# Aircraft Engine Particle Emissions during the 2023 NASA-Boeing ecoDemonstrator Field Measurements

**Francesca Gallo**[1,2], Bruce E. Anderson[1], Steven Baughcum[3], Matthew D. Brown[1,4], William M Griffin[4] Carolyn Jordan[1,2], Michael A. Shook[1], Elizabeth B. Wiggins[1], Edward L. Winstead[1,2], Luke D. Ziemba[1], and Richard H. Moore[1]

[1]NASA Langley Research Center, Hampton, [2]Analytical Mechanics Associates, Inc., Hampton, VA, VA, [3]Boeing, Everett, WA, [4]Science Systems and Applications, Inc., Hampton, VA

## INTRODUCTION

- Aircraft engines emit soot particles and nucleation mode droplets that are responsible for the formation of contrail cirrus clouds.
- In October 2023, NASA collaborated with Boeing **ecoDemonstrator** program conducting a contrail research campaign to study the **impact of different jet fuel compositions on aircraft particle emissions and contrail properties**.

ecoDemonstrator PROGRAM

## METHODS

- The NASA DC-8 aircraft was used to sample Boeing ecoDemonstrator Explorer 737-10 **engine exhausts** which alternatively burned: 1) **100%** HEFA SPK Paraffinic **Sustainable Aviation Fuel (SAF), 2) Low sulfur Jet-A**, and 3) **Conventional Jet-A**.

- Here, we use in situ aerosol and $CO_2$ measurements collected during 11 research flights to quantify how **changes in fuel chemistry impact particle emission index, particle size distribution, and volatile fraction.**

## RESULTS & CONCLUSIONS

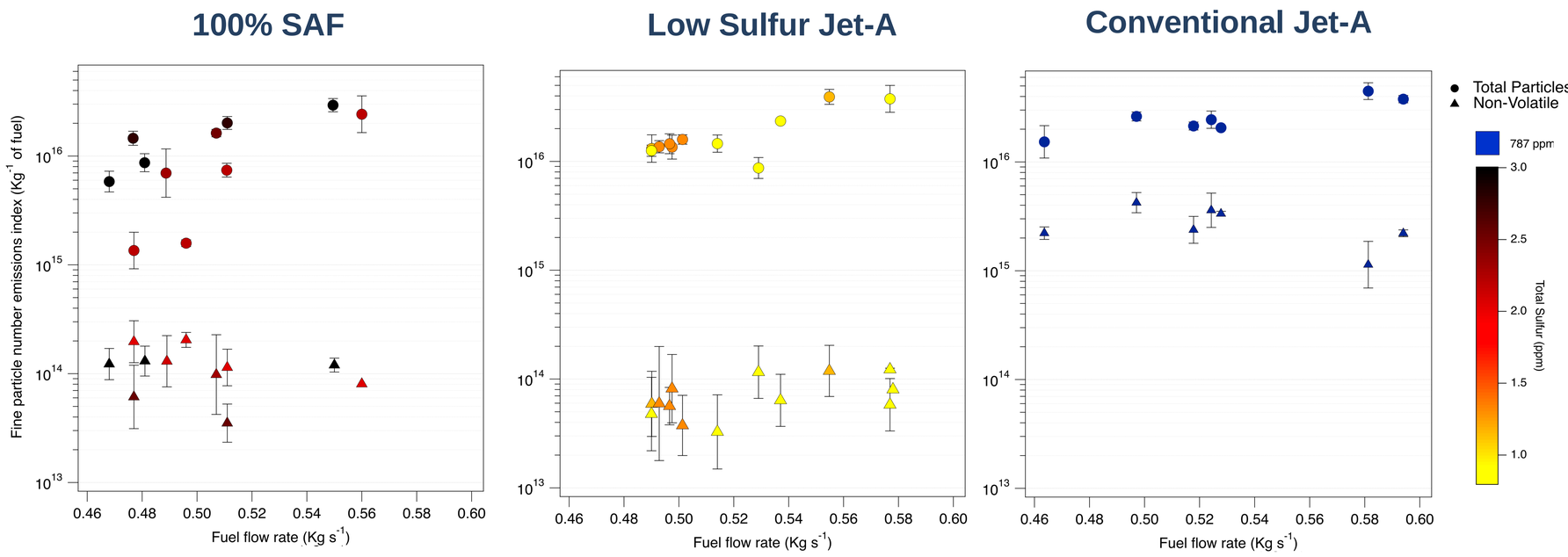
Clear impact of fuel chemistry on:

- **Emission Indices**: Non-volatile particles EI for 100% SAF ~25 times lower than for conventional Jet-A
- **Size Distribution**:

  **total particle** → mode < 10 nm for SAF vs > 10 nm for conventional Jet-A

  **non-volatile particle** → minor contribution and mode > 10nm for SAF vs enhanced emission of particles with $D_p$ ~ 6nm for non conventional Jet-A

## TOTAL and NON-VOLATILE PARTICLE EMISSION INDICES



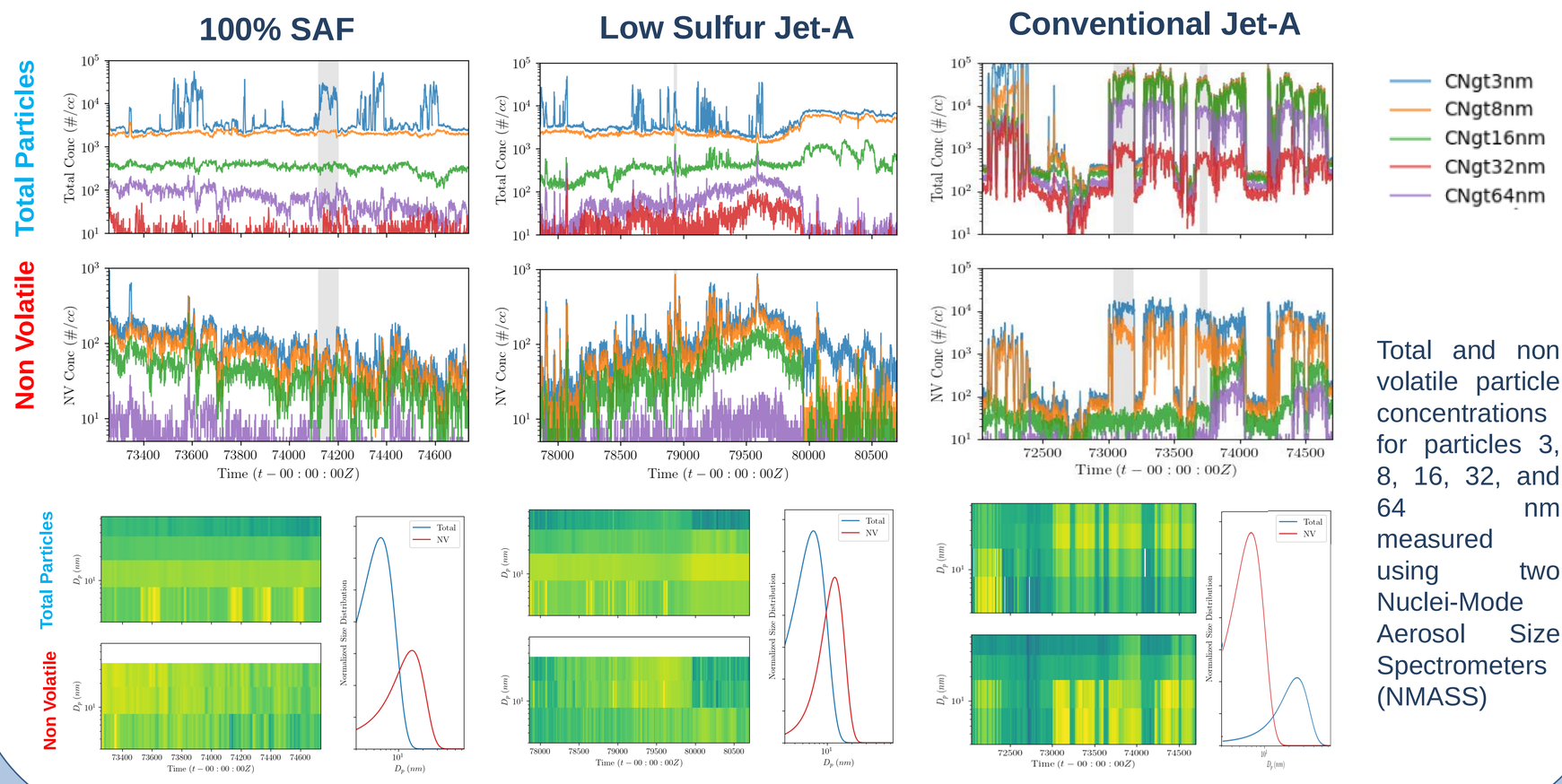

Fine particle emission index calculated article emissions indexes are calculated following Moore et al., 2013: $\mathrm{EI}_X = \frac{\Delta X \cdot V_m}{\Delta CO_2 \cdot M_{CO_2}} \left(EI_{CO_2}\right)$

where, SAF $EI_{CO_2} = 3107\ gCO_2\ kg{-}fuel^{-1}$

Low Sulfur Jet$-$A $EI_{CO_2} = 3175\ gCO_2\ kg{-}fuel^{-1}$

Conventional Jet$-$A $EI_{CO_2} = 3162\ gCO_2\ kg{-}fuel^{-1}$

## TOTAL AND NON-VOLATILE PARTICLE SIZES




Total and non volatile particle concentrations for particles 3, 8, 16, 32, and 64 nm measured using two Nuclei-Mode Aerosol Size Spectrometers (NMASS)