APMT-Impacts Development Update

Climate and Air Quality

Federal Aviation Administration

Presented to: REDAC Environment & Energy Subcommittee

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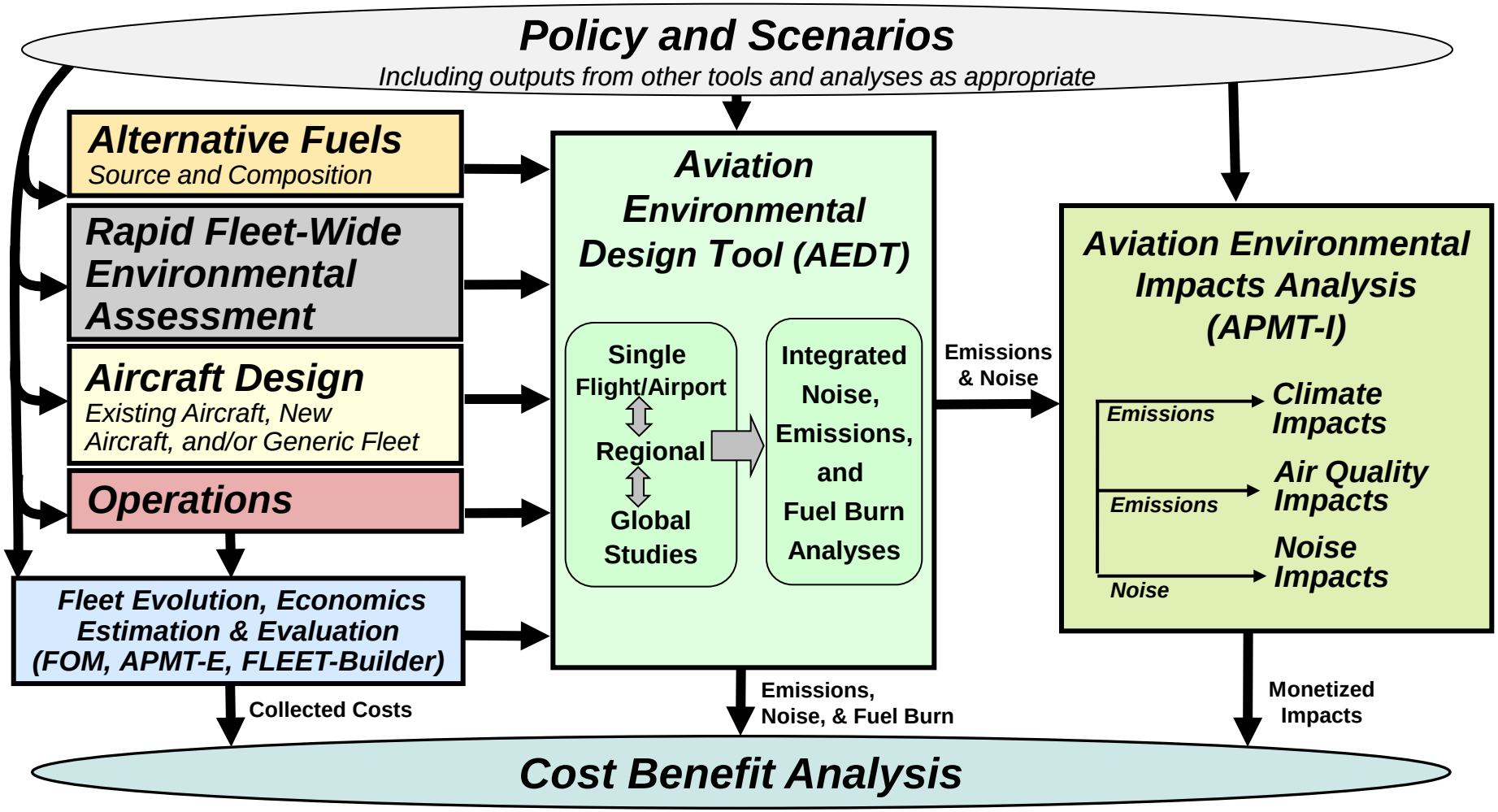
Outline

- **Aviation Environmental Portfolio Management (APMT) Tools**
- **Status and Outlook**
  - Climate Impacts Module
  - Air Quality Impacts Module

Aviation Environmental Portfolio Management (APMT) Tools

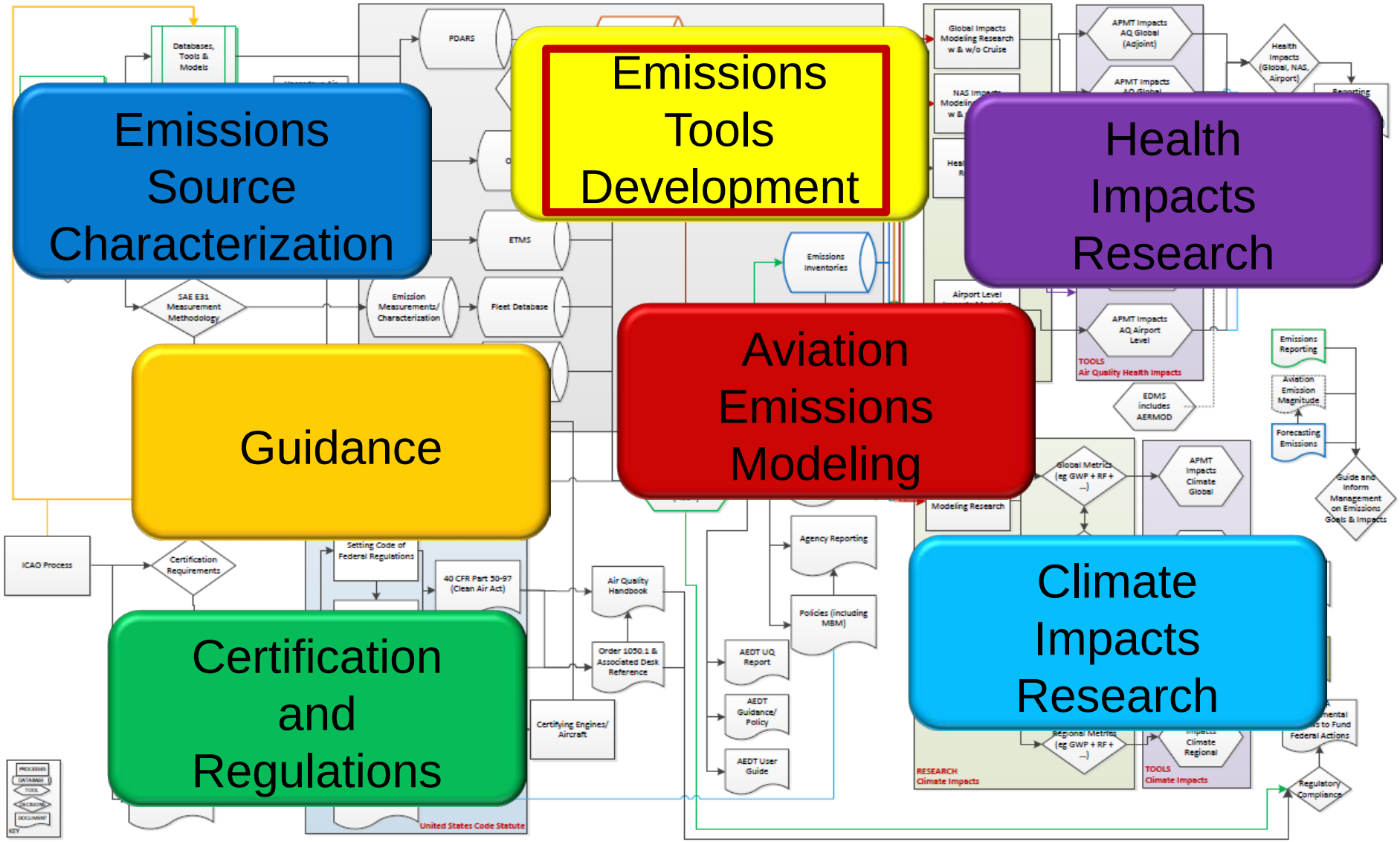
- Aviation benefits and environmental effects result from a complex system of interdependent technologies, operations, policies and market conditions
- Impacts typically considered in a limited context
  - Only noise, only air quality, only climate change
  - Only partial economic effects
- Actions in one domain may produce unintended negative consequences in another
- The Aviation Environmental Tools Suite facilitates consideration of these interdependencies in decision making.

Aviation Environmental Tools Suite

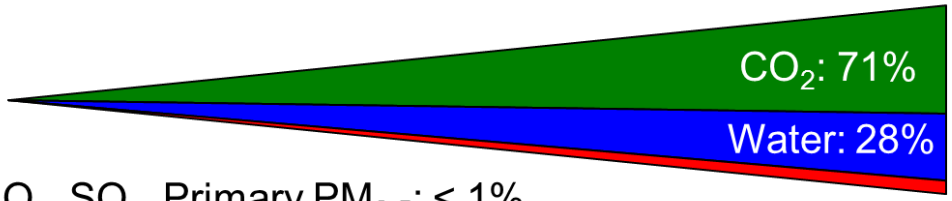


AEDT – Aviation Environmental Design Tool
APMT-E – Aviation environmental Portfolio Management Tool for Economics
APMT-I – Aviation environmental Portfolio Management Tool for Impacts Analyses
FLEET-Builder – FLeet Evolution, Estimation and evaluaTion Builder
FOM – Fleet and Operations Module

Emissions Roadmap



Aircraft Emissions & Climate Change - Simplified



CO, HC, NO_x, SO_x, Primary $PM_{2.5}$: < 1%

Atmospheric Chemistry and Physics

Combustion Emissions

soot

SO_x

NO_x

O_3

CH_4

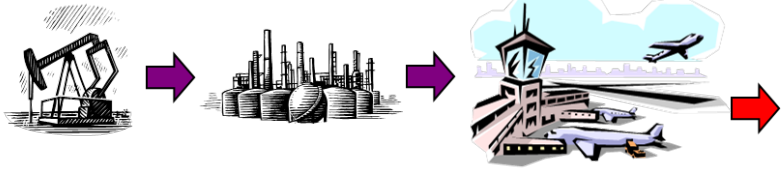
H_2O

CO_2

Contrails & Cirrus Clouds

Global Climate Change

Emissions from Fuel Production

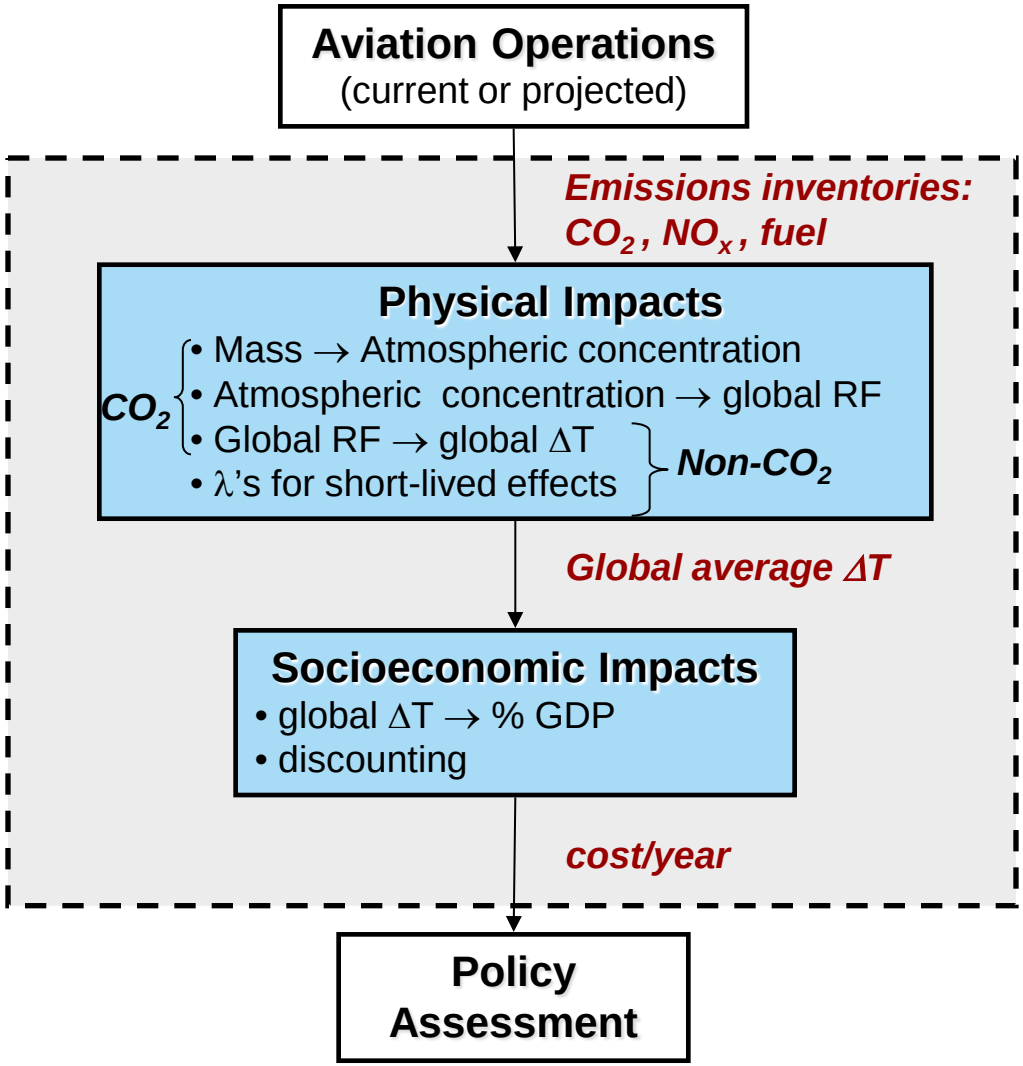


CH_4, N_2O, CO_2

Cooling Effects

Warming Effects

APMT-Impacts Climate Module



APMT-Impacts Climate module is a simplified model that provides:

- estimates of aviation induced impacts through a portfolio of physical and monetary units
- quantified uncertainties in the estimated climate impacts

Model has been used to:

- Support cost benefit analyses for ICAO CAEP standard setting
- Support evaluation of alternative jet fuel environmental impacts

APMT-Impacts Climate Module

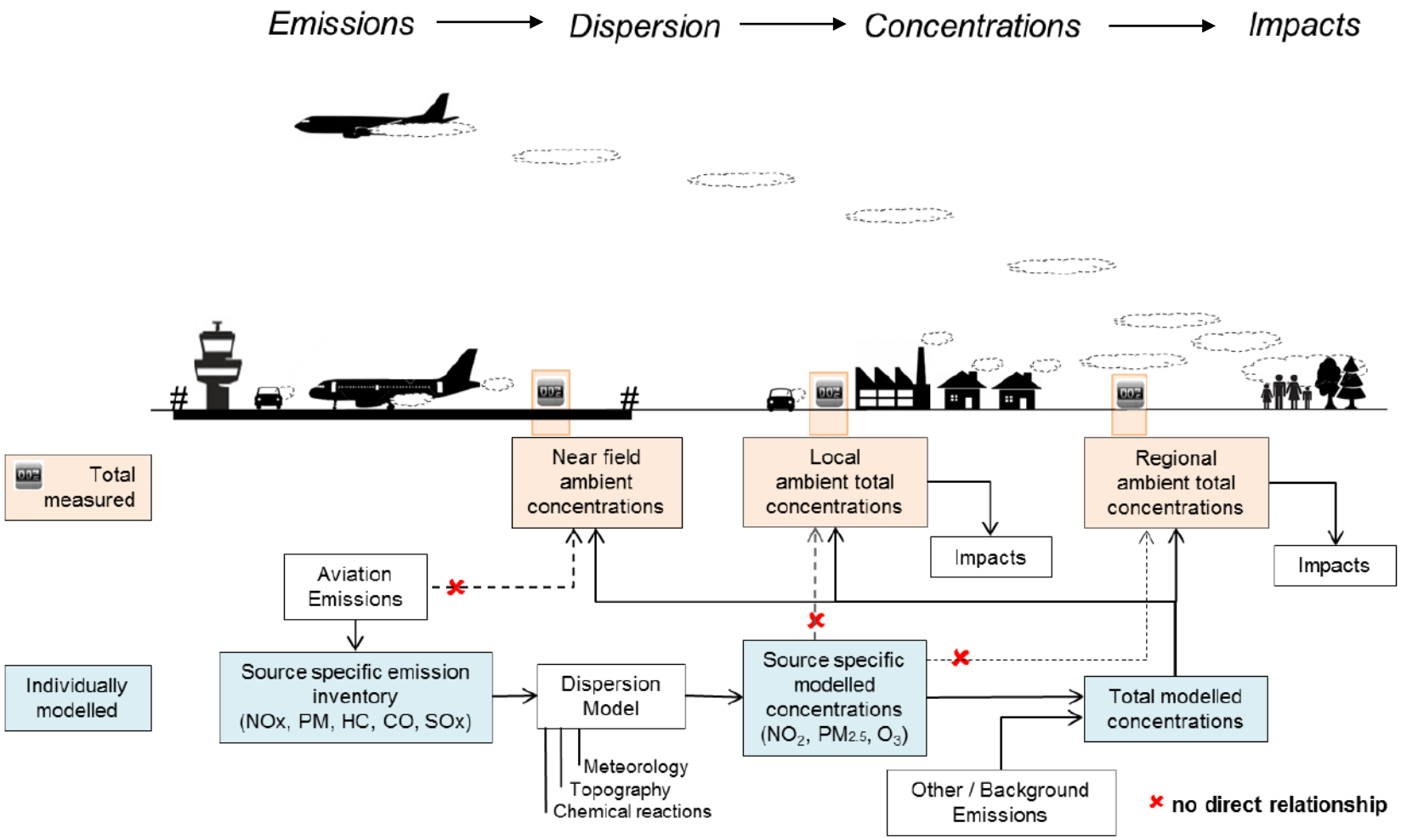
- **Continuously updated to implement up to date scientific understanding**
  - Current Code version 23
  - APMT uses as a baseline an impulse-response function carbon model, updated to a parameterization of the Bern Carbon Cycle from Joos et. Al. 2013. This is the IRF used in the IPCC AR5
  - Non-CO_2 from FAA ACCRI Phase 2 Report (Brasseur et al. 2015)
  - Latest version of Dynamic Integrated Climate-Economy Model (DICE2013)
  - Life cycle Emissions and Alt Fuel Impacts
- **Used to inform International Aircraft CO_2 standard**

APMT-Impacts Climate Future Outlook

- **Developed a requirements document for v24**
- **Will include:**
  - Implementation of Interagency Working Group on Social Cost of Carbon Method for monetizing CO_2 impacts
  - Add two additional short lived forcers
    - Stratospheric Water Vapor
    - Nitrate Particulate Matter
  - Improve Contrail Impacts Representation based on FAA Climate Change Research (CCR) results.

Air Quality – Measurements versus Modeling

Schematic presentation of emissions, dispersion, concentrations and impacts with their interaction at airport level (graphic from CAEP/10 ISG White Paper on Air Quality)



Aircraft Emissions and Air Quality Impacts

CO_2: 71%

Water: 28%

CO, HC, NO_x, SO_x, Primary $PM_{2.5}$: < 1%

Emissions

Atmospheric Chemistry & Physics

$PM_{2.5}$

SO_x

NO_x

HC

CO

Air Quality Model

Ambient Ozone

Ambient $PM_{2.5}$

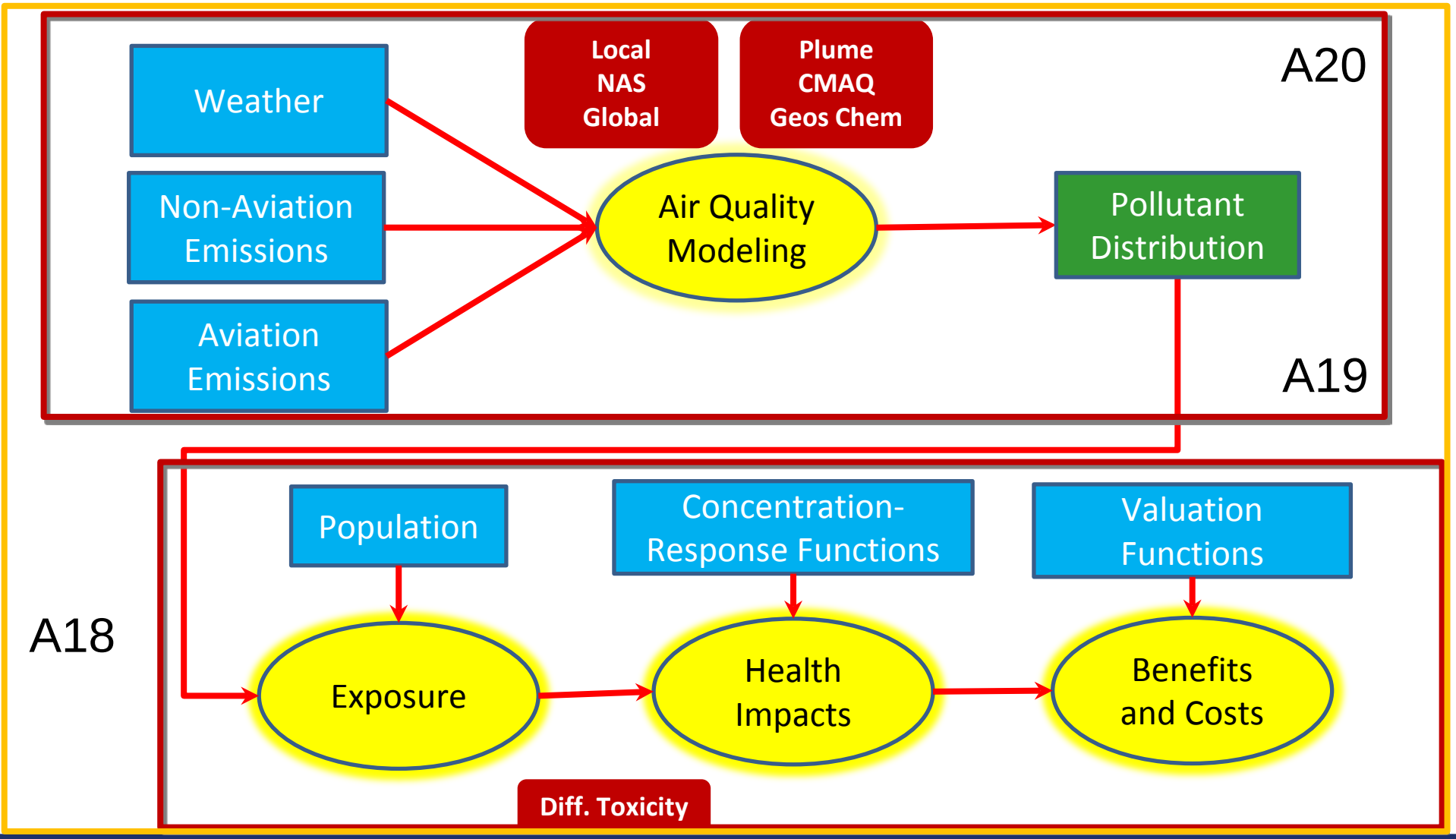
Air Quality Impacts

- Changes in $PM_{2.5}$ concentrations
- Changes in health risks (Concentration Response Functions)

Impacts Valuation

- Value of statistical life
- Discounting

APMT-Impacts Air Quality Module



Air Quality Analysis Tools

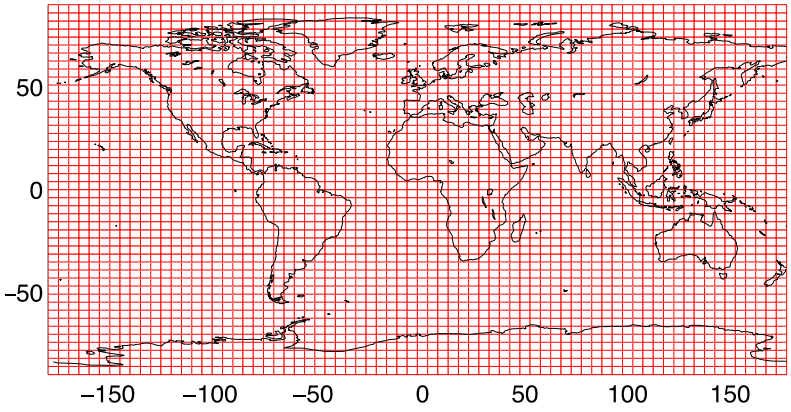
- **Supporting ICAO CAEP standard setting**
  - RSMv3 - covers U.S. – used for CAEP/8 NOx Std and CAEP/9 Noise Std cost benefit analyses
  - Adjoint Method – covers U.S. and globe – used for CAEP/10 CO2 Std cost benefit analysis
- **Domestic analysis**
  - Airshed Level Health Damage Functions – used for evaluation of air quality benefit of fuel burn reductions
  - CMAQ evaluations of the lower 48 states – used on as-needed basis

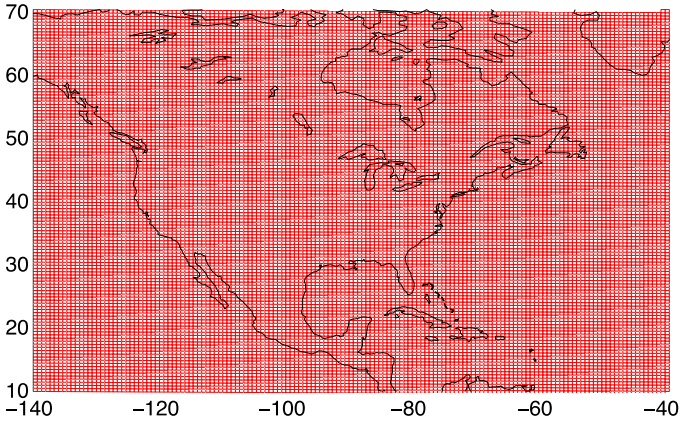
APMT-Impacts Air Quality - RSMv3 Module

- The Response Surface Model version 3 calculates $PM_{2.5}$ concentrations and premature mortality from aviation LTO emissions within U.S.
- It is based on a set of linear regressions of multiple CMAQ simulations
- Applicable for aviation emission policies that result in nationally uniform changes in emissions
- Accounts for changing background conditions when analyzing future-year scenarios

➢ While this was used for operational analyses, will be replaced by GEOS-Chem adjoint which captures changes in spatial distribution of emissions

APMT-Impacts Air Quality - Global and U.S. Adjoint



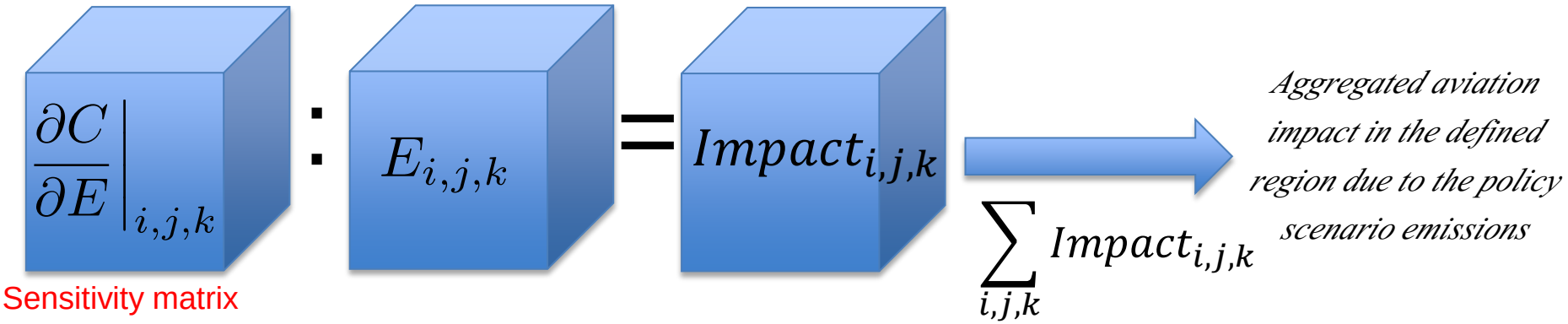


- Gives solution space of emissions' reductions that meet a specific AQ target
- Enables assessment of non-uniform emissions' growth or of non-uniform policies across country and/or world
- Very fast and hence suitable for Uncertainty Quantification
- Captures impact of background changes as well as of aviation

- Both versions provide monetized benefits of decision alternatives

APMT-Impacts Air Quality - Adjoint Approach

- Sensitivity of each grid cell provides the overall impact in the defined region due to the scenario emissions at the grid cell
- The adjoint approach allows to define different cost functions (e.g. concentration, population exposure, etc.)



APMT-Impacts Air Quality – Airshed Level

- Objective: quantify air quality and health impacts due to aircraft emissions during LTO at individual airports in the US
- Being developed to inform NextGen financial analyses
- Leverages CMAQ Direct Decoupled Method (CMAQ DDM)
- Health Damage Functions developed for multiple regional scales

$$\Delta Health\ Impacts_i = \underbrace{\Delta Fuel_i}_{\text{Policy / Technology Analysis (e.g., NextGen Implementation)}} \times \underbrace{\left(\frac{unit\ emission}{unit\ fuel}\right)_i}_{\text{Annual Fuel \& Emissions Inventory}} \times \underbrace{\left(\frac{mortality\ risk}{unit\ emission}\right)_i}_{\text{Health Damage Functions}}$$

Monitoring Ultrafine Particles (UFP) – Ascent 18

Goal

To develop tools that will enable quantification of airport-specific health impacts from aircraft emissions in the vicinity of selected airports by monitoring pollutants underneath flight paths

Tasks

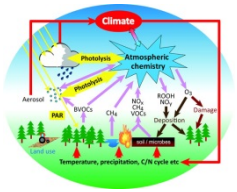
- Conduct ambient monitoring of ultrafine particle (UFP) and other pollutants in communities underneath flight paths near Boston Logan International Airport, to determine the locations and atmospheric/flight activity conditions under which exposures could be elevated

- Quantify total health impacts by source sector, pollutant, and state, allowing for contextualization of relative source contributions as well as insight about dominant pollutants by source sector

APMT-Impacts Air Quality Future Outlook

Inputs

Emissions Inventory (AEDT)



Background weather and chemistry

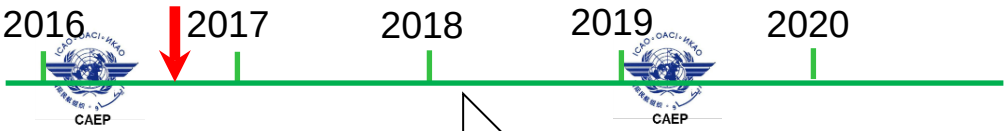
Population

Models

GLOBAL: GEOS-Chem Adjoint

NAS48: CMAQ and GEOS-Chem Nested Adjoint

AIRSHED: CMAQ DDM



Develop overall model with nested grids for U.S. + Asia + Europe

Further updates TBD

Evaluate uncertainties due to background emissions. Develop second order sensitivities

Update tool to account for Improved knowledge of pollutants, dispersion, chemistry and health

CAEP Cost Benefit Analysis

Develop airshed AQ CBA factors

Refine CMAQ modeling framework

Update tool to account for Improved knowledge of pollutants, dispersion, chemistry and health

NextGen Cost Benefit Analysis