Effects of biogenic emissions on atmospheric composition

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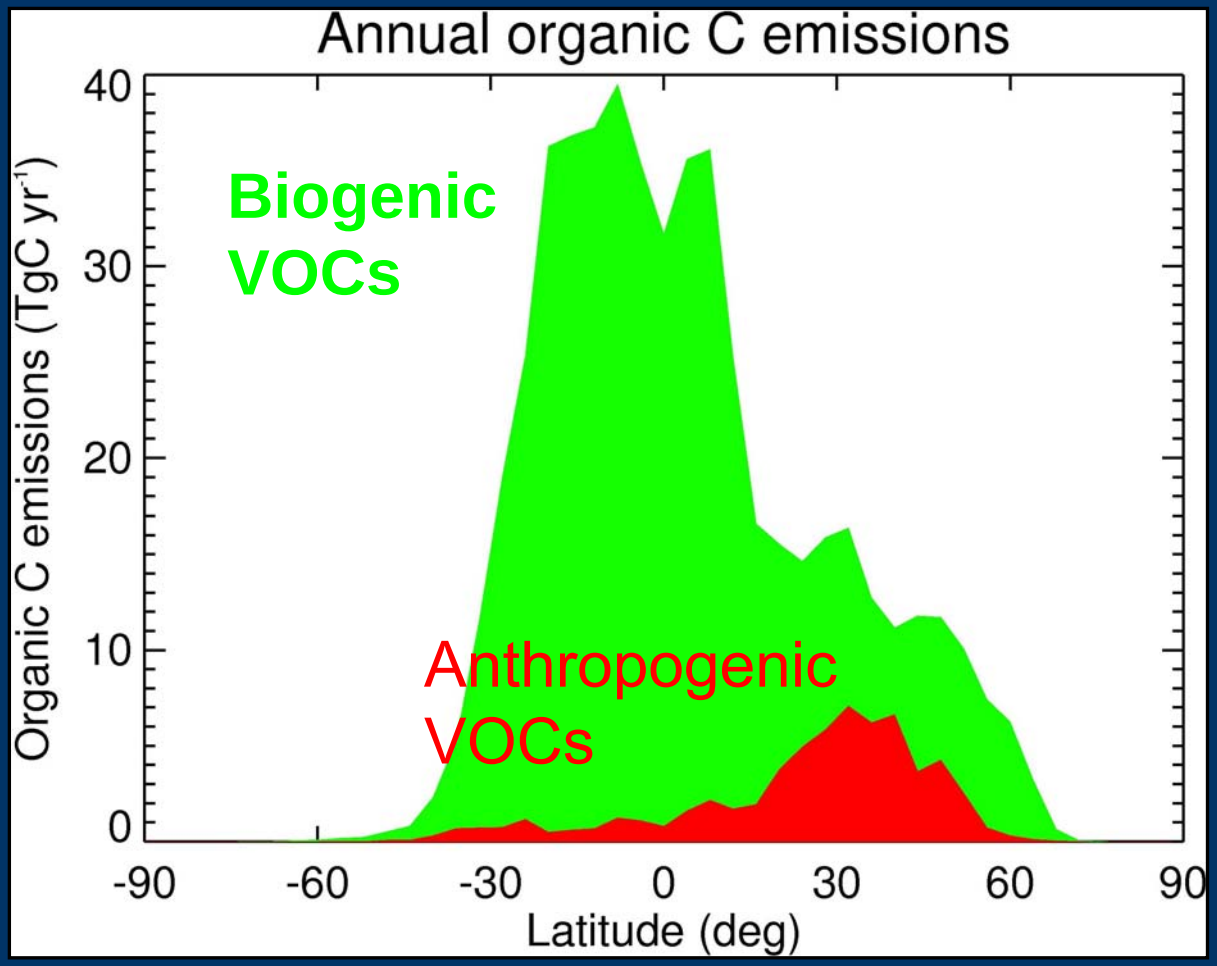
Outline

1. Why biogenic VOCs?
2. BVOCs and atmospheric chemistry
3. Future (?) BVOC emissions
    - The experiment
    - Some results
    - Some conclusions & caveats
4. Where next? (JULES)

Why are we interested?



~ 1000 Tg C yr^{-1}

Why are we interested?

May be highly reactive → large contribution to O_3 chem

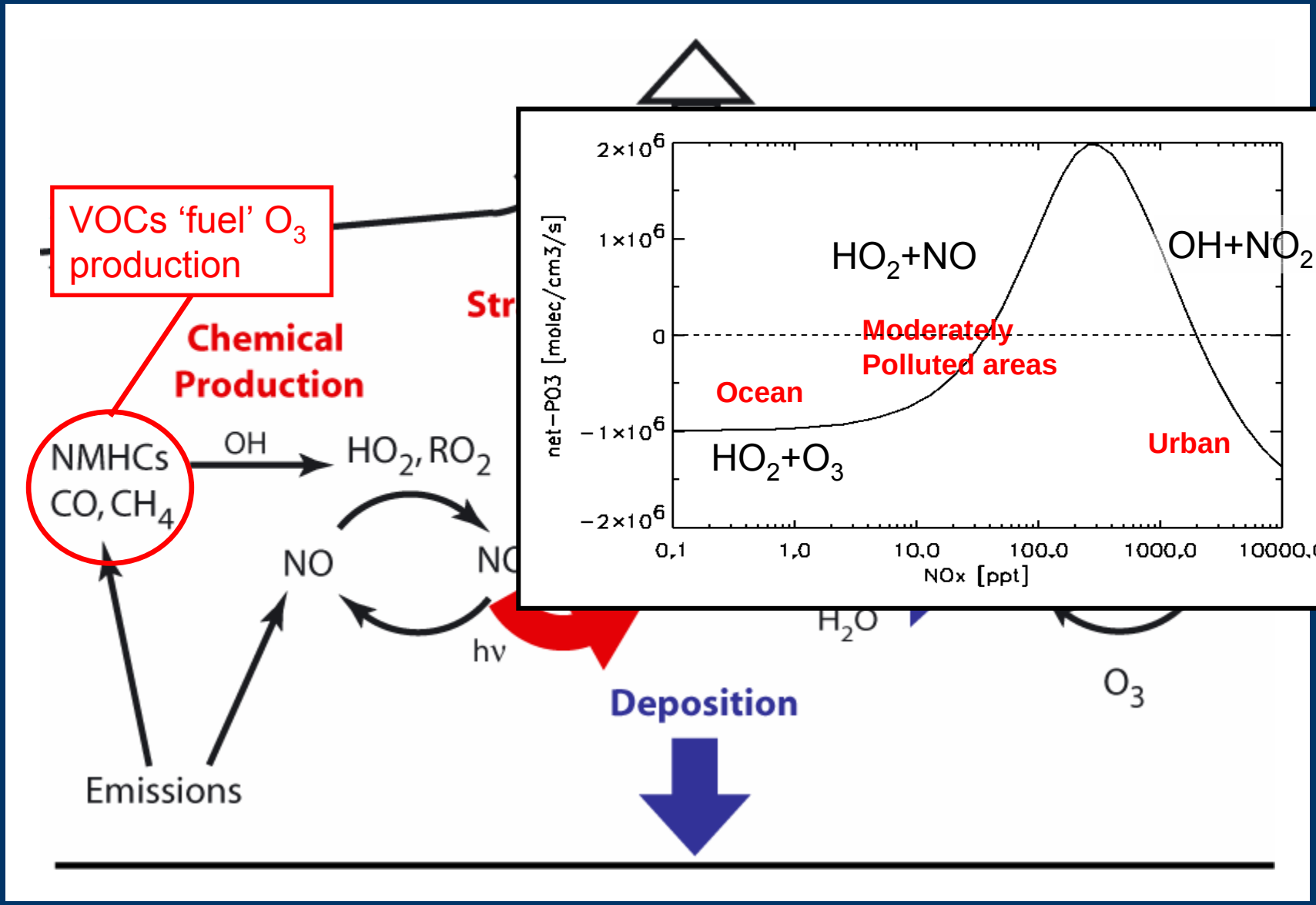
Oxidation products important globally

Ethene, acetone, methane (?), terpenes (isoprene, α-pinene, β-caryophylene

Role in organic aerosol formation

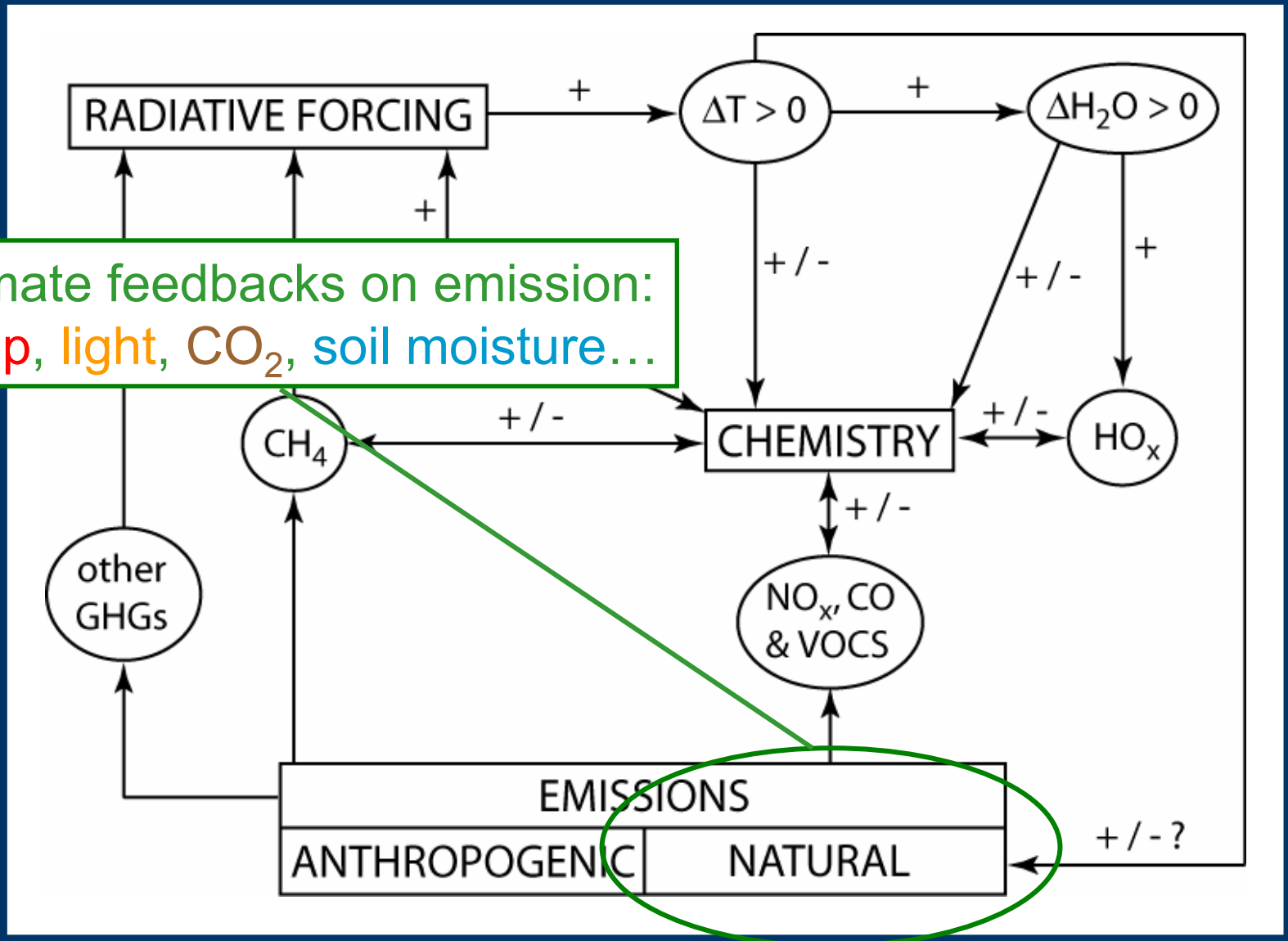
T, light, H_2O, CO_2, species, nutrients

Chemistry 101 – Tropospheric ozone



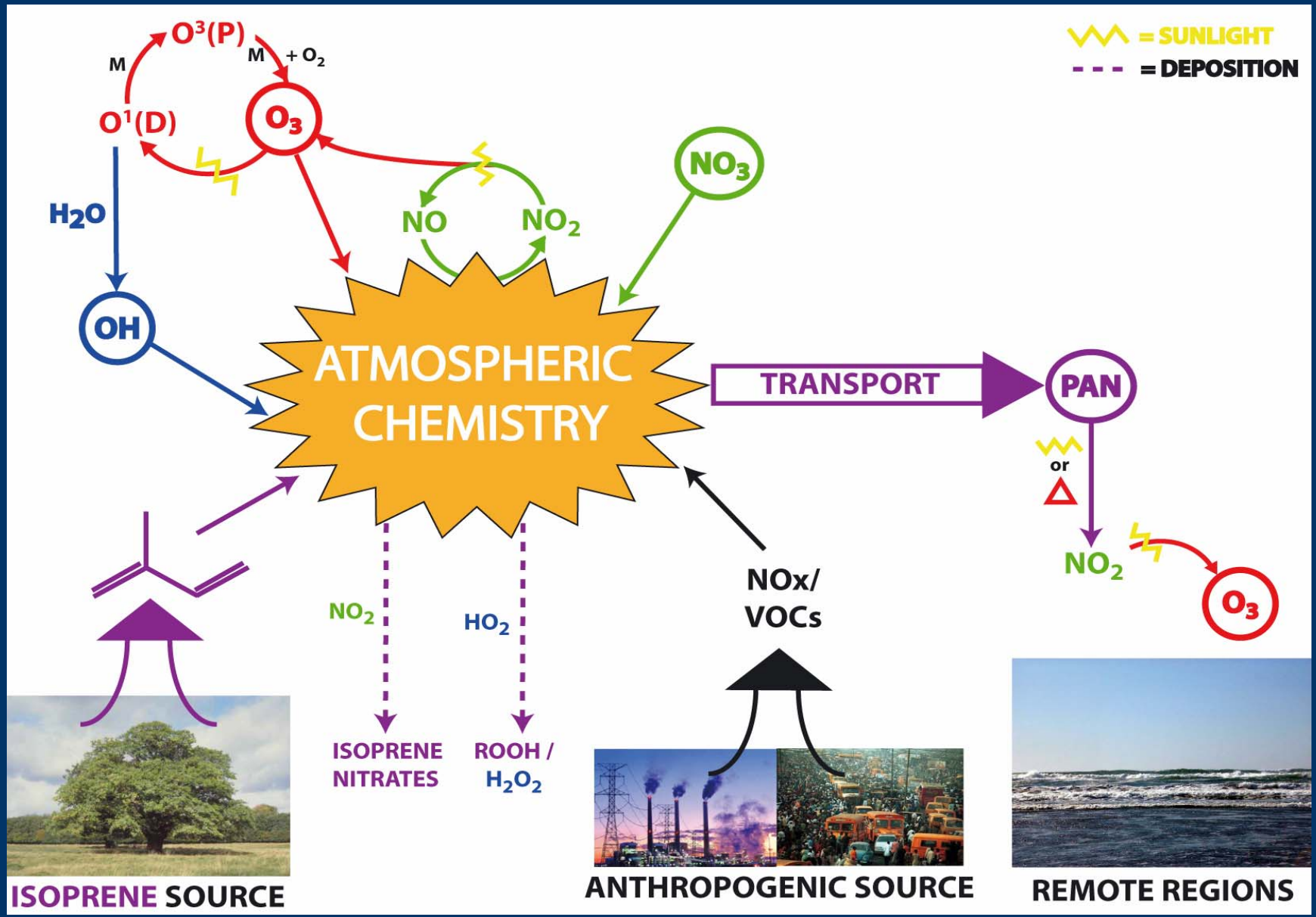
based on a diagram by Oliver Wild

Climate-chemistry links



based on Ramanathan *et al.* [1987]

Atmospheric chemistry



Increasing isoprene emissions in a pessimistic (A2) future

The experiment (a)

- Increase isoprene to a 2100 ($2xCO_2$) level using Guenther *et al.* [1995] algorithms and HadCM3 surf temperature output*

Present day

Future (2100)

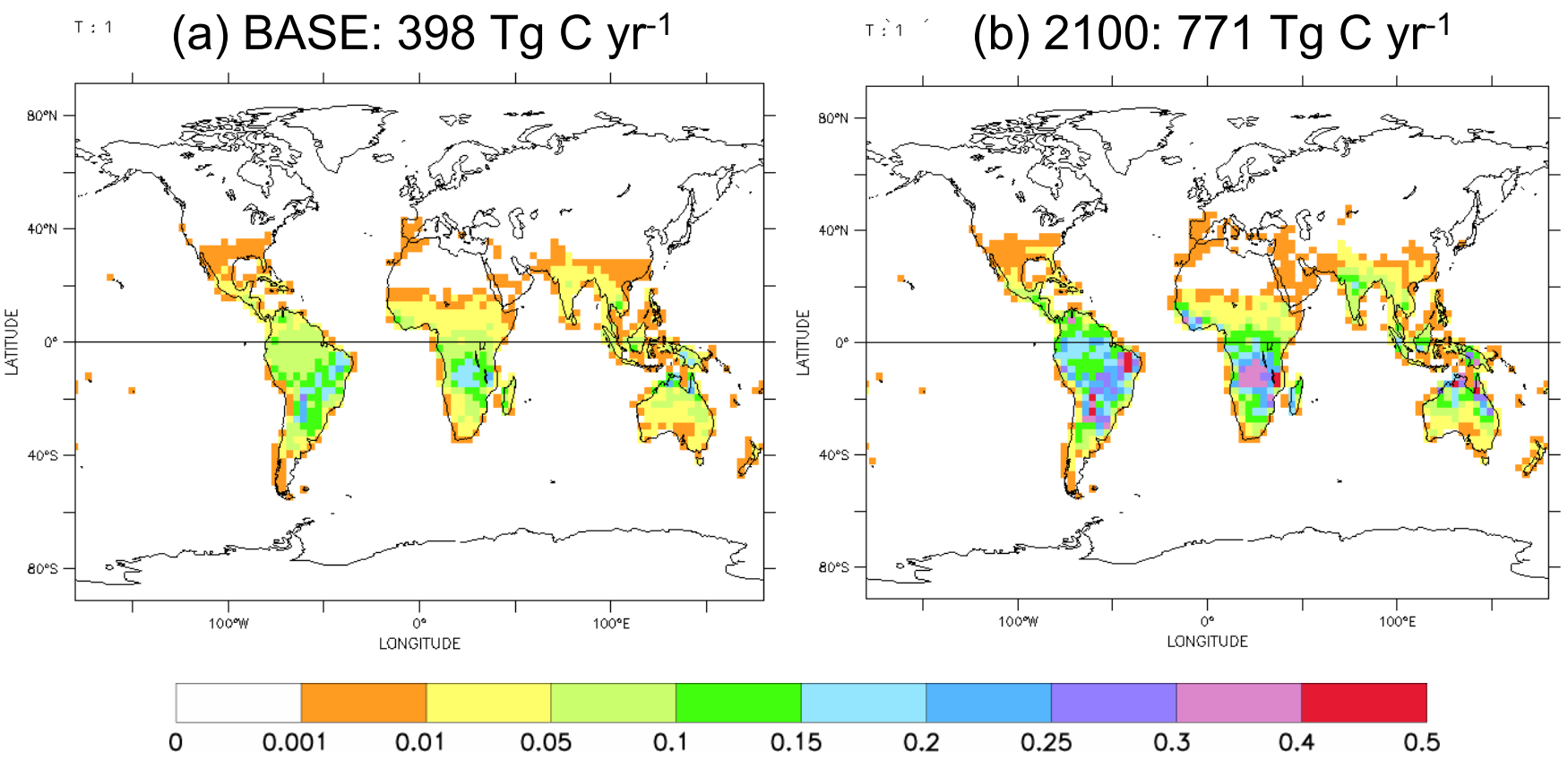
398 Tg C yr^{-1}

771 Tg C yr^{-1}

- Just consider potential isoprene response to temperature (e.g. no vegetation shifts)

*$\Delta T \sim 4K$

Isoprene emissions



Isoprene emissions / Tg month^{-1} (non-linear scale!)

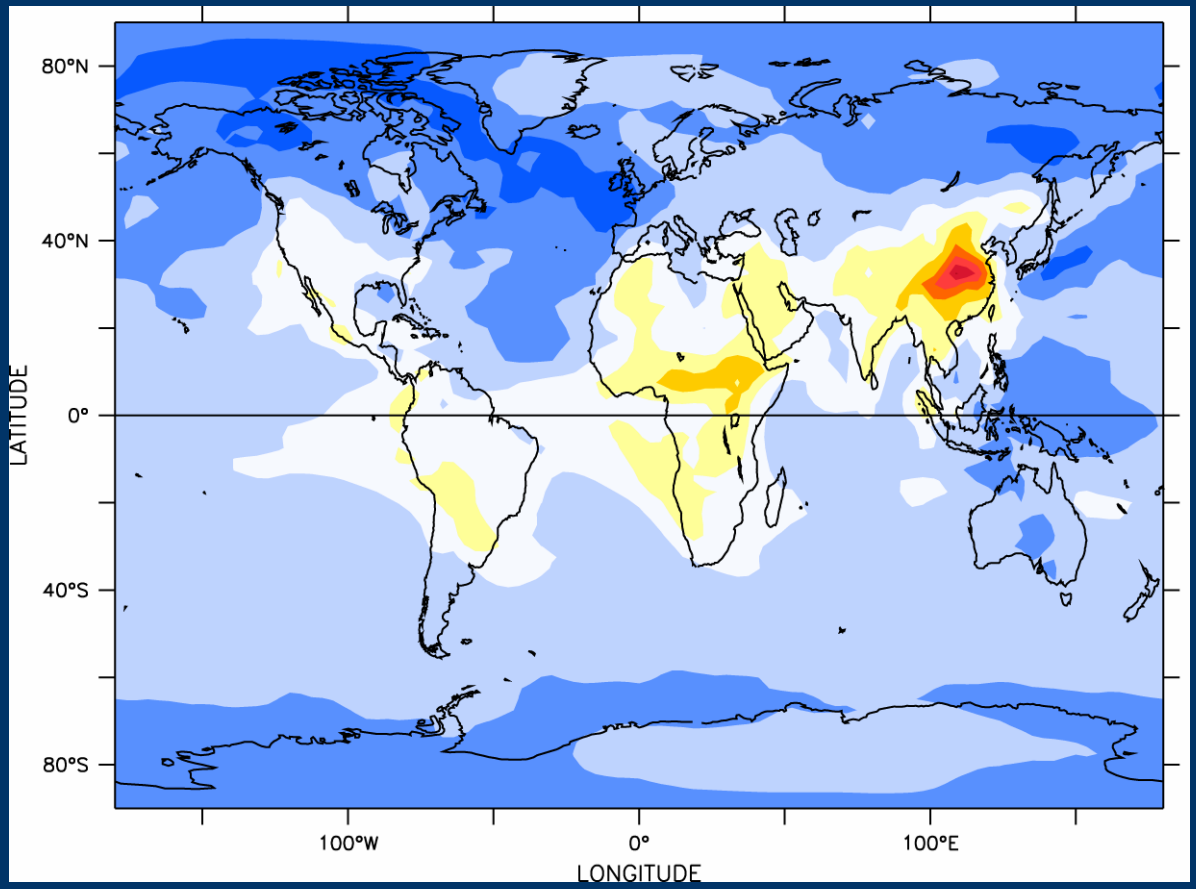
The experiment (b)

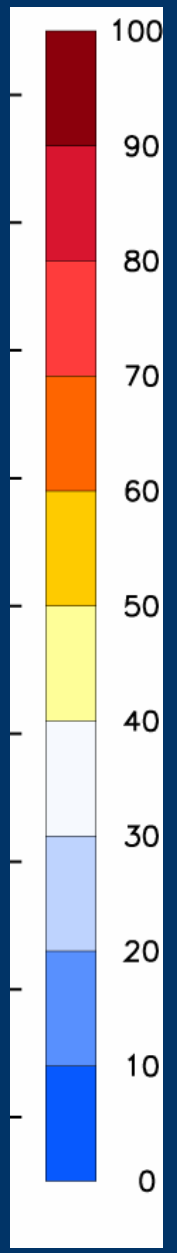
- Experiment matrix

	"Anthro."*	Isoprene	Climate
BASE	2000	2000	2000
ISOP	2000	2100	2000
ANTH	2100	2000	2000
ALL	2100	2100	2000
ALLcc	2100	2100	2100

*e.g. NO_x, CO, NMHCs (all non-isoprene emissions); based on SRES A2 Scenario

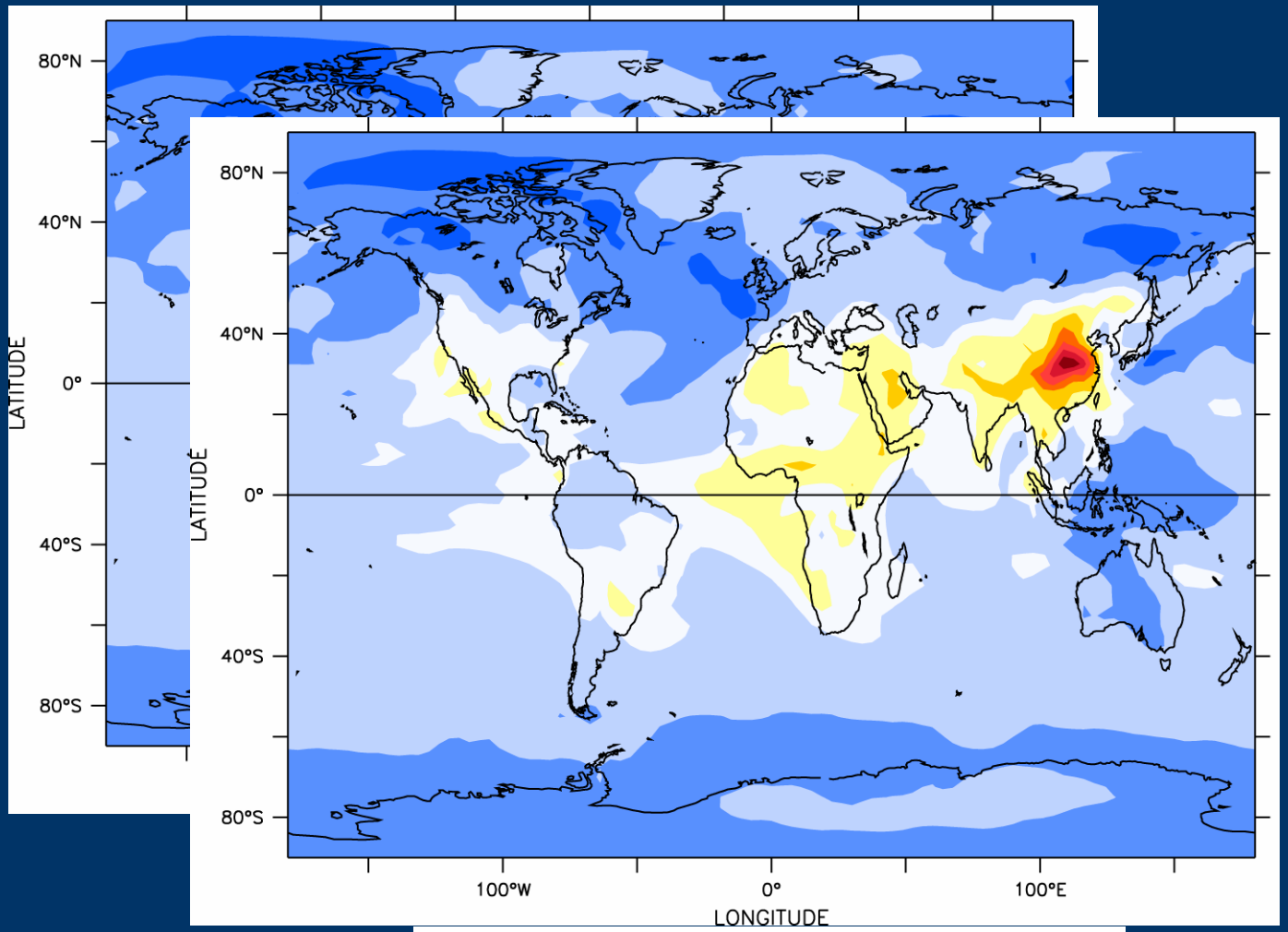
ΔO3 boundary layer [Jul] / ppbv

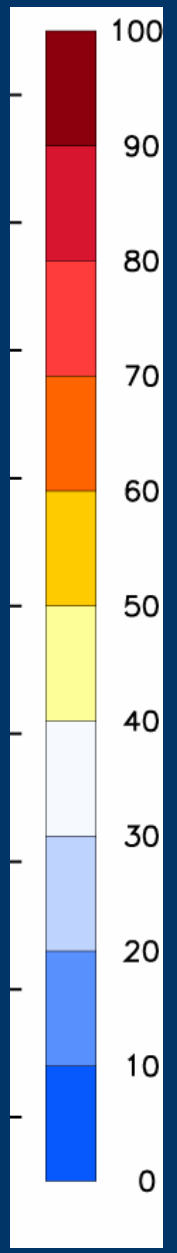




ANTH - BASE

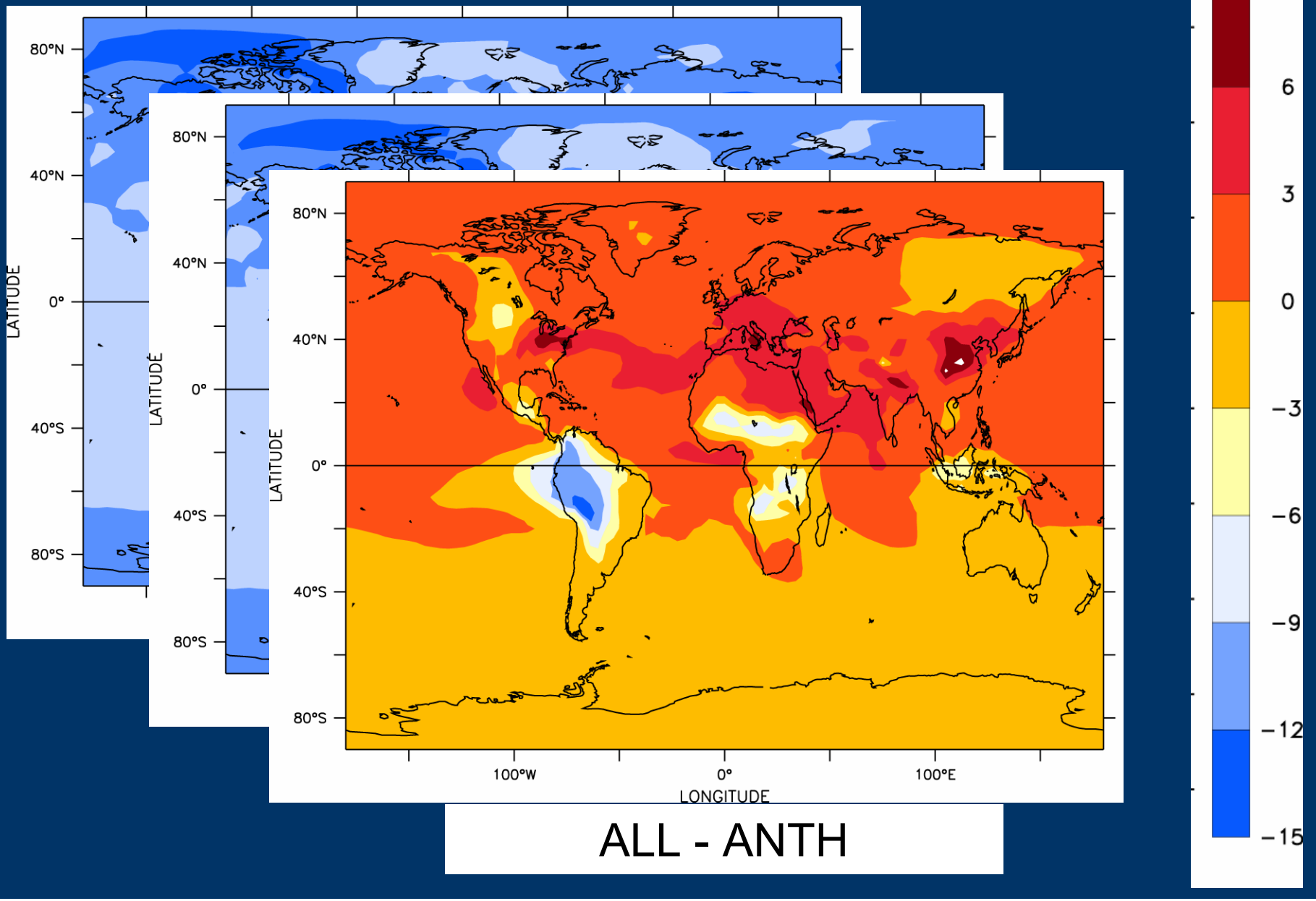
ΔO3 boundary layer [Jul] / ppbv





ALL - BASE

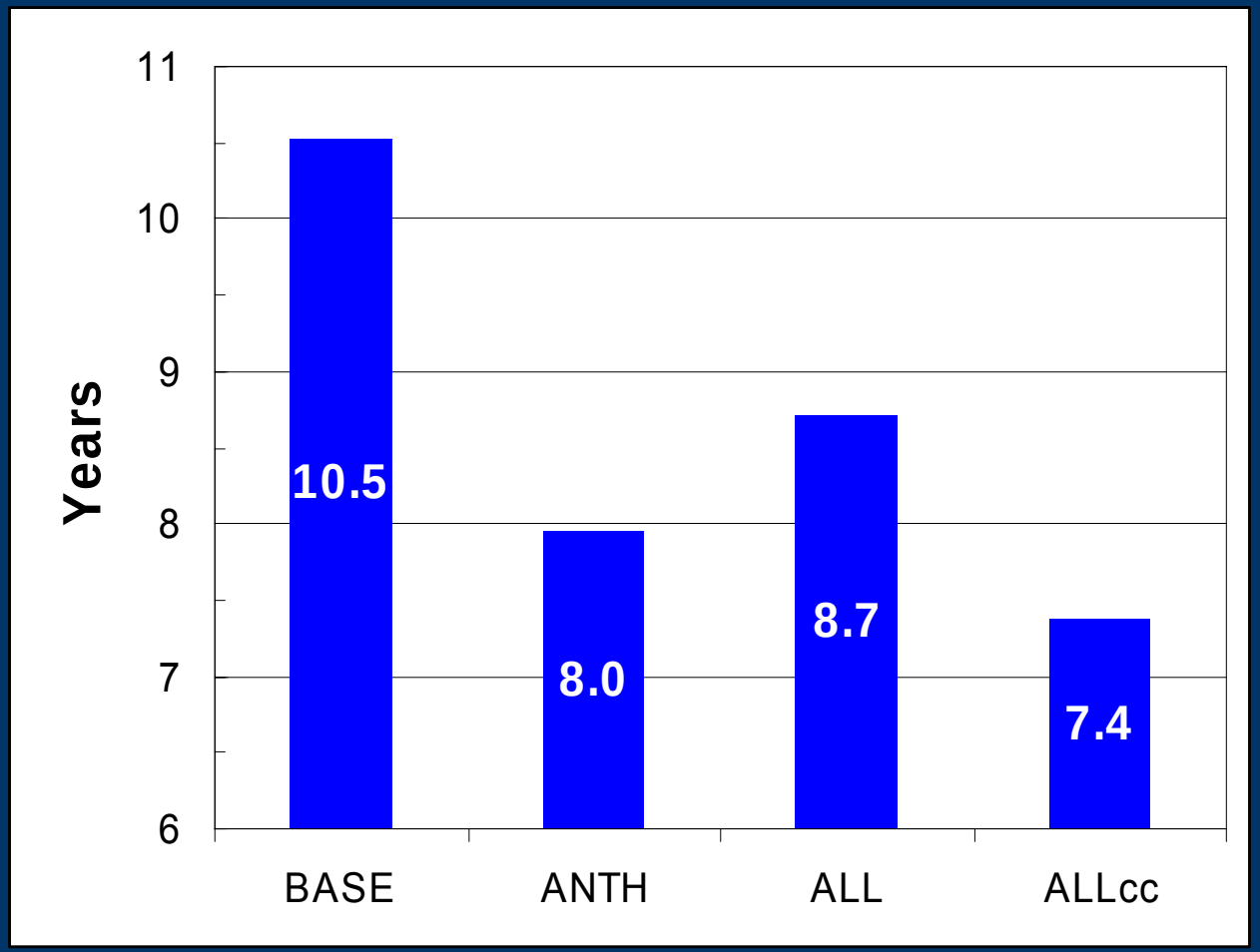
ΔO3 boundary layer [Jul] / ppbv



ALL - ANTH

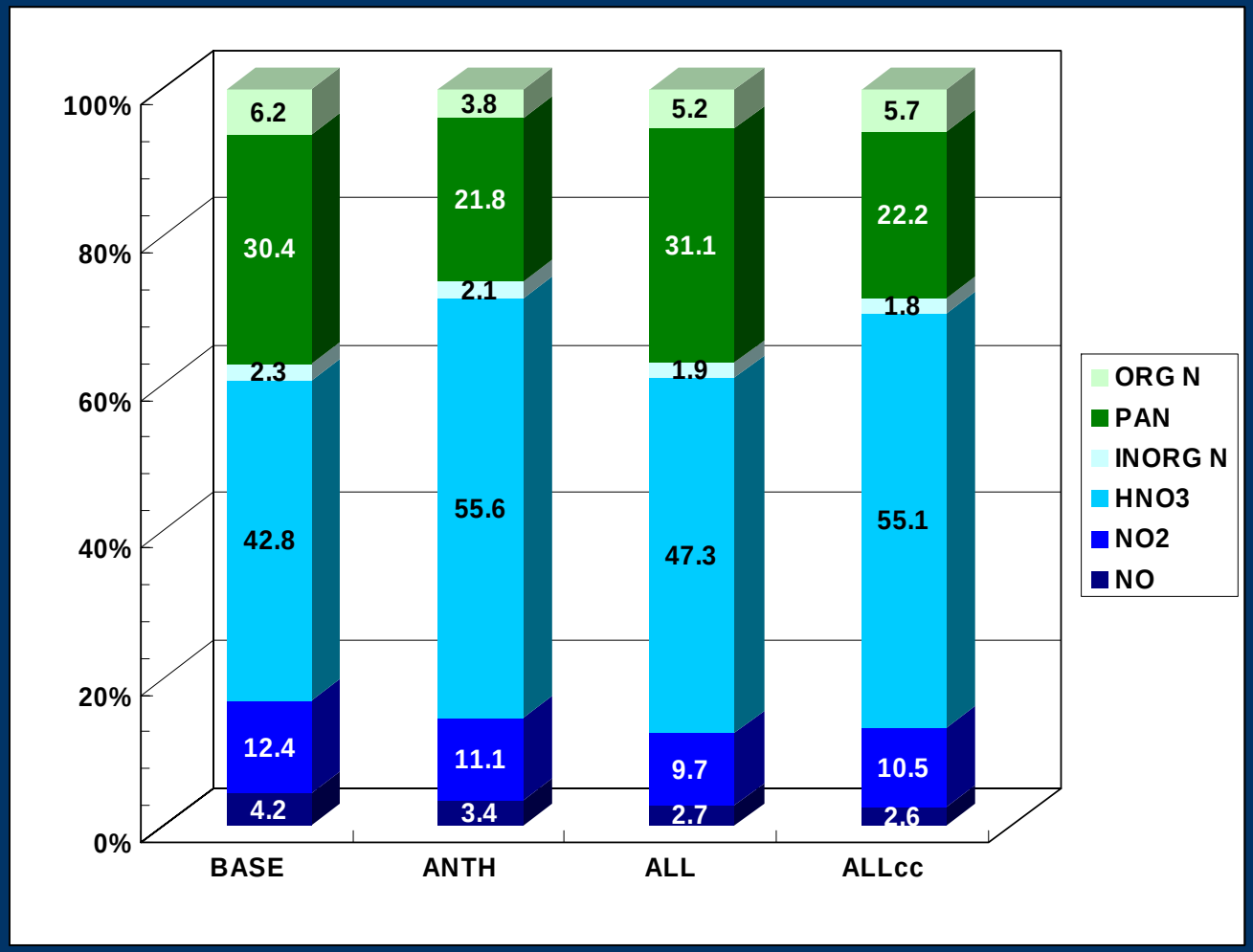
Tropospheric methane lifetime [Yr avg]

Impact of OH changes…



Tropospheric NO_y speciation [Yr avg]

What is the potential for NO_x redistribution?



	Tg N (as NO_y)
BASE	1.15
ANTH	2.92
ALL	3.09
ALLcc	2.60

Conclusions & Caveats

- Isoprene changes are important for atmospheric composition [Sanderson *et al.*, 2003; Hauglustaine *et al.*, 2005; Steiner *et al.*, 2006; Wiedinmyer *et al.*, 2006]

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- Impact is heterogeneous and complex: balance of HO_x and NO_y changes; depend on chemical characteristics of the region → sensitive to future emission estimates

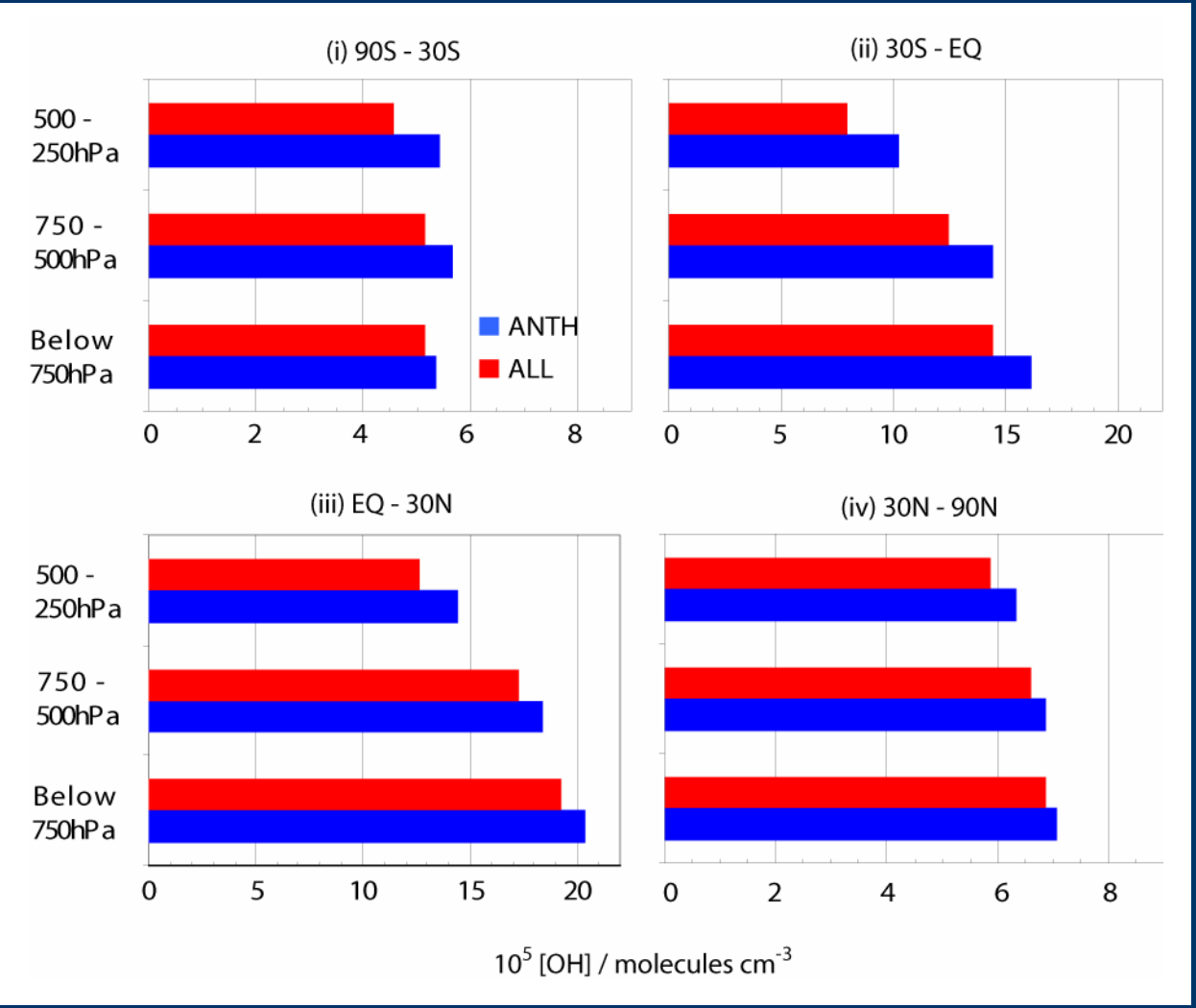
Conclusions & Caveats

- Isoprene changes are important for atmospheric composition [Sanderson *et al.*, 2003; Hauglustaine *et al.*, 2005; Steiner *et al.*, 2006; Wiedinmyer *et al.*, 2006]
- Impact is heterogeneous and complex: balance of HO_x and NO_y changes; depend on chemical characteristics of the region → sensitive to future emission estimates
- **But** models obviously over-simplify the problem: chemistry, canopy processes, sub-grid scale phenomena, vegetation-climate feedbacks, *etc. etc.*

Where next?

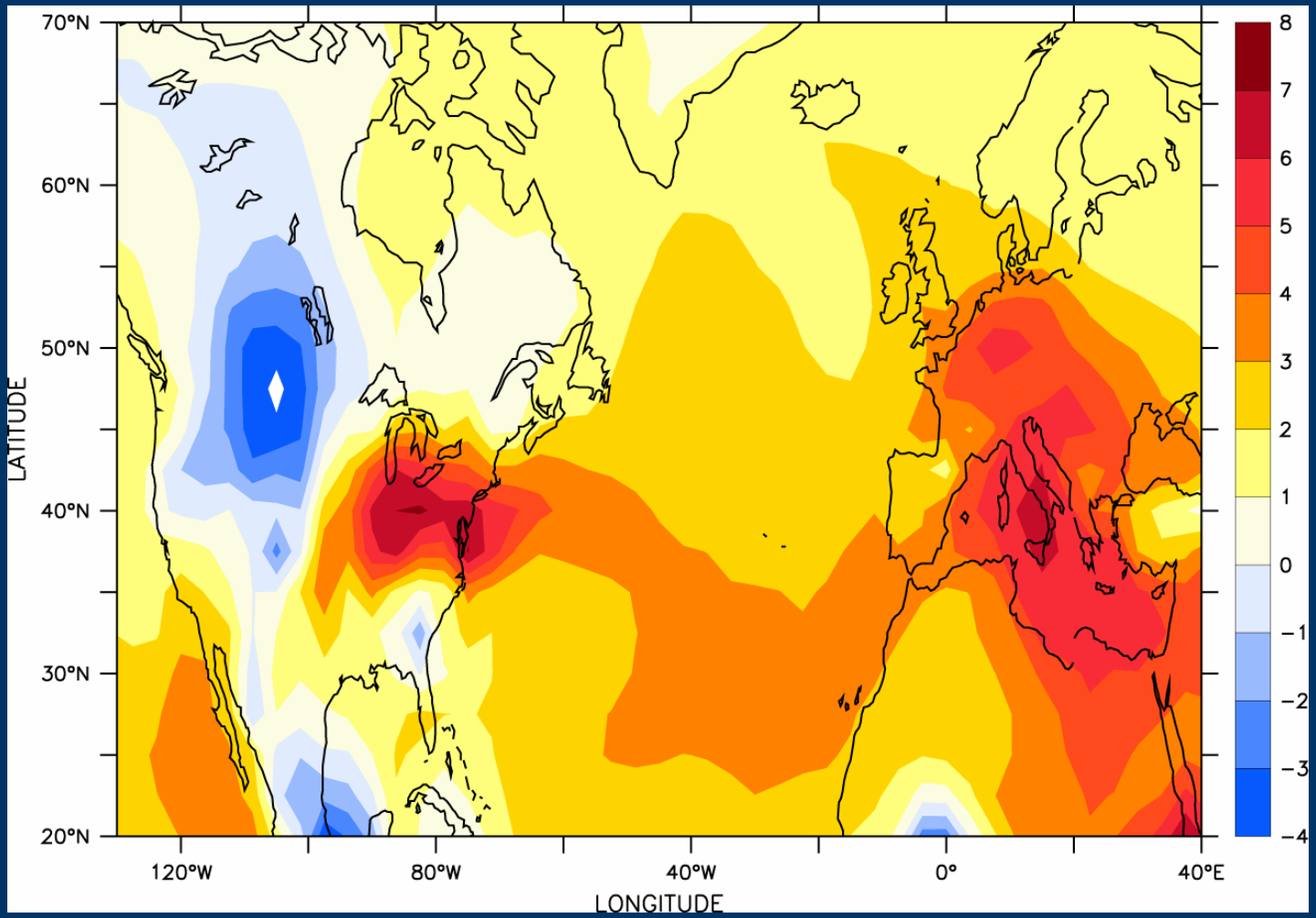
- Conducting model study using emissions estimated from LPJ-GUESS [Arneth *et al.*, 2007]
- Comparison with results from Juliette *et al.*'s work with **JULES** ('ensemble chemistry/emissions')
- …If isoprene CO_2-effect counteracts T effect, **changes in land use** become important

Tropospheric OH [Yr avg]

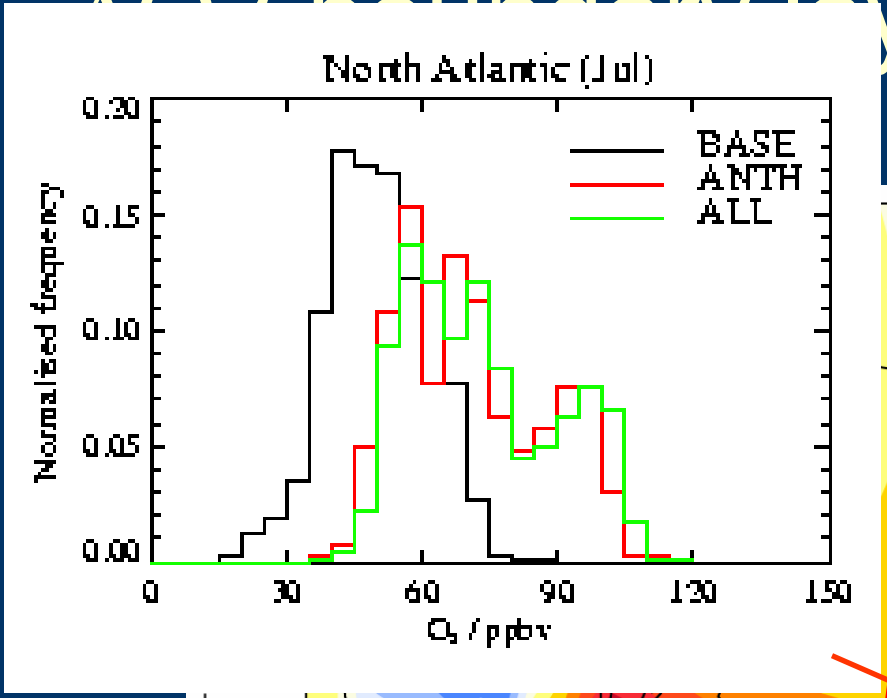


ALL *versus* ANTH

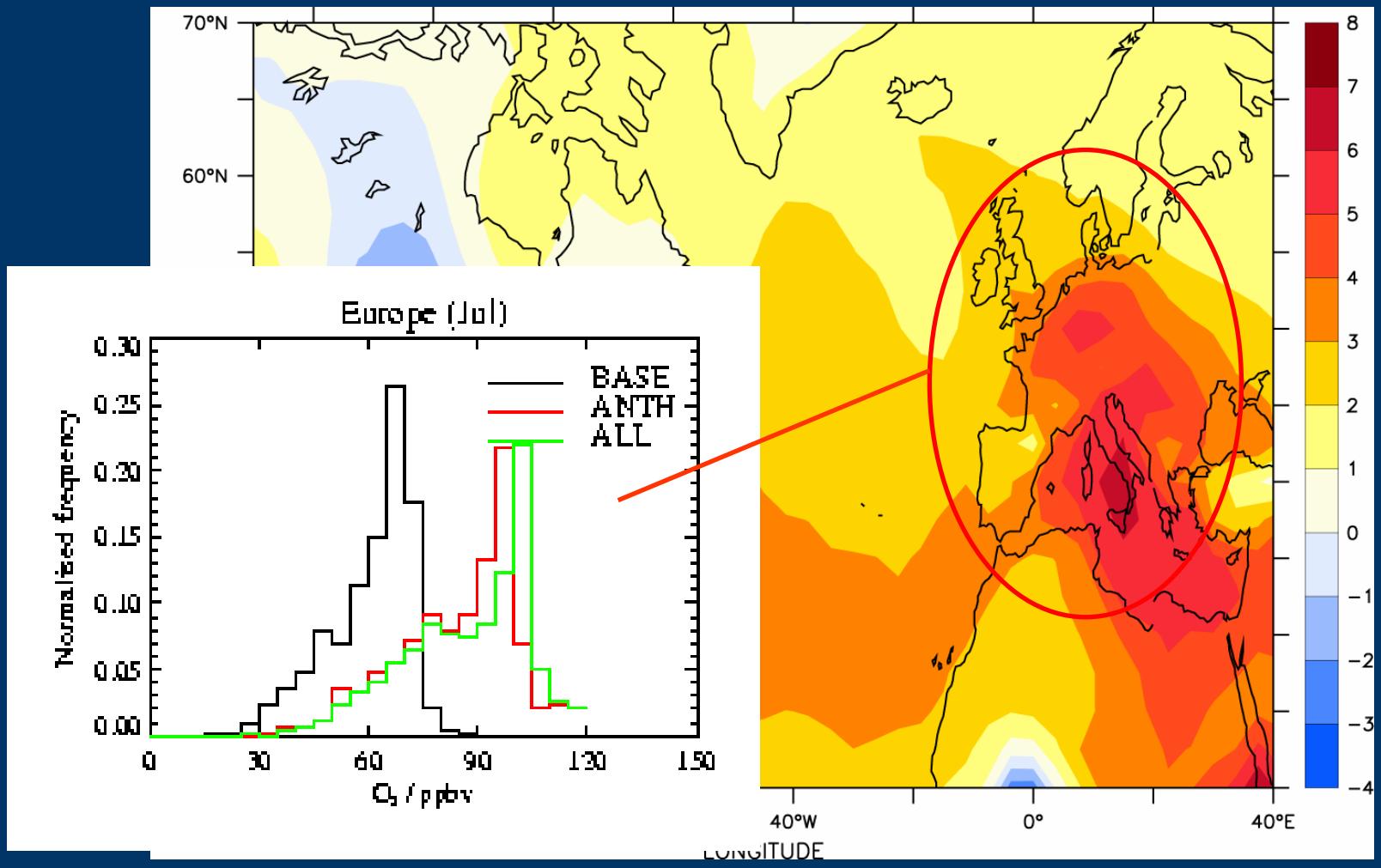
ΔO3 boundary layer [Jul] / ppbv



AQ2 boundary layer [Jul] / ppbv



ΔO3 boundary layer [Jul] / ppbv



ΔO3 boundary layer [Jul] / ppbv