

# Aviation climate impacts: a summary of ongoing European research programmes

David S Lee, Director

Centre for Air Transport and the Environment

Manchester Metropolitan University

*ICAS, 16<sup>th</sup> September, 2008*



# Overview

- European projects: Quantify
- European projects: ATTICA
- European projects: ECATS

# Overview - Quantify



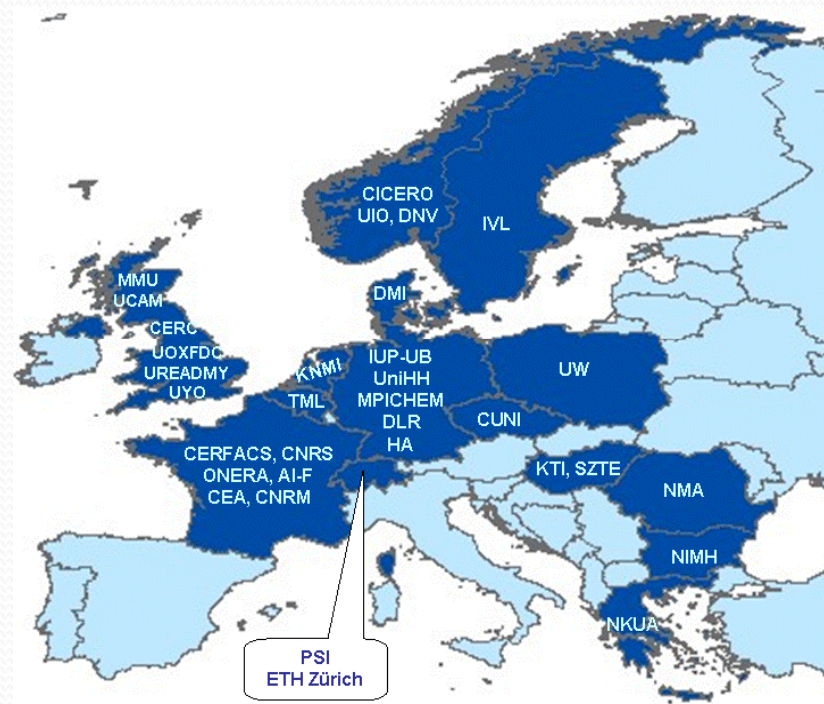
- Sponsored by the European Commission and partners; **‘To Quantify the climate impacts of the global and European transport systems for the present situation and for different scenarios of future development’**
- Aviation, road transport and shipping
- Coordinator: DLR (De), 35 partners from 16 countries funding €12M (total), €8M (European Commission)



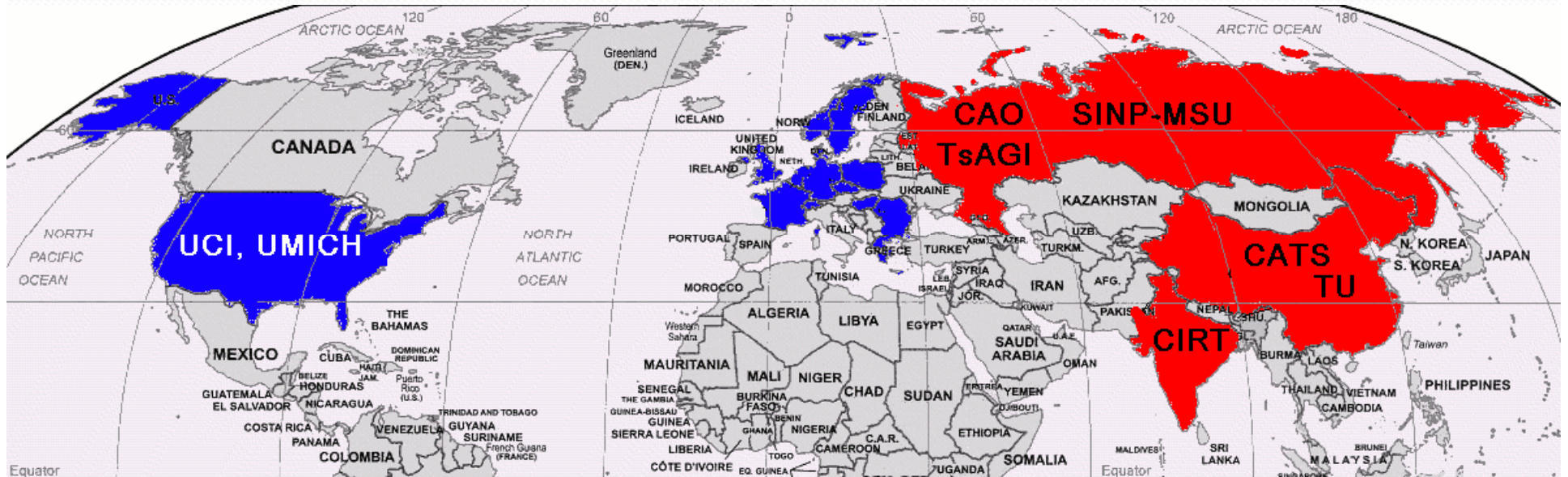
# Overview - Quantify

Co-ordinator: Sausen, DLR-IPA  
Participants: 35 from 16 countries  
Duration: March 2005 to February 2010  
Funds: 8.0 M€  
Total costs 12.0 M€

UCI  
UMICH

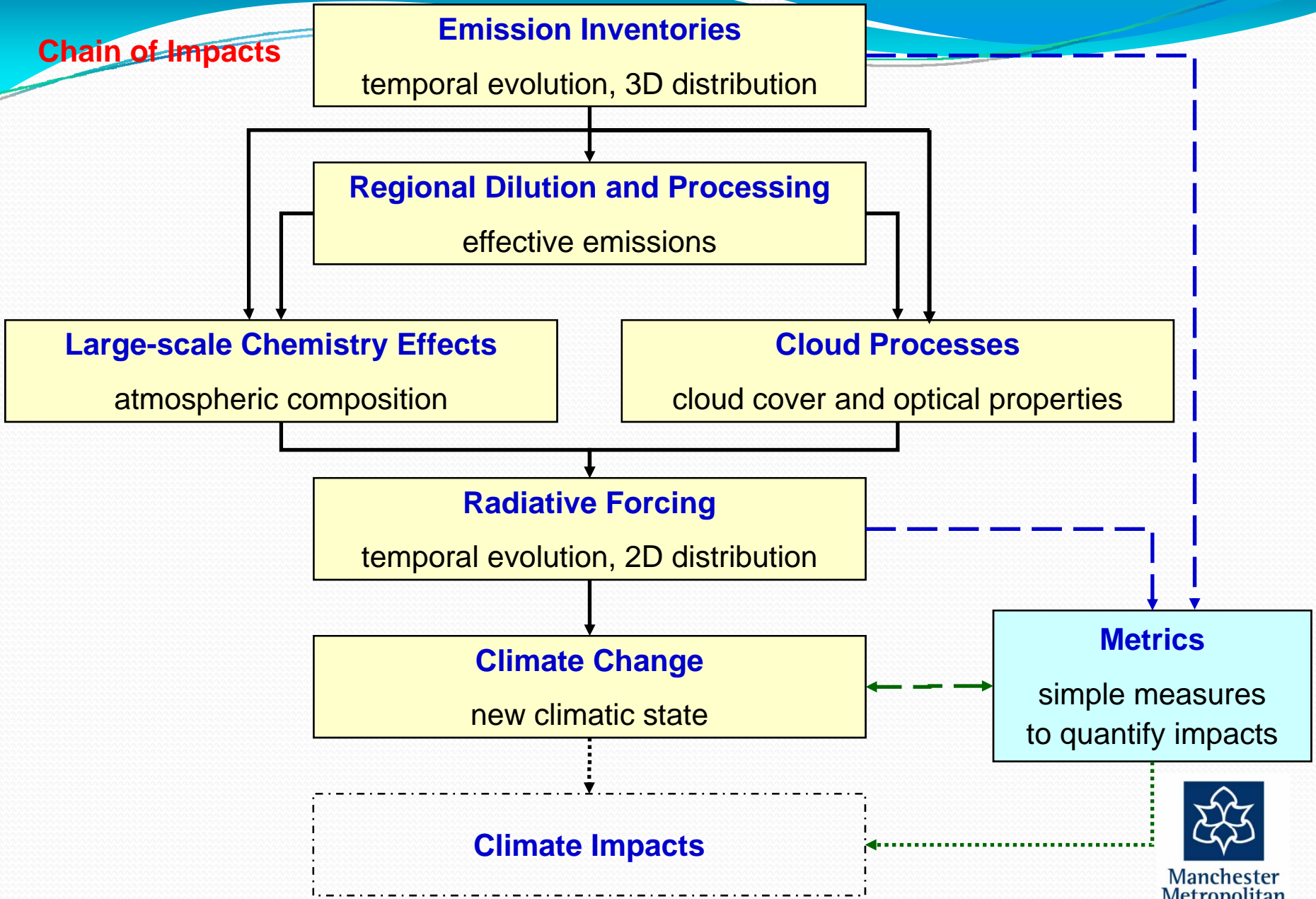


# Overview - Quantify



Participants:	41	from 19 countries
Funds:	8.4	M€
Total costs:	12.8	M€

**Chain of Impacts**



# Overview - ATTICA

- European projects: ATTICA
- EC FP6 Specific Support Action
- Sponsored by the European Commission and partners; **‘European Assessment of Transport Impacts on Climate Change and Ozone Depletion’**
- Scope: **to provide a coherent series of authoritative assessments of the impact of transport emissions on climate change and ozone depletion**
- Aviation; shipping; land transport; metrics; synthesis



# Overview - ATTICA

**Chair** – Robert Sausen

**Aviation** – David S. Lee, Gianni Pitari

**Land Transport** – Jos Lelieveld, Tomas Halenka

**Shipping** – Ivar Isaksen, Verkonika Eyring

**Metrics** – Jan Fuglestvedt, Keith Shine

**Synthesis** – Robert Sausen





# Overview - ATTICA



- Authors:
- Participation: Aviation (13, 6c), Shipping (10, 6c), Land (13, 7c), Metrics (9, 5c), Synthesis (9, 5c)
- Status: all assessments submitted to Atmospheric Environment and under review
- Review is 'open' process between CLAs and reviewers at meeting



# Overview - ECATS

- Aeronautical/environment EC 'Network of excellence' – NOT research - facilitation
- Funding: EC, partners, €10M (5 years)



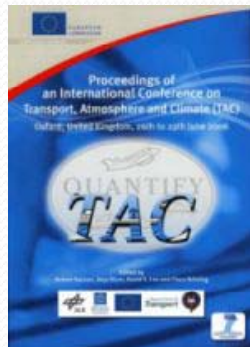
International conference  
**'Transport, Atmosphere and Climate'**



Oxford, United Kingdom  
25 - 30 June, 2006

<http://www.pa.op.dlr.de/tac/>

**Proceedings have appeared!**



# Quantify summer school

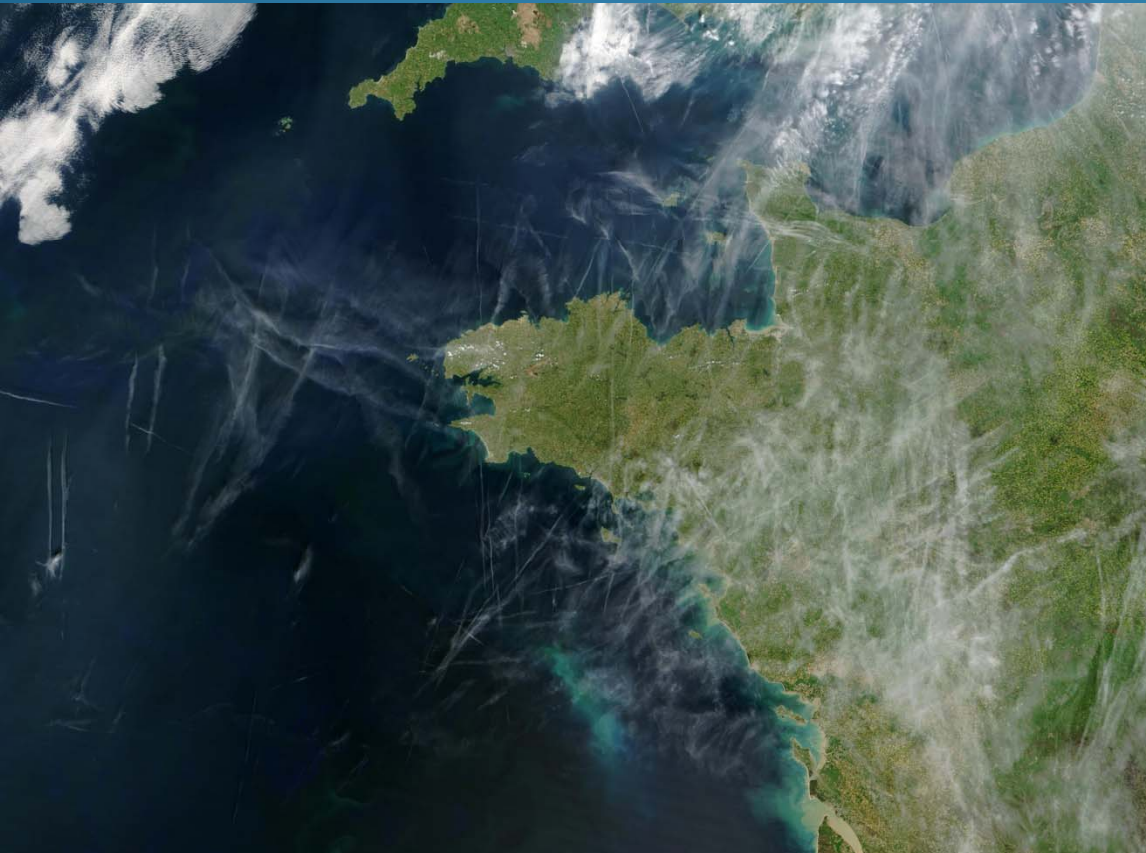


Quantify summer school , Athens, Greece (10 to 21 September 2007) preceding the celebration of the 20<sup>th</sup> anniversary of the Montreal Protocol



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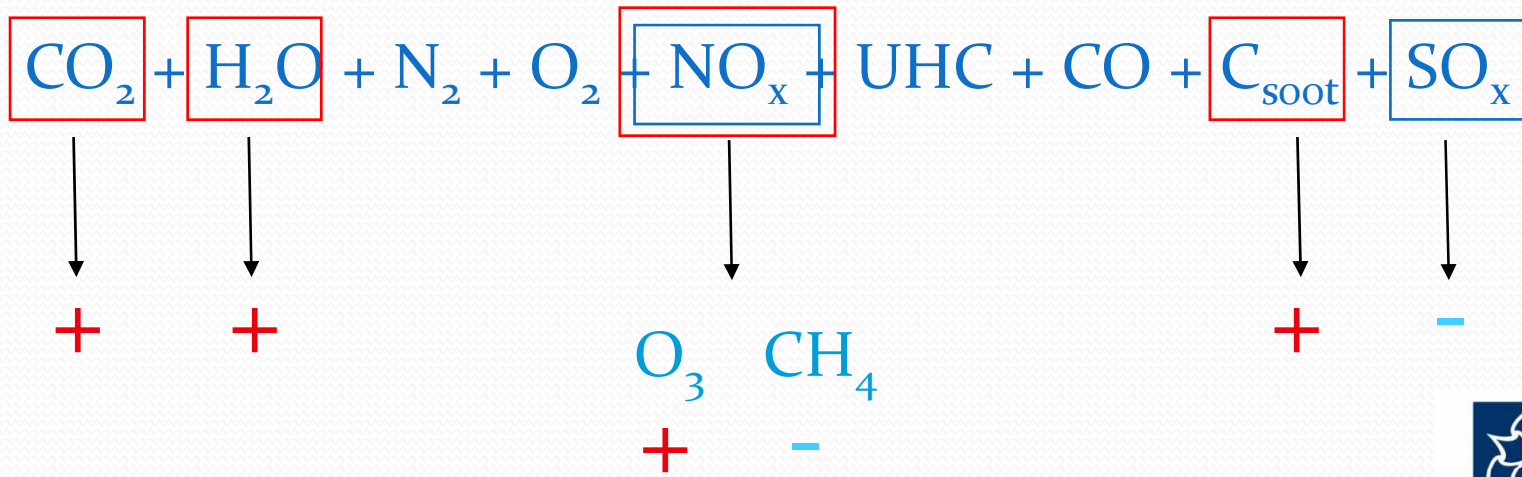
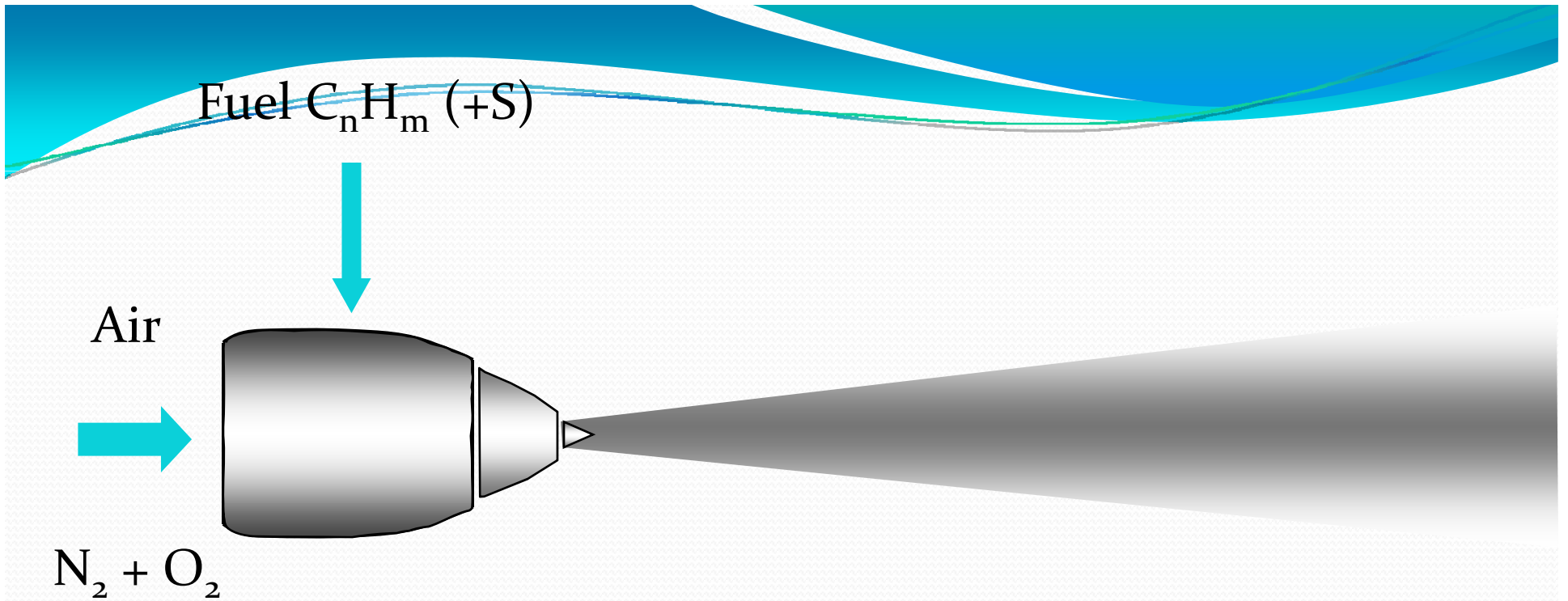
# Some science aspects and results



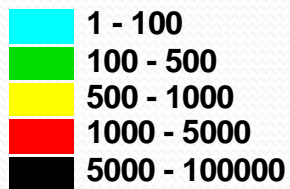
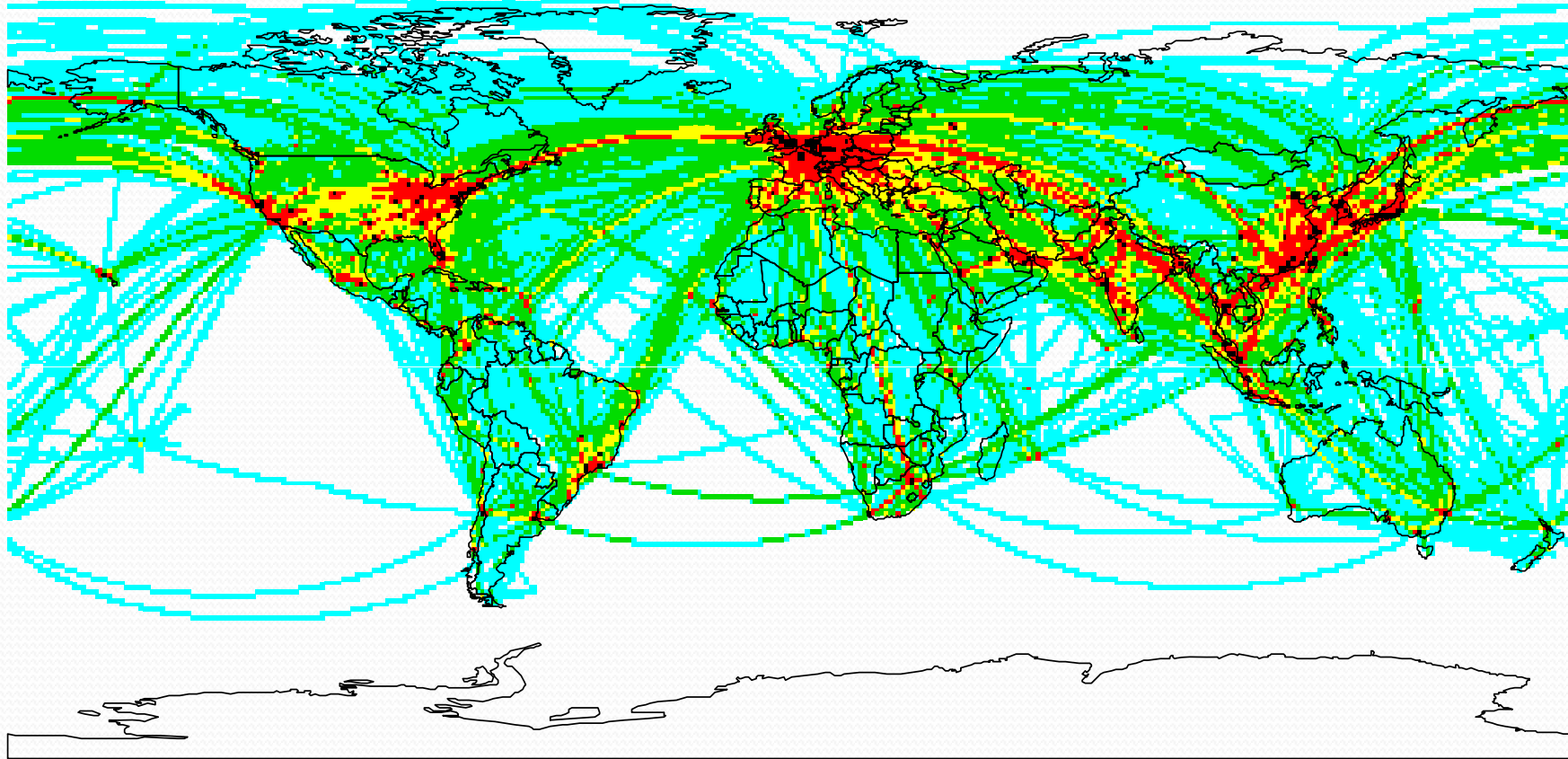
## Radiative forcing – a climate metric

- Radiative forcing is an index of the importance of a factor as a potential climate change mechanism
- It is expressed in watts per square metre ( $\text{W m}^{-2}$ )

$$\Delta T_{\text{surface}} = \lambda RF_{\text{trop}}$$



# Aviation Scenario 2050A1i - NOx (kg per degree grid cell per year)

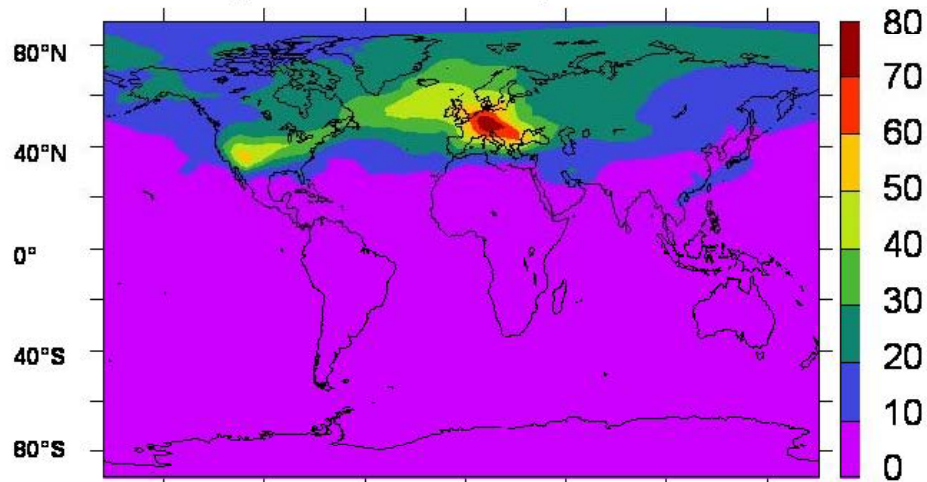


New data from flights in Russia being prepared

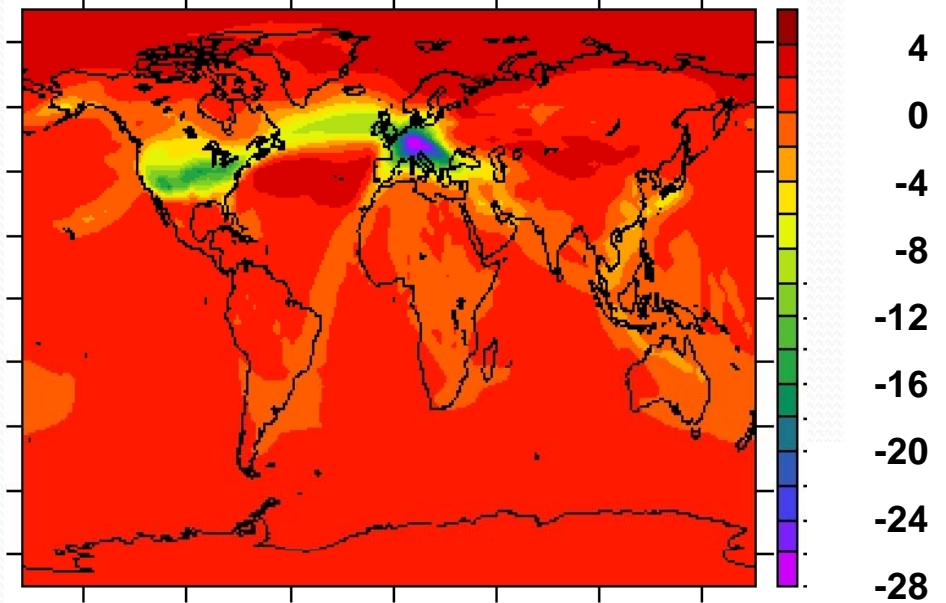
Quantify Activity 1 – Emissions



## NO<sub>x</sub> change (ppt<sub>v</sub>) at 240 hPa



## NO<sub>x</sub> change (ppt<sub>v</sub>) – 240 hPa



Quantify Activity 2 – Plume Processes

# Precipitation impact on $\text{HNO}_3$

LMDZ model

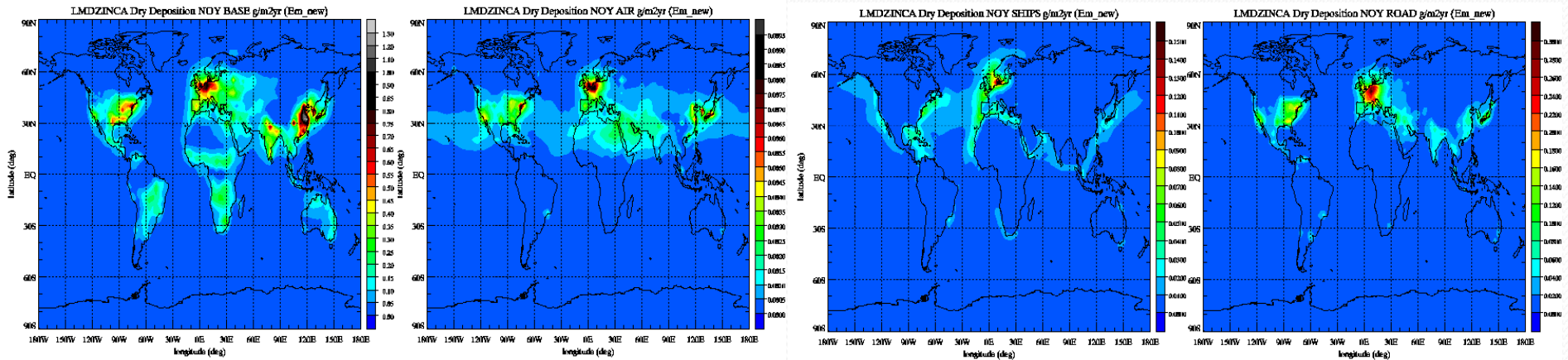
## Dry deposition

All emissions

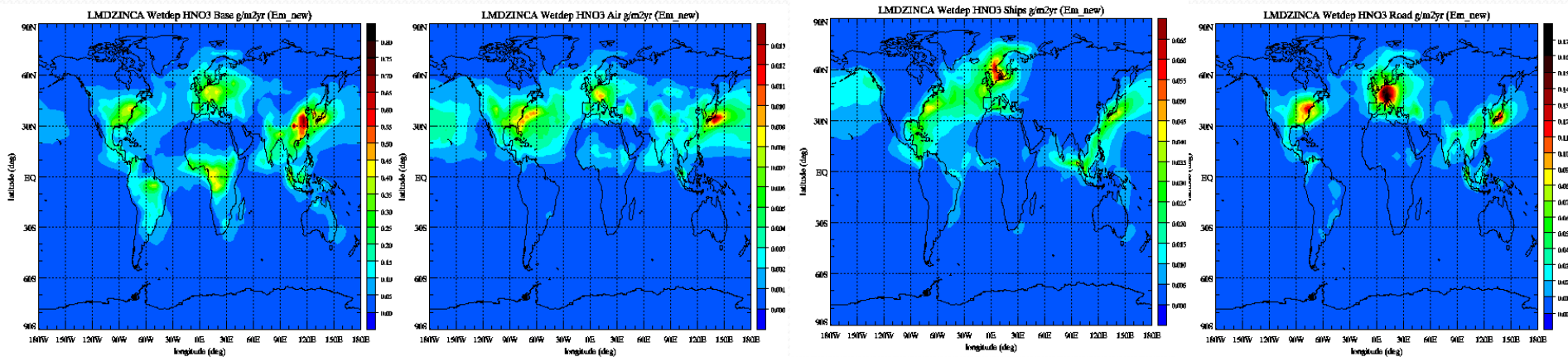
Aircraft

Ships

Road traffic

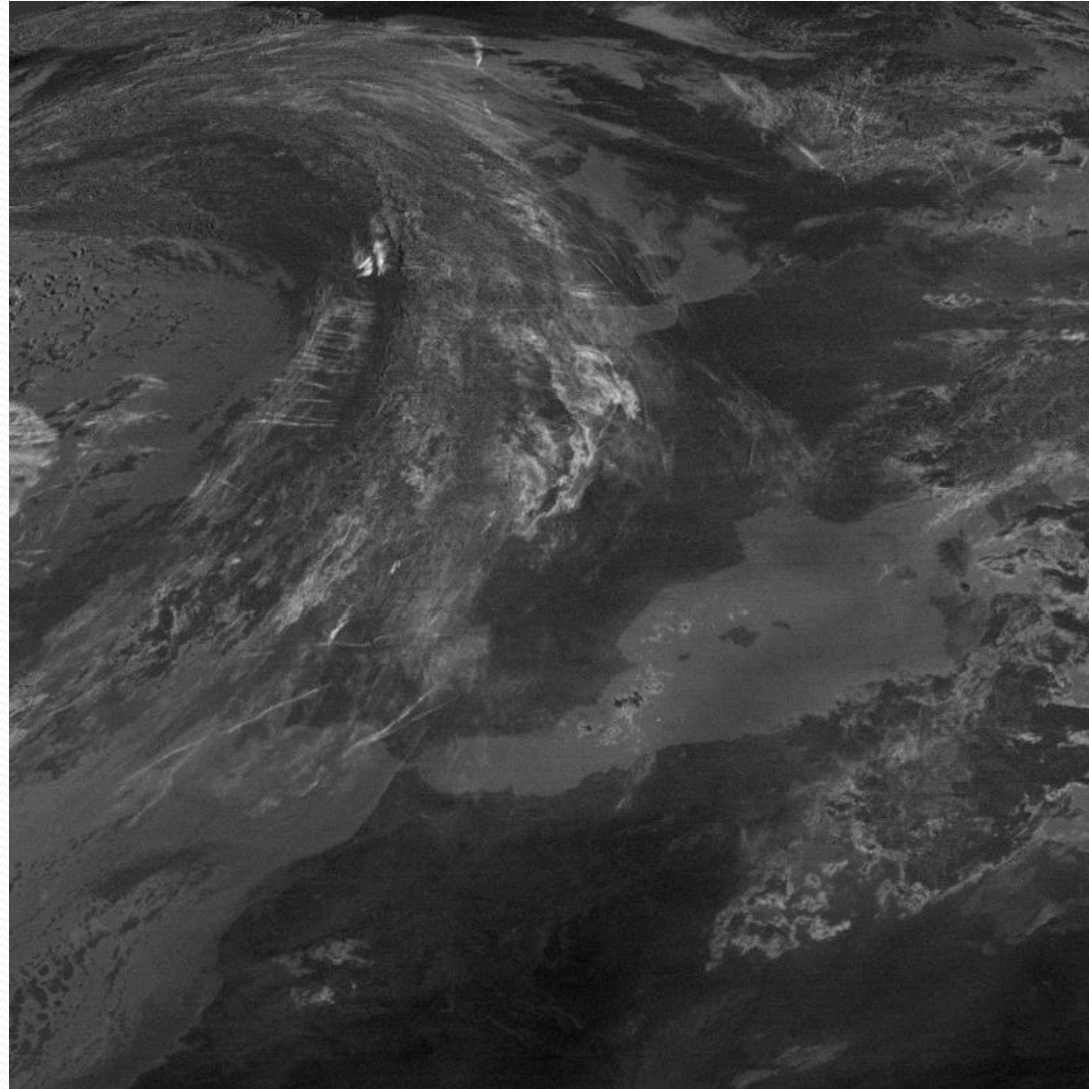


## Wet deposition



- Ship and road emissions deposited close to source: eastern US/Asia + western Europe coasts

Quantify Activity 3 – Large scale Chemical Effects

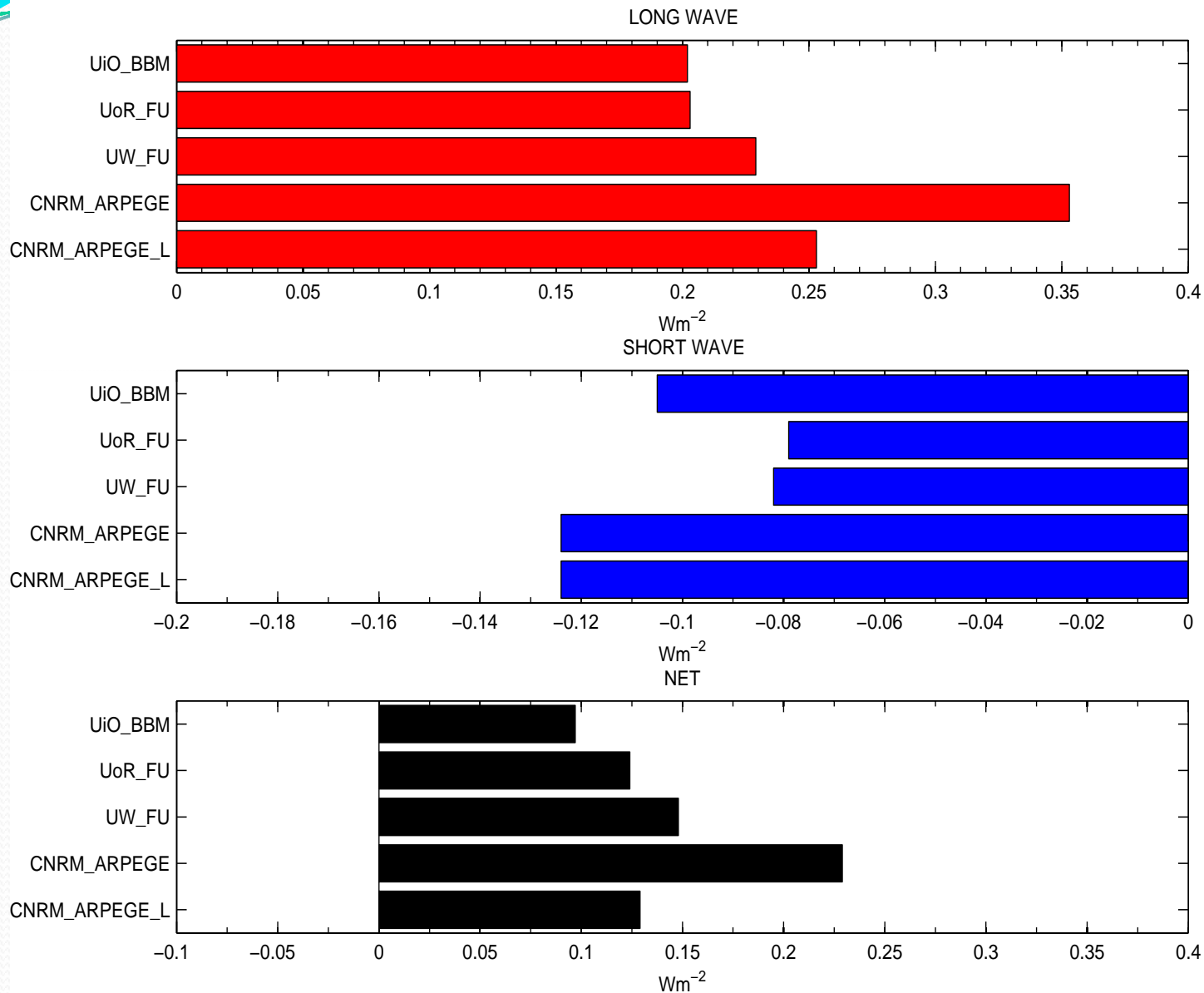


## Quantify Activity 5 – Aviation, Shipping and Clouds



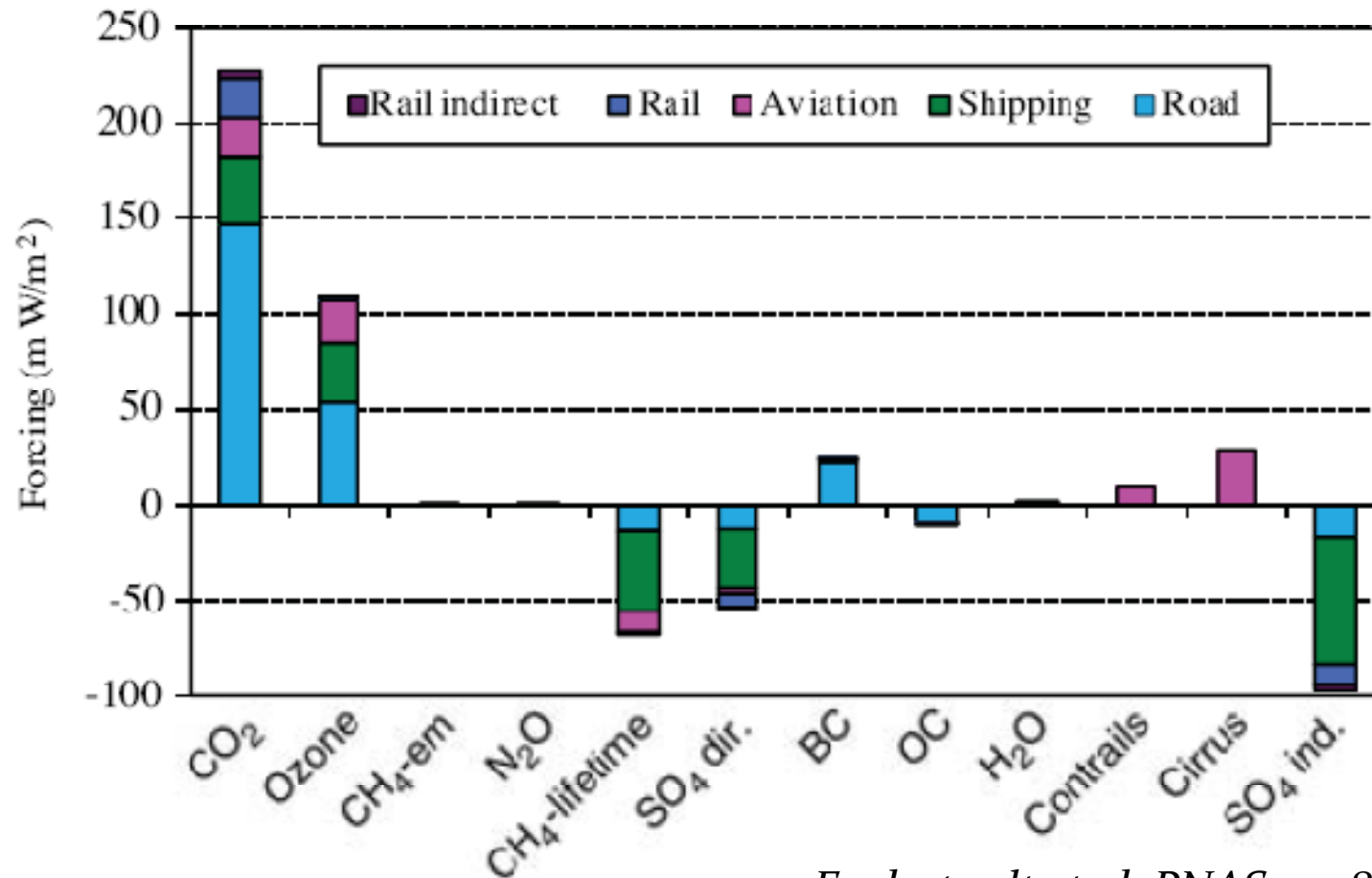
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# RF due to a global homogeneous 1% contrail cover (all sky results) – results from UiO, UREAD, UW and CNRM



Smaller  
uncertainty for  
contrails than  
changes in  
stratospheric  
water vapour –  
perhaps  
surprising

# First synthesis of all modes of transport



*Fuglestvedt et al. PNAS 2008*

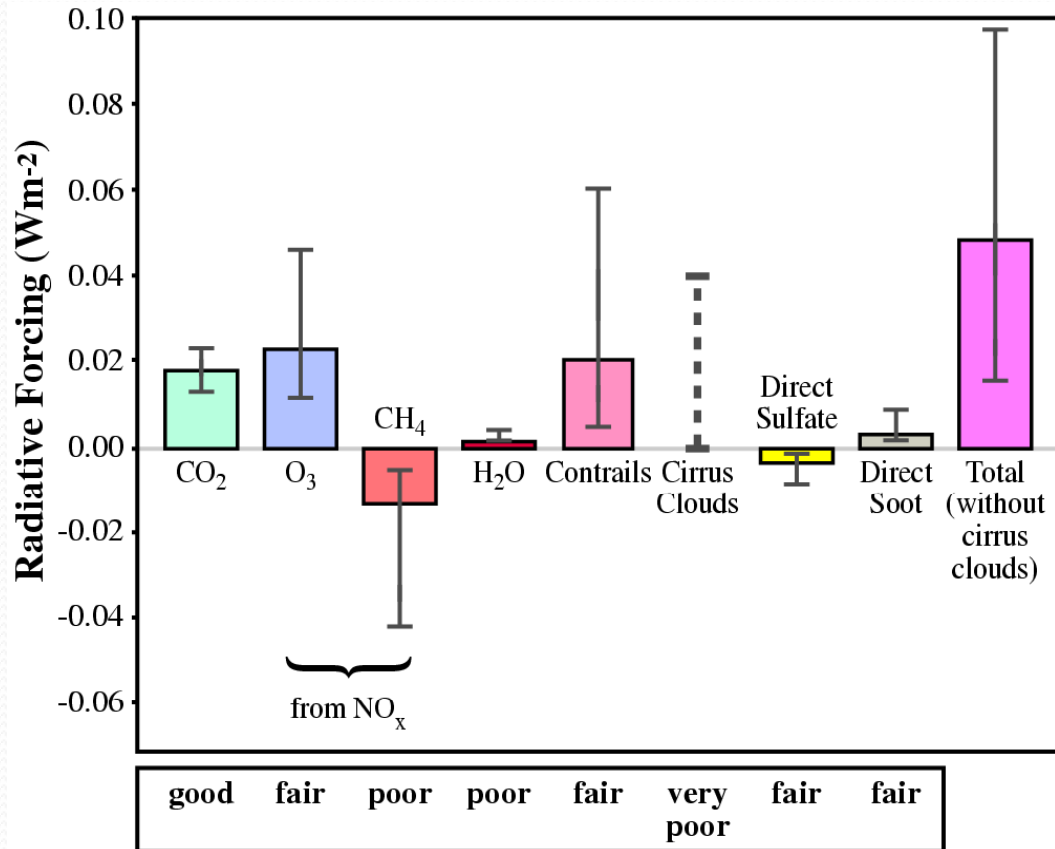


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# Aviation impacts: where we were: IPCC (1999)



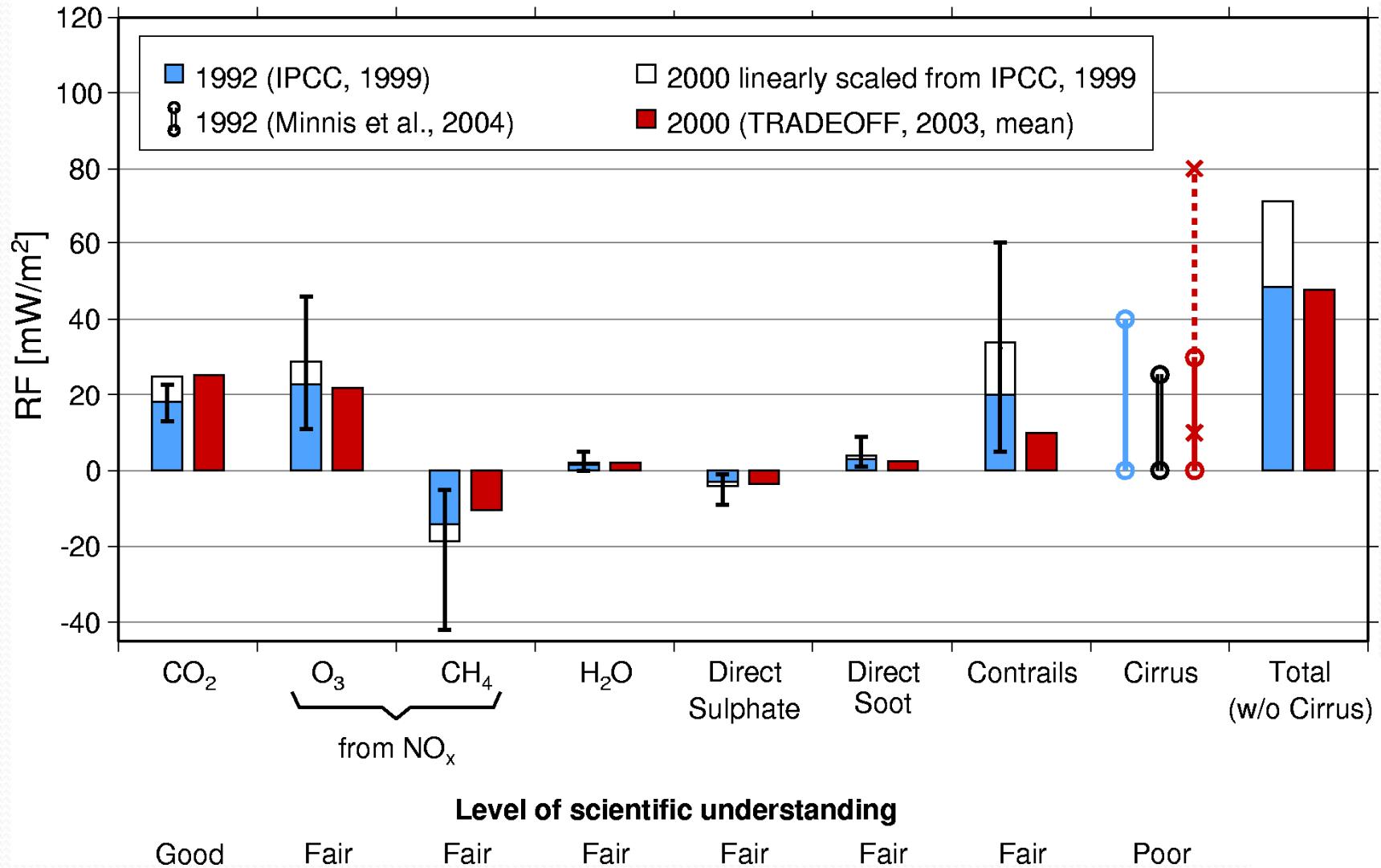
# Aviation RF in 1992 (IPCC, 1999)



IPCC, 1999

- A radiative forcing of  $0.05 \text{ W m}^{-2}$  in 1992
- About 3.5% of the total radiative forcing from all anthropogenic activities

# Updated Aviation Radiative Forcing for 2000



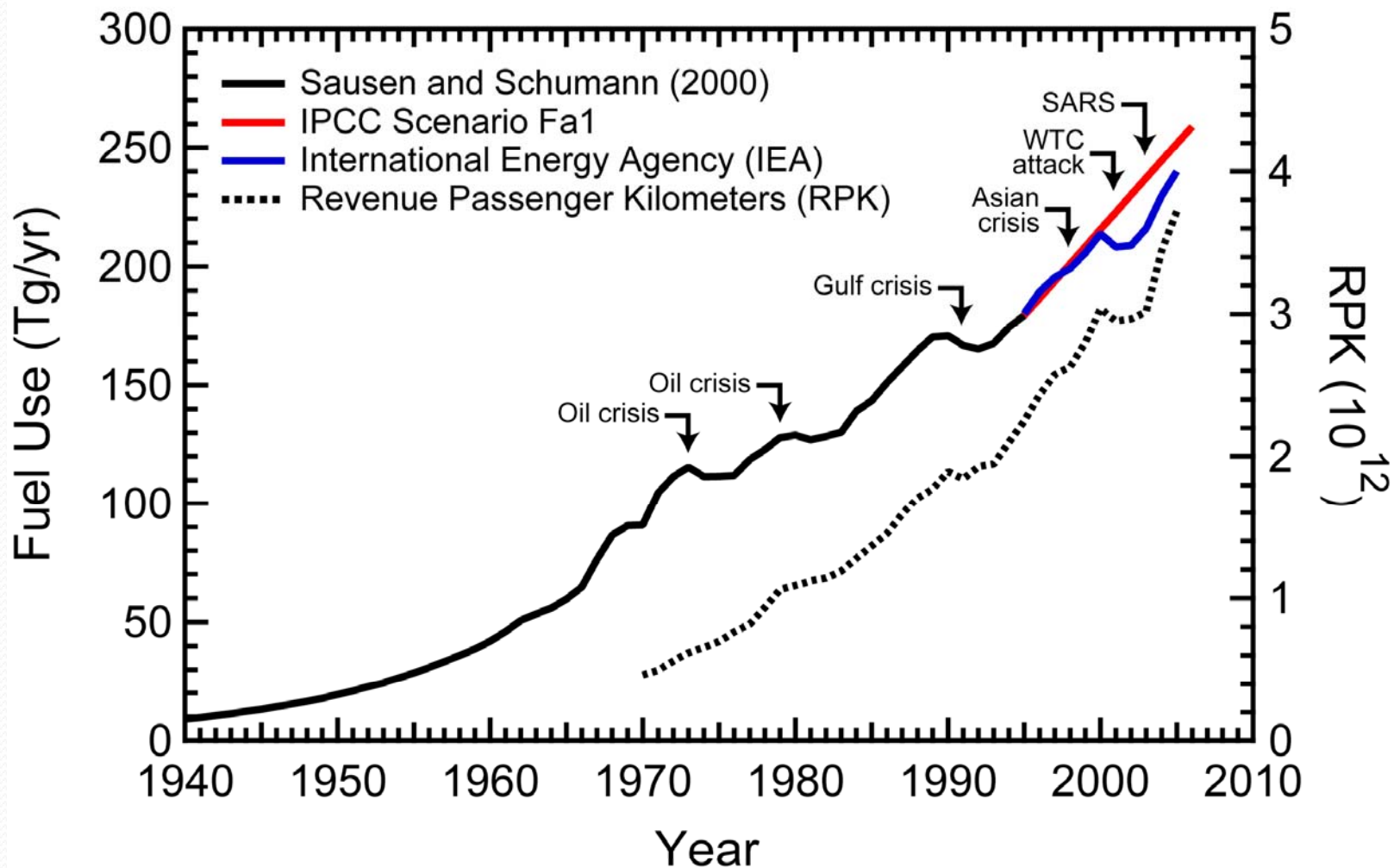
Sausen et al., 2005



# Today's impacts: where we are



## Aviation Fuel Use and RPK

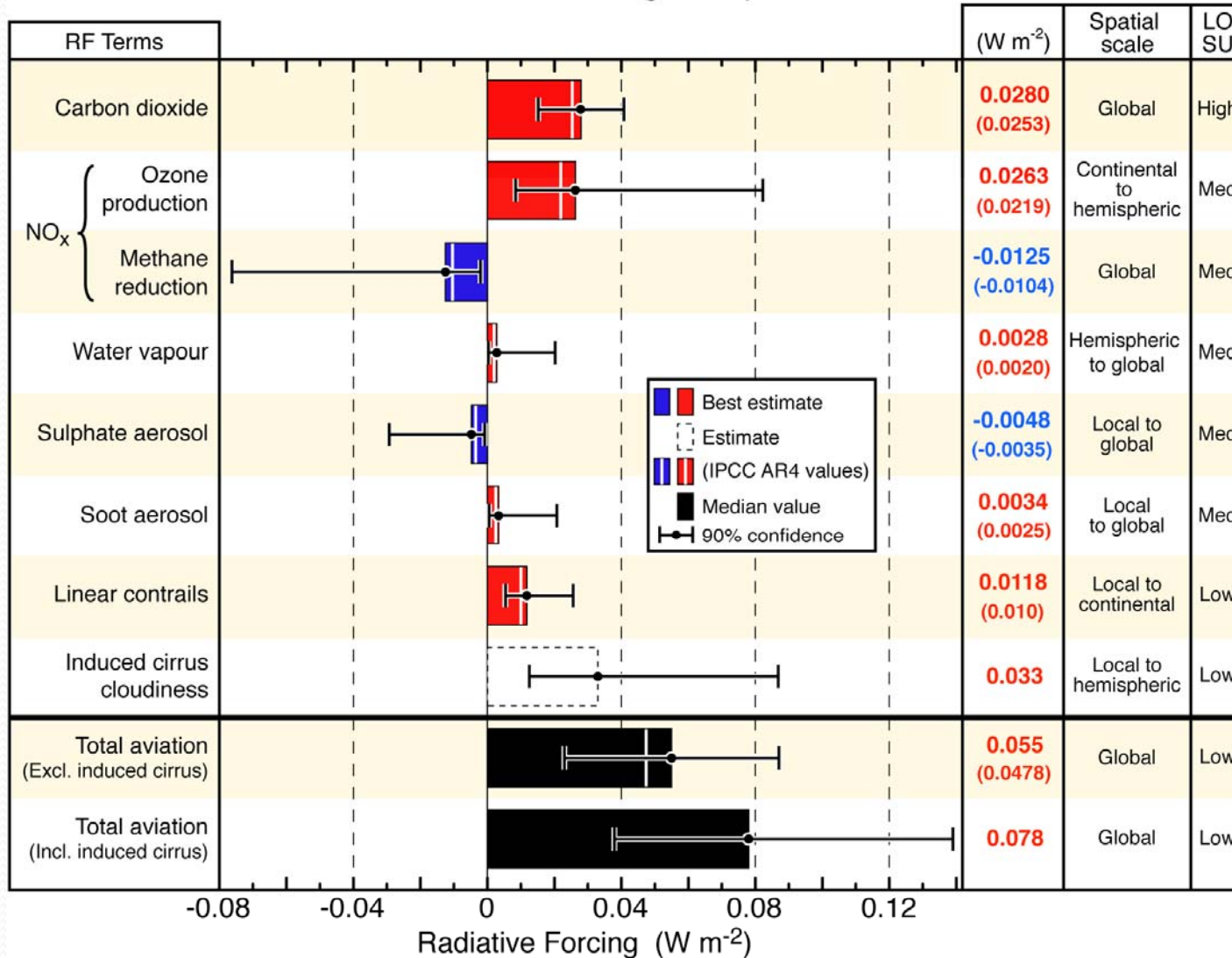


**Source:** Lee, Fahey, Forster, Newton, Wit, Lim, Owen & Sausen, *Atmospheric Environment* (under revision)



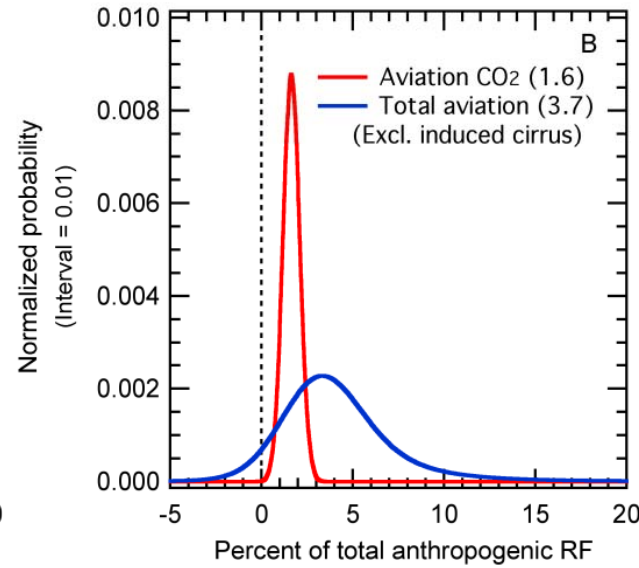
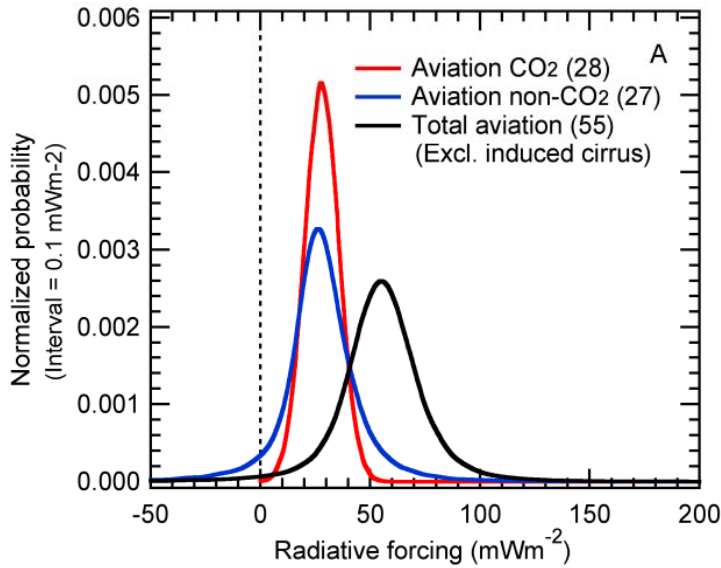
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## Aviation Radiative Forcing Components in 2005



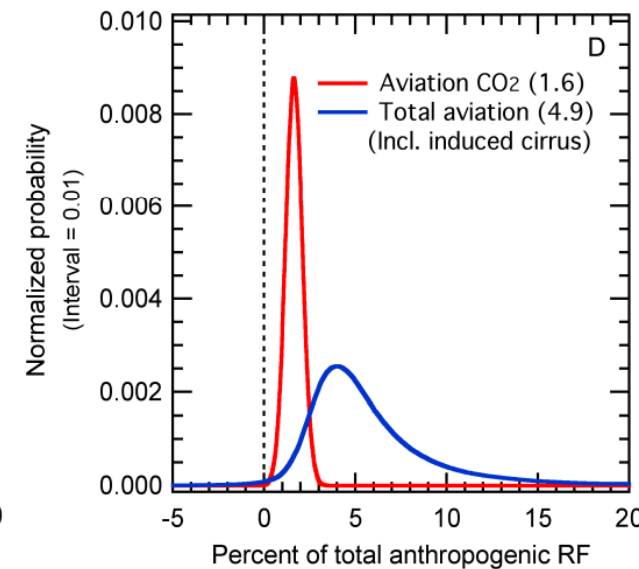
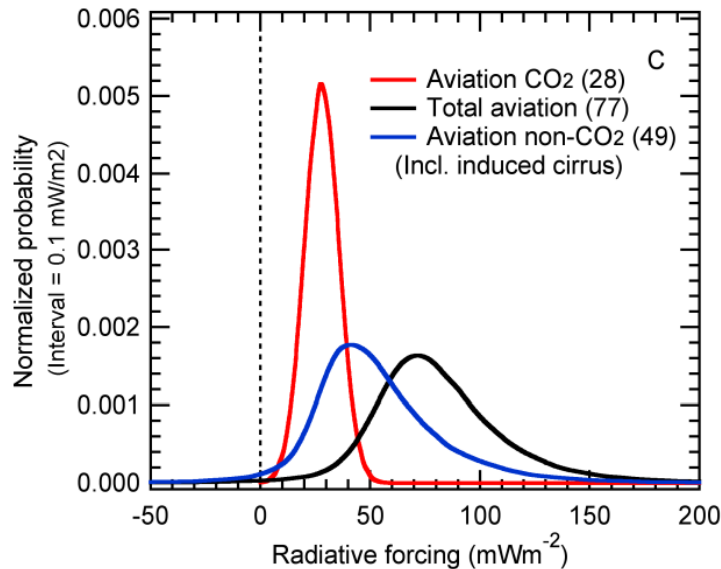
**Source:** Lee, Fahey, Forster, Newton, Wit, Lim, Owen & Sausen, *Atmospheric Environment* (under revision)

### Uncertainties in Aviation Radiative Forcing Components



3.5% (1.3 – 10%)

### Excluding induced cirrus Including induced cirrus



5.6% (2.4 – 15%)

Source: Lee, Fahey, Forster, Newton, Wit, Lim, Owen & Sausen, Atmospheric Environment (under revision)

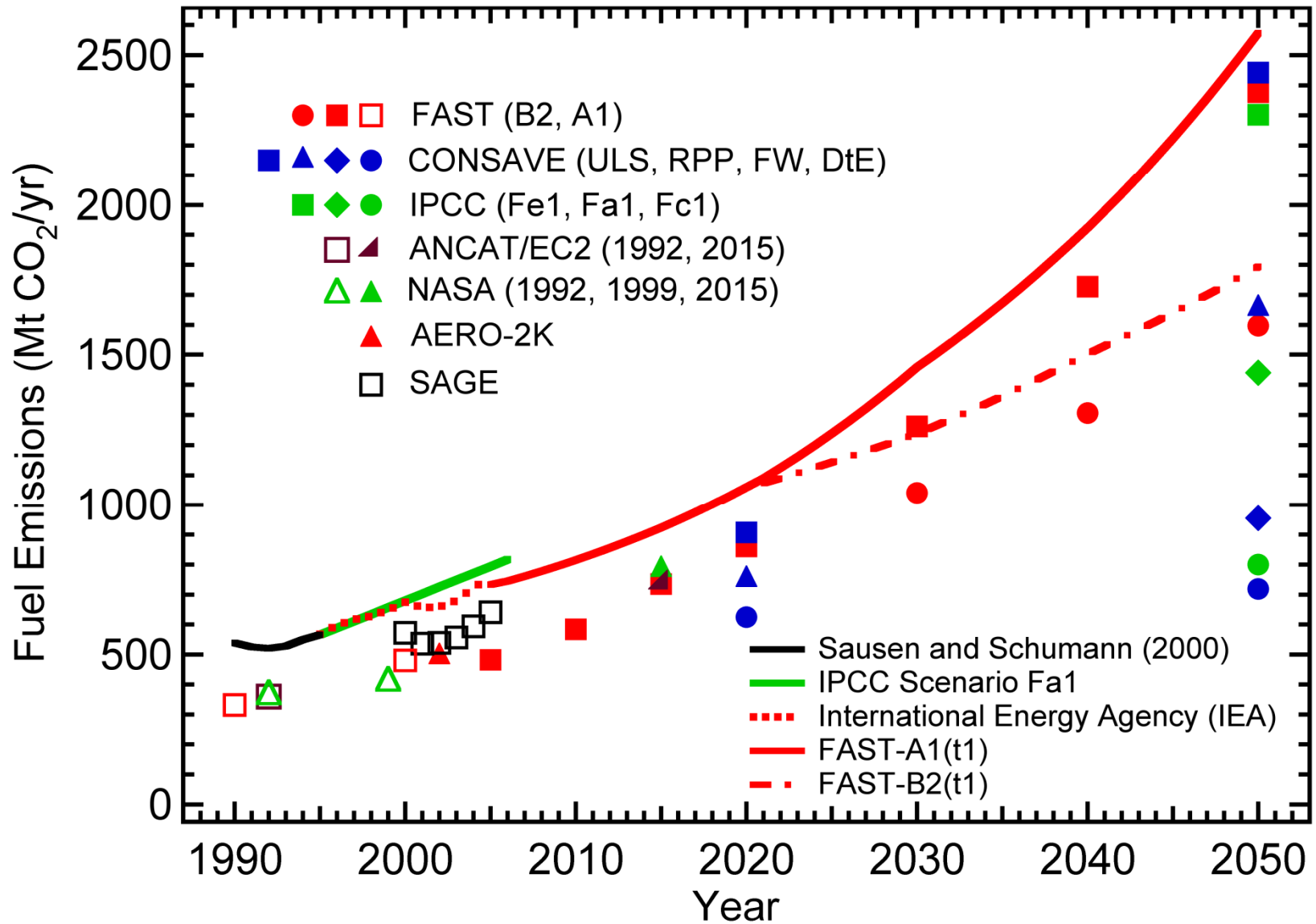
Source:



# Future impacts: where we're going?



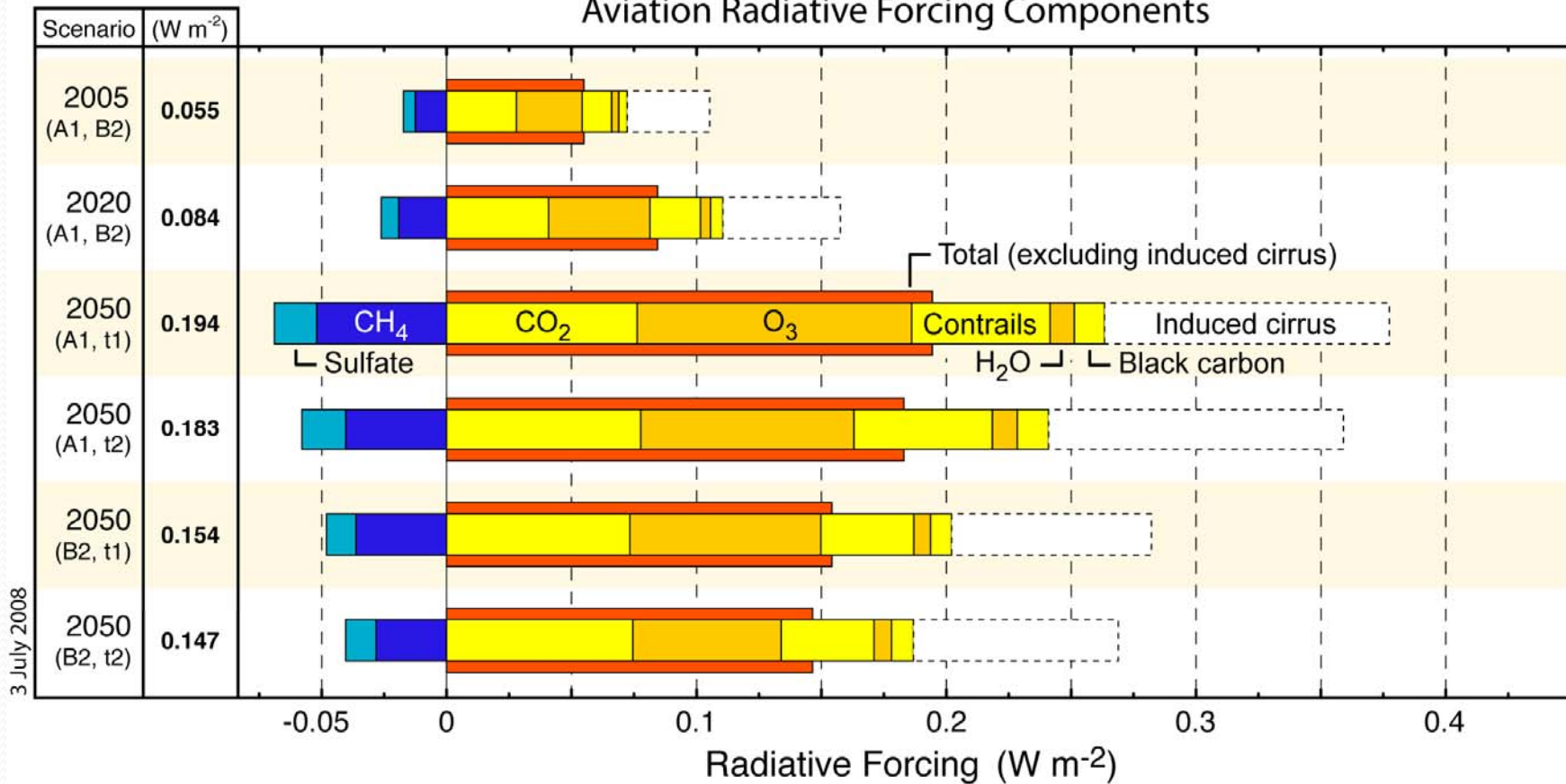
## Aviation Fuel Emissions



**Source:** Lee, Fahey, Forster, Newton, Wit, Lim, Owen & Sausen, *Atmospheric Environment* (under revision)

# Present-day, 2020 and 2050 A1/B2 aviation RF

Aviation Radiative Forcing Components



**Source:** Lee, Fahey, Forster, Newton, Wit, Lim, Owen & Sausen, *Atmospheric Environment* (under revision)

# Where do we want to go?

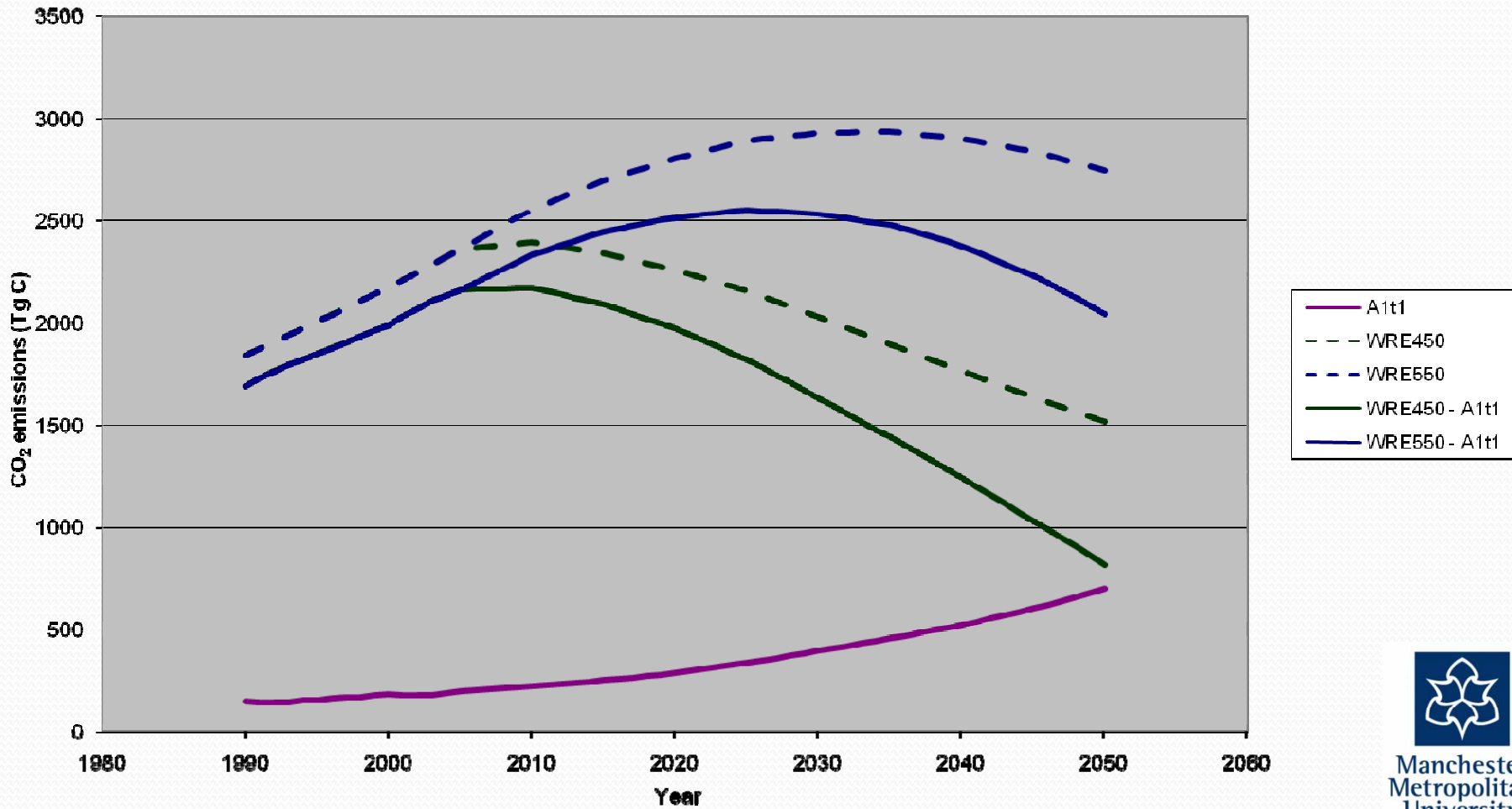
- SRES-based futures
- Post Kyoto world
- Stabilization-world (450, 550 ppm CO<sub>2</sub>)





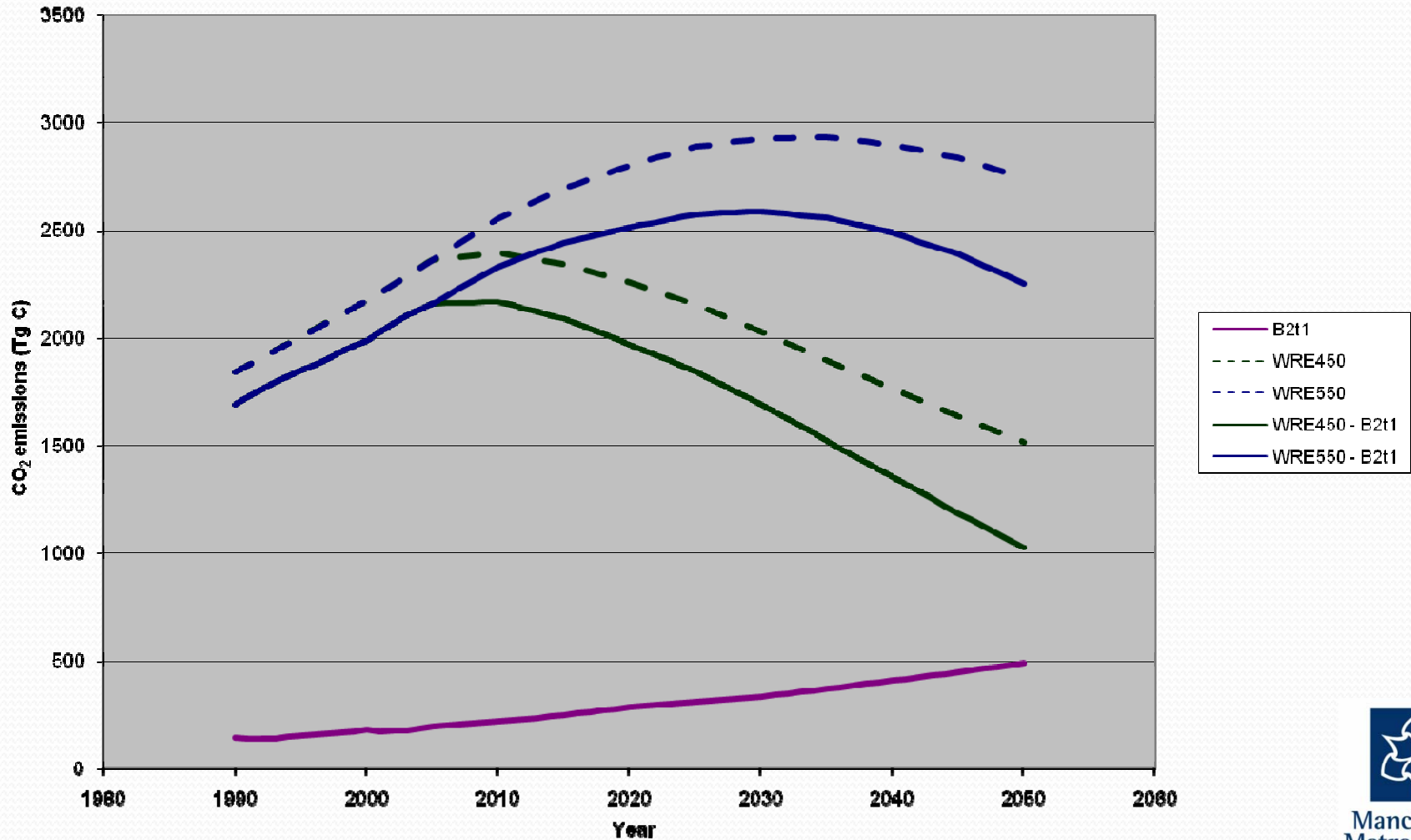
# Mixing A1 and stabilization worlds

Stabilization & Aviation (A1t1) CO<sub>2</sub> Emissions



# Mixing B2 and stabilization worlds

Stabilization & Aviation (B2t1) CO<sub>2</sub> Emissions



# Thank you for your attention

Acknowledgements: Grateful thanks to –  
Prof. Robert Sausen, DLR  
The Quantify community  
The ATTICA core project team

**EC Projects**



**UK Department for Transport**