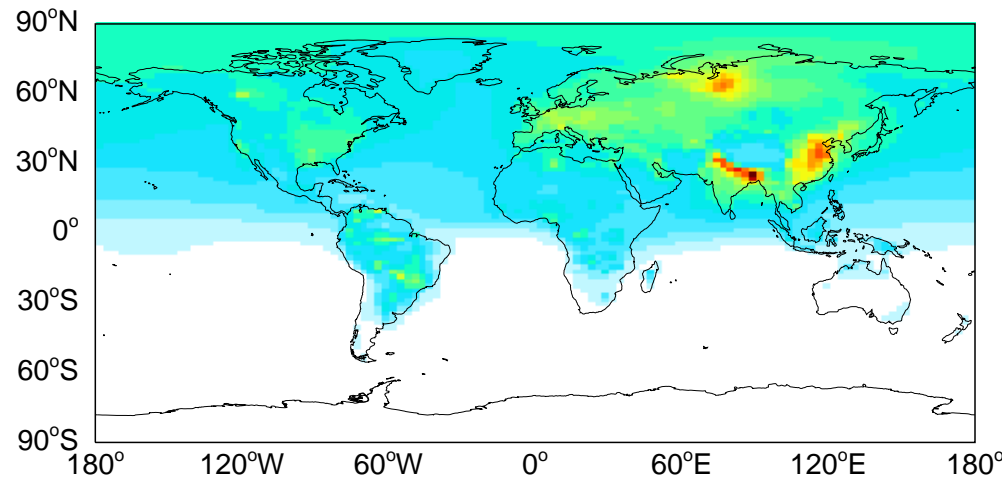
# Surface CH4 (winter)

## Small Reff



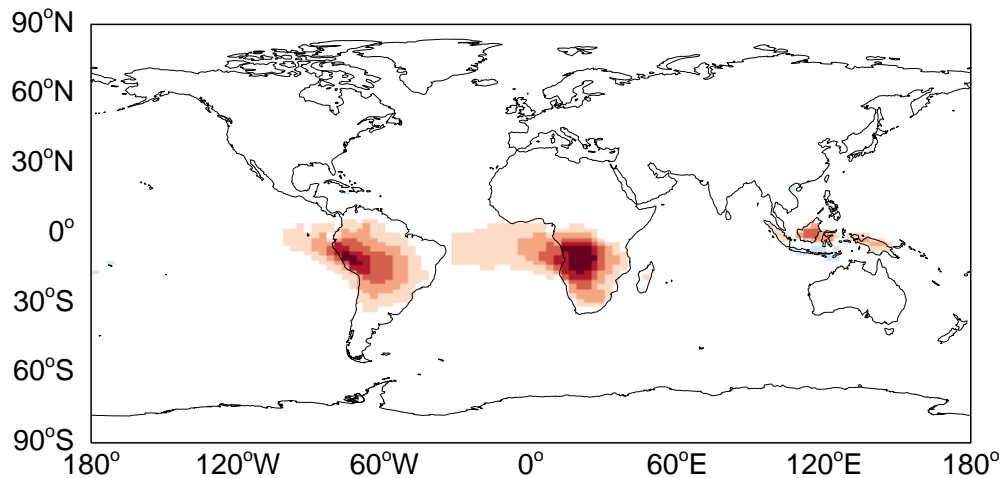
1.72e-06 1.86e-06 2.00e-06 2.14e-06 2.29e-06 []

## Normal Reff



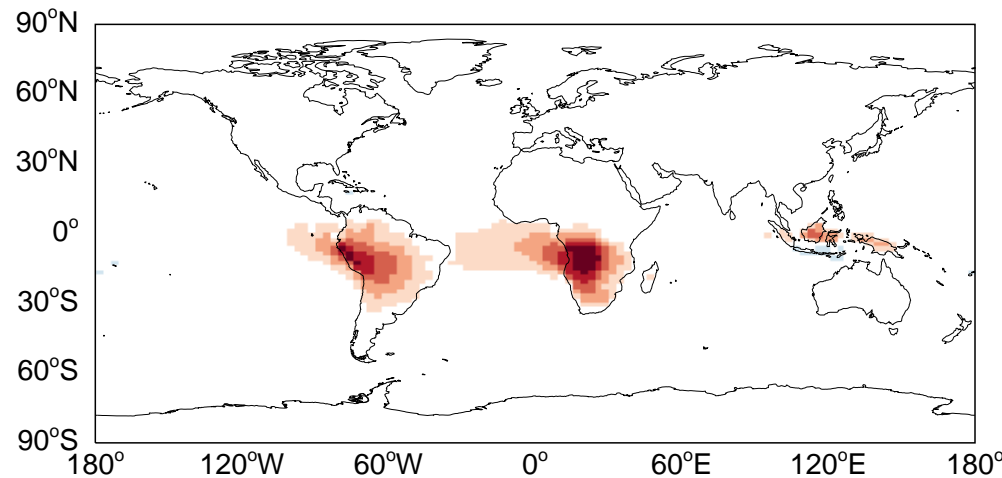
1.72e-06 1.86e-06 2.00e-06 2.14e-06 2.29e-06 []

## Difference (#2-#1)



-2.20 -1.10 0.00 1.10 2.20 [1e-10 \*]

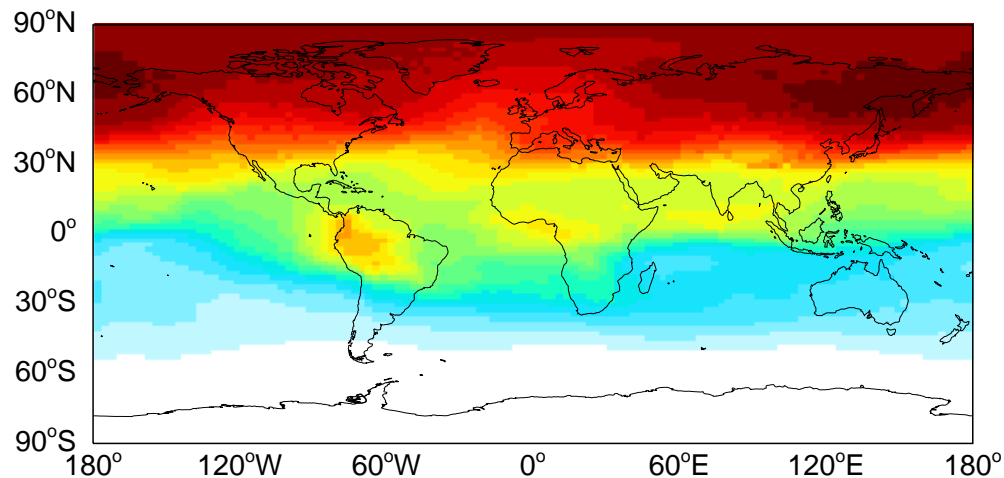
## Rel. Diff. [%]



-1.22 -0.61 0.00 0.61 1.22 [1e-2 \* %]

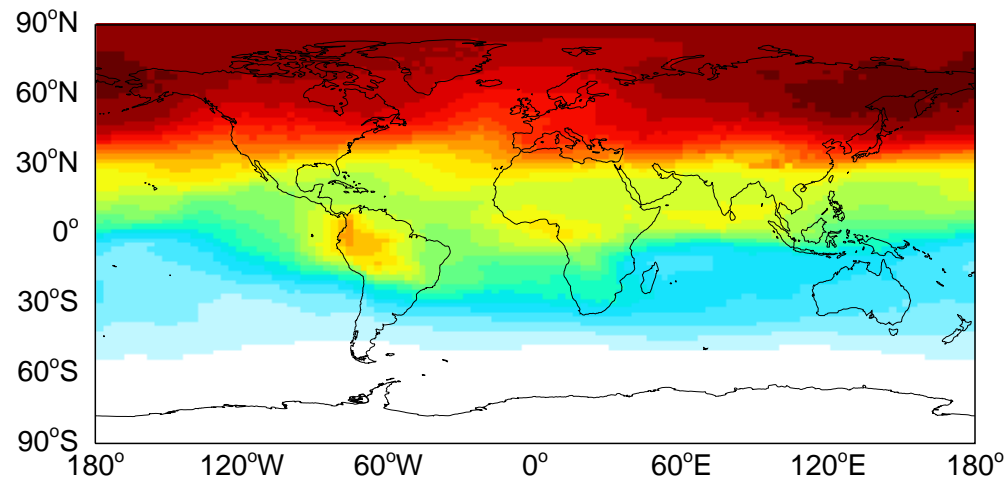
CH4 @ 500 hPa (winter)

Small Reff



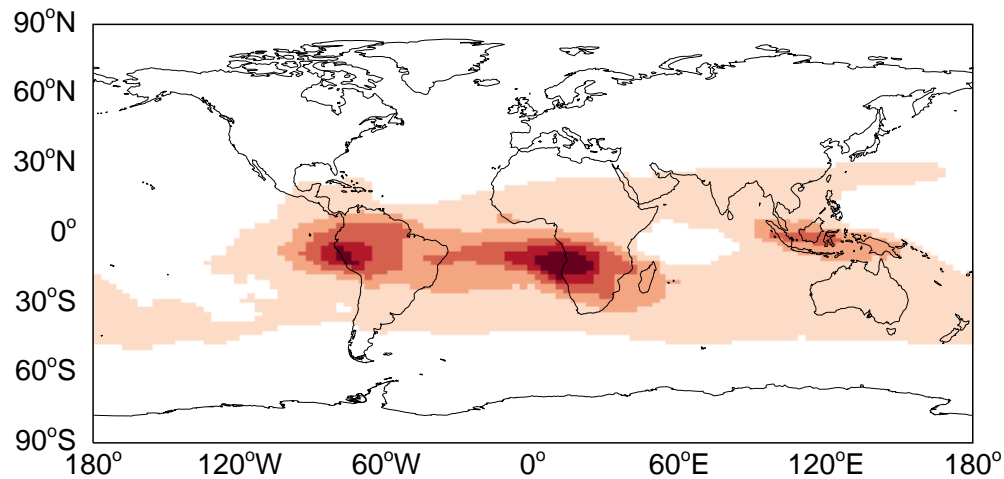
1.72e-06 1.75e-06 1.78e-06 1.81e-06 1.84e-06 []

Normal Reff



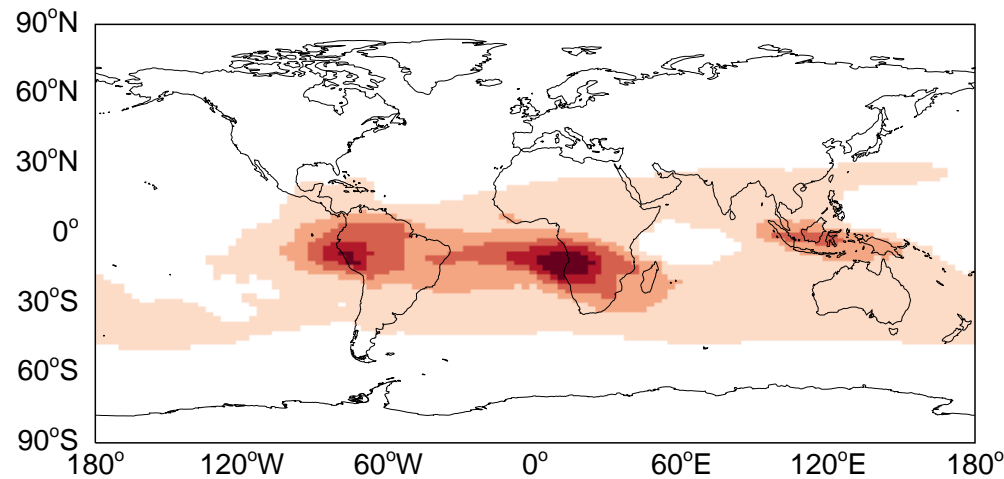
1.72e-06 1.75e-06 1.78e-06 1.81e-06 1.84e-06 []

Difference (#2-#1)



-2.39 -1.19 0.00 1.19 2.39 [1e-10 \*]

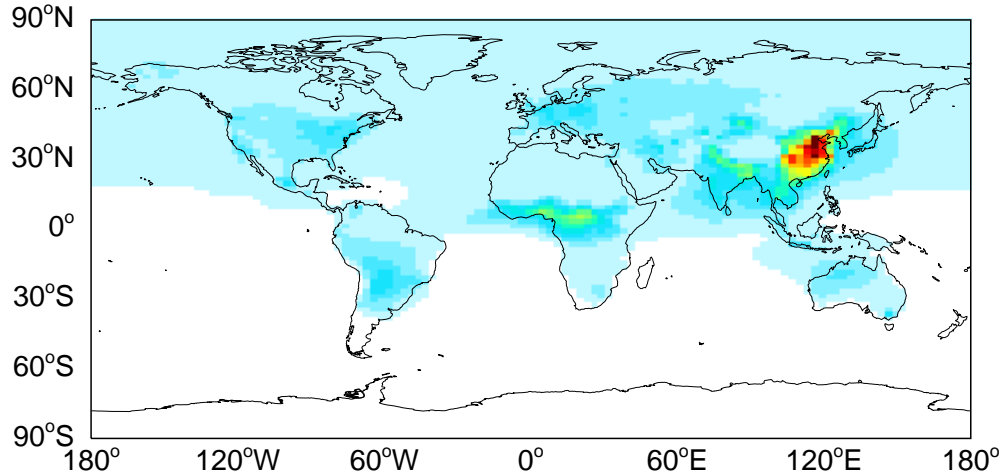
Rel. Diff. [%]



-1.36 -0.68 0.00 0.68 1.36 [1e-2 \* %]

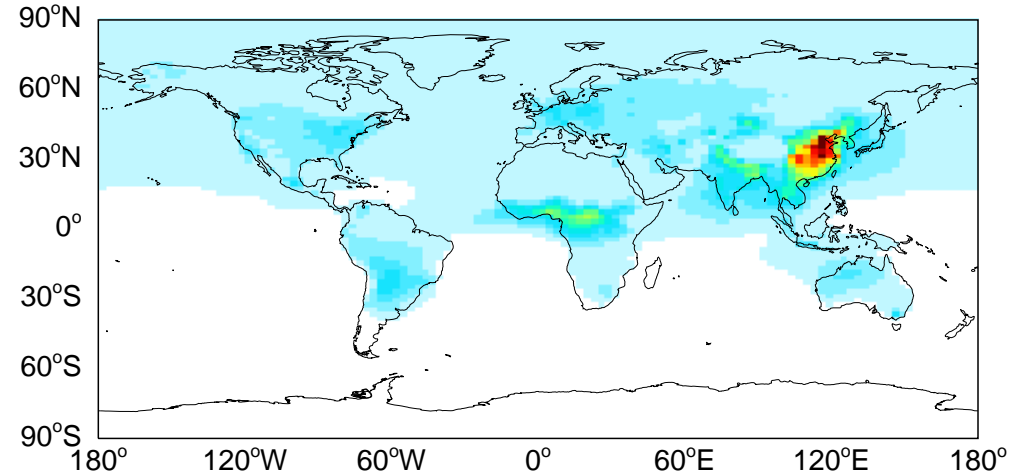
# Surface CO (winter)

## Small Reff



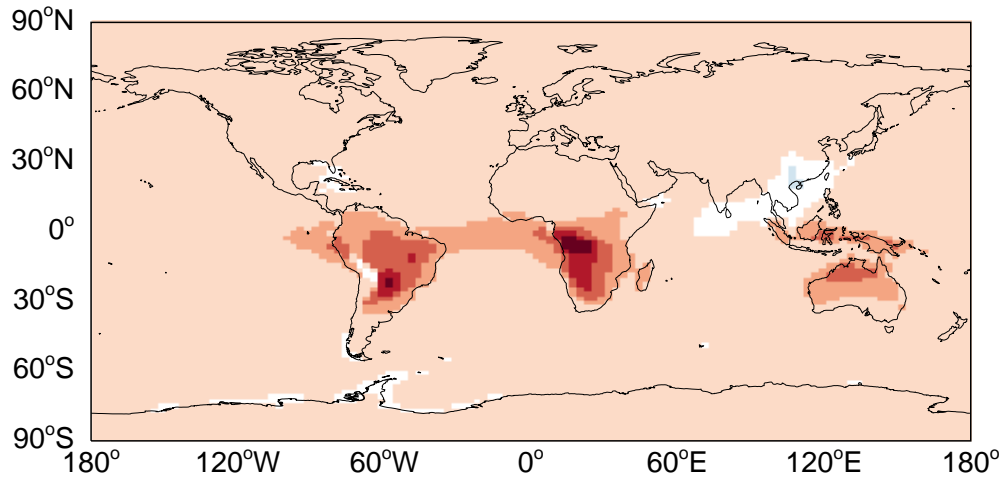
5.35e-08 2.70e-07 4.87e-07 7.04e-07 9.21e-07 []

## Normal Reff



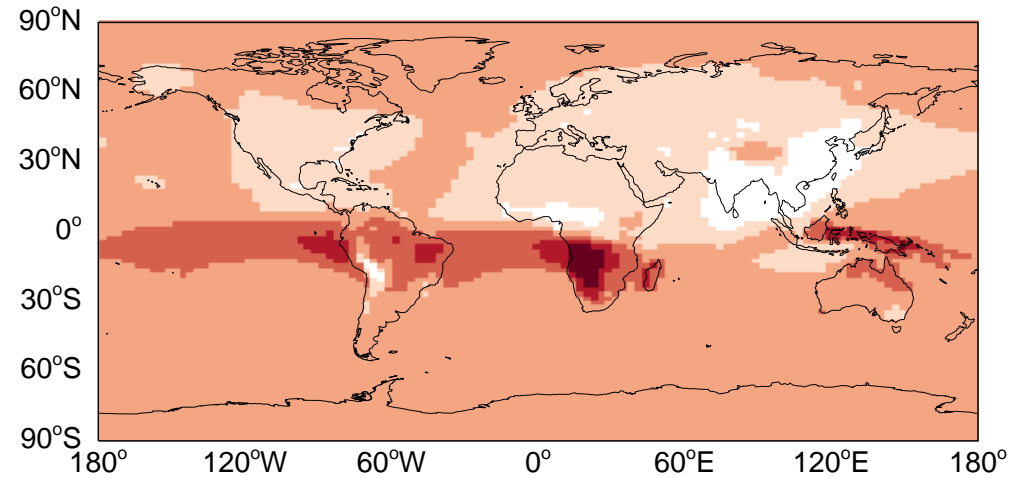
5.35e-08 2.70e-07 4.87e-07 7.04e-07 9.21e-07 []

## Difference (#2-#1)



-5.05 -2.53 0.00 2.53 5.05 [1e-10 \*]

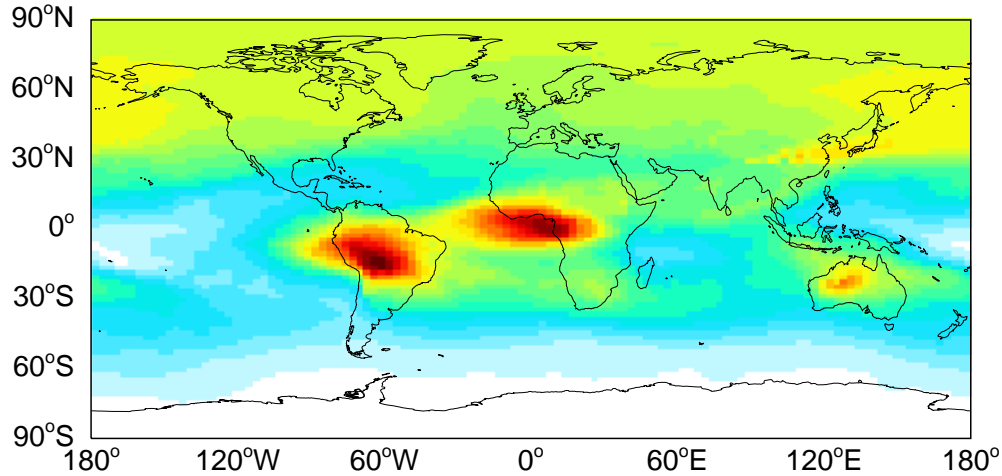
## Rel. Diff. [%]



-0.37 -0.18 0.00 0.18 0.37 [%]

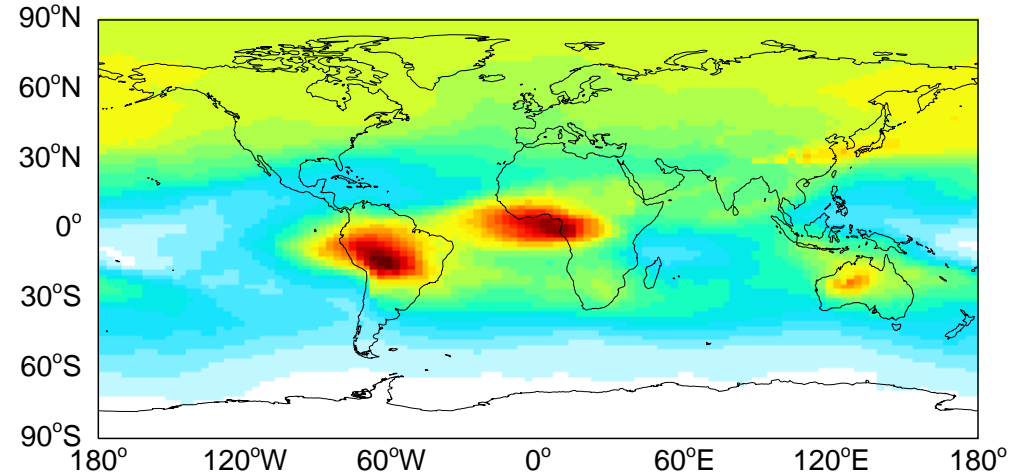
CO @ 500 hPa (winter)

Small Reff



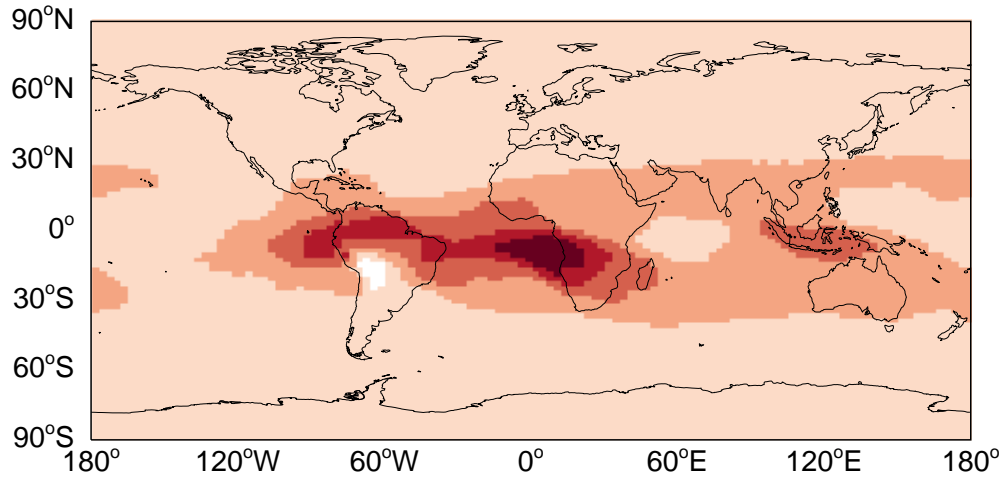
5.65e-08 8.20e-08 1.07e-07 1.33e-07 1.58e-07 []

Normal Reff



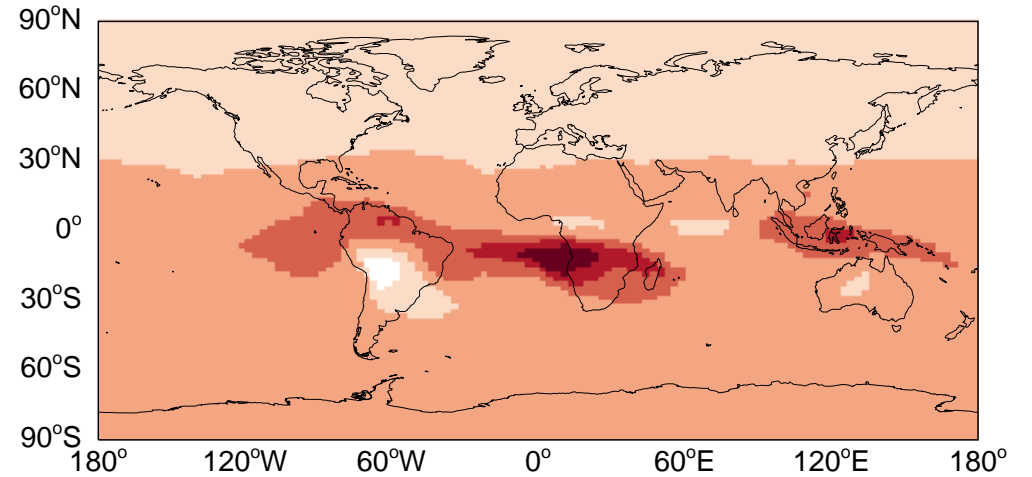
5.65e-08 8.20e-08 1.07e-07 1.33e-07 1.58e-07 []

Difference (#2-#1)



-4.69 -2.35 0.00 2.35 4.69 [1e-10 \*]

Rel. Diff. [%]

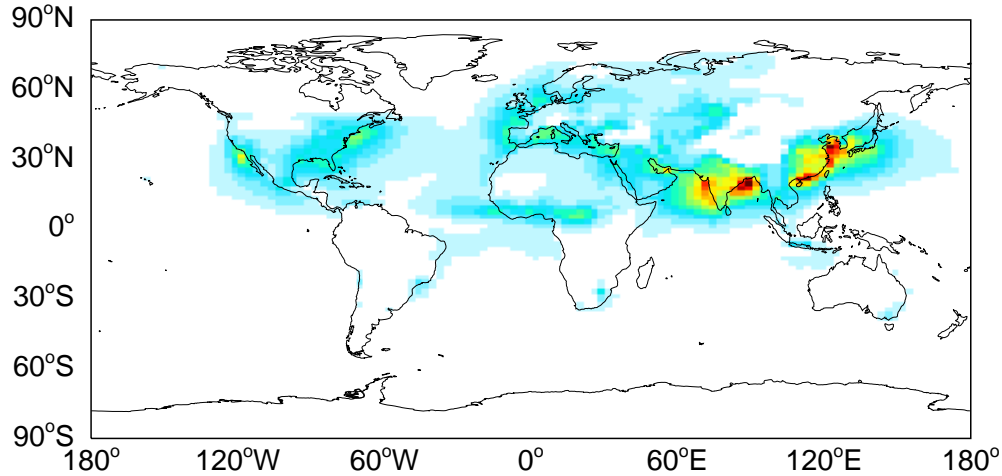


-0.49 -0.25 0.00 0.25 0.49 [%]



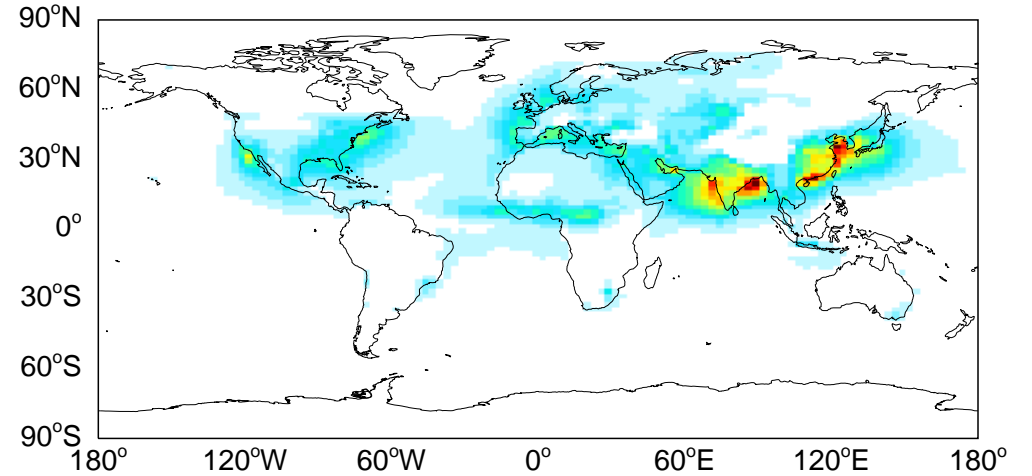
Surface HNO<sub>3</sub> (winter)

Small Reff



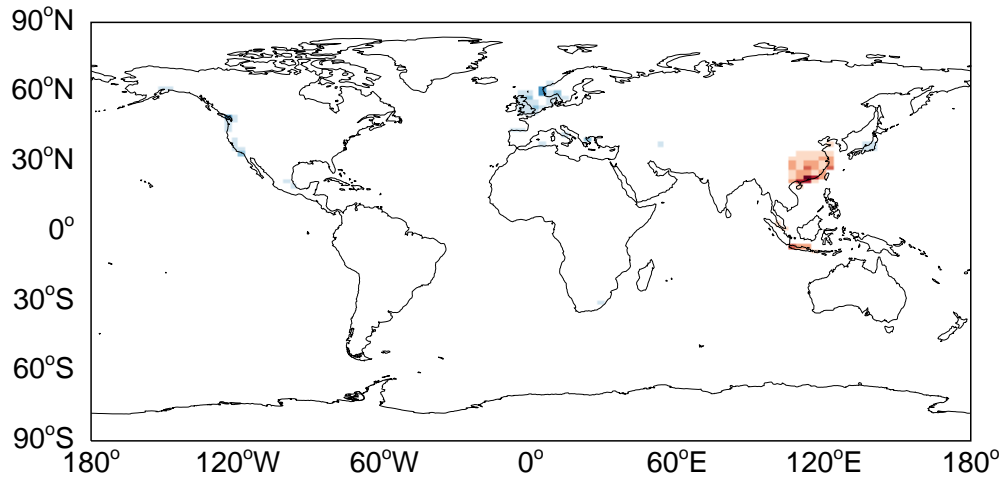
1.09e-12 9.09e-10 1.82e-09 2.73e-09 3.63e-09 []

Normal Reff



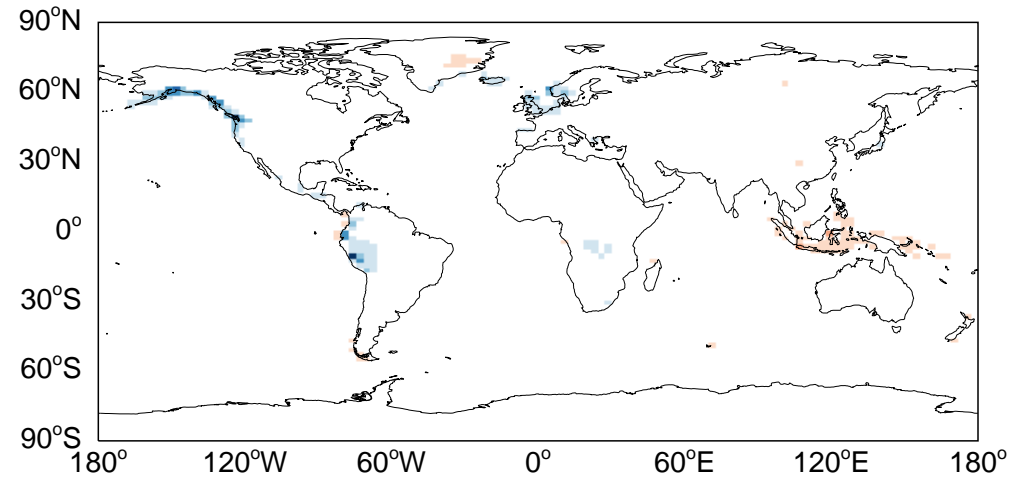
1.09e-12 9.09e-10 1.82e-09 2.73e-09 3.63e-09 []

Difference (#2-#1)



-2.00 -1.00 0.00 1.00 2.00 [1e-11 \*]

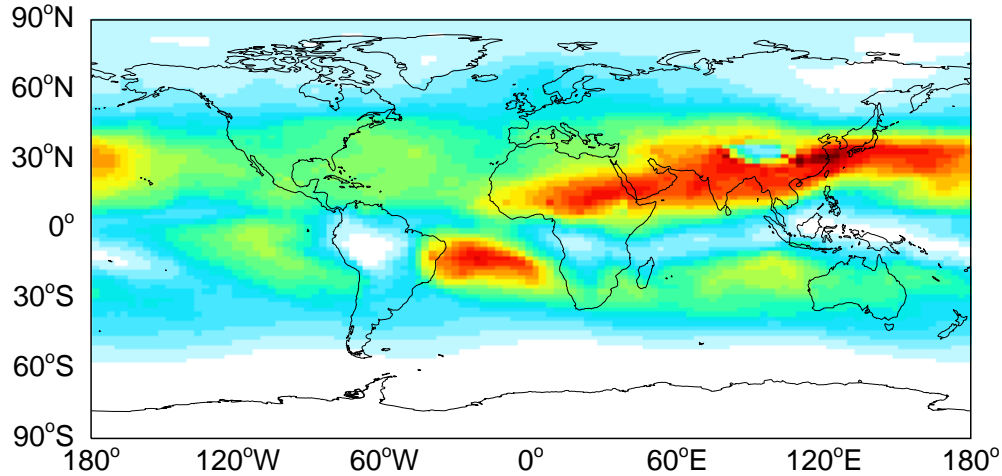
Rel. Diff. [%]



-4.49 -2.25 0.00 2.25 4.49 [%]

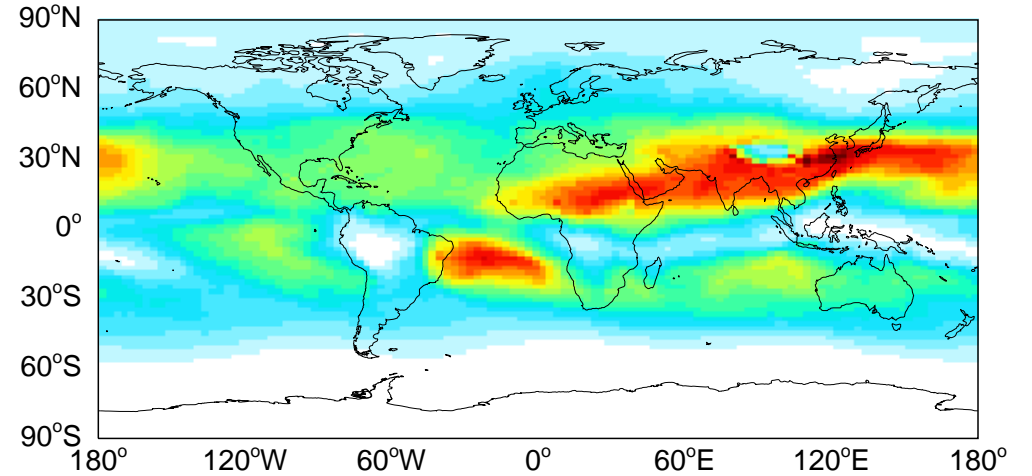
HNO<sub>3</sub> @ 500 hPa (winter)

Small Reff



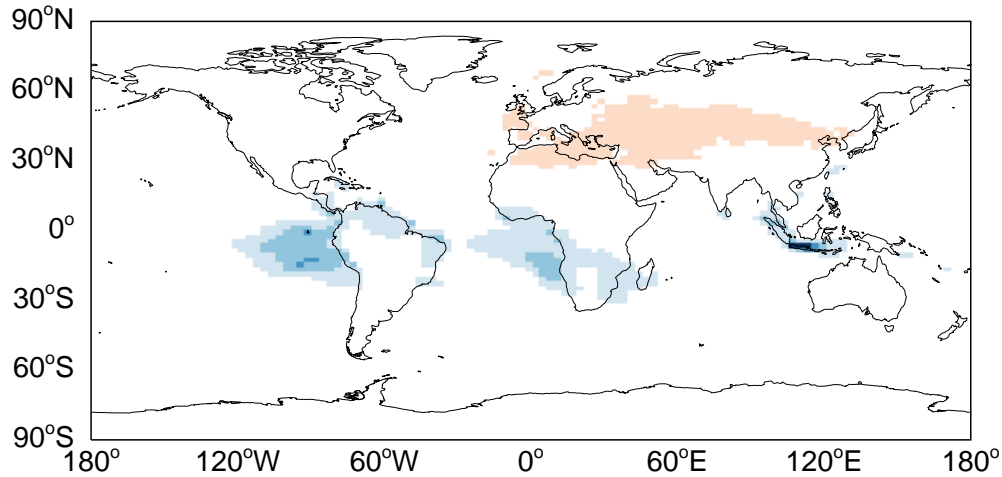
3.86e-12 1.05e-10 2.06e-10 3.06e-10 4.07e-10 []

Normal Reff



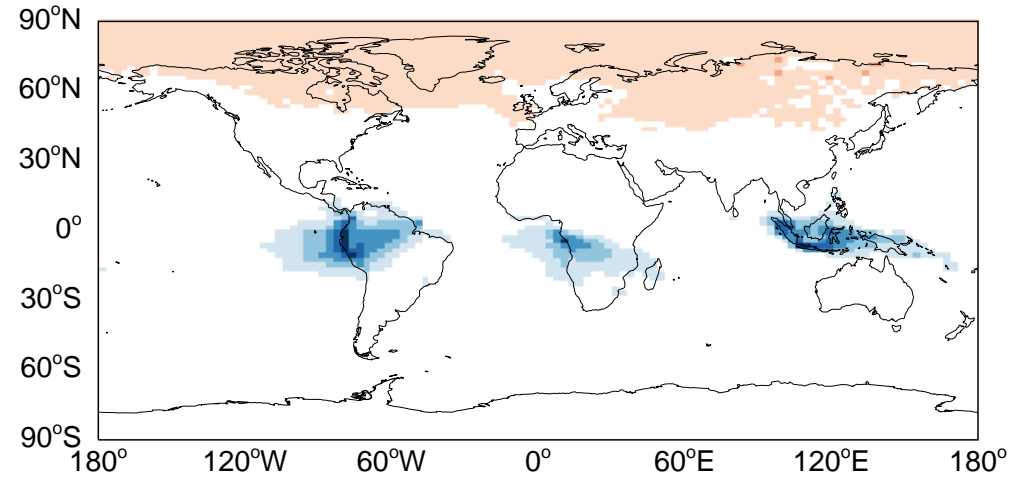
3.86e-12 1.05e-10 2.06e-10 3.06e-10 4.07e-10 []

Difference (#2-#1)



-2.13 -1.06 0.00 1.06 2.13 [1e-12 \*]

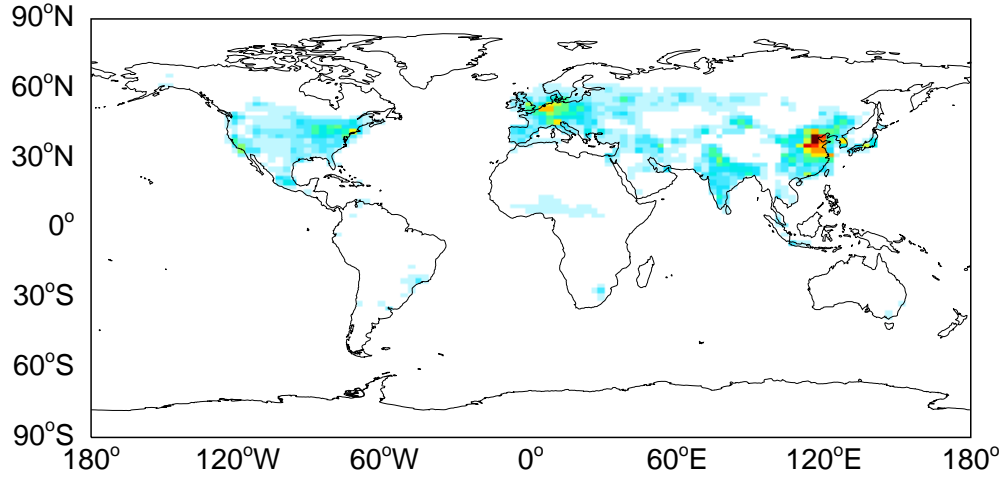
Rel. Diff. [%]



-2.14 -1.07 0.00 1.07 2.14 [%]

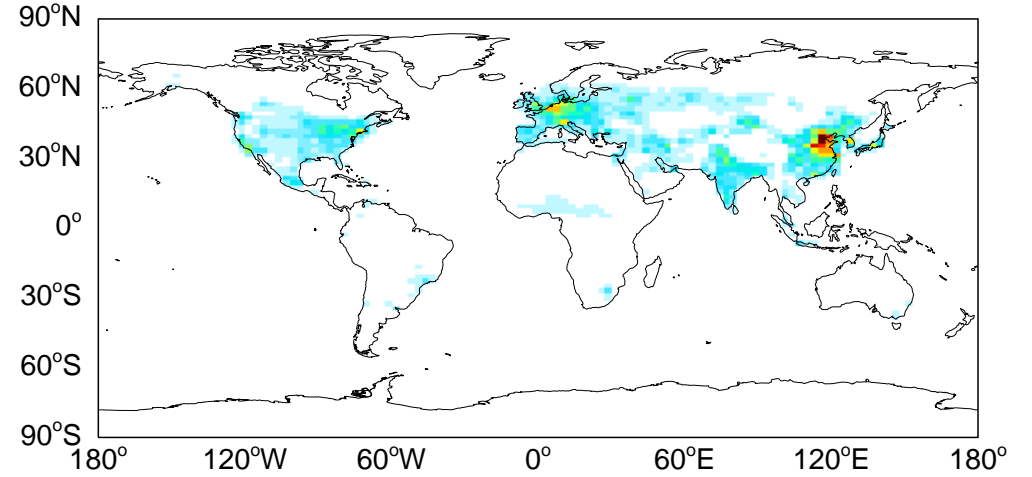
Surface NOX (winter)

Small Reff



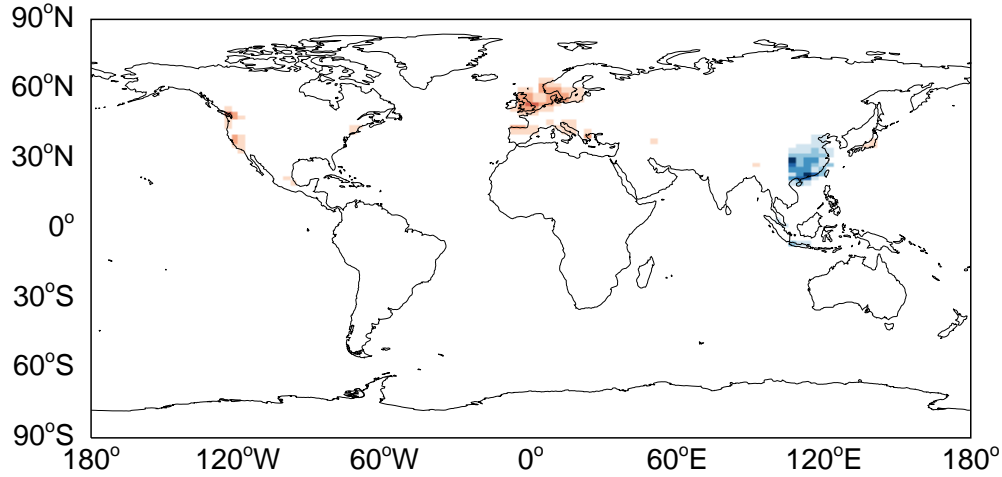
3.20e-12 7.93e-09 1.58e-08 2.38e-08 3.17e-08 []

Normal Reff



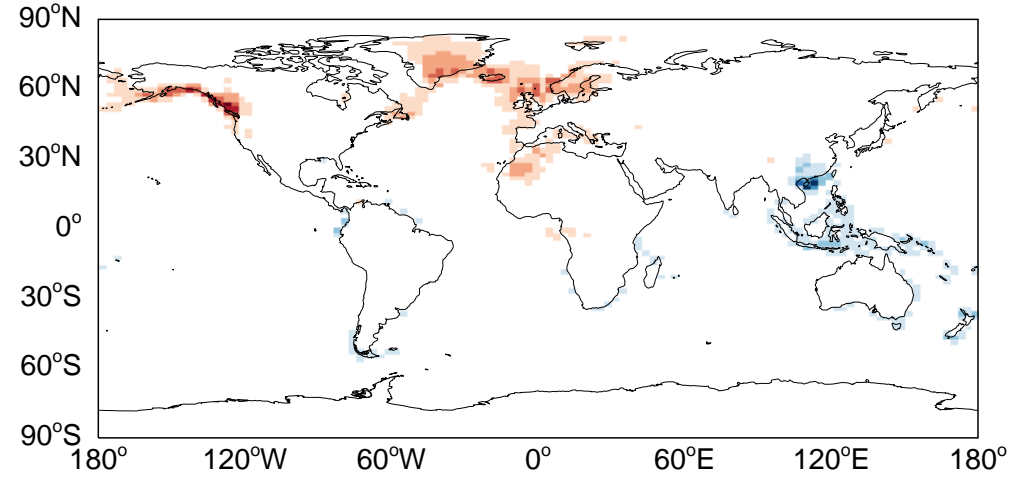
3.20e-12 7.93e-09 1.58e-08 2.38e-08 3.17e-08 []

Difference (#2-#1)



-6.00 -3.00 0.00 3.00 6.00 [1e-11 \*]

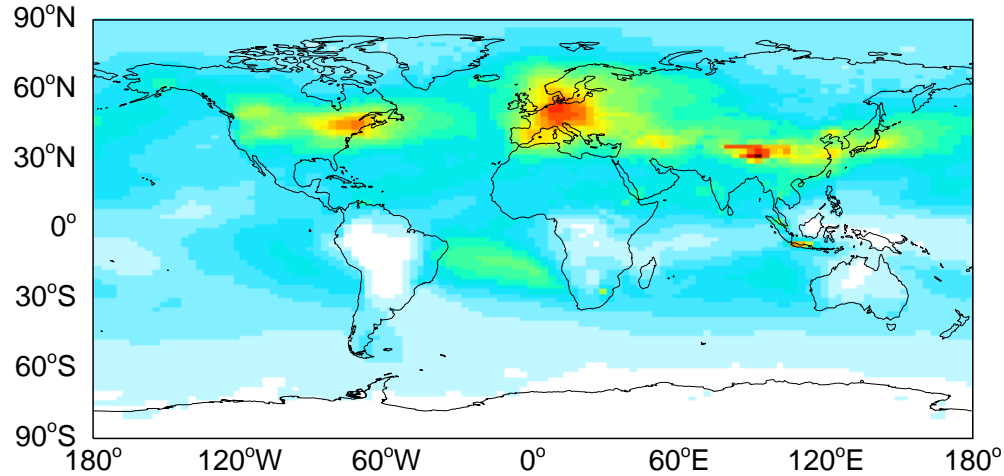
Rel. Diff. [%]



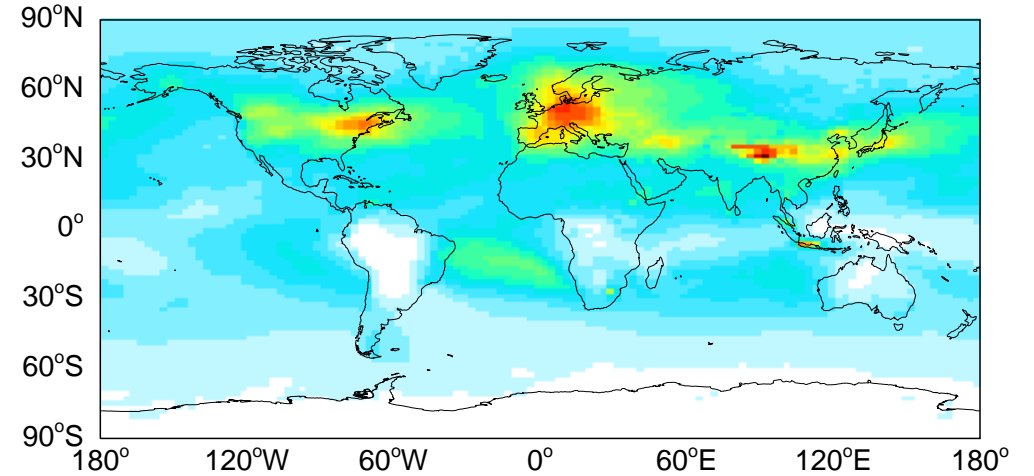
-2.51 -1.26 0.00 1.26 2.51 [%]

NOX @ 500 hPa (winter)

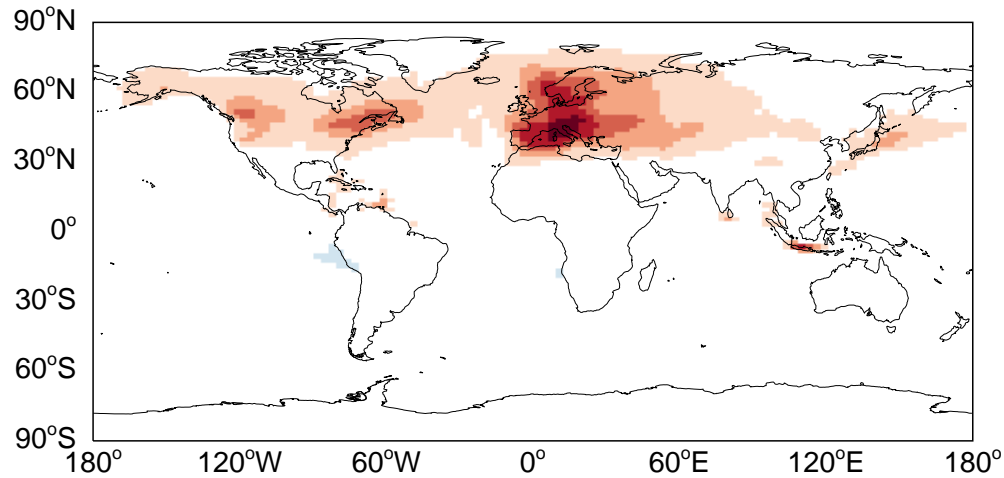
Small Reff



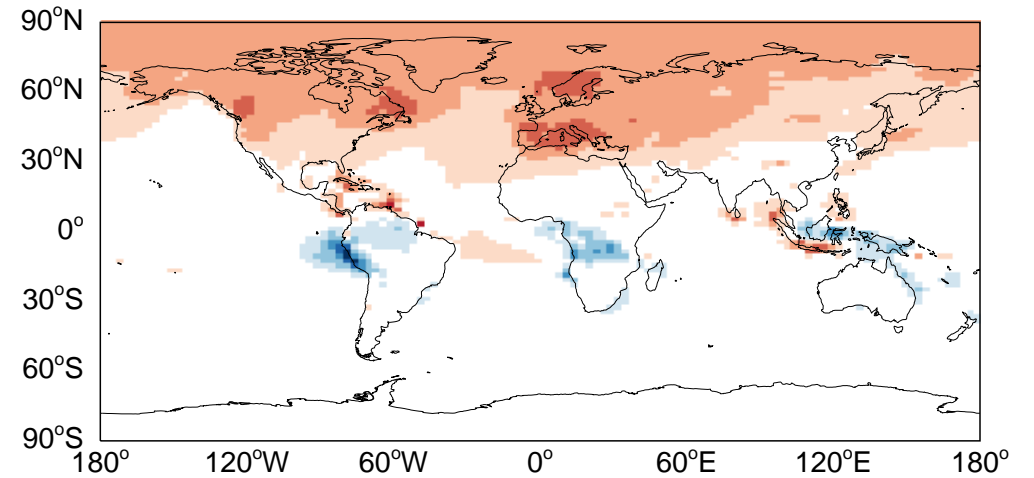
Normal Reff



Difference (#2-#1)

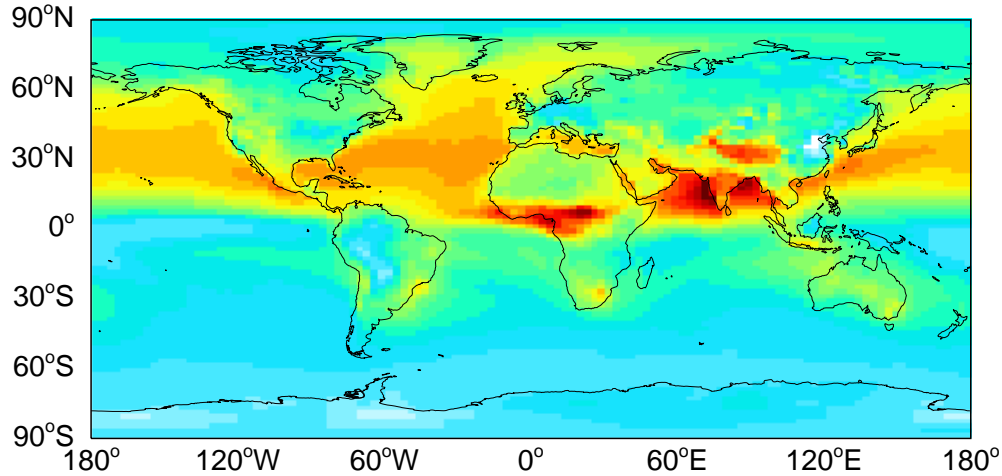


Rel. Diff. [%]



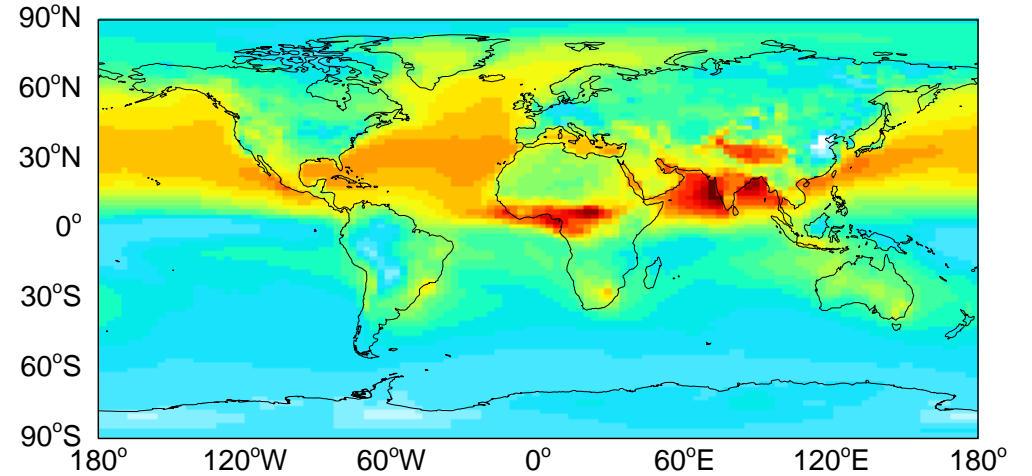
# Surface O3 (winter)

## Small Reff



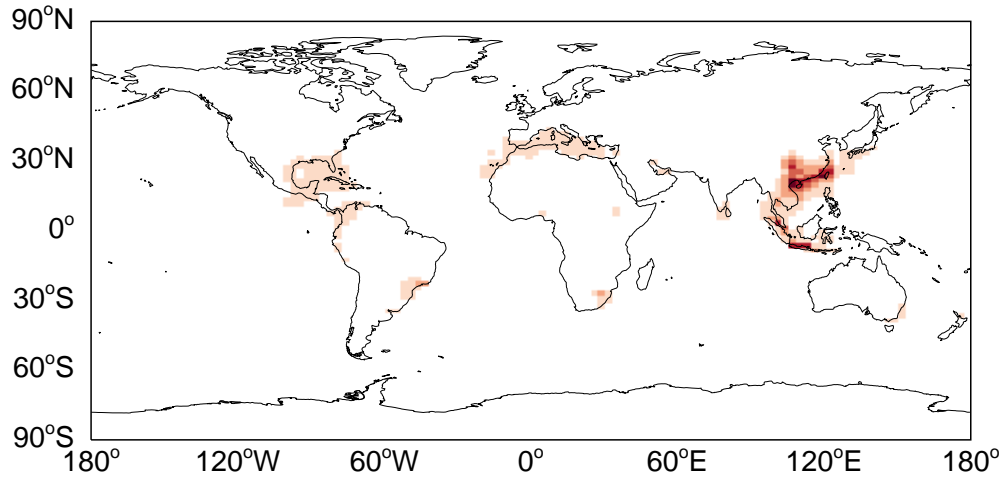
7.67e-09 2.39e-08 4.02e-08 5.64e-08 7.27e-08 []

## Normal Reff



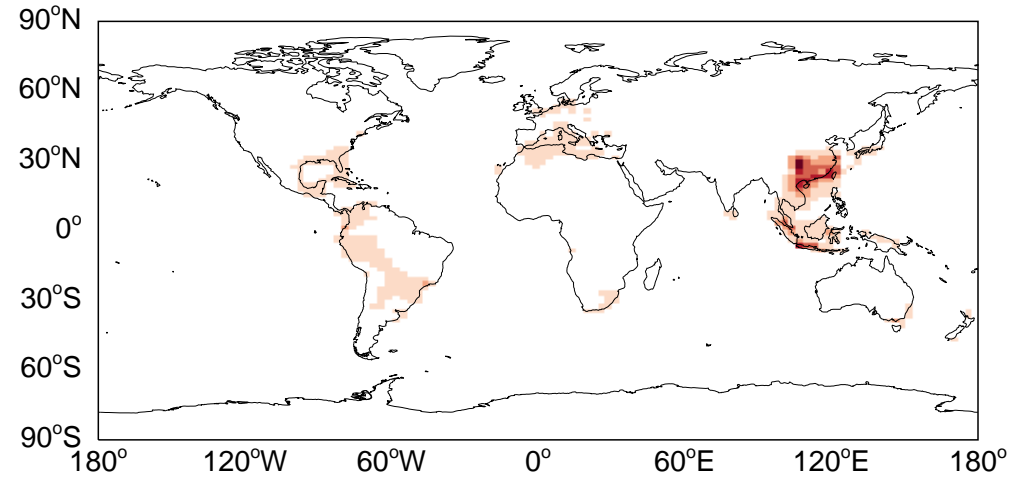
7.67e-09 2.39e-08 4.02e-08 5.64e-08 7.27e-08 []

## Difference (#2-#1)



-6.62 -3.31 0.00 3.31 6.62 [1e-10 \*]

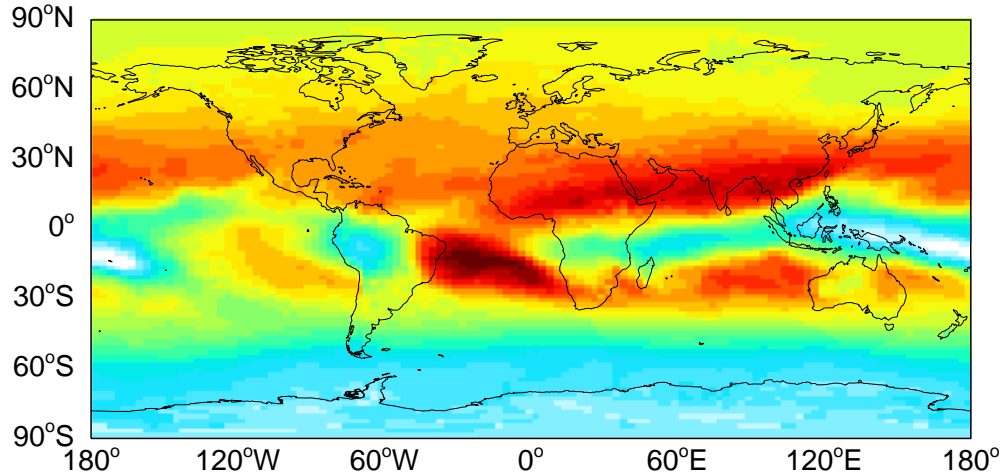
## Rel. Diff. [%]



-1.71 -0.85 0.00 0.85 1.71 [%]

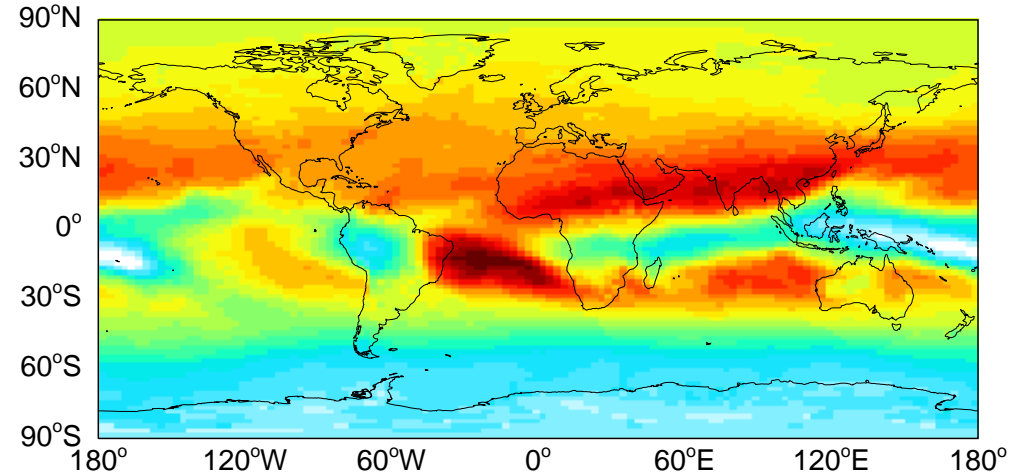
O3 @ 500 hPa (winter)

Small Reff



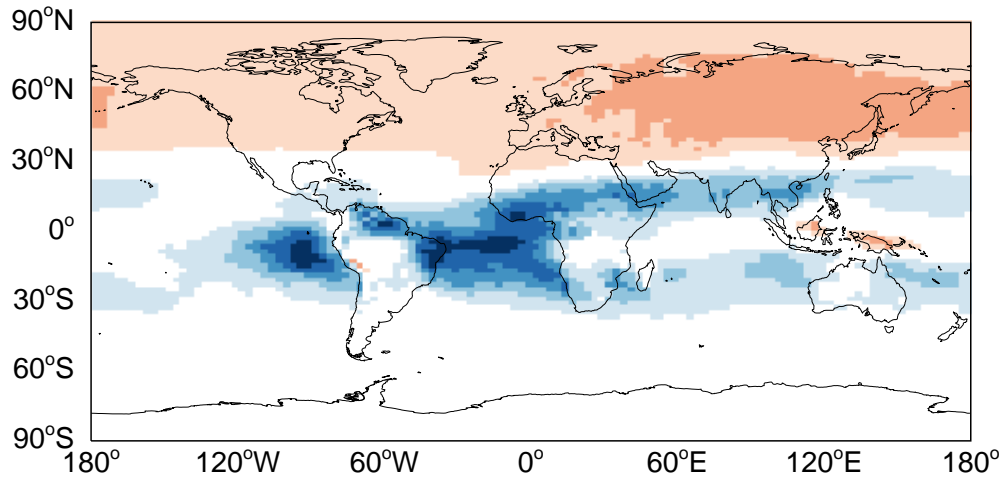
2.65e-08 3.99e-08 5.33e-08 6.66e-08 8.00e-08 []

Normal Reff



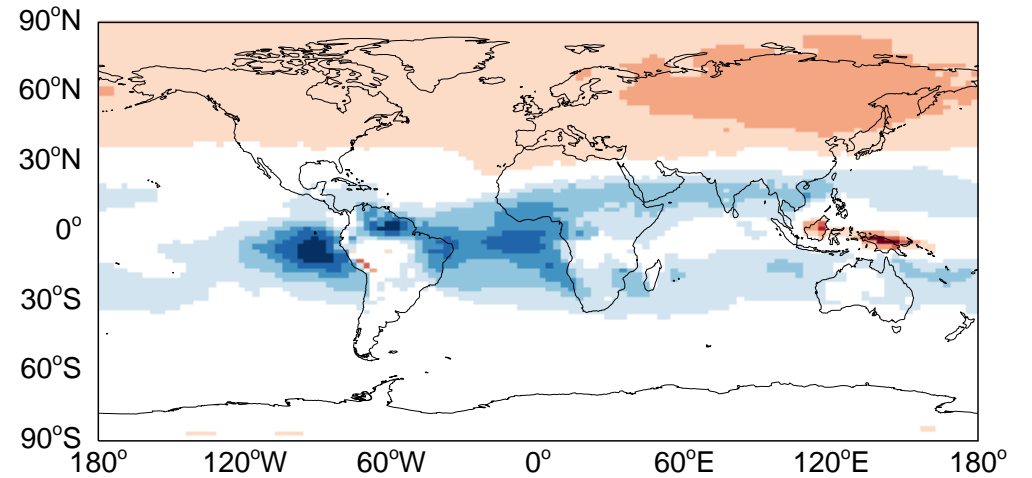
2.65e-08 3.99e-08 5.33e-08 6.66e-08 8.00e-08 []

Difference (#2-#1)



-1.35 -0.67 0.00 0.67 1.35 [1e-10 \*]

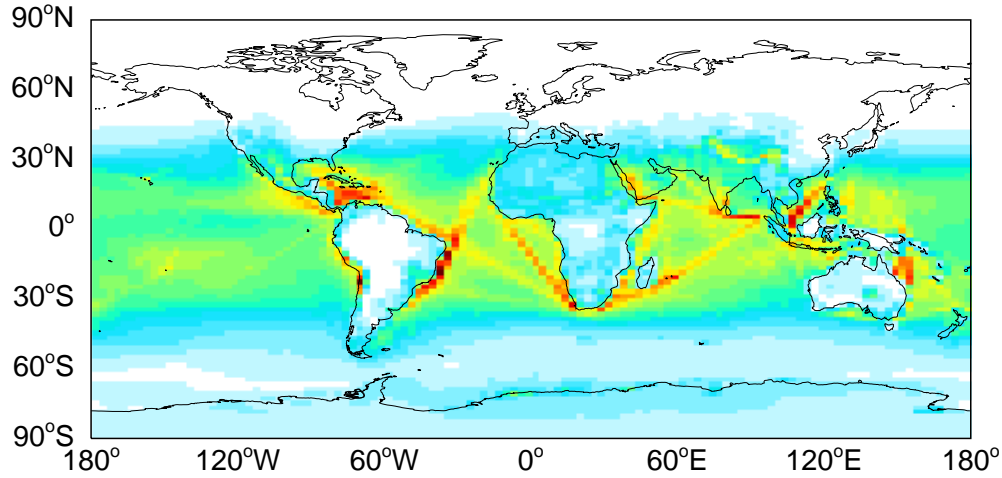
Rel. Diff. [%]



-0.25 -0.13 0.00 0.13 0.25 [%]

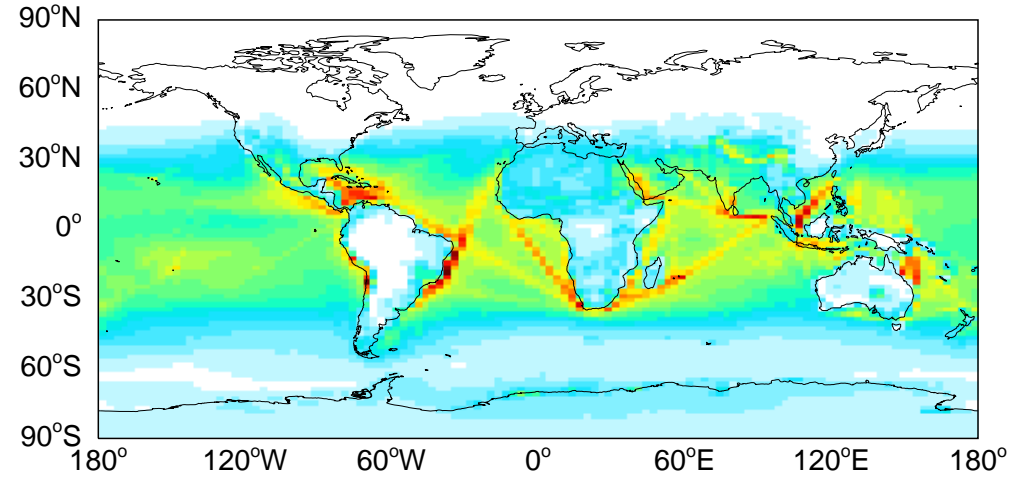
Surface OH (winter)

Small Reff



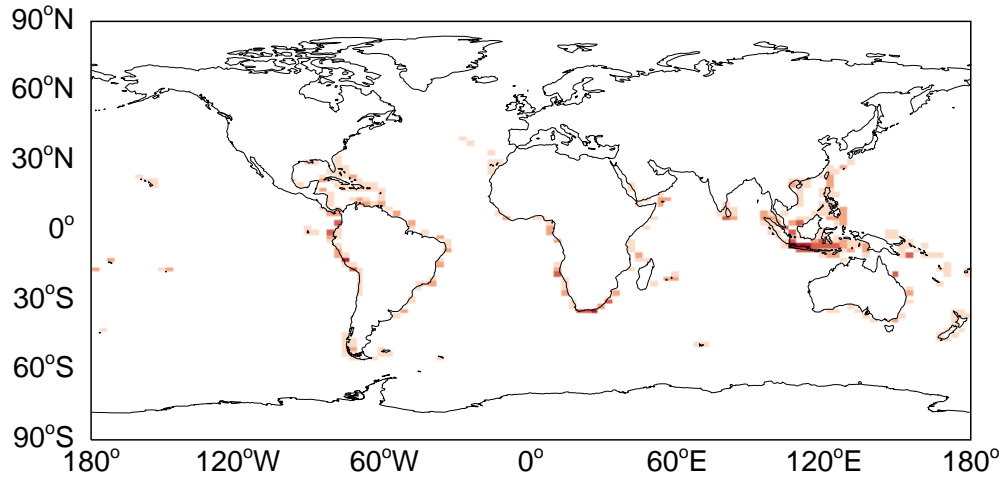
2.55e-18 5.15e-14 1.03e-13 1.55e-13 2.06e-13 []

Normal Reff



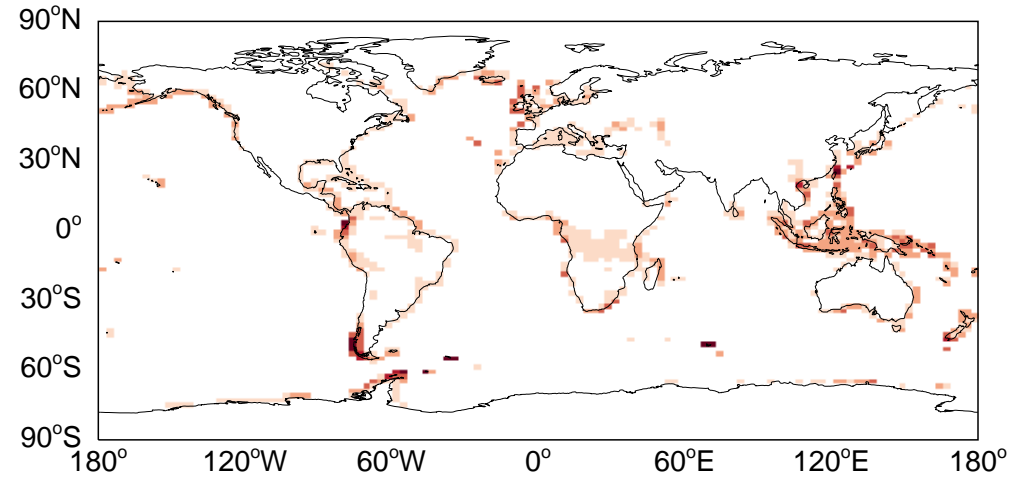
2.55e-18 5.15e-14 1.03e-13 1.55e-13 2.06e-13 []

Difference (#2-#1)



-1.42 -0.71 0.00 0.71 1.42 [1e-14 \*]

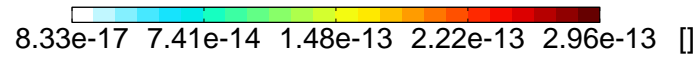
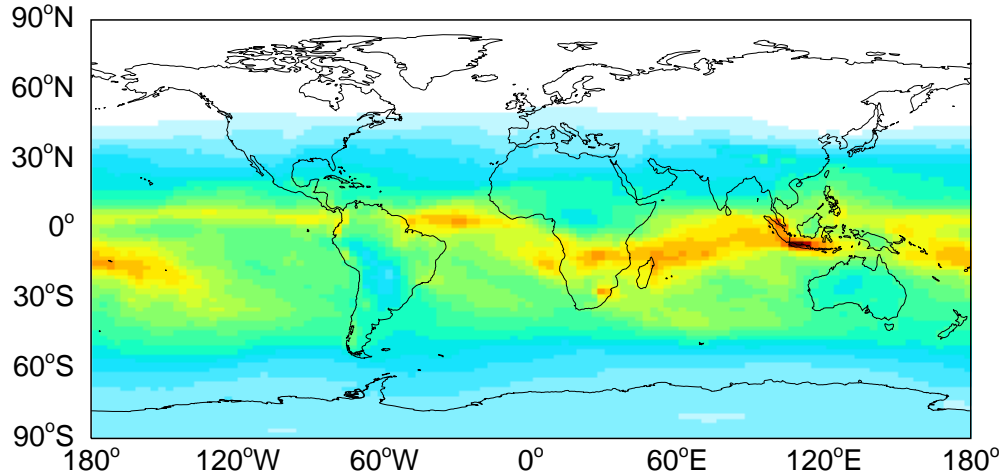
Rel. Diff. [%]



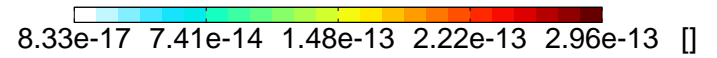
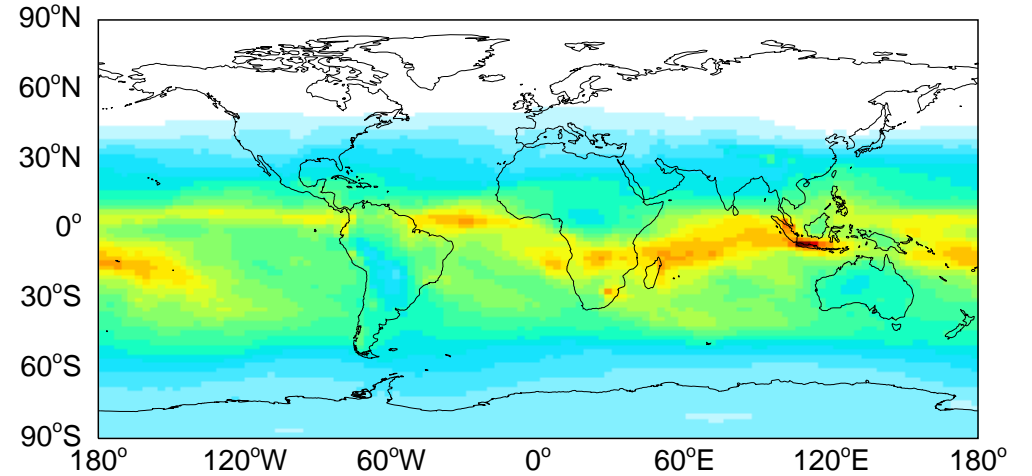
-17.5 -8.7 0.0 8.7 17.5 [%]

OH @ 500 hPa (winter)

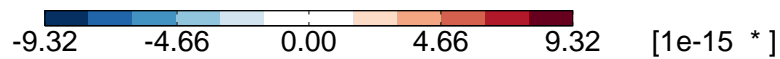
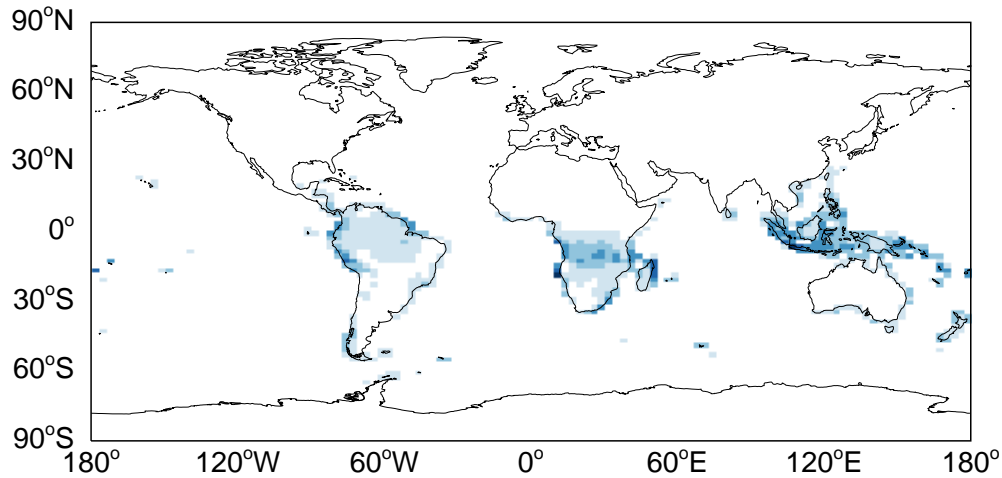
Small Reff



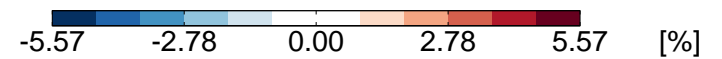
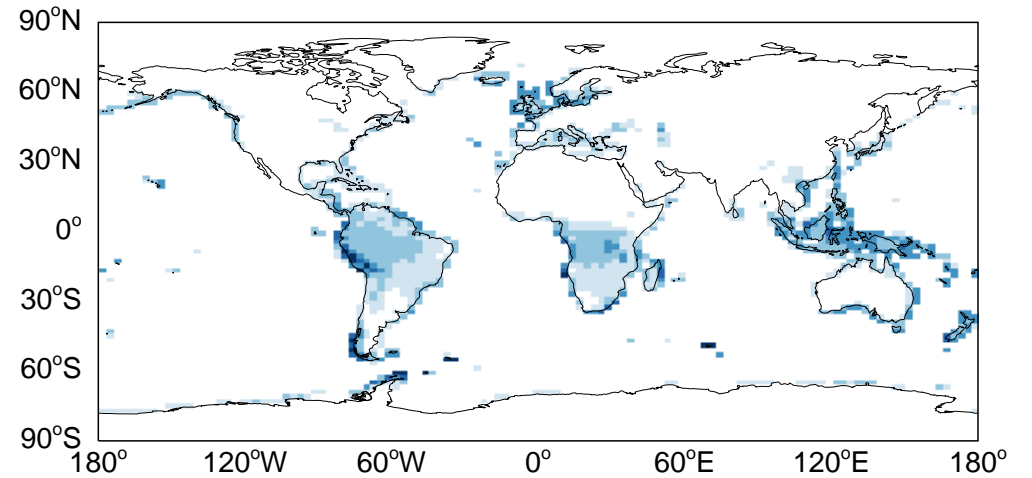
Normal Reff



Difference (#2-#1)



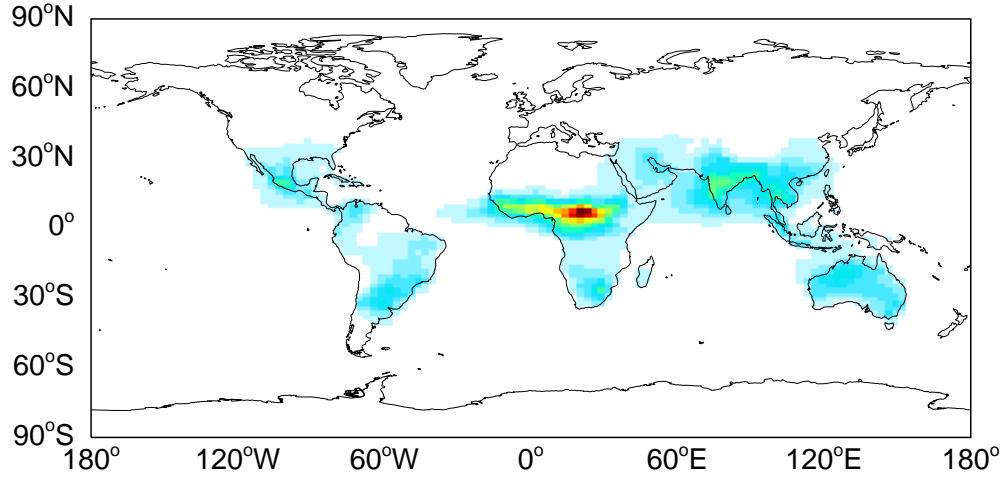
Rel. Diff. [%]





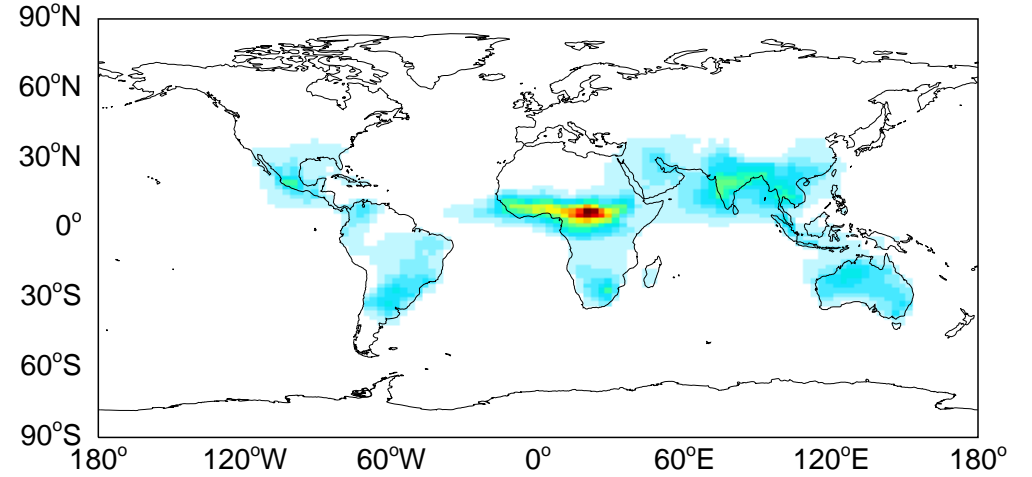
Surface ORGNTR (winter)

Small Reff



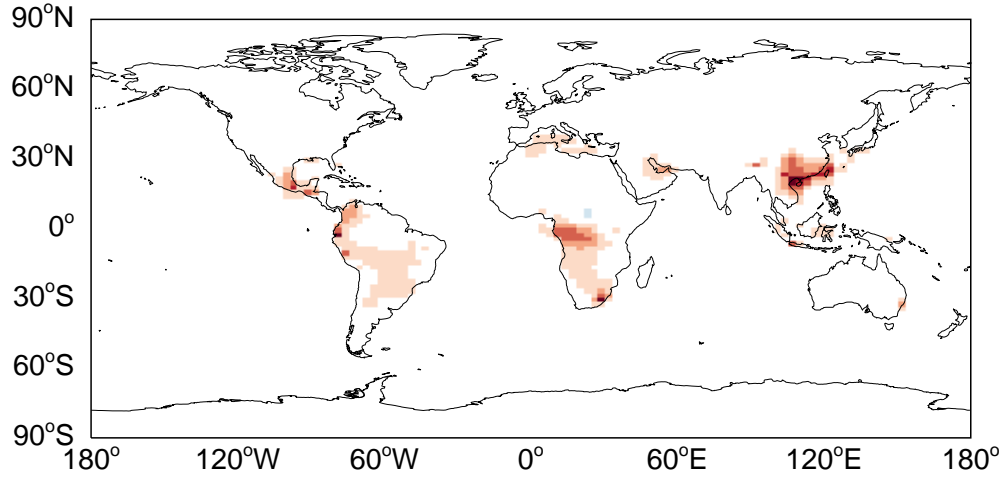
3.67e-14 1.00e-09 2.00e-09 3.00e-09 4.00e-09 []

Normal Reff



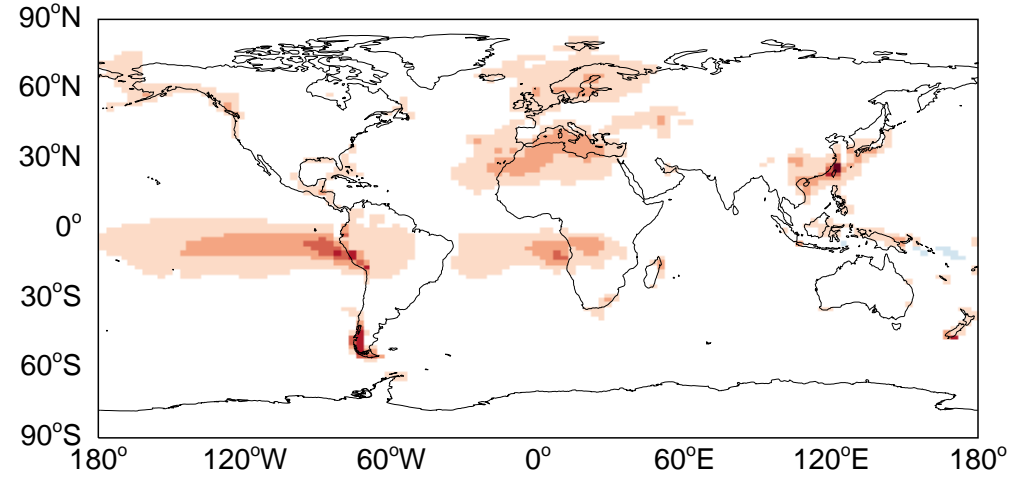
3.67e-14 1.00e-09 2.00e-09 3.00e-09 4.00e-09 []

Difference (#2-#1)



-5.13 -2.56 0.00 2.56 5.13 [1e-12 \*]

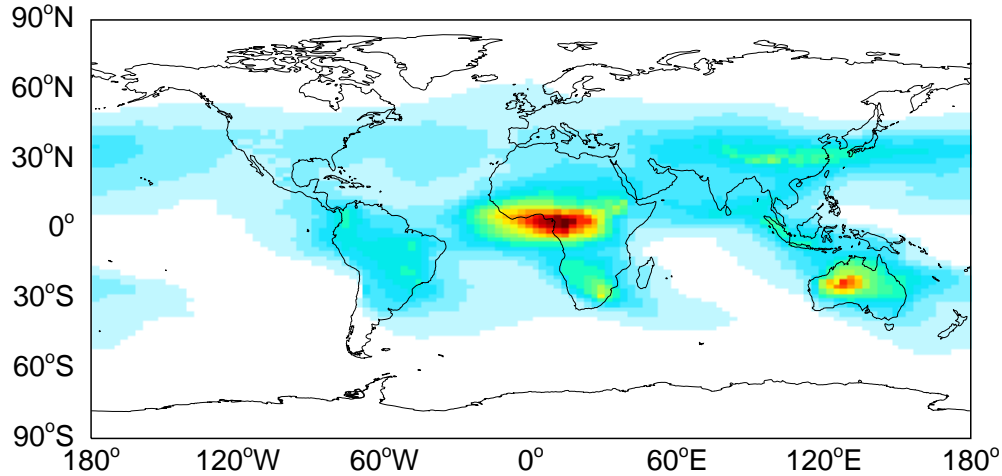
Rel. Diff. [%]



-1.78 -0.89 0.00 0.89 1.78 [%]

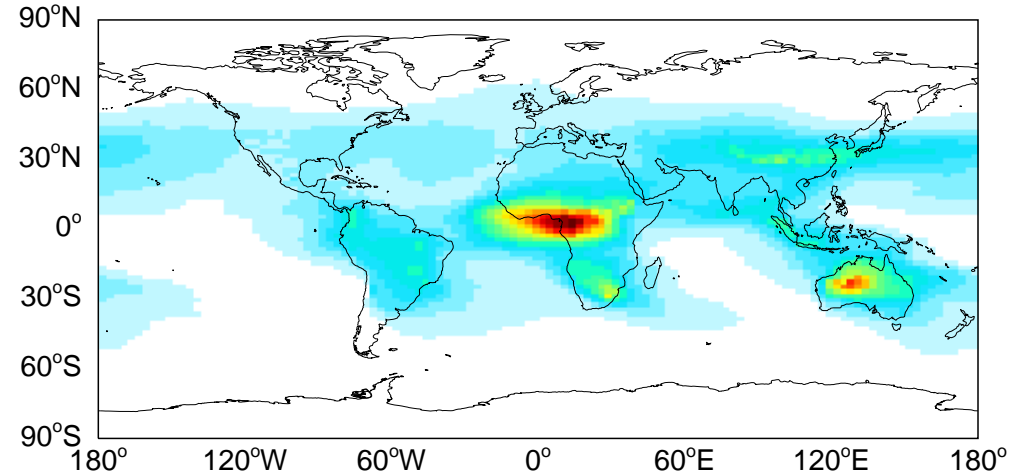
ORGNTR @ 500 hPa (winter)

Small Reff



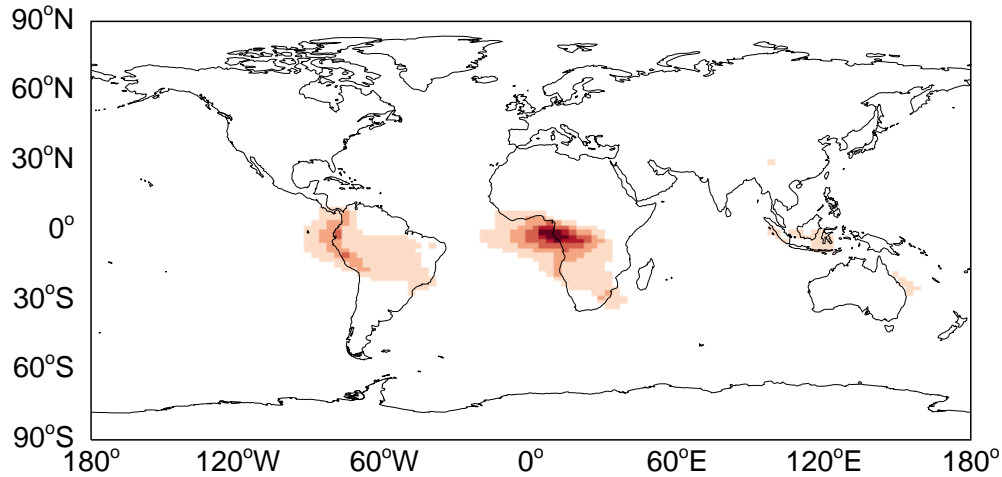
6.91e-14 1.01e-10 2.01e-10 3.02e-10 4.02e-10 []

Normal Reff



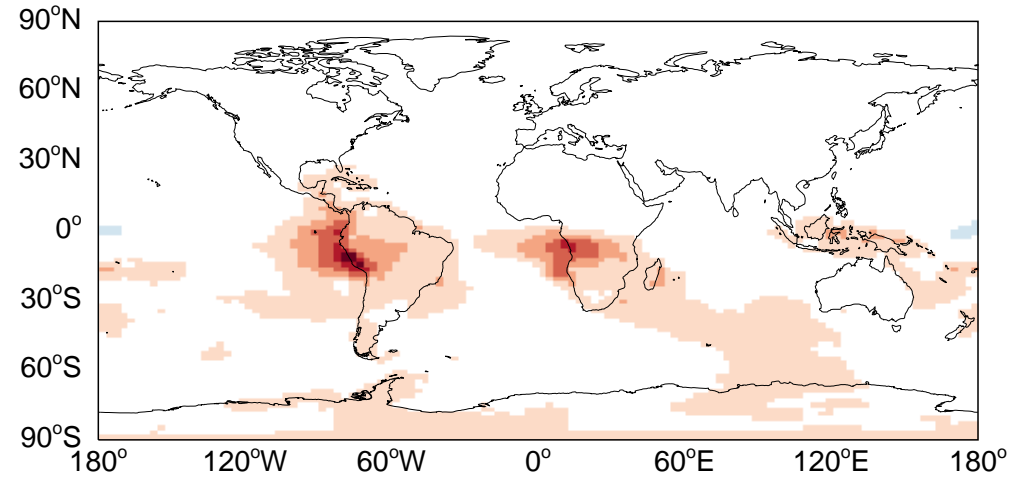
6.91e-14 1.01e-10 2.01e-10 3.02e-10 4.02e-10 []

Difference (#2-#1)



-1.64 -0.82 0.00 0.82 1.64 [1e-12 \*]

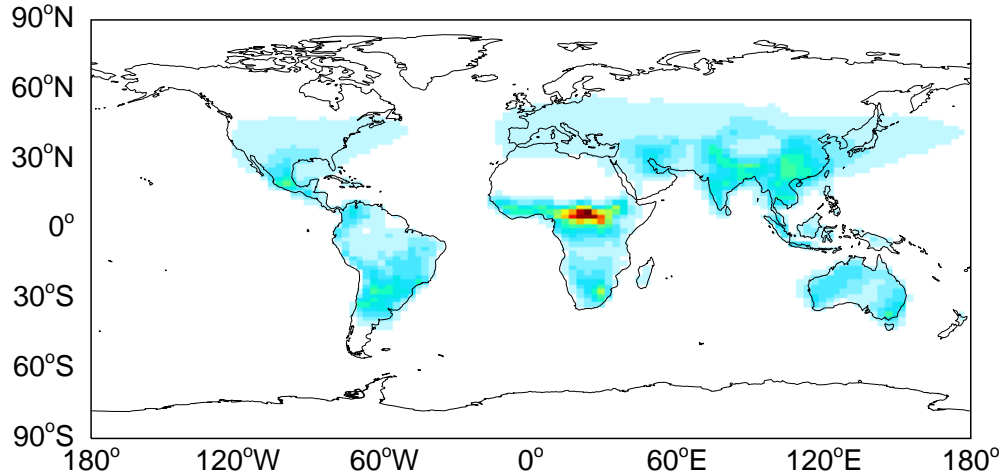
Rel. Diff. [%]



-1.38 -0.69 0.00 0.69 1.38 [%]

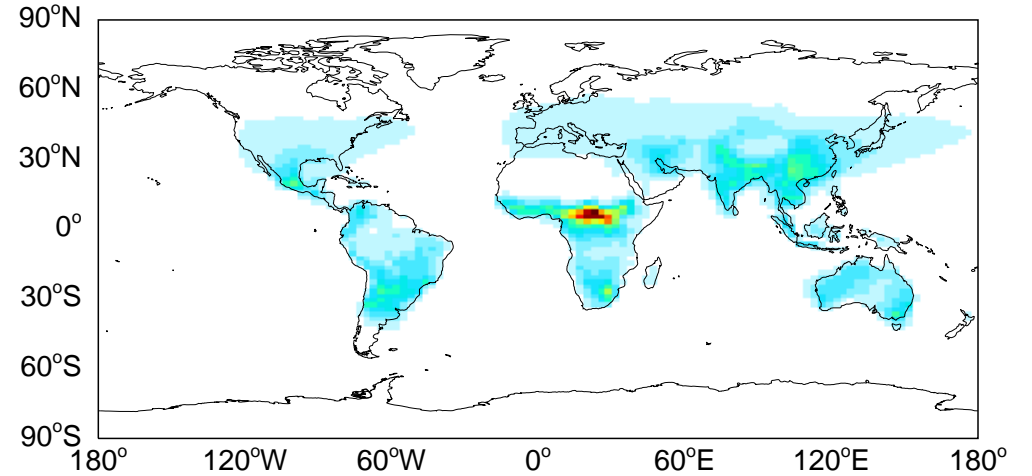
# Surface PAN (winter)

## Small Reff



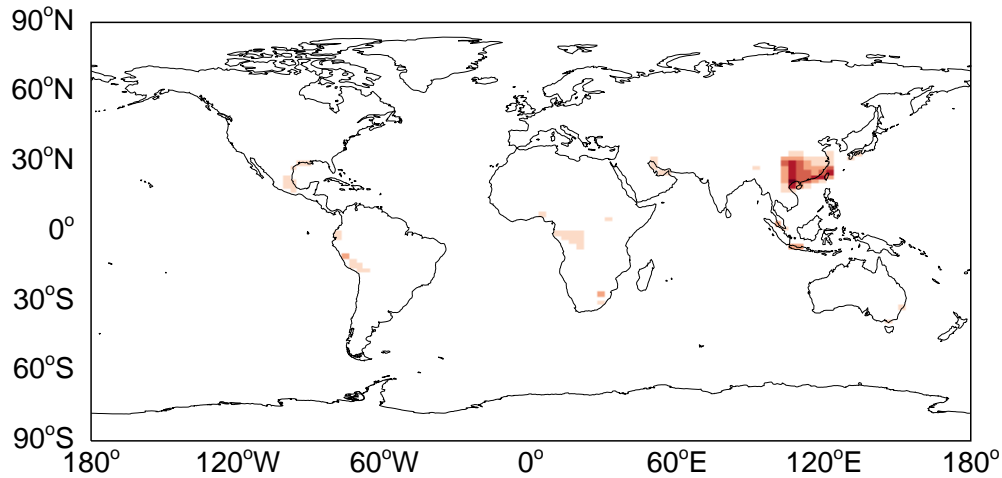
1.89e-13 5.68e-10 1.14e-09 1.70e-09 2.27e-09 []

## Normal Reff



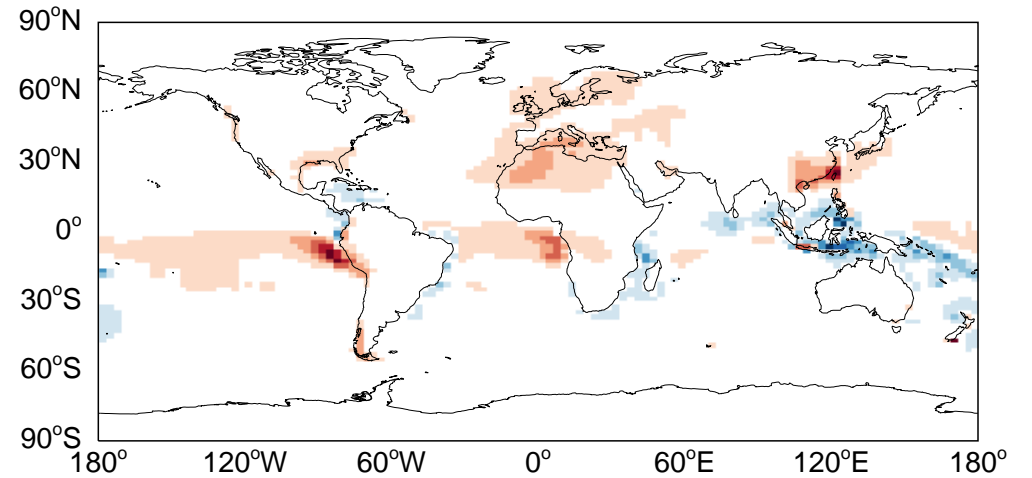
1.89e-13 5.68e-10 1.14e-09 1.70e-09 2.27e-09 []

## Difference (#2-#1)



-8.11 -4.06 0.00 4.06 8.11 [1e-12 \*]

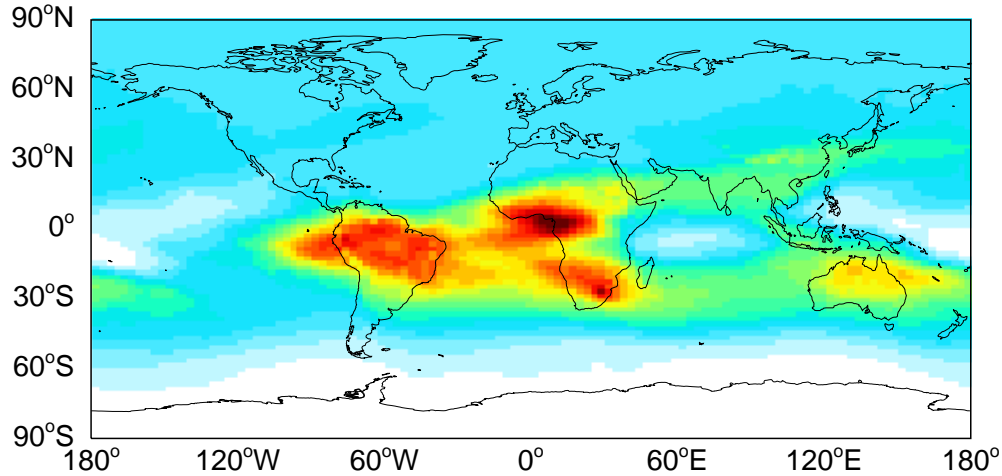
## Rel. Diff. [%]



-2.01 -1.00 0.00 1.00 2.01 [%]

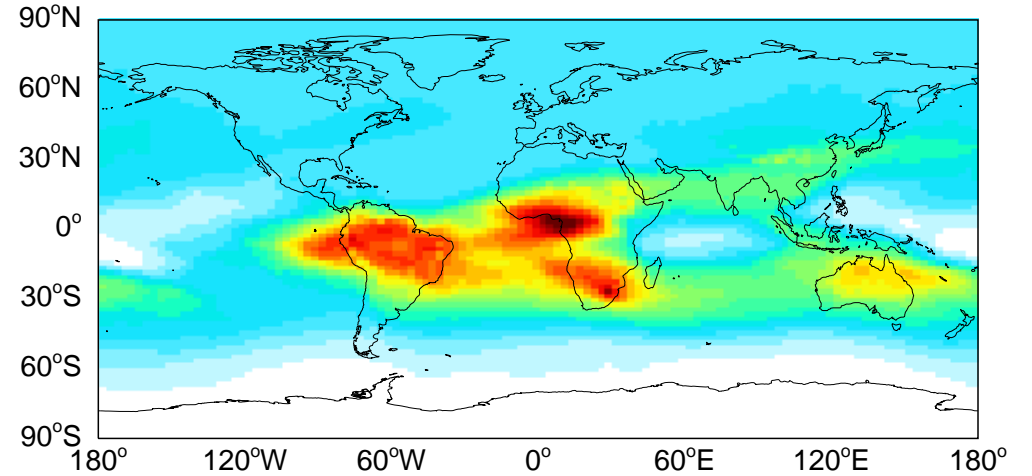
PAN @ 500 hPa (winter)

Small Reff



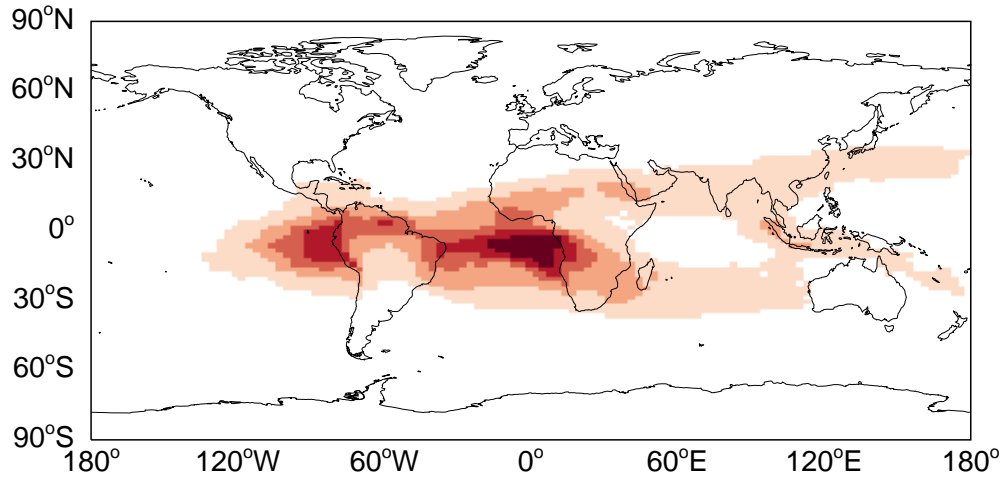
2.52e-11 1.75e-10 3.25e-10 4.75e-10 6.25e-10 []

Normal Reff



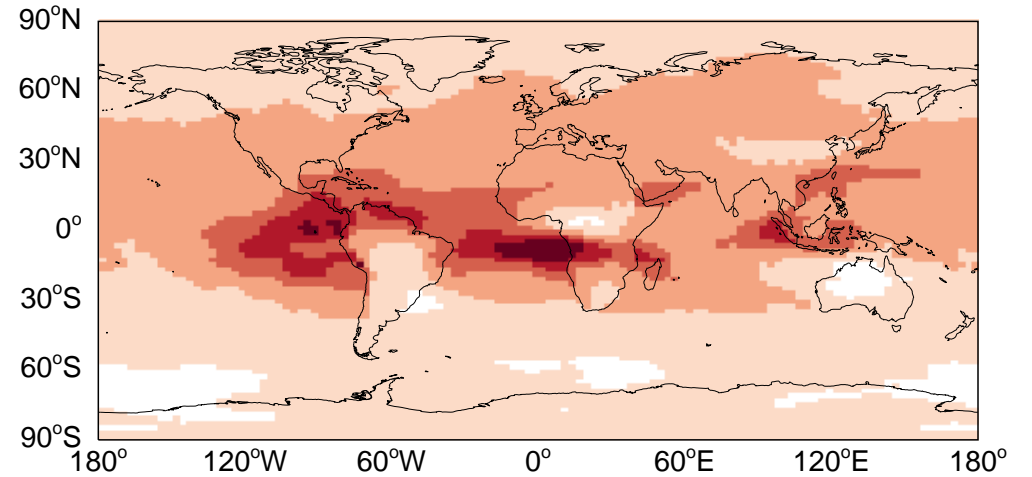
2.52e-11 1.75e-10 3.25e-10 4.75e-10 6.25e-10 []

Difference (#2-#1)



-3.95 -1.98 0.00 1.98 3.95 [1e-12 \*]

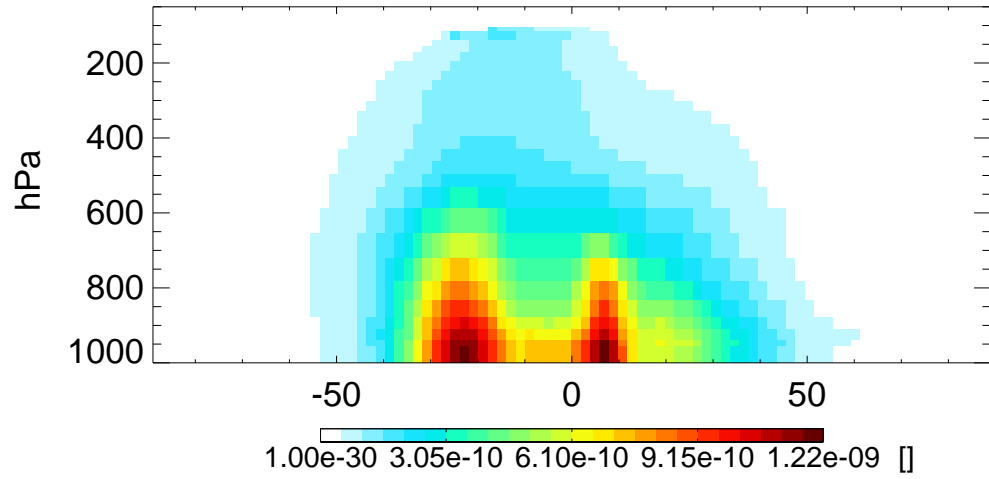
Rel. Diff. [%]



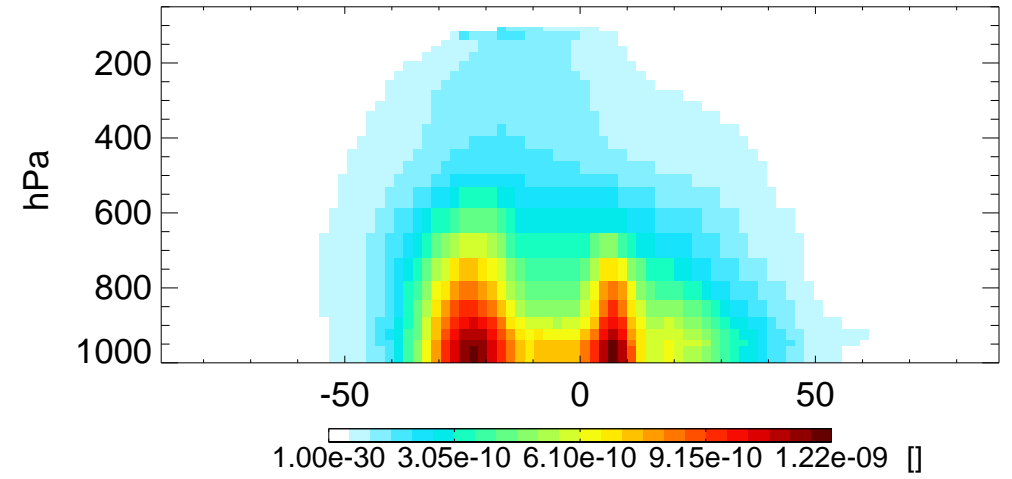
-0.96 -0.48 0.00 0.48 0.96 [%]

CH<sub>2</sub>O ZONAL MEAN (winter)

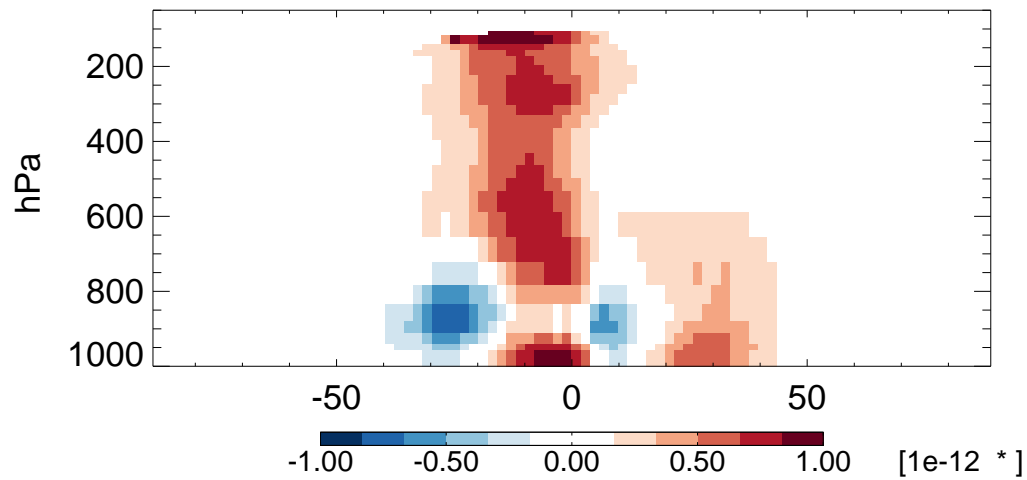
Small Reff



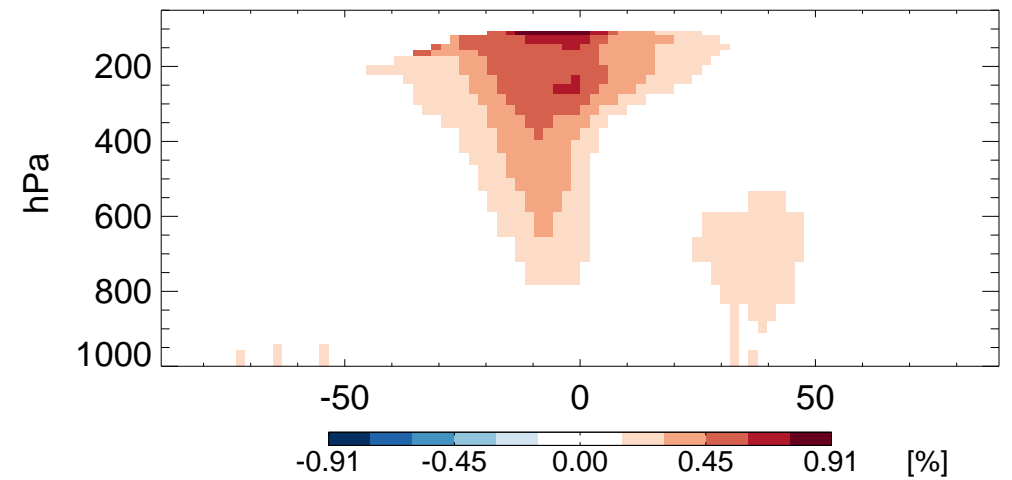
Normal Reff



Difference (#2-#1)

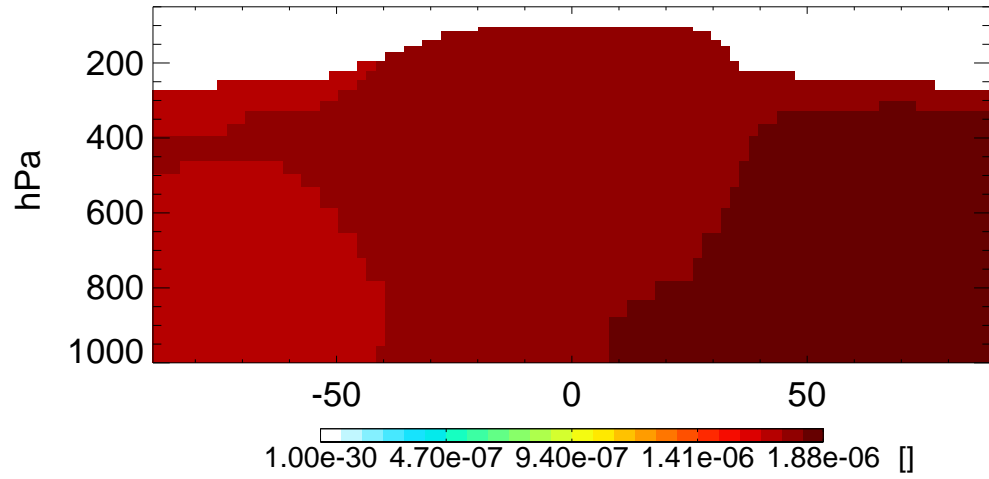


Rel. Diff. [%]

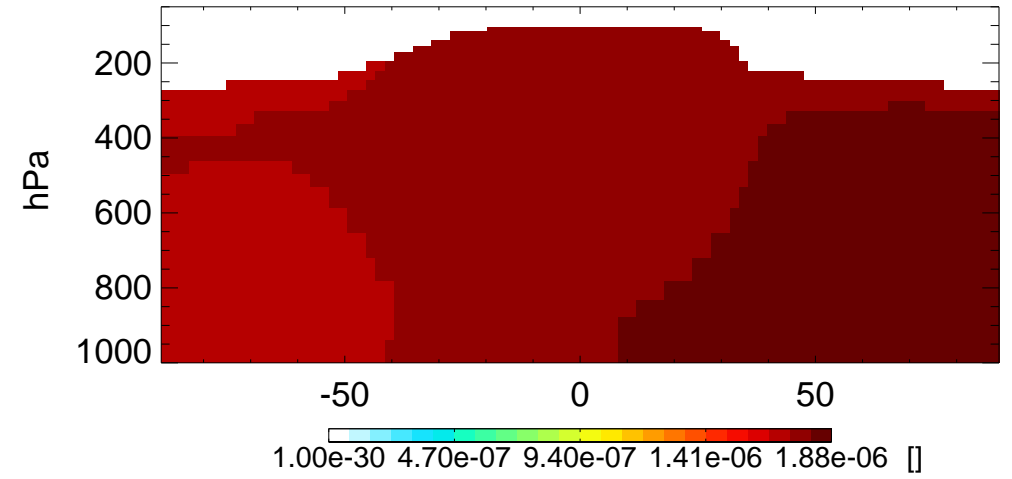


# CH4 ZONAL MEAN (winter)

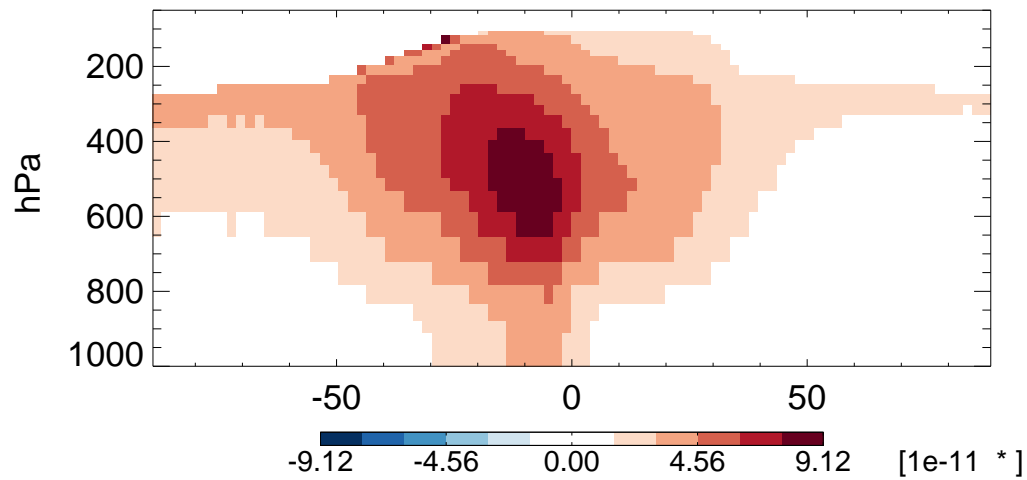
## Small Reff



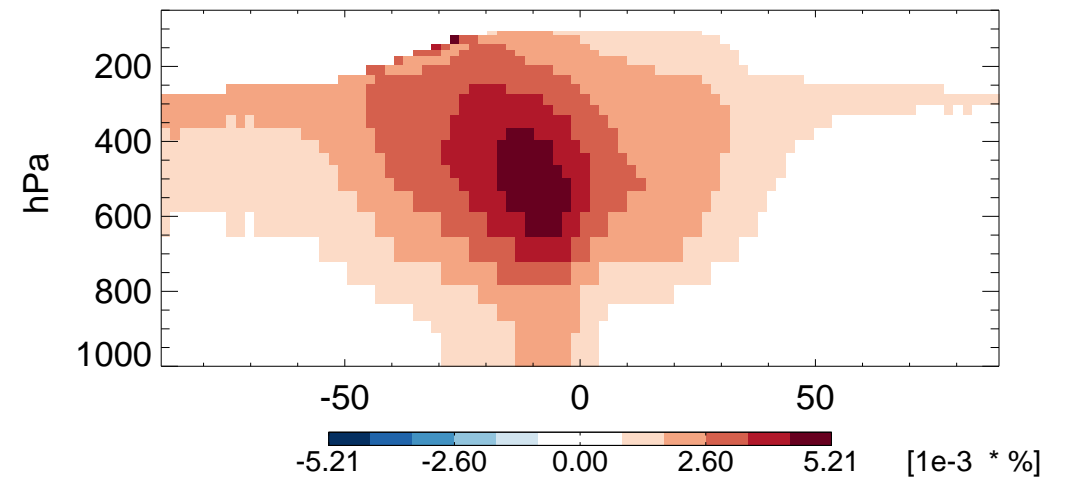
## Normal Reff



## Difference (#2-#1)

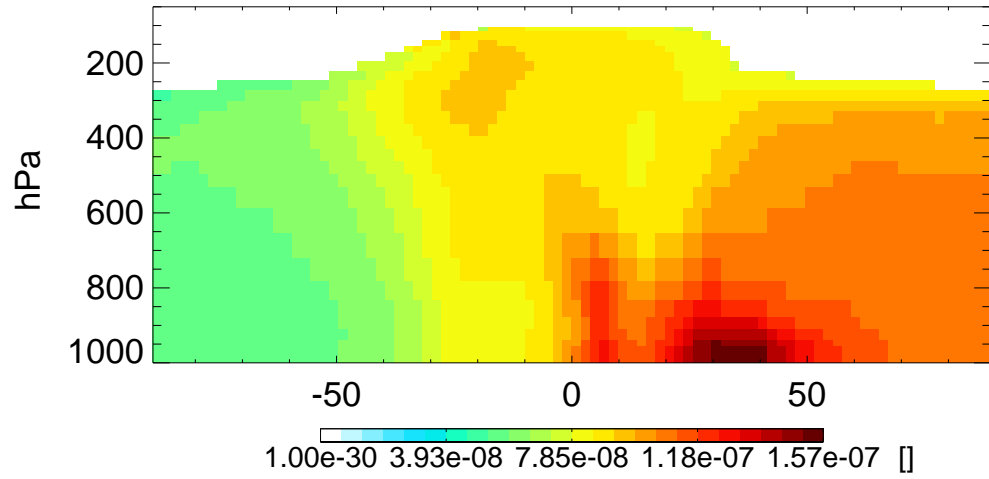


## Rel. Diff. [%]

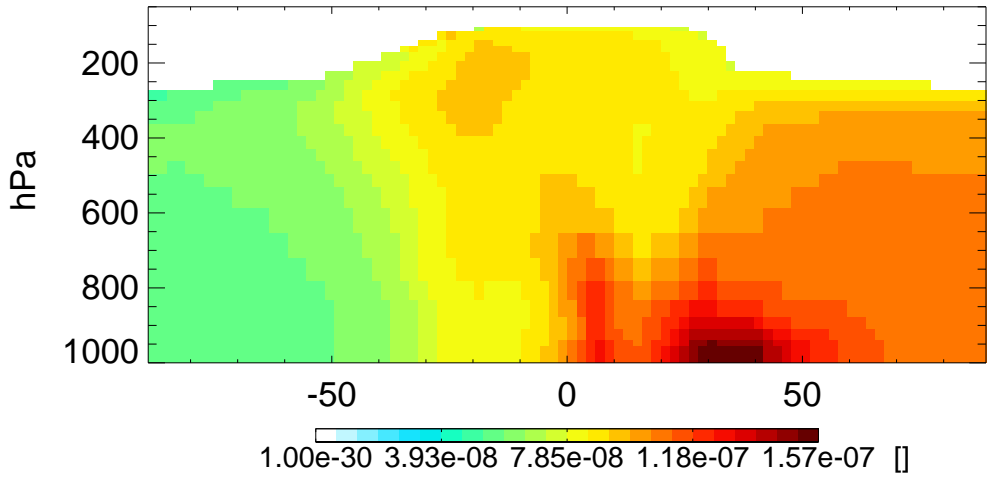


CO ZONAL MEAN (winter)

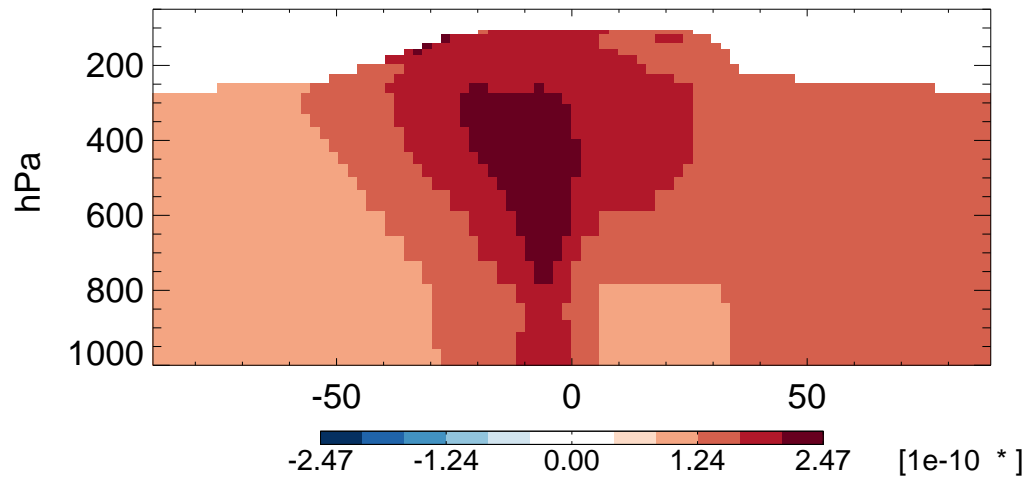
Small Reff



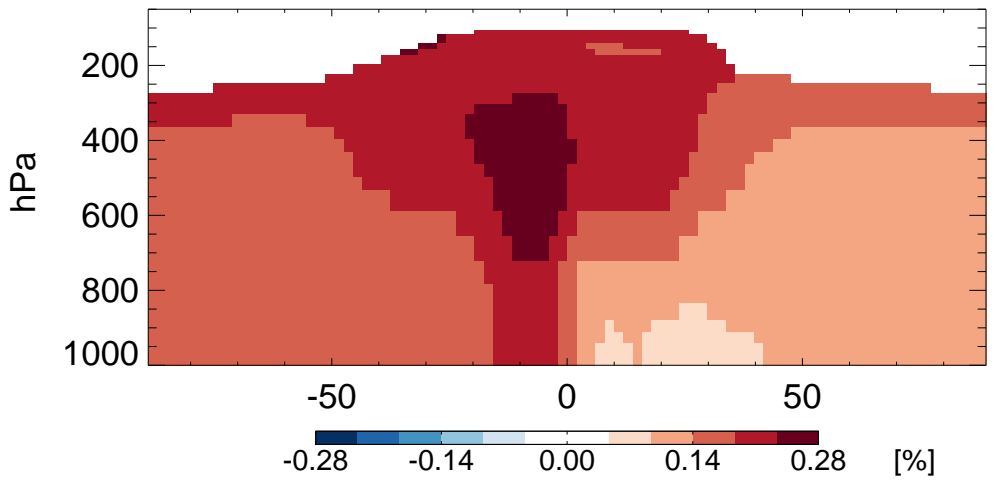
Normal Reff



Difference (#2-#1)

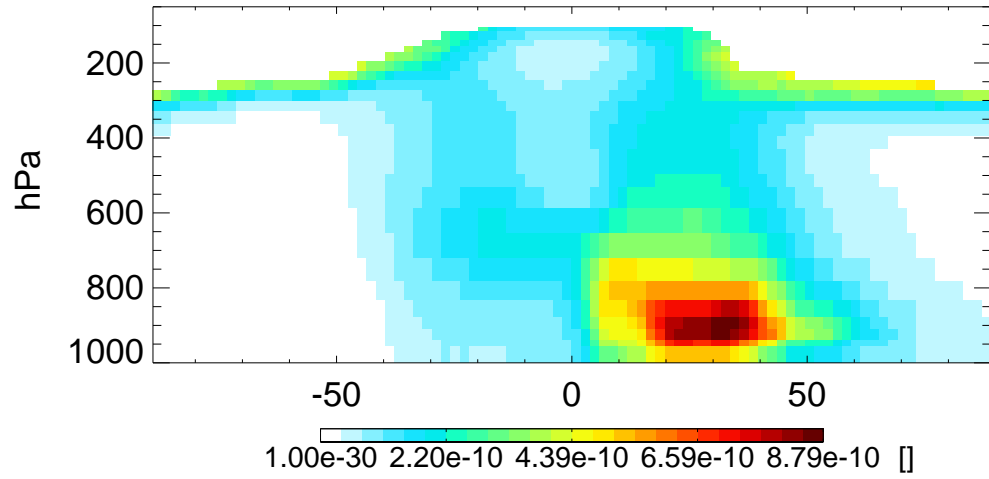


Rel. Diff. [%]

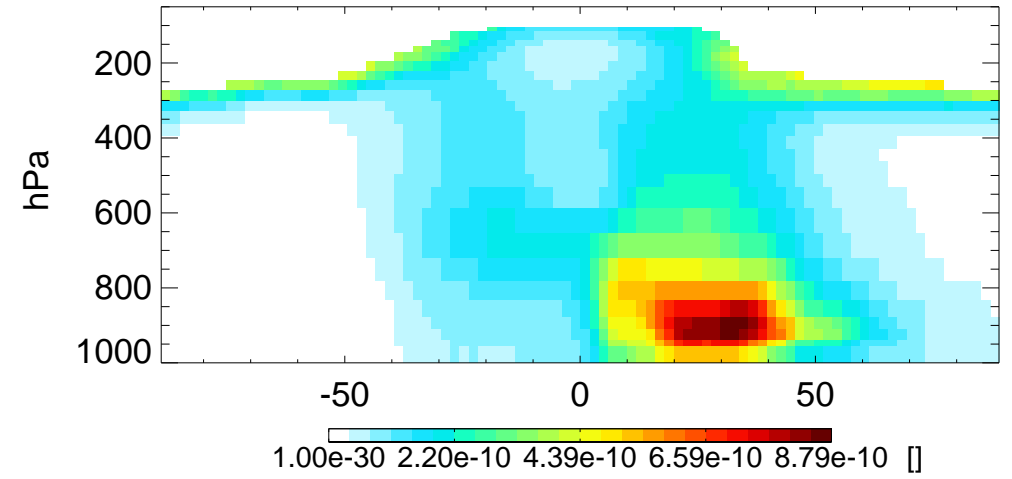


# HNO<sub>3</sub> ZONAL MEAN (winter)

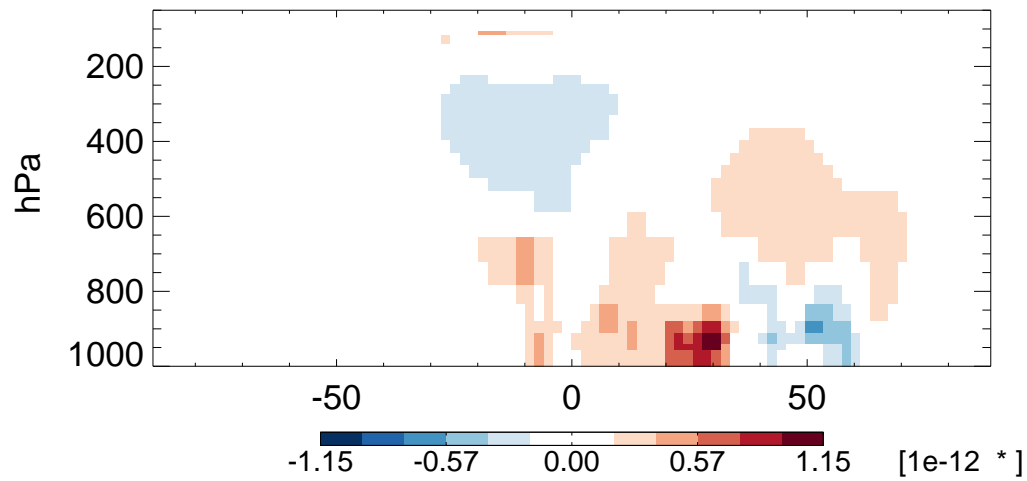
## Small Reff



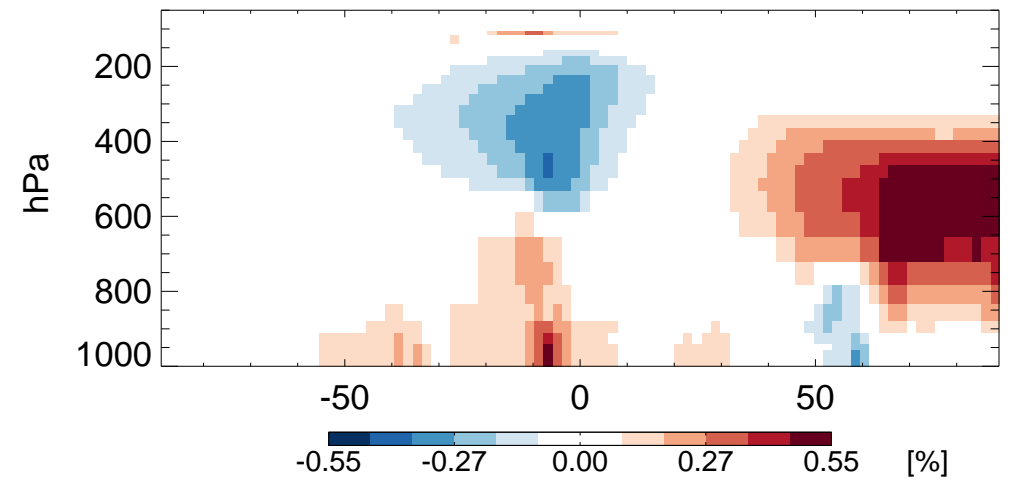
## Normal Reff



## Difference (#2-#1)



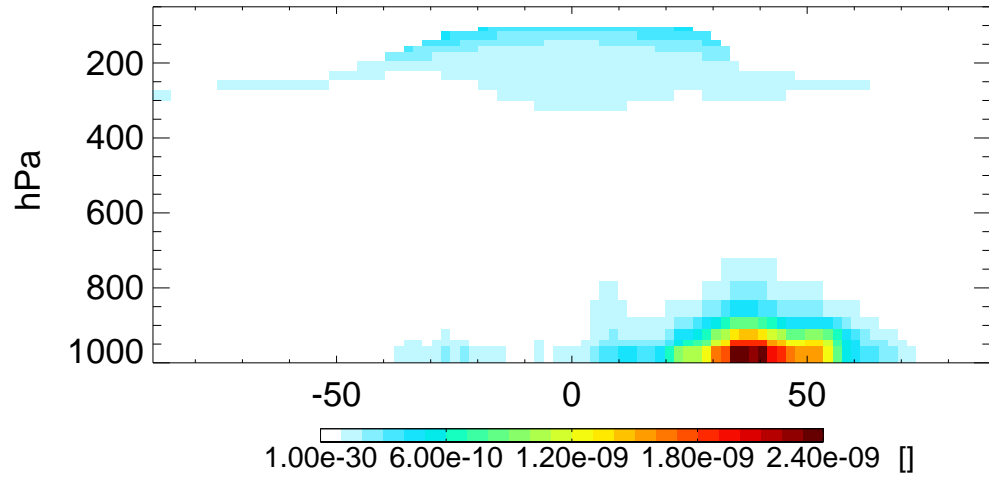
## Rel. Diff. [%]



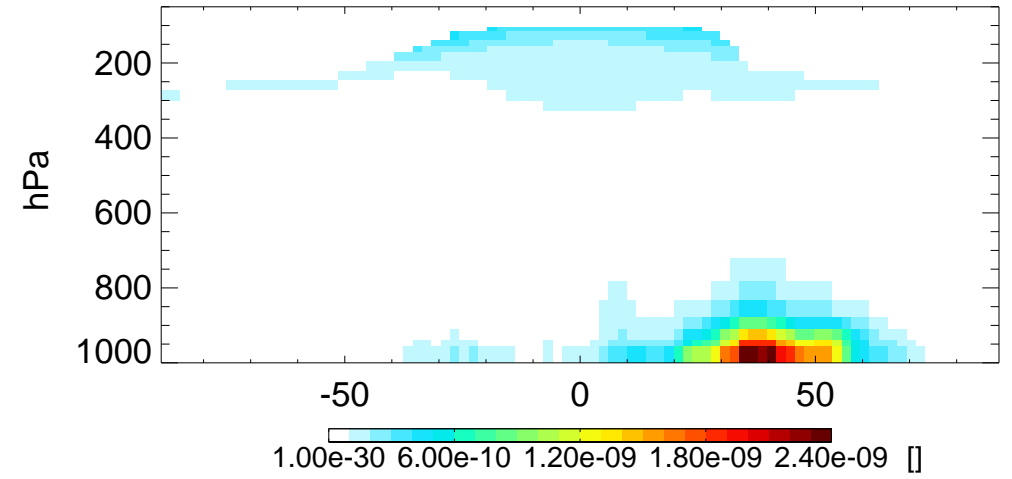


NOX ZONAL MEAN (winter)

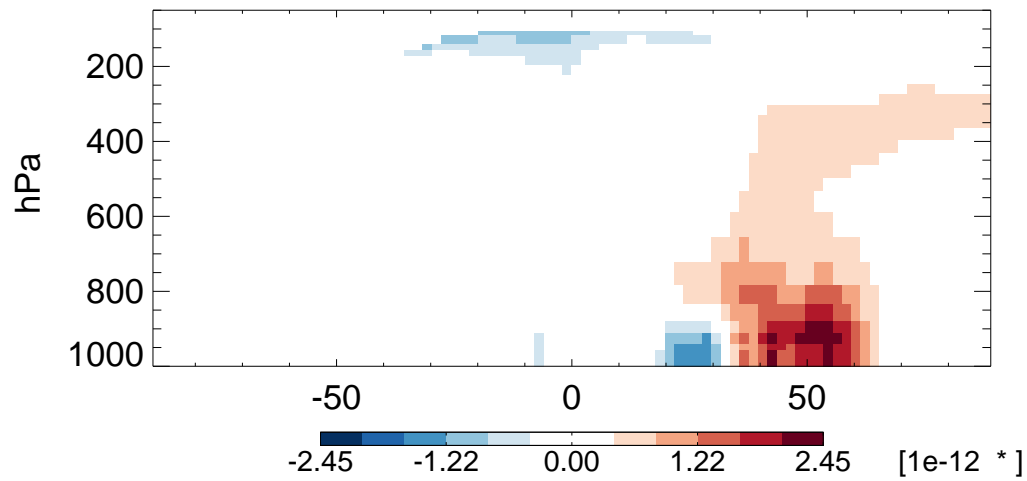
Small Reff



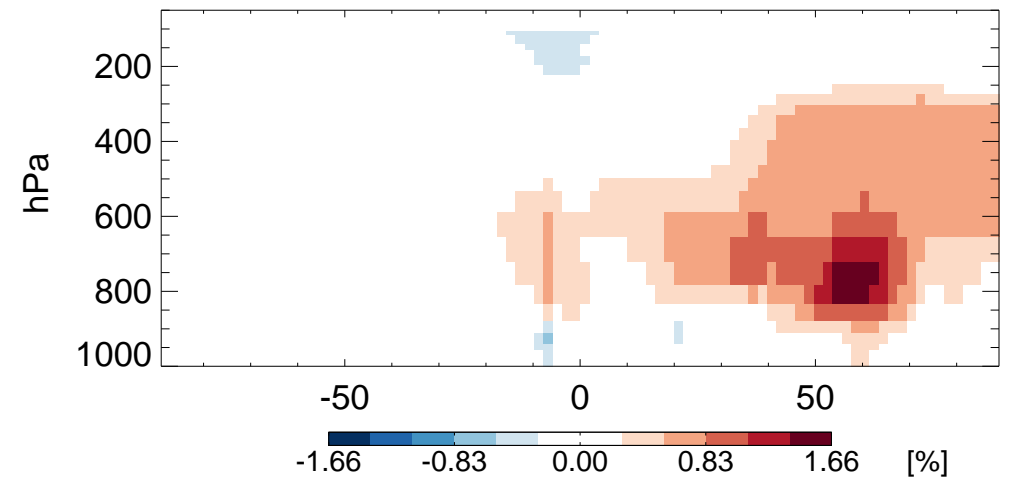
Normal Reff



Difference (#2-#1)

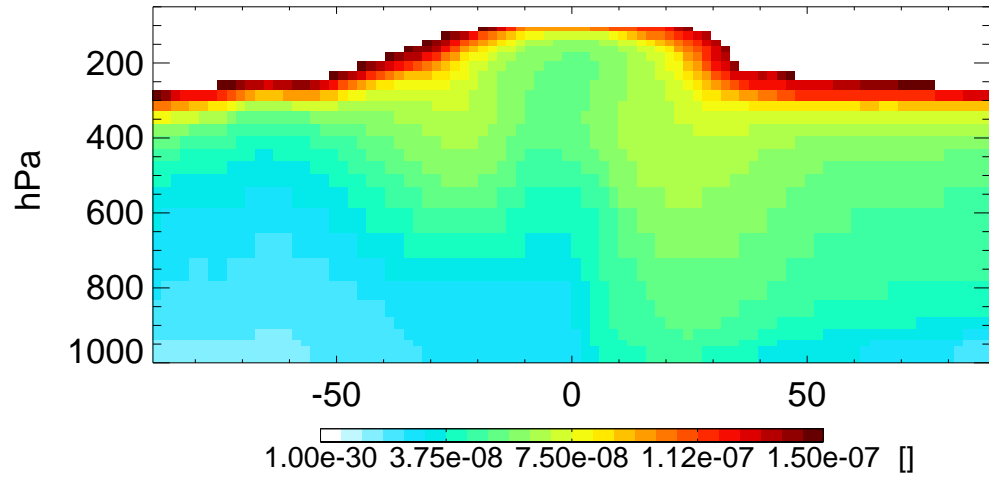


Rel. Diff. [%]

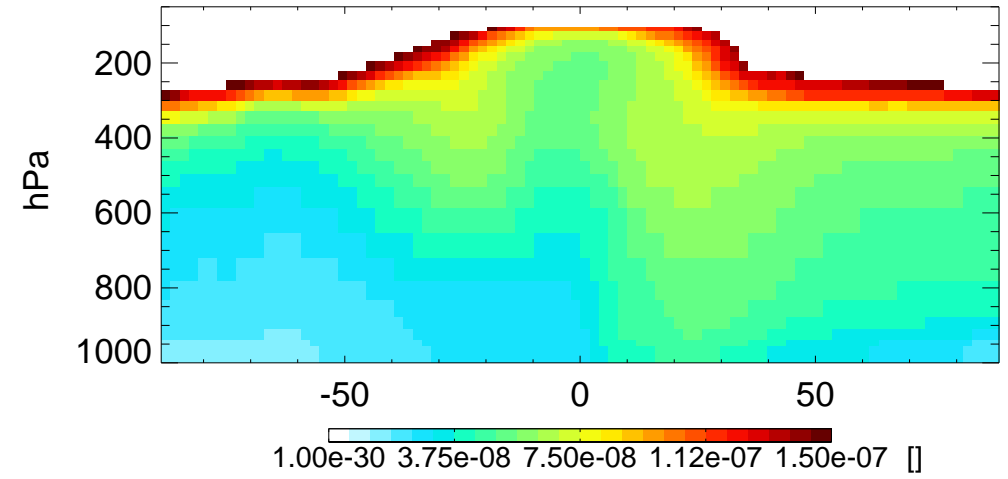


O3 ZONAL MEAN (winter)

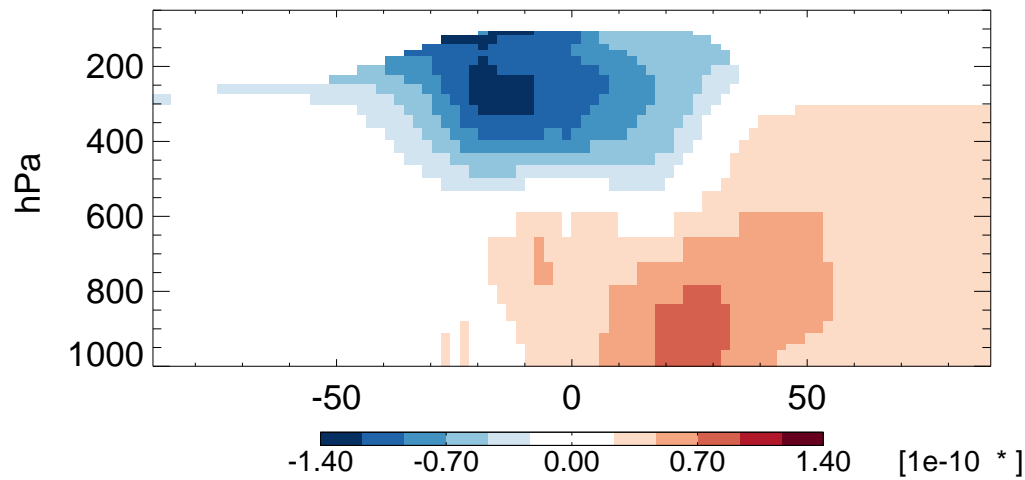
Small Reff



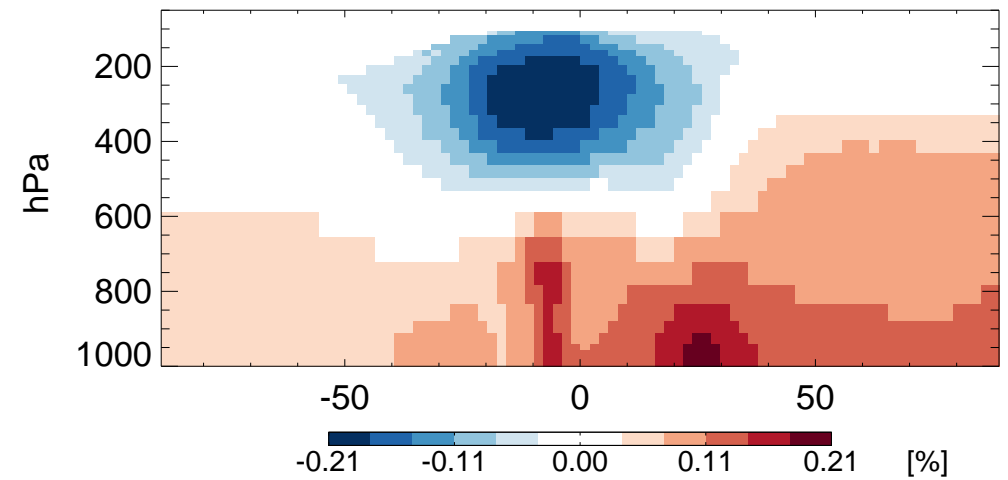
Normal Reff



Difference (#2-#1)

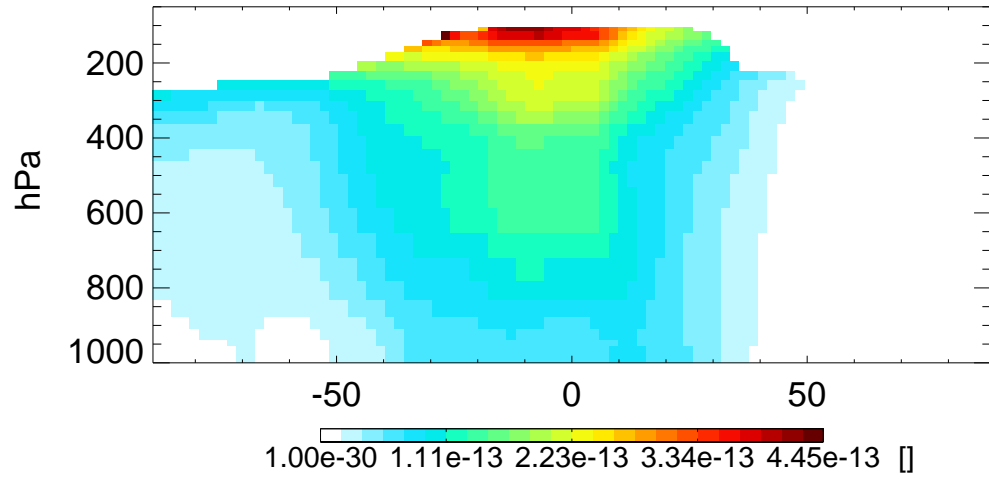


Rel. Diff. [%]

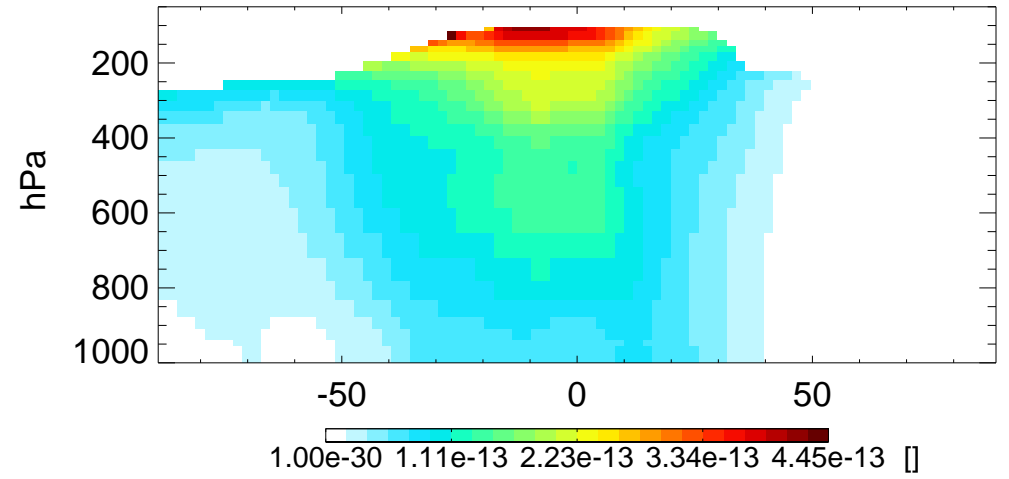


OH ZONAL MEAN (winter)

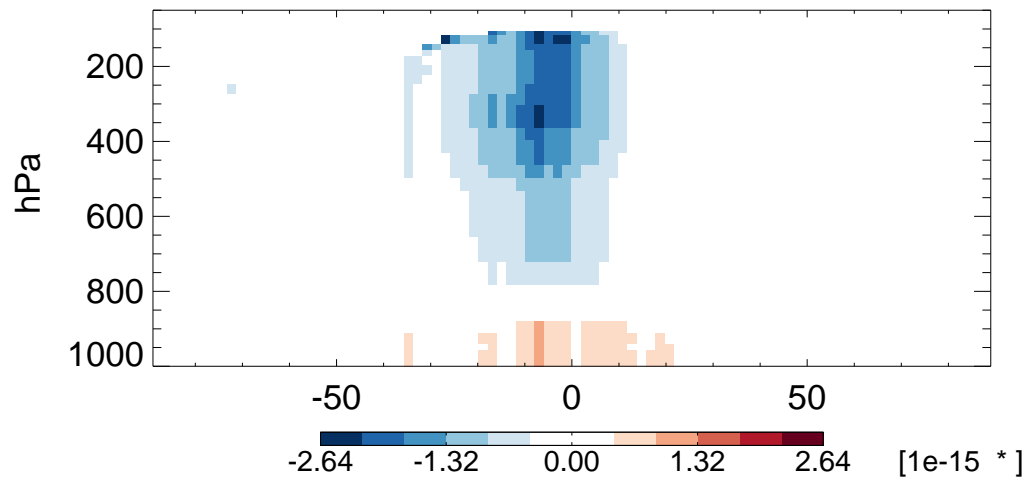
Small Reff



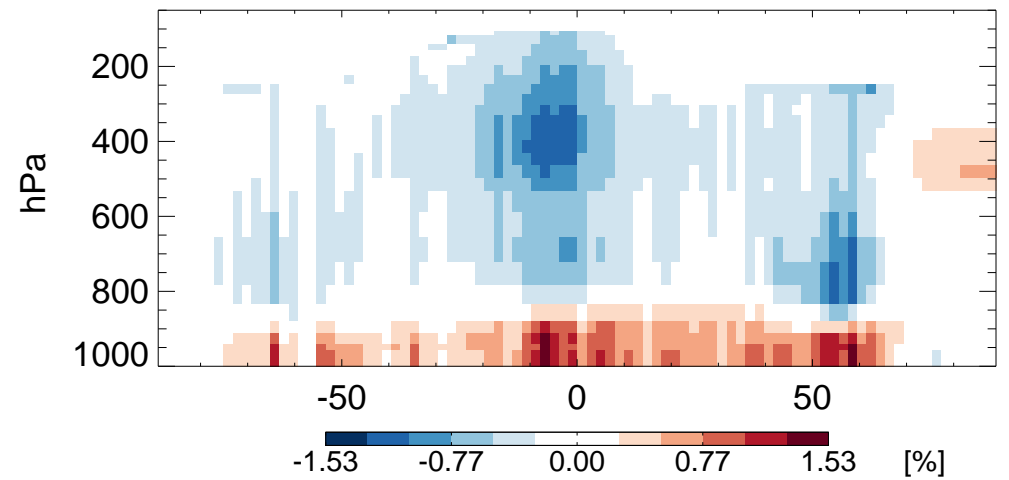
Normal Reff



Difference (#2-#1)

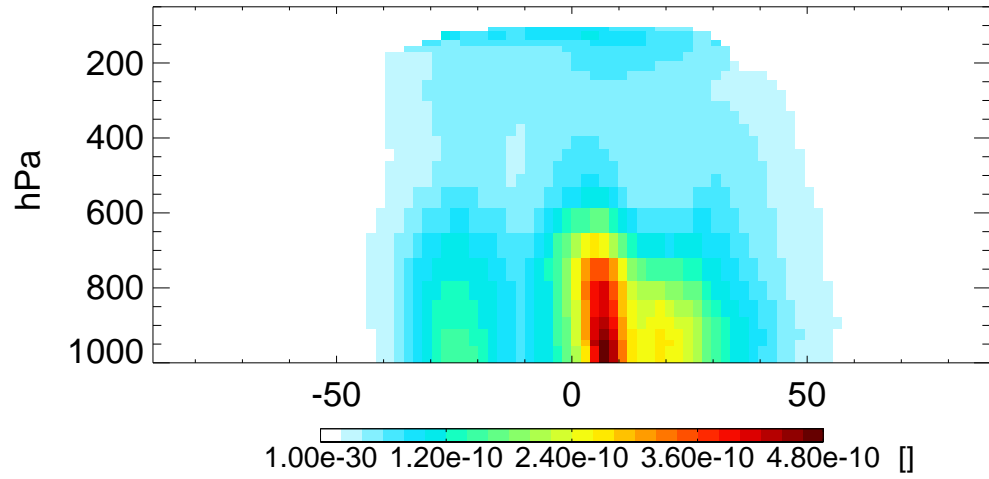


Rel. Diff. [%]

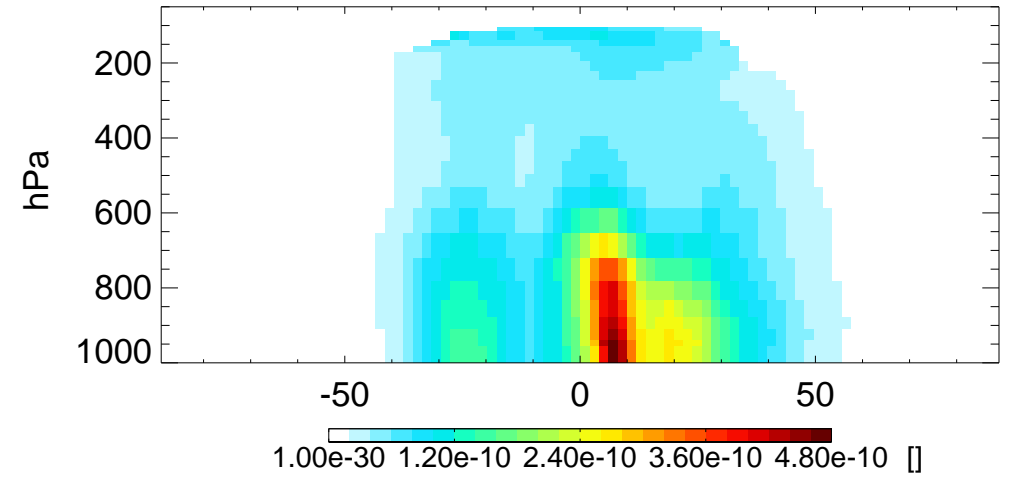


ORGNTR ZONAL MEAN (winter)

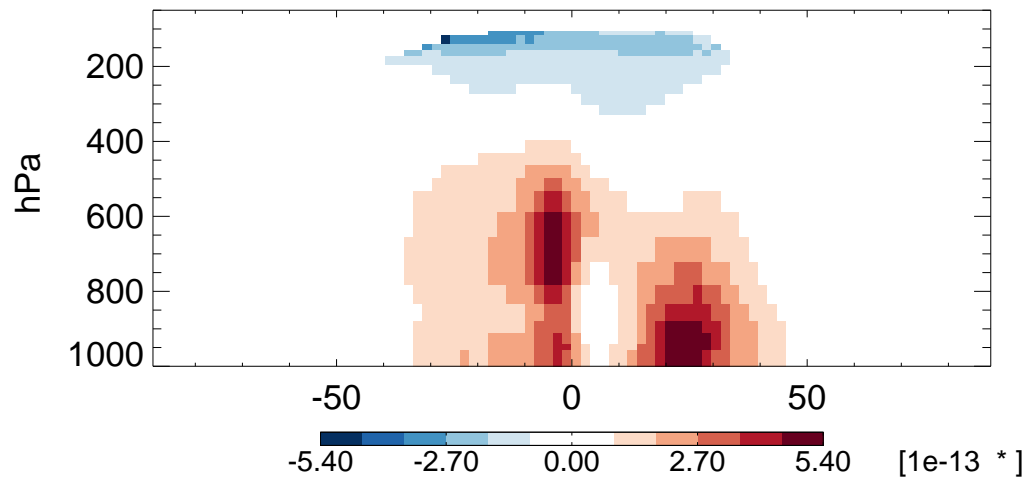
Small Reff



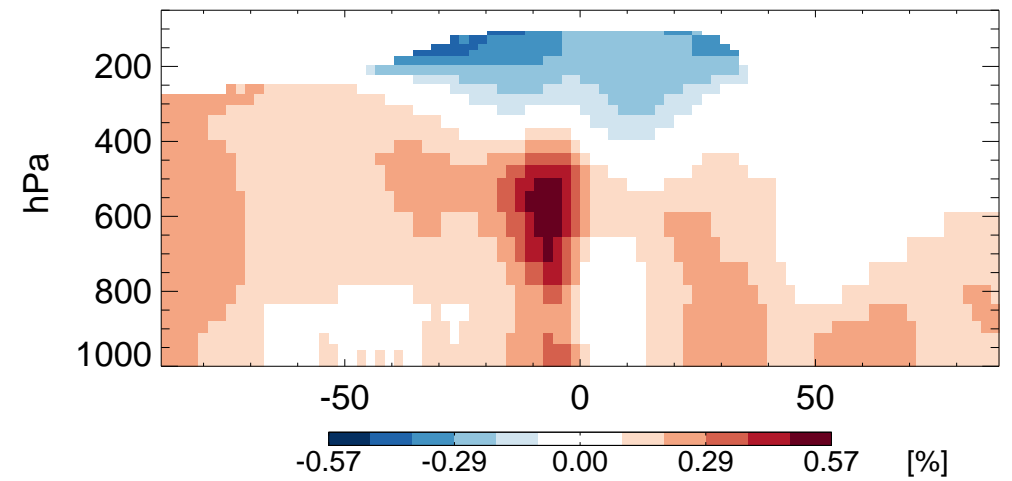
Normal Reff



Difference (#2-#1)

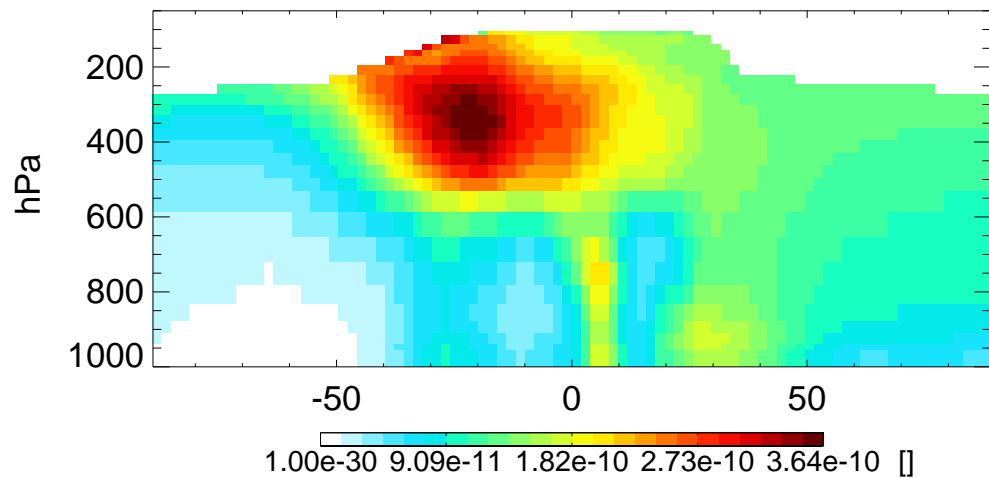


Rel. Diff. [%]

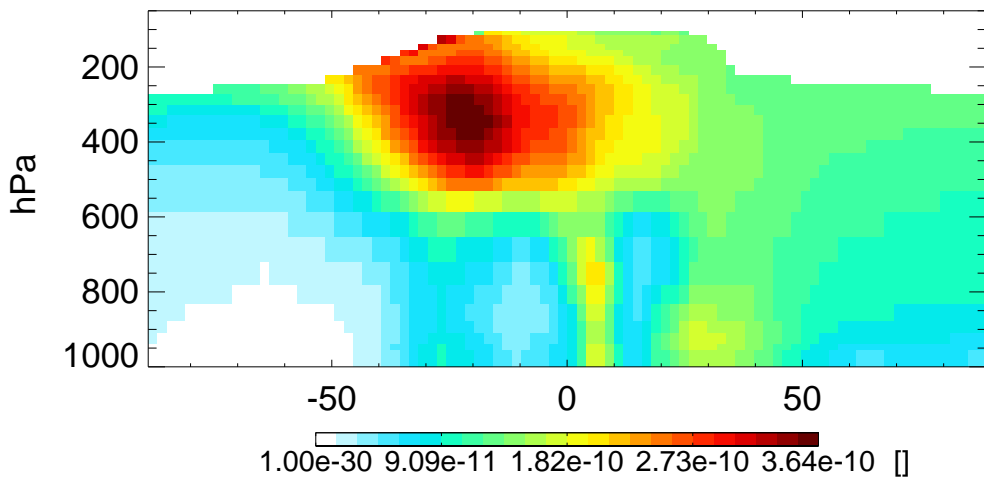


PAN ZONAL MEAN (winter)

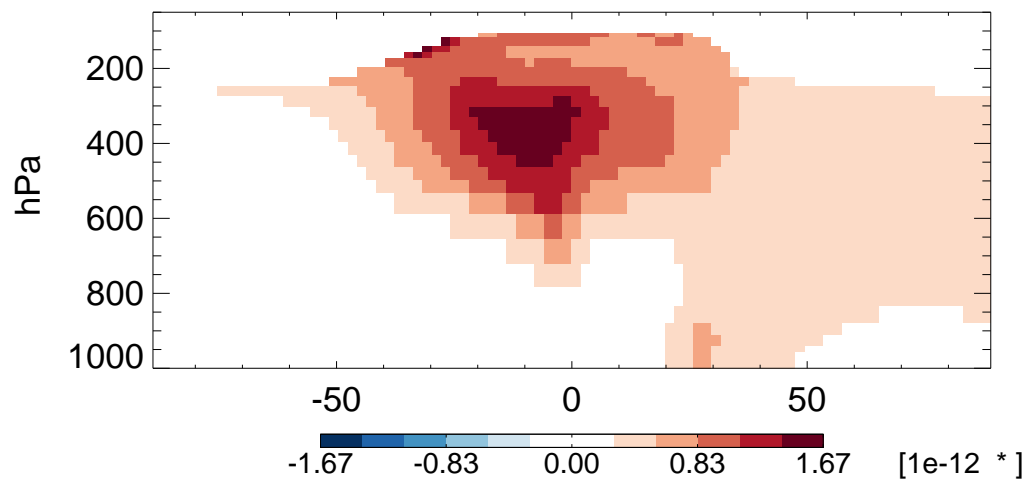
Small Reff



Normal Reff



Difference (#2-#1)



Rel. Diff. [%]

