Project 22
Evaluation of FAA Climate Tools

Motivation and Objectives

- Help the FAA and MIT to further advance the capabilities of the APMT model, which is useful to the FAA, to ICAO, and to the aviation industry.
- The assessment on the impacts of aviation on climate usually relies on computationally expensive chemistry-climate models. However, for aviation **policy analyses**, a wide range of different scenarios need to be evaluated, making the development of simple models like APMT very useful.
- The long-term **objective** of this project is to enhance the overall understanding of aviation impacts on climate and the evaluation of the capabilities and limitations of the simple models (e.g., APMT).

Methods and Approach

- Through the use of the results from multiple complex models and analysis in ACCRI, aviation-induced effects calculated in APMT were compared to the results from ACCRI. Some components (stratospheric water vapor, indirect aerosols and nitrates) , which are included in ACCRI, are missing in APMT.
- The impact that non-linearity has on the calculation of aviation-induced effects in the background atmosphere was explored by calculating the APMT 2050 RF using reference year RF from the years 2006 (ACCRI) and 2050 (ACCRI).

Results and Discussion

- This recent project using v23 of the APMT-I climate was successfully implemented at UIUC and a representative case was generated.
- The components that are not represented in APMT (stratospheric water vapor, indirect aerosols and nitrates) have a significant effect on the model estimate of the overall aviation-induced RF and as such have to be included in the model.
- The 2050 RFs calculated in the APMT model, using different reference RFs, are taken as inputs to explore the impact of non-linearity in the background environment on the sea surface temperature change and climate cost induced by the aviation emissions [Table 1].

Table 1. 2050 RFs calculated from APMT

RF Terms	APMT calculated 2050 RF (mW/m^2)		Difference(%)
	If the used reference RF is from the year 2006 (ACCRI)	If the used reference RF is from the year 2050 (ACCRI)	
H20	-6.8	-4.9	-27.94
Sulfates	-13.7	-15	9.49
Soot	2.2	0.6	-72.73
Contrails	87.1	72	-17.34
CH4	-19.4	-25.9	33.51
O3-short	43.3	42	-3.00
O3-long	-8.7	-8.1	-6.90

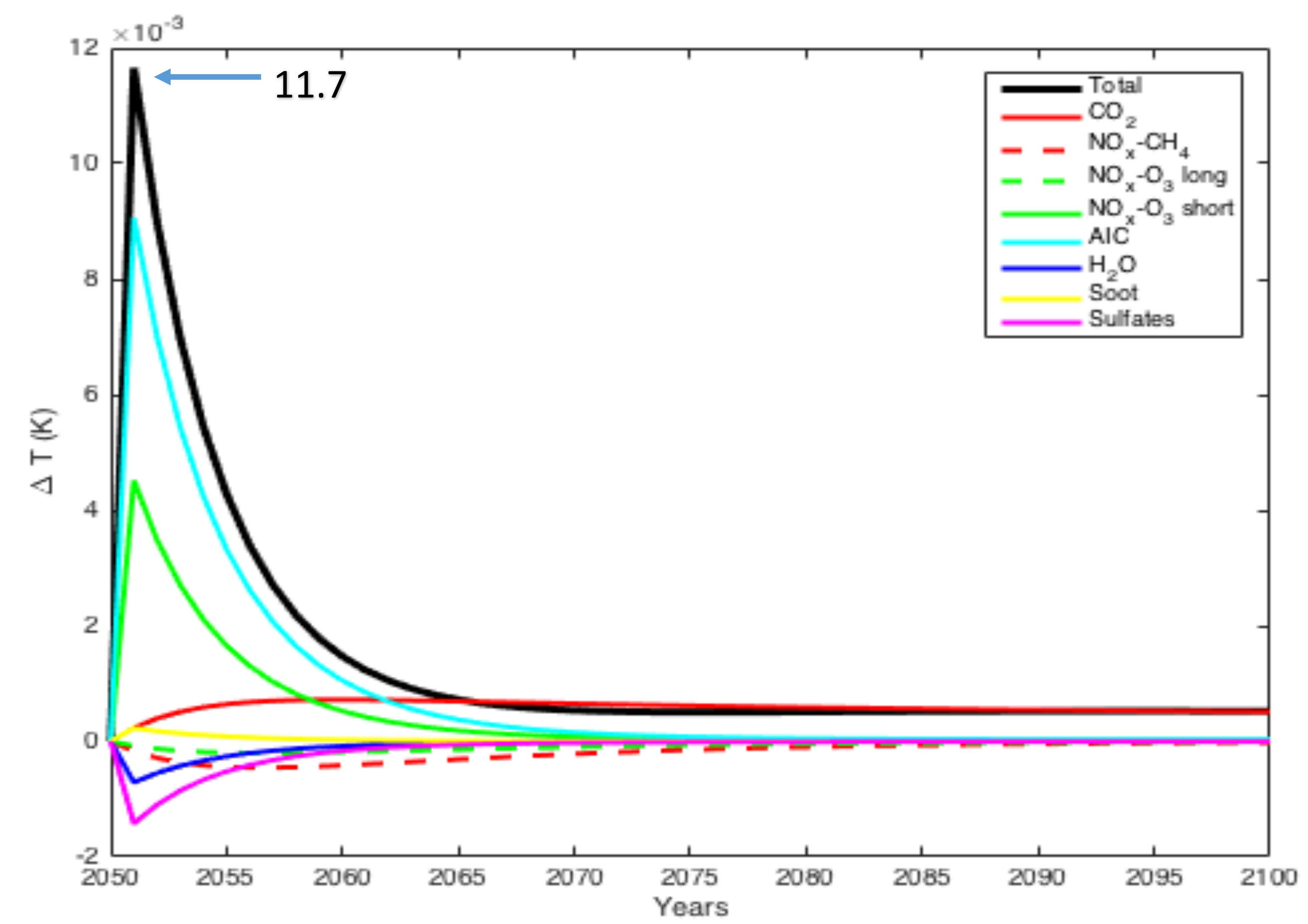

Figure 1. (a) Using 2006 Reference RFs

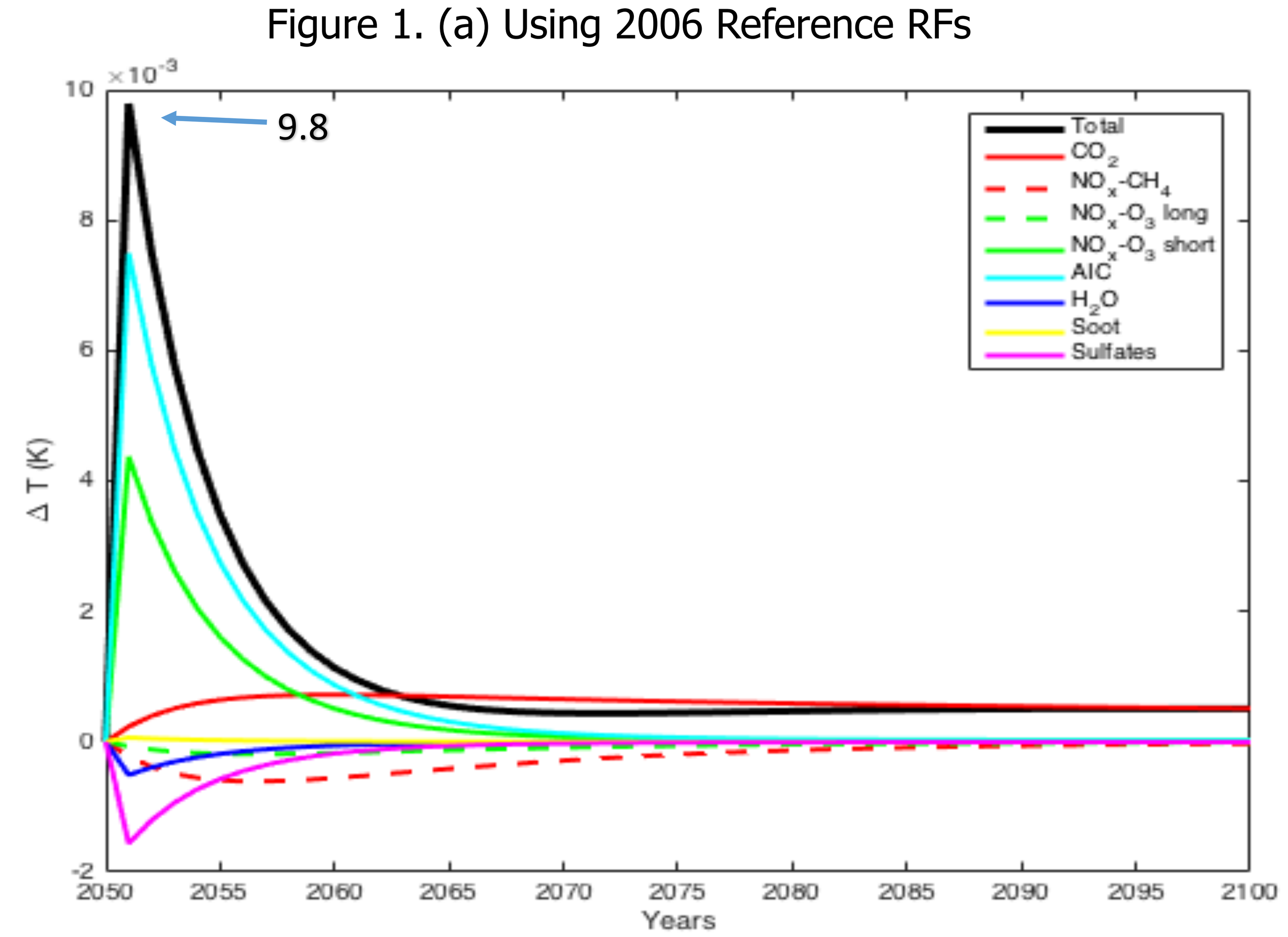

Figure 1. (b) Using 2050 Reference RFs

Figure 1. Temperature change due to aviation impacts (aviation impulse)

Table 2. Exploring the non-linearity of short-lived forcings in the background atmosphere

Short-lived Forcings	APMT calculated 2050 temperature change (10^{-3} K)		Difference (%)
	If the used RFs are linearly scaled from the year 2006 (ACCRI)	If the used RFs are the simulated RFs from the year 2050 (ACCRI)	
H20	-0.7	-0.5	-40.00
Sulfates	-1.4	-1.6	12.50
Soot	0.2	0.06	233.33
Contrails	9.1	7.5	21.33
O3-short	4.5	4.4	2.27

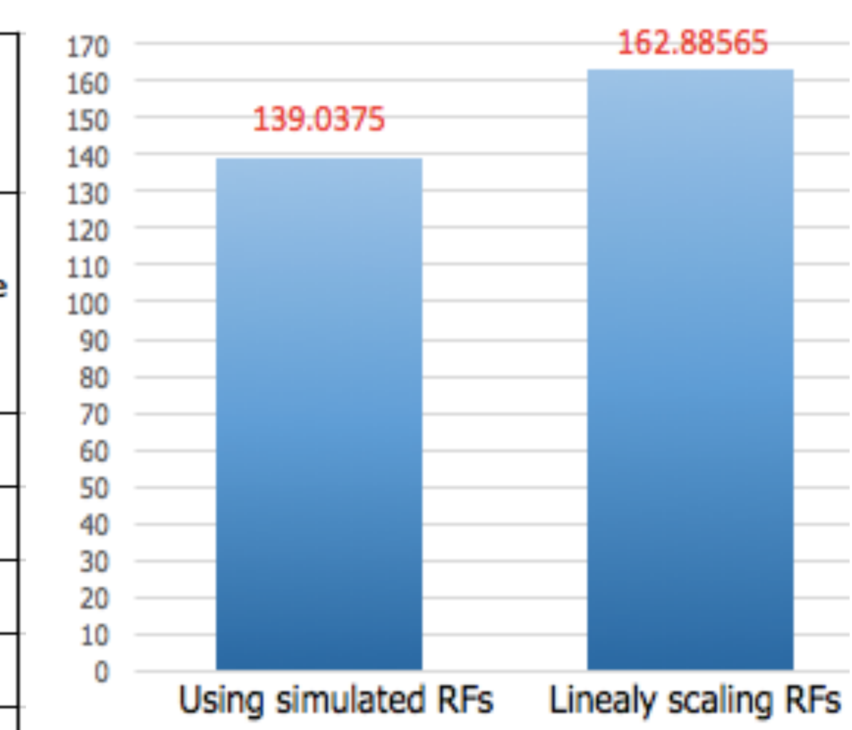

Figure 2. Calculated 2050 climate cost

- The temperature change induced by 2050 impulse emission is significantly different when using the 2006 and 2050 reference RFs. The averaged total temperature change from all forcings is 0.0117K and 0.0098K respectively, which has a difference exceeding 19% (Figure 1).
- The 2050 climate cost calculated in APMT is 17% greater when using the 2006 RFs as reference to linearly scale 2050 RFs from emissions rather than using the 2050 actual simulated RFs in ACCRI which are treated non-linearly (Figure 2).
- Main non-linearity is indicated by H_2O, Soot, Contrails [Table 2] and long-term effects since they strongly depend on the background atmosphere. Thus, the main model improvement should be on the treatment of long-term effects and effects that are dependent on the background atmosphere.

Conclusions and Next Steps

- All missing components (stratospheric water vapor, indirect aerosols and nitrates) should be included in APMT.
- The future model improvements should be focused on the non-linearity in APMT to be better used for policy analyses.

The **Next Steps** include:
- Evaluation of the v24 of APMT-I Climate (which will include stratospheric water vapor and nitrates)
- Evaluation of Regional Temperature Potential from CICERO

Lead investigator: D. J. Wuebbles, University of Illinois at Urbana-Champaign
Project manager: D. Jacob and R. Halthore, FAA

September 27-28, 2016

This work was funded by the US Federal Aviation Administration (FAA) Office of Environment and Energy as a part of ASCENT Project 22 under FAA Award Number: 13-C-AJFE-UIUC. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the FAA or other ASCENT Sponsors.