Climate Impact and Mitigation Concepts

FORUM-AE Workshop

ECATS Conference

ECATS International Association FORUM-AE

Aviation Climate Impact and Mitigation Options

Scope of Conference Session

- **Aviation** contributes to **climate change** and a joint effort is necessary to ensure both **sustainable mobility** and **growth of aviation**.
- However, large **uncertainties** remain when quantifying overall climate change from aviation.
- We focus on contributions which emphasise the need to establish solid **knowledge** and well-evaluated **measures** and means, to provide **quantitative estimates** of aviation climate impact and mitigation concepts.
- Which **approach** is best suited to help aviation identify a durable path into the future?

FORUM-AE COORDINATION ACTION

FP7 European coordination action ; GA 605506 ; 2013-2017

FORUM-AE Overview & Perspectives

EASN Conference, Porto, Oct 2016

Presenter: Sigrun Matthes, DLR

Coordinator: Olivier Penanhoat, Snecma

www.forum-ae.eu

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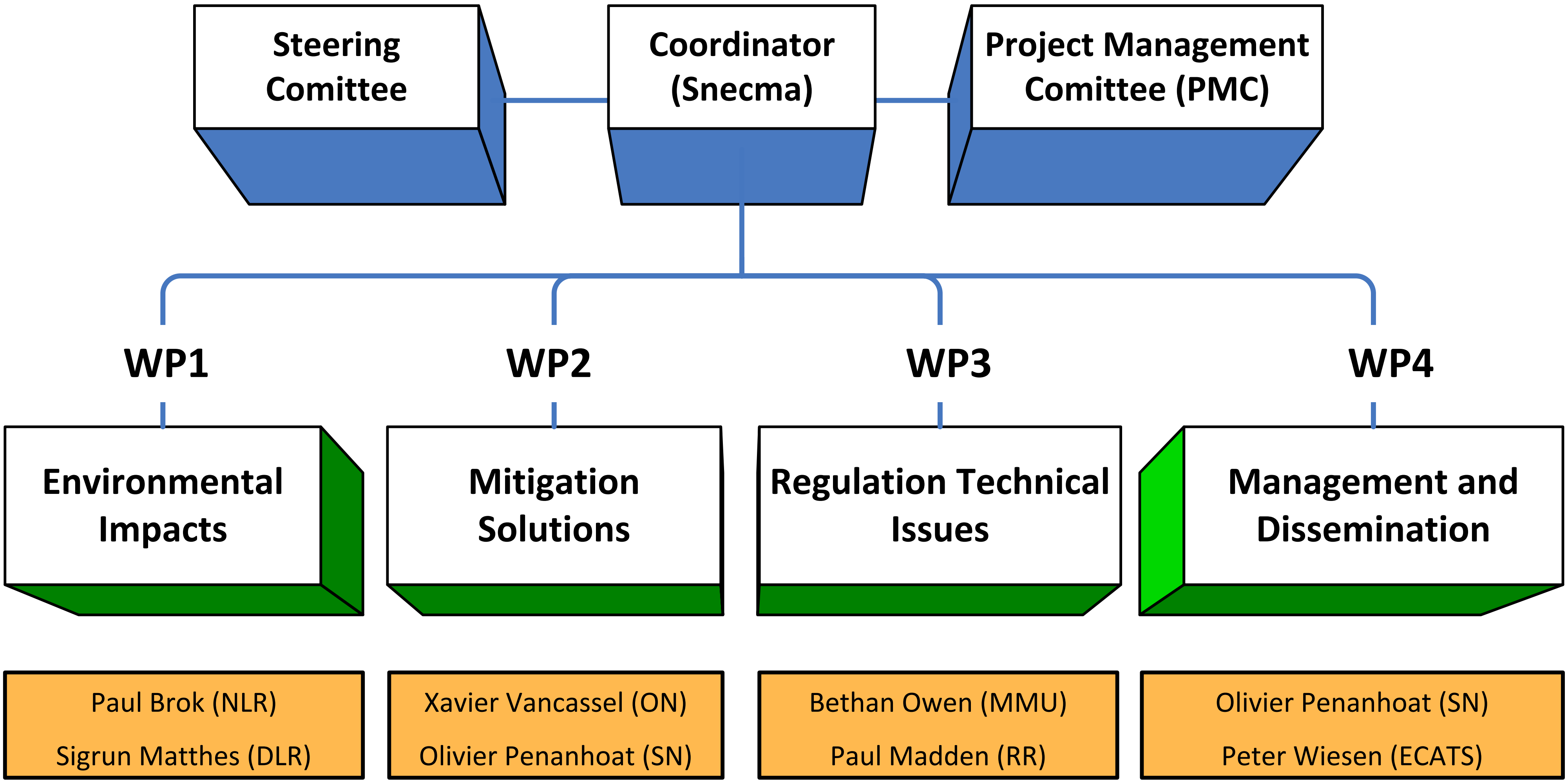
FORUM on Aviation and Emissions (& Environment)

- **FORUM-AE offers a European technical forum addressing:**
  - emissions environmental impacts
  - most-promising mitigation solutions
  - technical recommendations on regulation issues

- **Assesses major European RTD programs progress against ACARE environmental goals**

- **Compiles recommendations in terms of future RTD priorities**

PROJECT'S SCOPE AND ORGANISATION



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WORKSHOPS & MONITORING

➔ Large number of topical workshops:

Workshops	Date	Location	Hosting partner
Kick-off Workshop	Sept, 19th&20th 2013	Brussels	EC
Air Quality Workshop	January, 9th 2014	Manchester, United Kingdom	MMU
non volatile Particulate Matter (nvPM)	January, 10th 2014	Manchester, United Kingdom	MMU
Climate Change	April, 2nd & 3rd 2014	Oberpfaffenhofen, Germany	DLR
CO2 and Fuel Burn Technology	July, 1st 2014	Paris, France	Snecma
non-CO2 Technology Workshop	July, 2nd 2014	Paris, France	Snecma
Alternative Fuels Workshop (SAFF)	October, 21st 2014	Madrid, Spain	SENASA
Basket of Measures / MBM	May, 19th 2015	Toulouse, France	Airbus
Basket of Measures / CO2 standard	May, 20th 2015	Toulouse, France	Airbus
Mid-Term Meeting	July, 8th & 9th 2015	Brussels	EC
Inventory Workshop	Sept., 1st & 2nd 2015	Zurich, Switzerland	Zurich Airport
ATM	19& 20/01/2016	Paris/Brussels	Eurocontrol
Air Quality Workshop-bis	April, 14th 2016	Amsterdam	NLR
non volatile Particulate Matter (nvPM)-bis	April, 15th 2016	Amsterdam	NLR
Climate Change-bis (with ECATS 2nd Conf)	November, 8th 2016	Athens	ECATS
non-CO2 Technology Workshop-bis	March, 8th & 9th 2017	Berlin	RRD
CO2 and Fuel Burn Technology + elect. a/c	May 2017 - TBD	Reims	Onera
Final Conference	June 2017 - TBD	Paris	Snecma

➔ Detailed outputs in: www.forum-ae.eu

- General Status / SoA / Statements / RTD priorities / Recommendations

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CONTEXT: ACARE GOALS

ACARE Environmental Goals by 2050

- CO_2 emissions per passenger kilometre have been reduced by 75%, NOx emissions by 90% and perceived noise by 65%, all relative to the year 2000.
- Aircraft movements are emission-free when taxiing.
- Air vehicles are designed and manufactured to be recyclable.
- Europe is established as a centre of excellence on sustainable alternative fuels, including those for aviation, based on a strong European energy policy.
- Europe is at the forefront of atmospheric research and takes the lead in formulating a prioritised environmental action plan and establishes global environmental standards.

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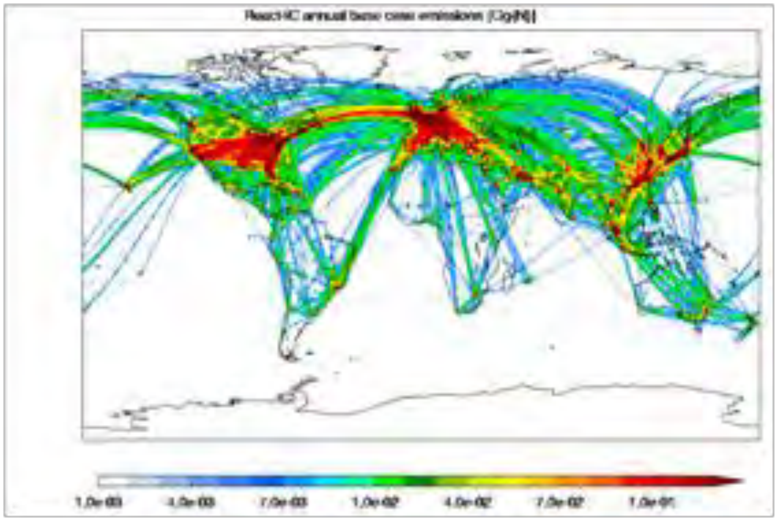
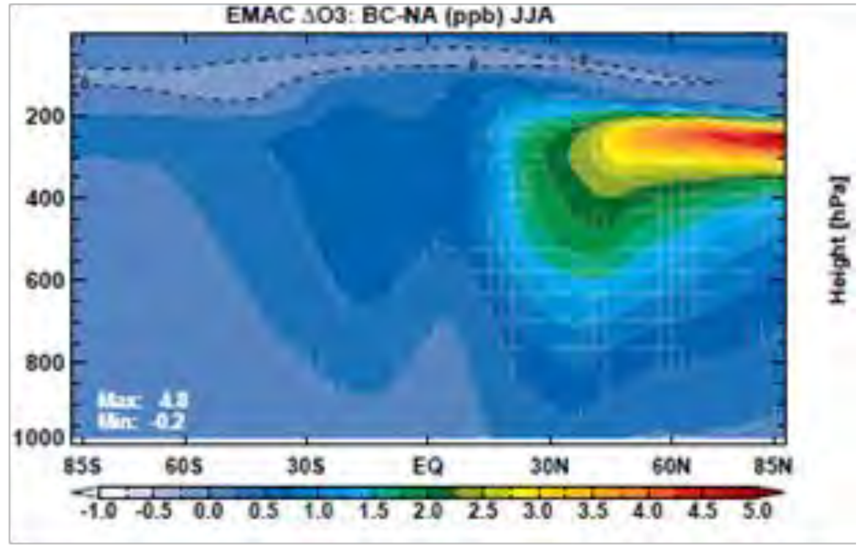
GLOBAL ENVIRONMENTAL IMPACT & RECOMMENDATIONS

- **Studies show how results vary with different emission inventories**
  - sensitivity analysis to emissions inventories are recommended.





Aviation NOx in 2006 (left) and resulting Ozone perturbation (right

- **Need for clear documentation of assumptions in future scenarios**
  - sensitivity studies on such assumptions are also fully relevant

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GLOBAL ENVIRONMENTAL IMPACT & RECOMMENDATIONS

- **Metric is still an open key issue.**
  - Quantitative estimates should be provided for a set of typical metrics (e.g. **RF, ATR, GWP**...) to demonstrate sensitivity of results on choice of metric. Then, there is a need of careful selection of calculation methods and metrics, appropriate to the question to be answered.

- **Sources of uncertainties must be analysed & means for robust decisions under uncertainty must be developed**

- **Climate-optimised flight routing must be further developed,**
  - ideally considering the individual weather situation.
  - Interest of climate cost functions, measuring with the appropriate metric the effect of an unit of a given species emitted locally on the climate warming

- **Better correlation between contrail/contrail cirrus properties and particle emissions is required**
  - both for prediction accuracy and for mitigation strategy

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MITIGATION SOLUTIONS & RECOMMANDATIONS:

➔ **The range of technological solutions at aircraft level and engine level, complemented by operational solutions (ATM & flight optimisation), is extremely large, when looking to medium and long term**

- See detailed status & preliminary recommendations on: www.forum-ae.eu
- This ECATS conference provides opportunity to consider in details a selection of mitigation options and what is delivered today and most promising solutions
- Two dedicated FORUM-AE workshops in 2017:
  - Non-CO2 Technology workshop in Berlin (hosted by RRD)
  - FB/CO2 Technology workshop in Reims (hosted by Onera)

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Climate modellers perspective on aviation
Emissions of CO_2 equivalents

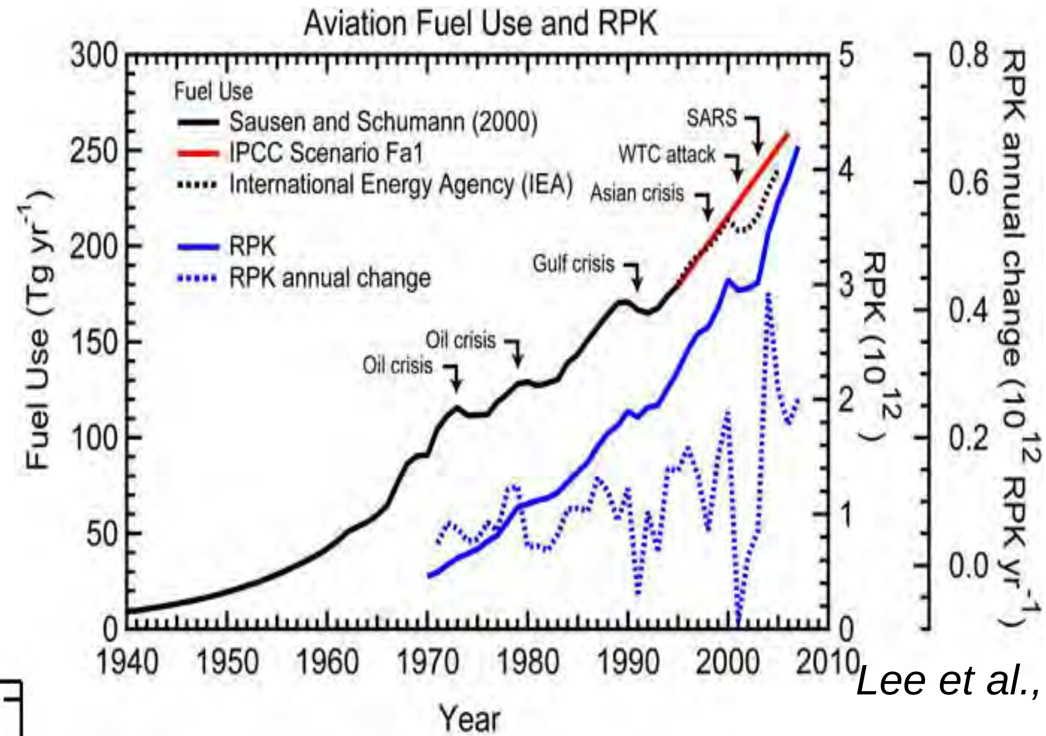
comprises CO_2, CH_4, NO_2, SF_6, HFCs, CFCs (without gases from the Montreal Protocol)

country / sector	emissions 2012 [Tg CO_2]	tendency
France	452	↘
Germany	936	↘
United Kingdom	579	↘
internat. aviation	528	↗

data: unfccc.int

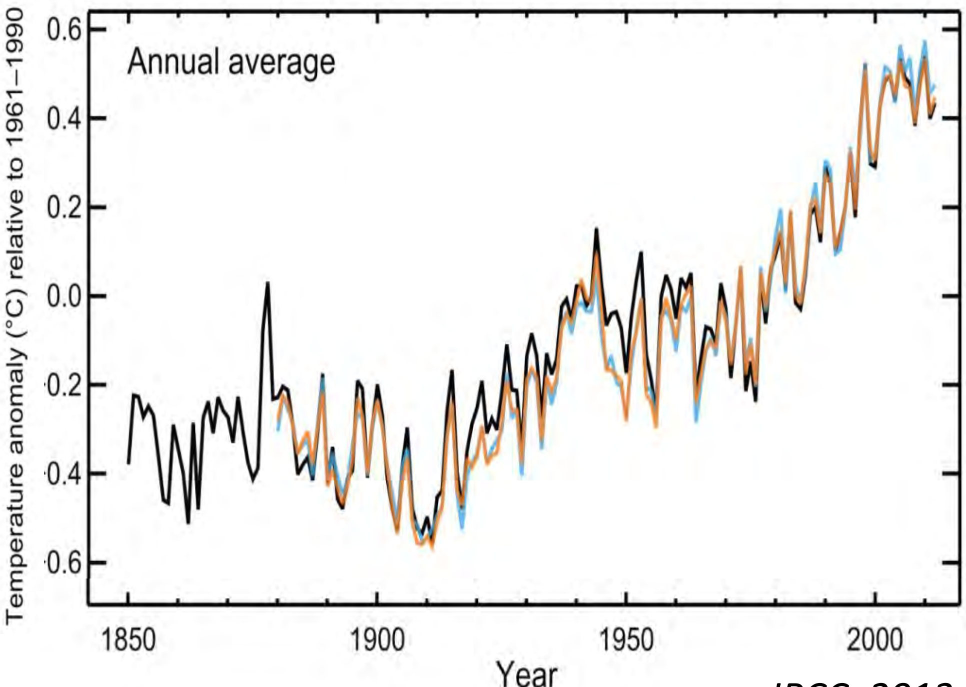
Challenges

- ✈ Increasing transport volume
- ✈ Increasing emissions
- ✈ But, reduce anthropogenic climate change

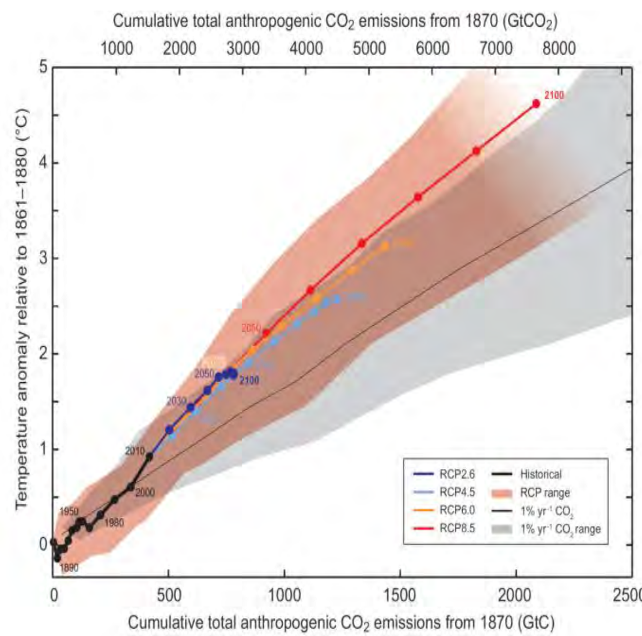


Lee et al., 2009

Observed globally averaged combined land and ocean surface temperature anomaly 1850–2012

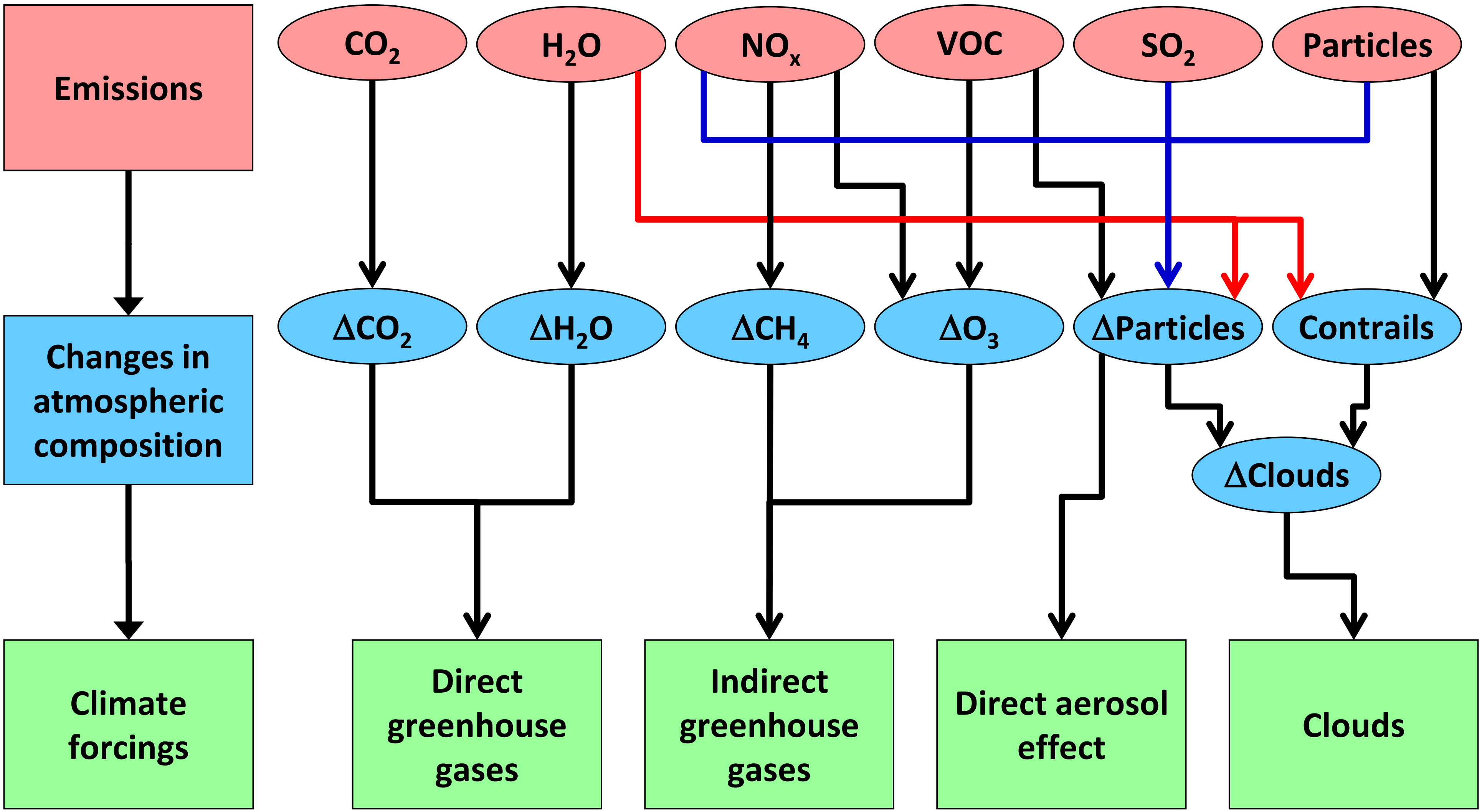


IPCC, 2013



IPCC, 2013

Atmospheric effects of transport emissions



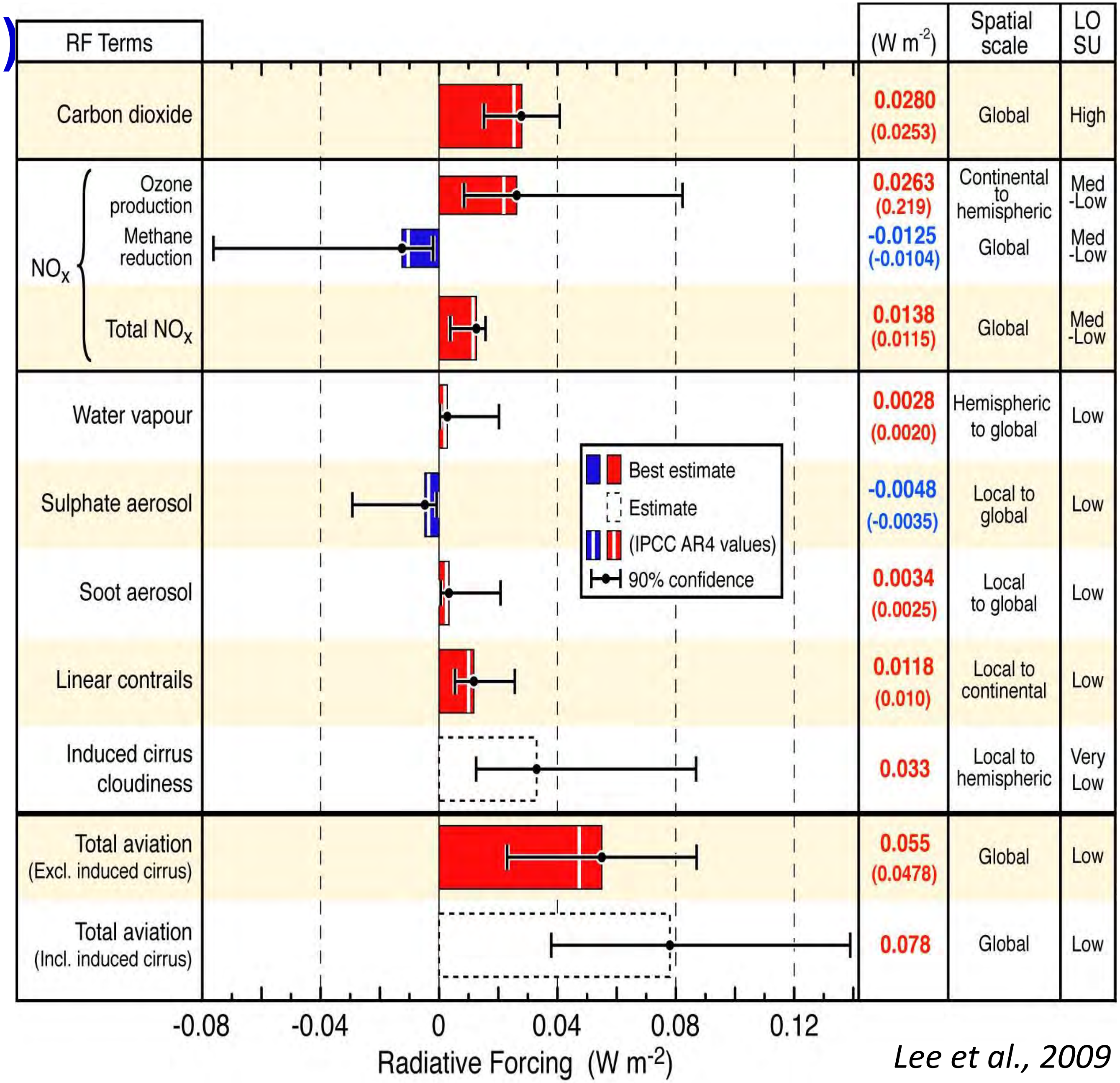
Radiative forcing (RF) from aviation 2005

$$\Delta T_{surf} = \lambda \cdot RF$$

Total anthropogenic forcing 1.6 W/m^2

Aviation fraction:

CO_2	1.6 %
Total	4.9 %



Lee et al., 2009

Contrails by old and new aircraft

Modern aircraft

⇨ **more energy for propulsion**

⇨ **cooler exhaust**

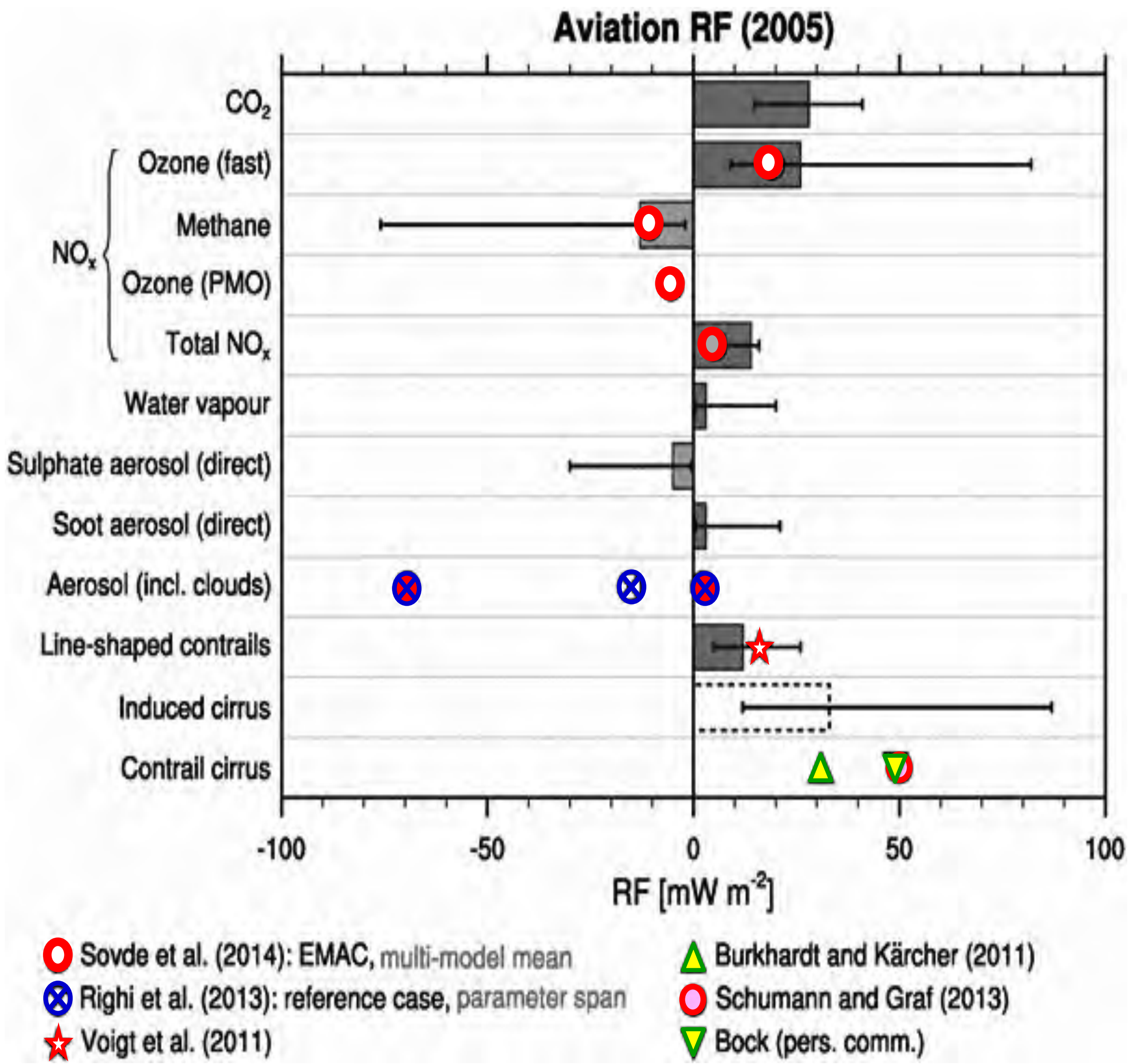
Schumann et al., 2000

Contrails can develop into contrail cirrus
(at suitable conditions)

Radiative forcing (RF) from aviation 2005

$$\Delta T_{surf} = \lambda \cdot RF$$

Note:
Different base years and different emission data have been used



Indirect effects on cirrus clouds?

recent DLR results

Weighing the non-CO_2 effects

- Fixed multiplier for the CO_2 emissions?
  - no incentive to work on the non-CO_2 effects
  - multiplier does not account for different aircraft or different flight trajectories
- Radiative forcing (RF)?
  - RF is a measure of the emissions of the past
- Global warming potential (GWP)?
  - used in the Kyoto Protocol to calculate CO_2 equivalents
  - does not account for the heat capacity of the climate system
  - problems the short-lived climate forcers

$$AGWP = \int_0^H RF_{spec}(t)dt$$

- Average temperature response (ATR)?
  - accounts for both, short-lived and long-lived climate forcers
  - provides consistent results for pulse emissions and longer emission scenarios

$$ATR = \frac{1}{H}\int_0^H \Delta T(t)dt$$

How can we mitigate the climate impact of aviation?

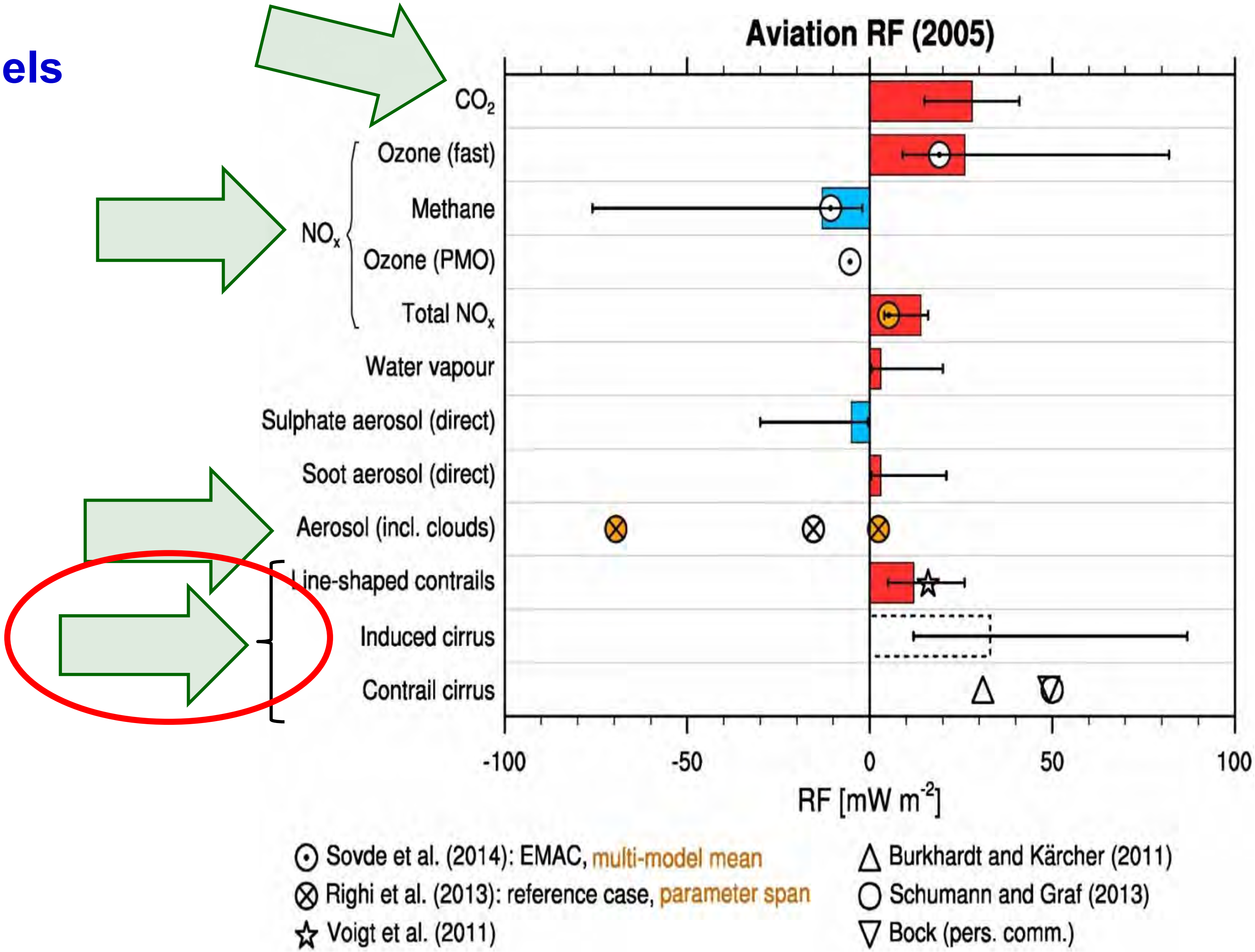
Focus more on emissions:

- ✈ Reduction of the specific emissions
- ✈ Reduction of the absolute emissions

Focus more on impact of emissions:

- ✈ Climate optimized aircraft
- ✈ Eco-efficient flight trajectories

Impact of alternative fuels



Less soot ➔ Impact on contrails

alternative fuels

↓

less emissions of soot

↓

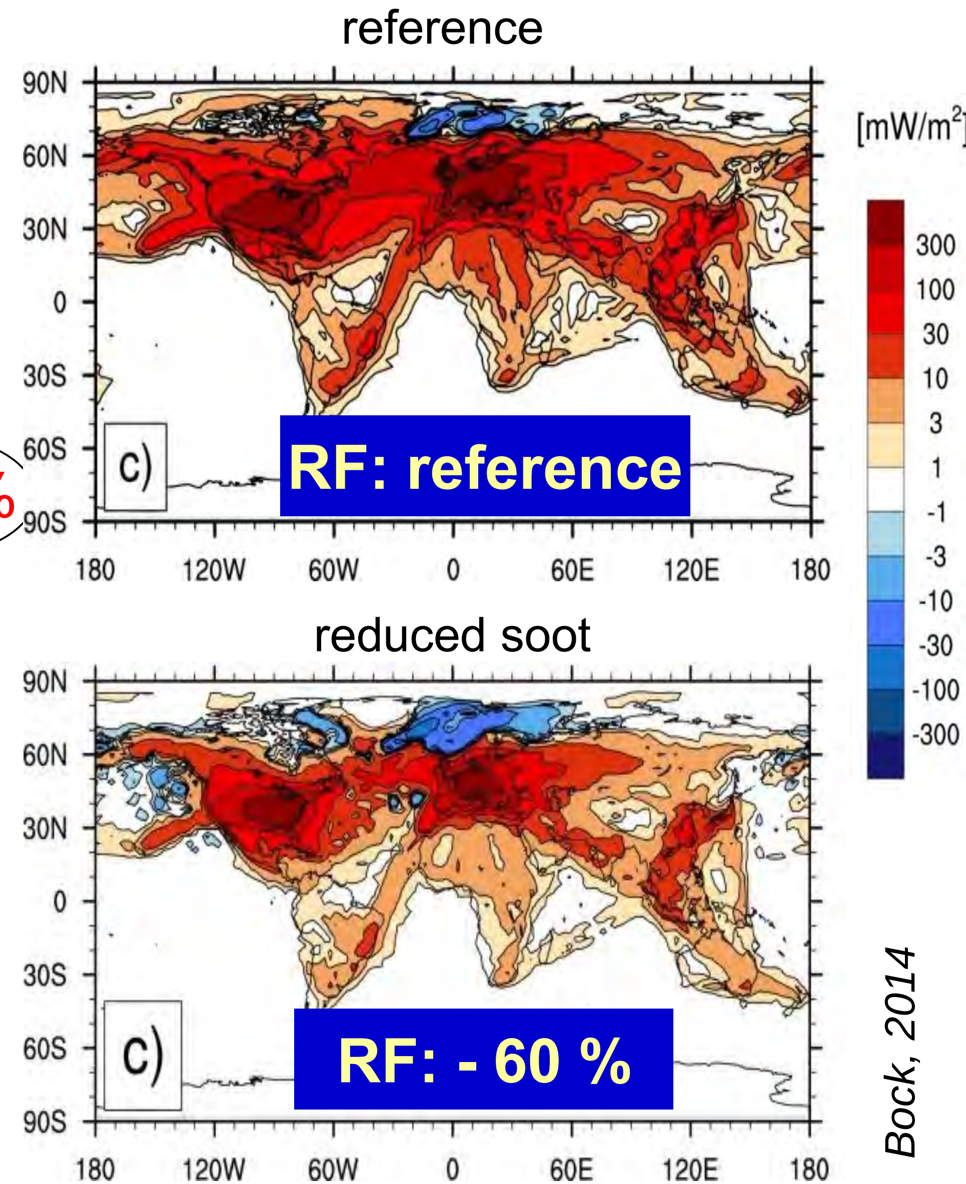
smaller number of initial ice particles in contrails (- 80 %)

↓

change of micro-physical and optical properties of contrails and contrail cirrus

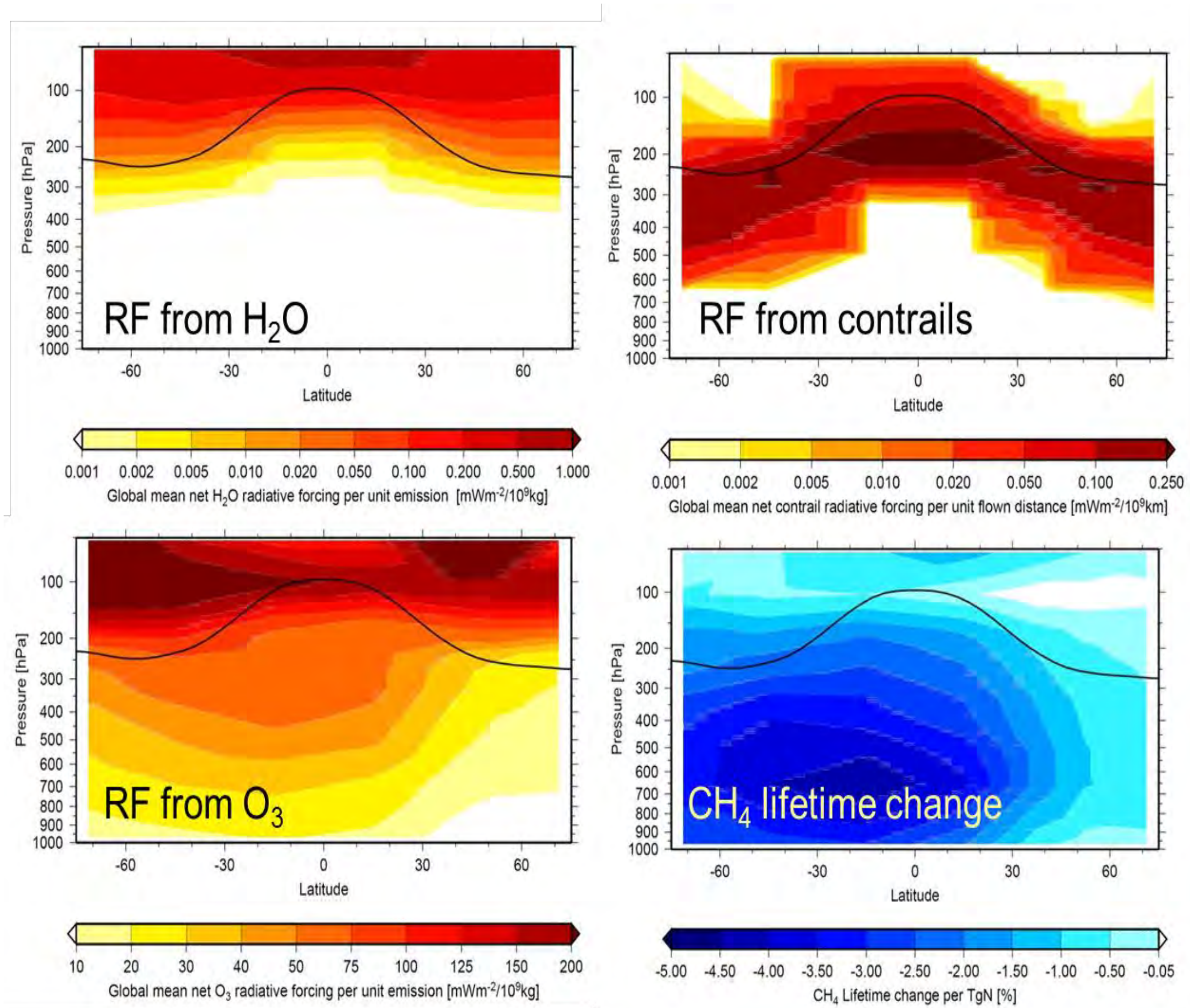
↓

change of life-time and climate impact of contrails and contrail cirrus



Bock, 2014

Impact of unit "emissions" as function of latitude and altitude of emission



Fichter , 2009

Climate impact of aviation – CO_2 and more

- Aviation significantly contributes to **climate change**.
- The impact of **the non-CO_2 effects** is particularly large for aviation.
- The impact of the non-CO_2 effects **depends on** location, altitude and time of emissions.
- Mitigation options **reduce** aviation emissions, aviation emission climate impact or both
- E.g. **alternative fuels** can reduce both the contribution to CO_2 and the non-CO_2 emission, hence overall climate impact.
- E.g. The non-CO_2 effects can be substantially reduced by flying according to **eco-efficient flight trajectories**, at a small increase of DOC, via reducing climate impact of emissions.

Climate impact workshop

Impacts and Mitigation Options

- **Atmospheric impacts**
- **Chair/Rapporteur: Sigrun Matthes / Etienne Terrenoire**
  - Intro: Climate impact of aviation
  - Climate impact of CO_2 emissions (Etienne Terrenoire)
  - IMPACT project (Didier Hauglustaine)
  - Climate impact of contrail and contrail cirrus (Lisa Bock)
  - Chemical impacts of aviation emissions (Volker Grewe)
  - Alternative routing: Climate impact mitigation studies (Sigrun Matthes)
- **Technology mitigation options**
- **Chair/Rapporteur: Didier Hauglustaine / Ling Lim**
  - Greener by design (John Green)
  - Emission and mitigation concepts (Paul Madden)
  - Flame stabilisation aerodynamics (Panayotis Koutmos)
  - Intercooled recuperation aero engine (Dimitrios Misirlis)
  - Assessment of PM emissions from engines (Olivier Penanhoat)
  - Strut-braced Wing concepts and a/c configuration (Florian Linke
  - Drag reduction in aircraft wings (Zinon Vlaxostergios)
  - Aircraft level assessment of contrail mitigaiton (Jean-Charles Khou)

CONTEXT: NEW INTERNATIONAL REGULATION

→ **2 New international certification standards on aviation emissions in 2016!**

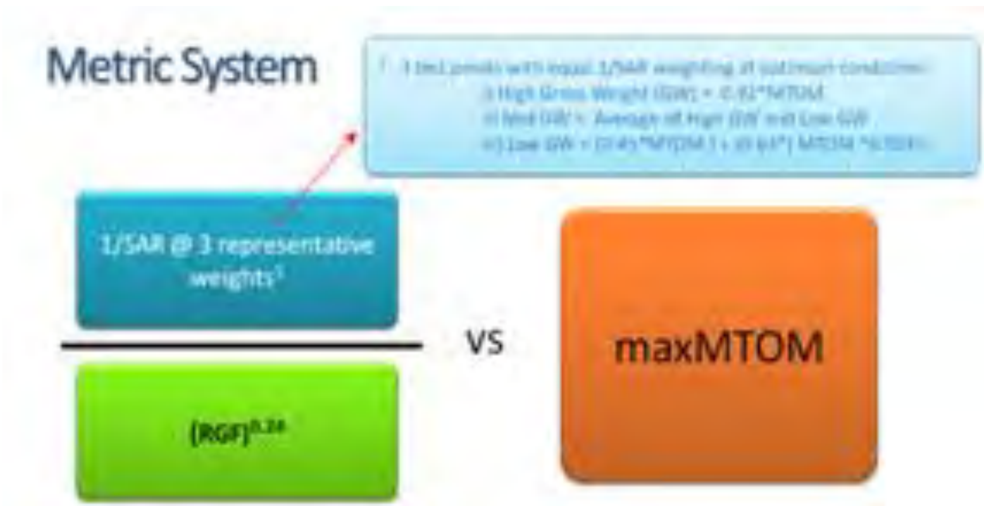
- With an application date after 1st January 2020

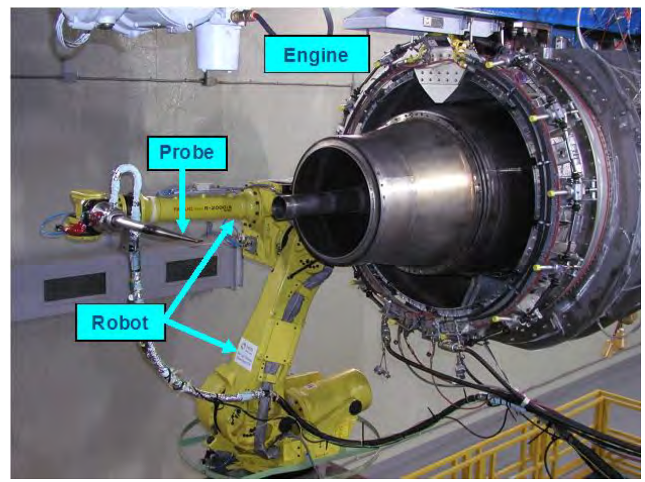
→ **CO2 standard:**

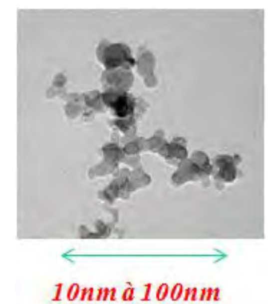
- Applying to TF & TP commercial aircrafts

→ **non Volatile Particulate Matter (nvPM) standard:**

- Applying to all in production turbofans above 26.7kN







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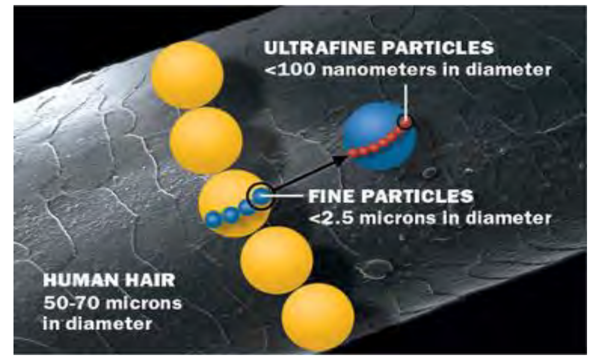
AIR QUALITY IMPACT & RECOMMENDATIONS

→ **Key pollutants linked to Air Quality (AQ): NO2 & particles.**

- Particles issue to be addressed both in PM2.5 and ultra fine particles (UFP) for which number concentration appears more relevant
- SO2 from the aircraft engine may be important contributor to PM2.5



→ **Strong regulation framework exists:**

- At emission source level, workplace level, ambient AQ level
- However nothing yet for APUs => strong uncertainty on their emission factors

→ **Measurements in Europe of PM10 & PM2.5 in airport vicinity are well harmonised and demonstrate a good quality level**

- Nevertheless no such exercise done for UFPs

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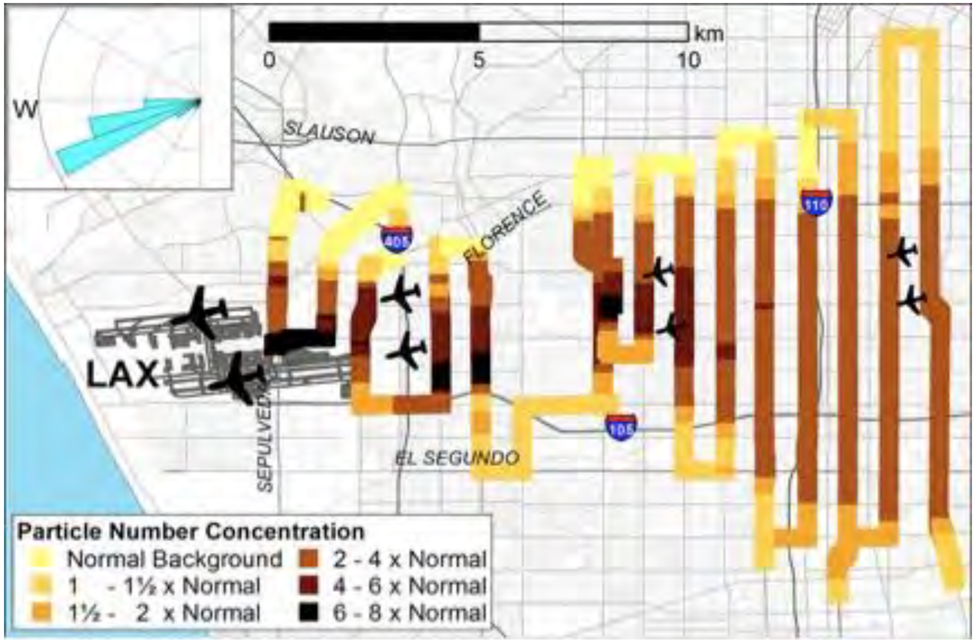
AIR QUALITY IMPACT & RECOMMENDATIONS

➔ **PM2.5 mass concentrations linked to airport activities appear :**

- most of the time small compared to PM2.5 coming from other sources
- & very small against AQ limits
- UFPs from airport activities may be a stronger concern with elevated concentrations potentially observed (this should be perhaps verified however on a more representative number of airports?)



UFP concentrations at Los Angeles Airport

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AIR QUALITY IMPACT & RECOMMENDATIONS

➔ **Airport emissions inventory and AQ modelling improvements are required to predict more accurately concentrations at and around airports:**

- Better knowledge of emissions sources, performance based modelling, benchmarking (generic CAEPport), validation against field measurements…
- Better nvPM emissions factors ; potential improvement of FOA3 ; UFP dispersion modelling

Source	Activity	Emission factor	Calculation
Aircraft engine	Stop&go behaviour, Idle vs taxi, flex take-off	ICAO Emissions Data Bank (EDB); PM is work in progress	Fuel Flow Method (e.g. Boeing 2 FFM); First Order Approx. (FOA3) for nvPM & PM2.5
APU	Duration for Environmental Control System (ECS)	Very coarse in Doc 9889	Simple product
Aircraft frame	Brakes, tires	Assumptions	Simple product
GSE	Inventory good, else poor	EU Non-Road Mobile Machinery (EUNRMM) emissions & standards	Simple product
Stationary Sources	Usually well known	EMEP-EEA guidance, manufacturer data	Simple product
Landside vehicles	Fair, lots of assumptions	Handbook Emission Factors for Road Transport (HBEFA), EEA COPERT, etc.	Simple product

Status & Identified Gaps in Airports Inventory

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Mitigation Technology Status & Key Priorities for Future Research in Europe

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MITIGATION SOLUTIONS & RECOMMENDATIONS:

➔ Status against ACARE goals

	Reference 2000	ACARE 2020 Goals (at TRL6)		ACARE 2050 Goals (at TRL6)		FORUM-AE Assessment (2015) (extrapol. at TRL6 in 2020)
		High Level	detailed (SRA)	High Level	detailed (SRIA)	
CO2	*Representative technology of aircraft & engine with 2000 EIS, & representative 2000 ATM*	"-50% per pass km"	aircraft: -20% to -25% engine: -15% to -20% ATM: -5% to -10%	"-75% per pass km"	aircraft & engine: -68% ATM: -12% Other: -12%	**aircraft + engine +ATM: ≈ -38% in average per pass km**
NOx (LTO)		"-80%"	engine: -60% CAEP6 ; complement achieved by aircraft + ATM	"-90%"	engine: -75% CAEP6 ; complement achieved by aircraft + ATM	**engine: [-55%, -65%] CAEP6**
NOx (Cruise)		"-80%"	Achieved through -50% Fuel Burn & -60% cruise EINOx reduction	"-90%"	Achieved through -75% Fuel Burn & further cruise EINOx reduction	not quantified
Other emissions		"damaging emissions reduced"	emissions qualitatively reduced (particles, CO, UHC) and better understanding of impacts	"emissions-free taxiing" + qualitative reduction	knowlegde of emissions (particles, VOC) and better understanding of impacts	better knowledge of engines particles emissions

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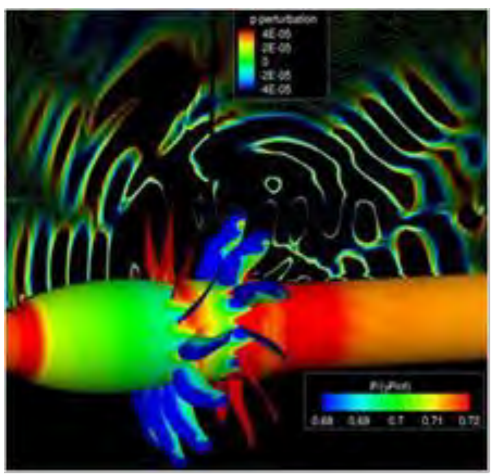
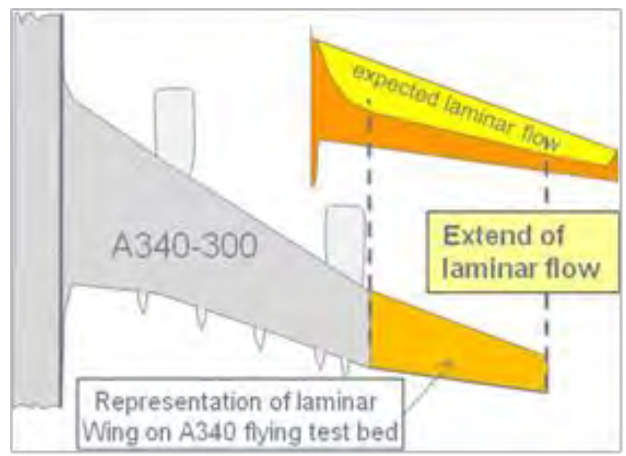
RECOMMENDATIONS & NEEDS (CO2 MITIGATION SOLUTIONS)

- **ACARE 2050 very challenging CO2 reduction objective would permit to mitigate substantially the effect of traffic growth.**
  - So, it is essential to pursue a tremendous effort at the aircraft level, the engine level and the ATM & flight operation level in order to progress towards this ambitious goal.

- **Unconventional configurations like aircrafts equipped with CROR concept or UHBPR concepts, must be further developed.**
  - Their mitigation potential, complemented with laminar wing benefit, must be maximised and their maturity must be pushed over TRL5

URANS CROR calculation





Laminar wing test bed

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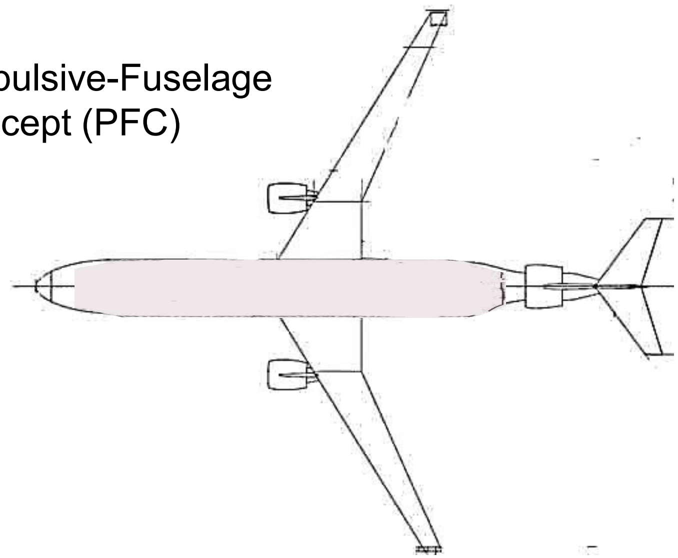
RECOMMENDATIONS & NEEDS (CO_2 MITIGATION SOLUTIONS)

➔ **Aircraft/Engine technologies must be further and continuously improved**

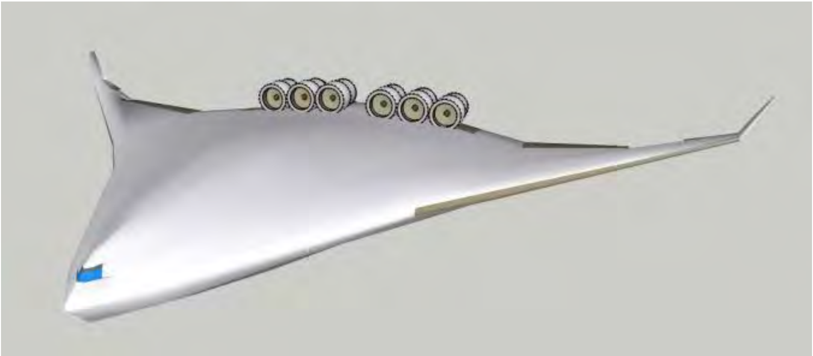
- both for evolutionary aircraft/engine applications and longer term disruptive ones

➔ **More radically unconventional solutions (distributed propulsion a/c…) should be also considered for much longer term and at lower TRL**

Propulsive-Fuselage Concept (PFC)



Distributed Multiple-Fans Concept (DMFC)



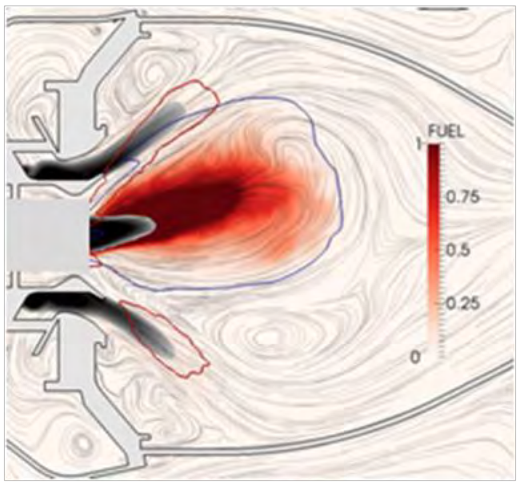
DISPURSAL Project Analysis

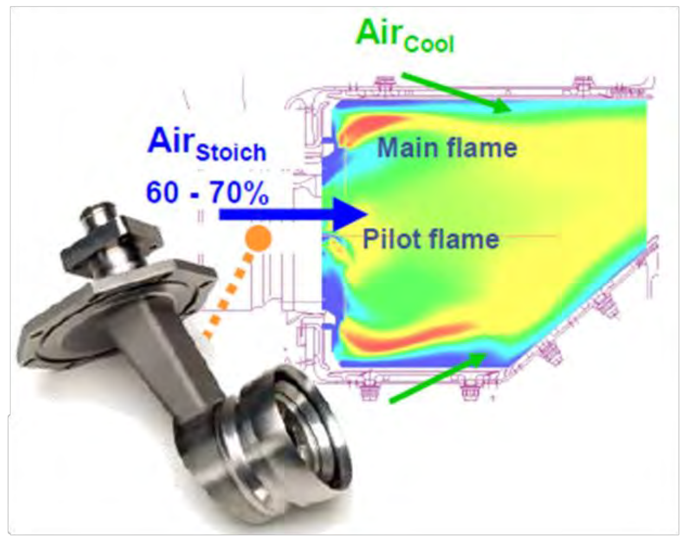
RECOMMENDATIONS & NEEDS (NON-CO2 MITIGAT. SOLUTIONS)

Consensus appears that fine particles (nvPM) reduction must be also achieved, in addition to NOx. This induces critical R&T on:

➔ **The combustor technology itself in order to reduce both NOx & nvPM**

- enhanced lean combustion in general (achieving TRL6 maturity & extending its application to smaller size and/or smaller OPR engine combustors),
- focus on more specific aspects which may be beneficial to particles reduction





Lean combustion technology: Snecma calculation (left), Rolls-Royce solution (right)

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RECOMMENDATIONS & NEEDS (NON-CO2 MITIGAT. SOLUTIONS)

→ **The modeling of emissions (NOx + particles),**

- Modelling for particles is far from being predictable today, because of the physical complexity of particles formation and of the modeling of combustion related operability aspects

→ **The experimental analysis, which is absolutely necessary to support modeling development or to assess technology.**

- This assumes advanced measurements (in particular intrusive and non intrusive measurements of particles in the combustion chamber)
- and appropriate test capability (from multi-sector tests to full annular tests, with ability to achieve high pressure levels)

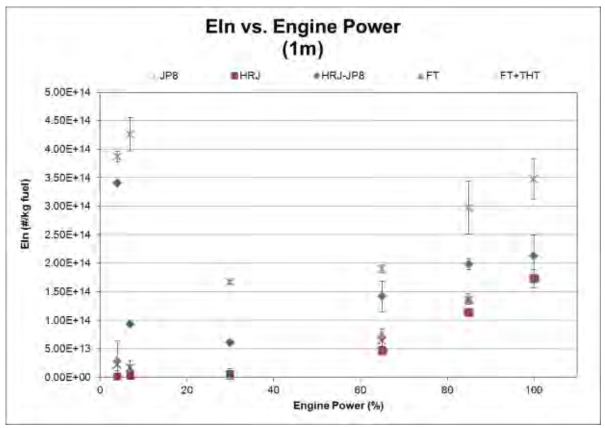
RECOMMENDATIONS & NEEDS (ALTERNATIVE FUELS)

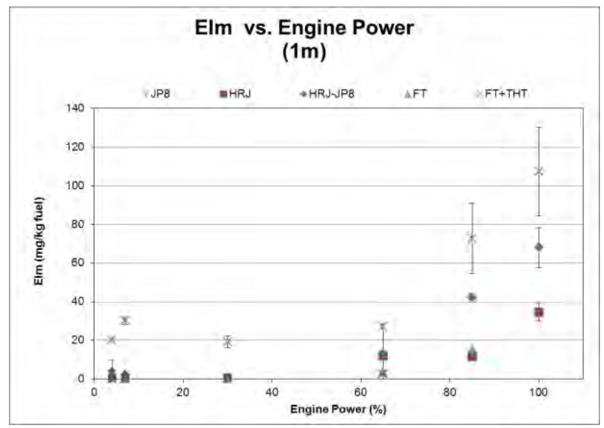
- **Harmonisation is needed to converge on a common and technically satisfactory CO2 LCA methodology** in order to assess alternative jet fuel production pathways**.**

- **The aromatic content of future jet fuels (fossil or renewable) should be minimized as much as possible in order to reduce particles emission. Reduction of sulphur content will be also beneficial.**

- **Need to develop predictive tools to model the fuel interaction with the aircraft fuel system or with the engine.** => fuel composition optimisation to improve fuel compatibility and help reducing ASTM certification costs**.**

Fuel effect on non volatile particles (CFM56 test in AAFEX II)





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FORUM-AE support to ACARE WG3 & Contribution to SRIA up-date

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ACARE WG3 & SRIA UP-DATE

- Technical inputs (status & recommendations) are provided periodically to ACARE WG3. Participation to the ACARE WG3 meetings is ensured by the FORUM-AE project's coordinator and (or delegated to one of the) individual FORUM-AE partners representatives.

- Inputs are strictly based on the conclusions agreed inside FORUM-AE.

- A contribution to the SRIA up-date was provided before the summer but the work must be pursued more accurately in order to be sure the content is consolidated by FORUM-AE.

ACARE Activity Summary 2014-15

ACARE

2.3. Reducing Environmental Impact

Aviation has an importan[t] local air quality issues. T[...] impact of aviation are rec[...]

The FORUM-AE project, in its mid-term synthesis report of July 2015, provided a status including state of the art and future trends, status of the aviation effect on climate change, mitigation solutions for CO_2 and other emissions, utilisation of alternative fuels, regulations and standards, as well as the evaluation of the progress towards the Vision 2020 goals and recommendations for the next steps.

While FORUM-AE addresses alternative fuels as one of the means to mitigate emissions, the CORE-Jet-Fuel project is dedicated to the production and deployment from well to tank, *i.e.* from

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ACARE SRIA UPDATE 2017

SRIA Challenge 3 – Protecting the environment and the energy supply

FORUM-AE input from WP on

- 3.1 - Defining air vehicles of the future: evolutionary steps ↔ Mitigation
- 3.2 - Defining air vehicles of the future: revolutionary steps ↔ Mitigation
- 3.3 - Increasing material recycling and re-use ↔ Impacts
- 3.4 - Improving air operations and traffic management ↔ Mitigation
- 3.5 - Improving the airport environment ↔ Impacts
- 3.6 - Providing necessary quantity of affordable alternative energy sources ↔ Mitigation
- 3.7 - Understanding aviation's climate impact ↔ Impacts
- 3.8 - Adaptation to climate change ↔ Mitigation
- 3.9 - Providing appropriate regulation and incentives ↔ Regulation

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Conclusions & Perspectives

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CONCLUSIONS & PERSPECTIVES

→ **FORUM-AE delivered in July 2015 its mid-term report, containing a first complete status and identifying research priorities linked to:**

- Aviation Emissions Environmental Impact
- Mitigation Solutions (Technology/ATM/ Alternative Fuels)
- Regulation issues

→ **Since then, this status was partially consolidated and 3 forthcoming major workshops** (on Climate Change / on Combustor Technology/ on Aircraft & engine Technology) **will provide complementary material.** Monitoring of relevant projects (see appendix) is a permanent task**.**

→ **On this base, R&T strategy for the future will be recommended:**

- To ACARE WG3, including SRIA update 2017
- In the project's final synthesis (July 2017)

→ **Potential network follow-up is currently evaluated**

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Thank You!

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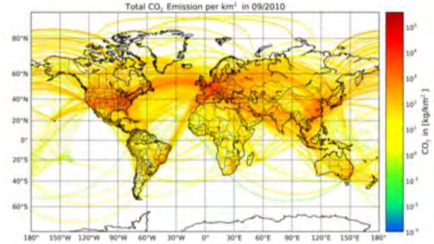
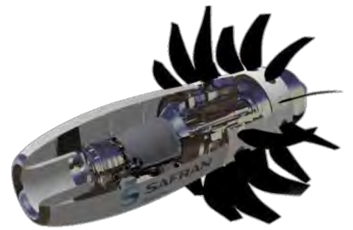
MONITORING[A]

➔ Very large number of relevant projects

PROJECT	T0	STATUS	Coordinator	TITLE	TYPE
REACT4C	2010	Completed	DLR*	Reducing Emissions from Aviation by Changing Trajectories for the Benefit of Climate	Impacts
ECATS	2005	Foundation	ECATS*	Environmental Compatible Air Transport System => Foundation	Impacts
MOZAIC	1994	On-going	RC Jülich	Measurement of Ozone, Water Vapor, Carbon Monoxide, Nitrogen Oxide by Airbus In-Service Aircraft	Impacts
IAGOS	2008	On-going	RC Jülich	In service Aircraft for a Global Observing System	Impacts
IAGOS ERI	2009	On-going	RC Jülich	In service Aircraft for a Global Observing System / European Research Infrastructure	Impacts
CARIBIC	2004	On-going	MPI Chemie, Mainz	Civil aircraft for the regular investigation of the atmosphere based on an instrument container	Impacts
QUANTIFY	2005	Completed	DLR*	Quantifying the Climate Impact of Global and European Transport Systems	Impacts
CleanSky - SFWA	2008	On-going	AI*	SMART Fixed Wing Aircraft	Aircraft
CleanSky - GRA	2008	On-going	Alenia	The Green Regional Aircraft	Aircraft
CleanSky - GRC	2008	On-going	Eurocopter	Green Rotorcraft	Aircraft
NACRE	2005	Completed	AI*	New Aircraft Concepts Research	Aircraft
AHEAD	2011	On-going	TU Delft	Advanced Hybrid Engines for Aircraft Development	Aircraft
DISPURSAL	2013	On-going	Bauhaus	Distributed Propulsion and Ultra-high By-pass Rotor Study at Aircraft Level	Aircraft
CleanSky - SAGE	2008	On-going	RR*&SN*	Sustainable And Green Engine	Engine
DREAM	2008	Completed	RR*	valiDation of Radical Engine Architecture systeMs	Engine & Fuel
NEWAC	2006	Completed	MTU	NEW Aero engine Core concepts	Engine HP
VITAL	2005	Completed	SN*	Environmentally Friendly Aero-Engine	Engine BP
LEMCOTEC	2011	On-going	RRD*	Low Emissions Core-Engine Technologies	Engine BP
EBREAK	2012	On-going	TM*	Engine Breakthrough components and subsystems	Engine
ENOVAL	2013	On-going	MTU	The Engine mOdule Validators	Engine BP

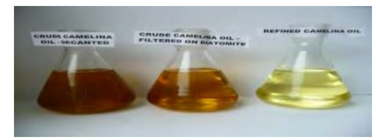


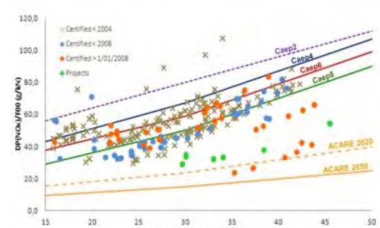


➔ Monitoring activity (continued)

Soprano: kick-off in Sept 2016

KIAI	2009	Completed	SN*	Knowledge for Ignition, Acoustics and Instabilities	Combustor
FIRST	2010	On-g			Combustor
FACTOR	2010	On-g			Combustor
IMPACT-AE	2011	On-going	RRD*	Design methodologies	Combustor
TECC-AE	2008	Completed	SN*	Technology Enhancements for Clean Combustion	Combustor
INTELLECT D.M.	2003	Completed	RRD*	Integrated Lean Low-Emission Combustor Design Methodology	Combustor
TIMECOP-AE	2006	Completed	TM*	Toward Innovative Methods for Combustion Prediction in Aero-engines	Combustor
TLC	2005	Completed	SN*	Towards Lean Combustion	Combustor
LOPOCOTEP	2000	Completed	SN*	LOw POllutant COmbustor TEchnology Project	Combustor
ALFA-BIRD	2008	Completed	Eu-Vri	Alternative Fuels and Biofuels for Aircraft Development	Fuel
SWAFEA	2009	Completed	Onera	Sustainable Way for Alternative Fuels and Energy in Aviation	Fuel
burnFAIR	2010	On-going	LH*	Searching for a viable kerosene replacement	Fuel
ITAKA	2012	On-going	SEN*	Initiative Towars sustAinable Kerosene for Aviation	Fuel
SESAR	2007	On-going	JU	Single European Sky ATM Research	Operations
CleanSky - SGO	2008	On-going	Thales	System for Green Operation	Operations
AIRE	2009	On-going	SJU-FAA	Atlantic Interoperability Initiative to Reduce Emissions	Operations
ERAT	2007	Completed	To70	Environmental Responsible Air Transport	Operations
CS-EcoDesign	2008	On-going	DA&FHF	Eco-Design (co-leaded by Dassault & Fraunhofer)	Recyclability
CleanSky - TE	2008	On-going	Thales	Technology Evaluator	Assessment
AERONET III	2003	Completed	DLR*	Aircraft Emissions and Reduction Technologies	Network & monitoring
X-NOISE EV	2010	On-going	SN*	Aviation Noise Research Network and Coordination	Network & monitoring for NOISE
COREJet-fuel	2013	On-going	FNR	Coordinating research and innovation of jet and other sustainable aviation fuel	Network & monitoring for Fuel
Team-Play	2010	Completed	DLR*	Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis	Regulation
NEPAIR	2003	Completed	Qinetiq	Development of the technical basis for a New Emissions Parameter covering the whole AIRcraft	Regulation
GreenAir	2009	On-going	EADS	Generation of Hydrogen by Kerosene Reforming via Efficient and Low-Emission New Alternative, Innovative, Refined Technologies for Aircraft	Others





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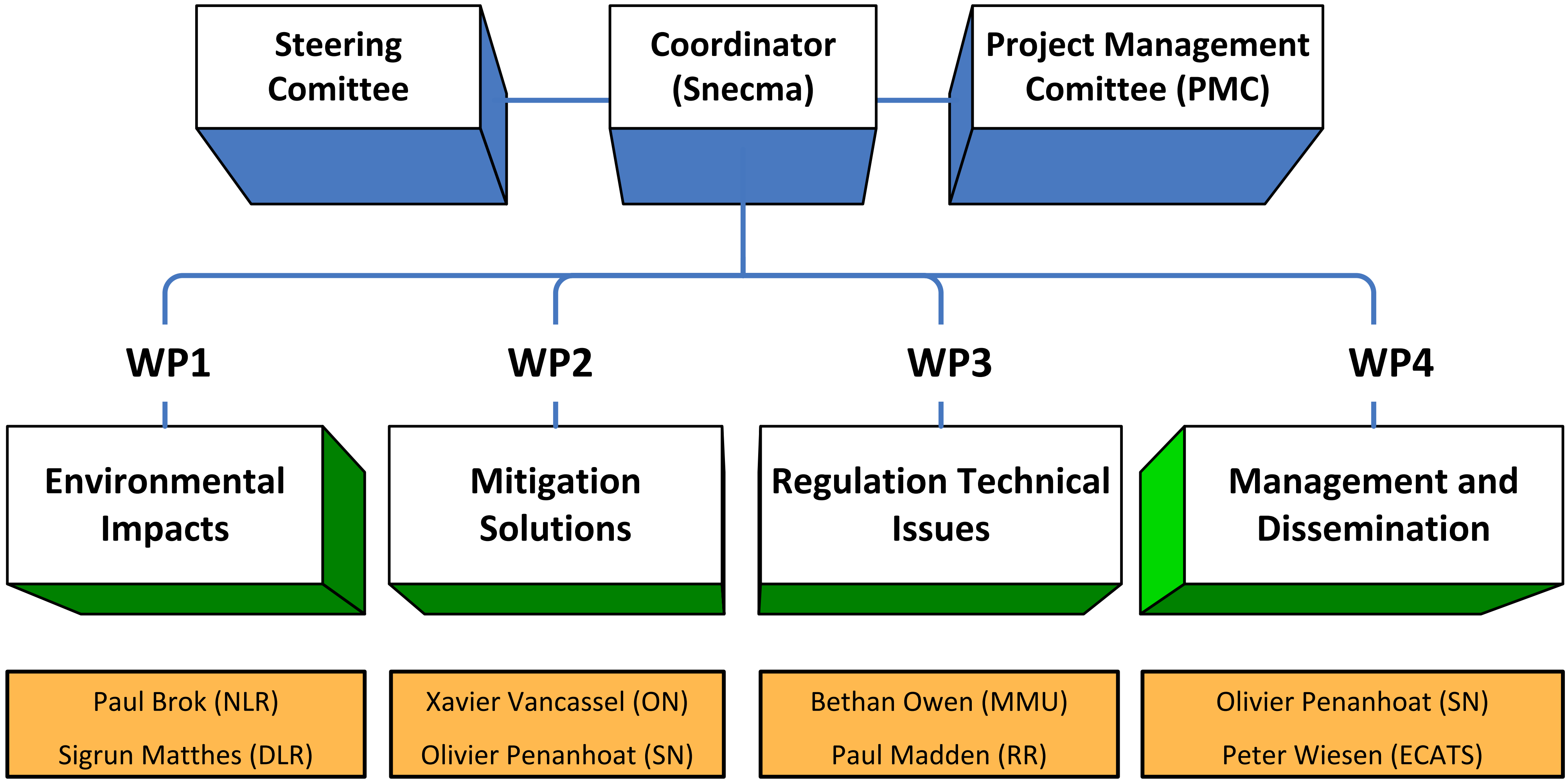
PROJECT'S SCOPE AND ORGANISATION



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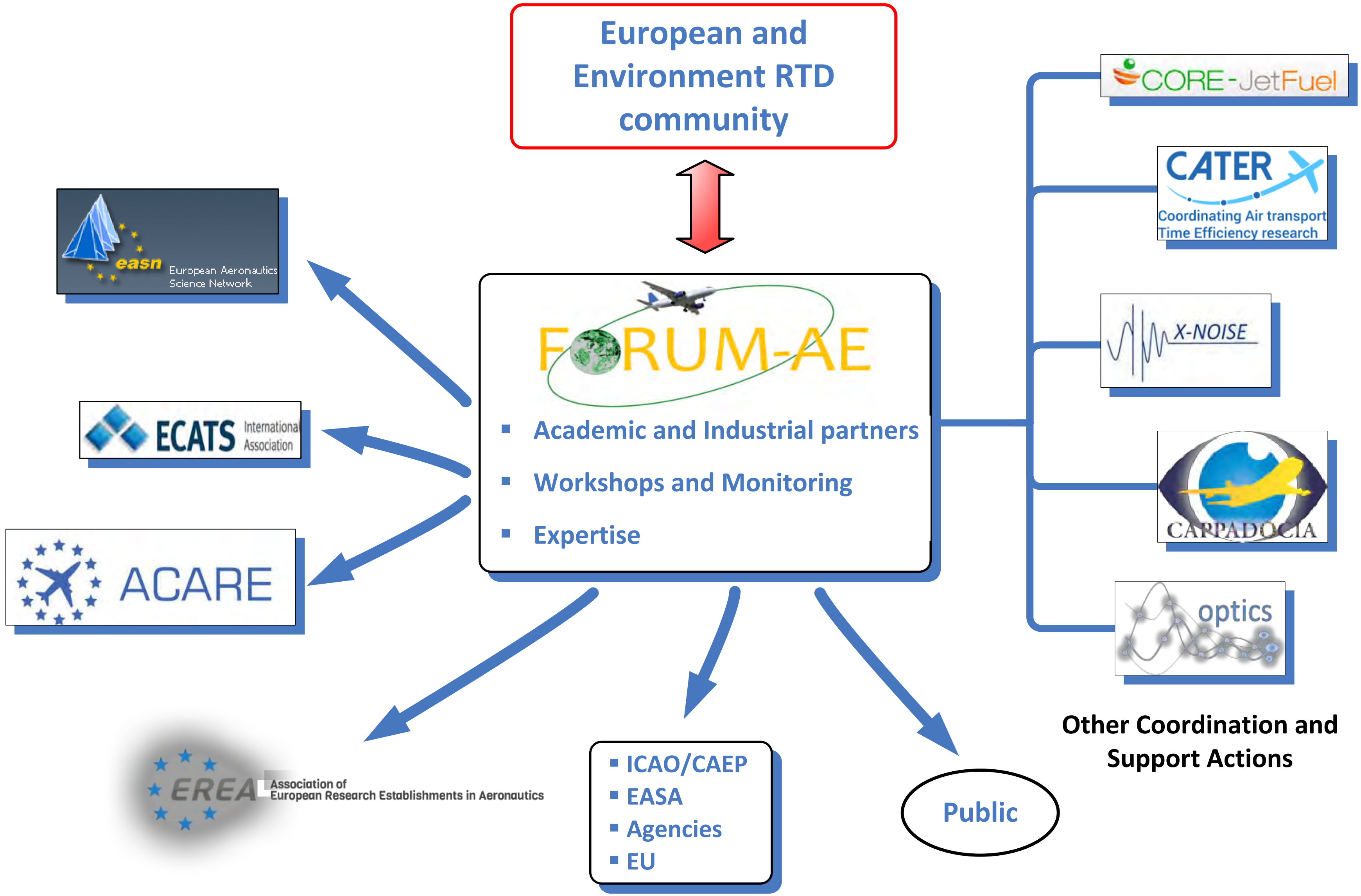
DISSEMINATION OBJECTIVE



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Regulation Technical Status

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