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The sensitivity of the Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM) mission to dust aerosols: a pseudo-observations analysis

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Text S1. Calculations of the dust complex refractive index under internal mixing assumption

The spectral complex refractive index for dust in the 2.5 to 100 µm range is calculated based on the volume mixing approximation (VMA), which considers internal mixing between the different minerals composing dust. In this approach the real and imaginary parts of the dust CRI are obtained as:

$$CRI = \sum_i v_i \cdot CRI_i \qquad (1)$$

where v_i is the volume fraction of each individual mineral composing dust and CRI_i is its complex refractive index. The single mineral spectral CRI_i data are taken from the literature as summarized in Table S1. The v_i values are calculated based on the weight percentages of the different minerals composing dust samples (w_i), the single minerals density (ρ_i), and the total density of the dust mixture (ρ_{mix}). The volume fraction was calculated using the formula $v_i = \frac{w_i \cdot \rho_{mix}}{\rho_i}$. The w_i of the different minerals composing dust samples are taken from Di Biagio et al. (2017, 2019) for Morocco (LMLD1) and Australia (LMLD2) and Baldo et al. (2020) for Iceland-H (HLD1) and Iceland-M (HLD2). To note that only total clays weight fractions are reported in Di Biagio et al. (2017) for Morocco and Australian dust samples. In the present analysis the clays were speciated as illite and kaolinite, two major clay species, based on literature values of the illite/kaolinite (I/K) ratio. The I/K ratio for North African sources, previously estimated by Formenti et al. (2011), ranges from 1.6 to 7.0; an average of 4.3 is considered in this study to speciate the mass fractions of illite and kaolinite for LMLD1. Conversely, this ratio has not been extensively studied for Australian dust. Dust samples from Amsterdam Island, approximately 5000 km from the closest spot in Australia, showed I/K ratios between 0.8 and 2.1 (Gaudichet et al., 1989) and kaolinite is known to be more prevalent in Australian soils (Butler, 1974; Ward, 1999). Therefore, we adopt a I/K value of 1.45 for the LMLD2 sample.

The densities for the single minerals (ρ_i) are taken as 2.62 g cm^{-3} (kaolinite), 2.75 g cm^{-3} (illite), 2.65 g cm^{-3} (quartz), 2.59 g cm^{-3} (feldspars), 2.71 g cm^{-3} (carbonates), 5.15 g cm^{-3} (iron oxides), 3.22 g cm^{-3} (nesosilicates), 3.30 g cm^{-3} (inosilicates) and 2.48 g cm^{-3} (glass) (source https://webmineral.com/).

Table S1. References for the pure minerals complex refractive indices considered in this work.

Group Family	Mineral or Rock	Wavelength range	CRI References
Phyllosilicates	Kaolinite	50 - 4000	*Querry, 1986*
		4000 - 40000	*Eggn & Helgman, 1979*
	Illite	50 - 650	*Querry, 1986*
		650 - 40000	*Deschutter, 2022*
Tectosilicates	Quartz	50 - 650	*Peterson and Weinman, 1969*
		650 - 40000	*Herbin et al., 2023*
	Feldspars (Orthoclase)	250 - 4000	*Arnold et al., 2014 **
Carbonates	Calcite	50 - 650	*Posch et al., 2007*
		650 - 40000	*Deschutter, 2022*
Iron oxides	Hematite	50 - 40000	*Triaud, 2005*
Nesosilicates	Olivine	50 - 25000	*Zeidler et al., 2011**
Inosilicates	Pyroxene	50 - 1480	*Henning and Mutschke, 1997**
Glasses	Obsidian	200 - 40000	*Pollack et al., 1973**

* unavailable data for silicates sub-groups at some spectral intervals were replaced by quartz data interpolated down to 50 cm^{-1}.

Table S2. Mineralogical composition (% by volume, v_i) of the different minerals composing dust samples calculated as detailed in Text S1. The total density of the dust mixture, calculated as $\rho_{mix} = \sum w_i \cdot \rho_i$, is reported in the Table.

	Mineral group								Mixture density (g cm^{-3})
	Phyllosilicates (%)	Tectosilicates (%)		Carbonates (%)	Iron oxides (%)	Nesosilicates (%)	Inosilicates (%)	Glass (%)	
	Clays	Quartz	Feldspars						
LMLD1	63.3	8.8	2.2	25.0	0.7	0.0	0.0	0.0	2.75
LMLD2	57.3	34.5	6.4	0.0	1.9	0.0	0.0	0.0	2.76
HLD1	0.0	0.0	58.3	0.0	0.7	6.4	25.4	9.2	2.87
HLD2	0.0	0.0	3.5	0.0	0.5	0.0	2.7	93.2	2.54

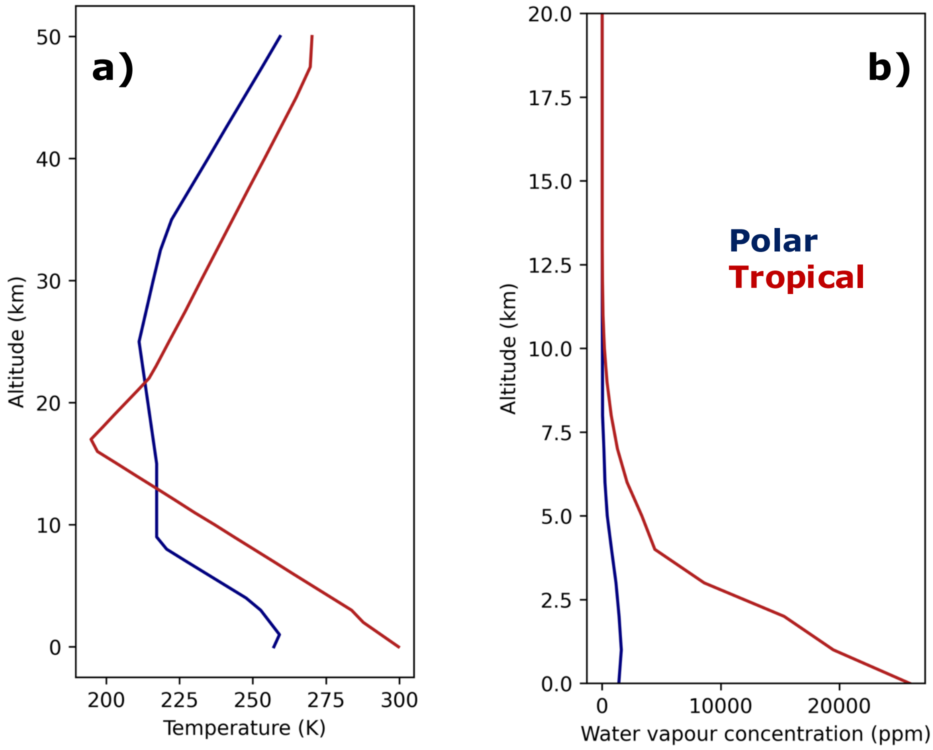

Figure S1: Vertical pofiles of temperature (a) and water vapour concentration (b) for the two background atmospheric states used in this work (polar and tropical, blue and red curves, respectively).

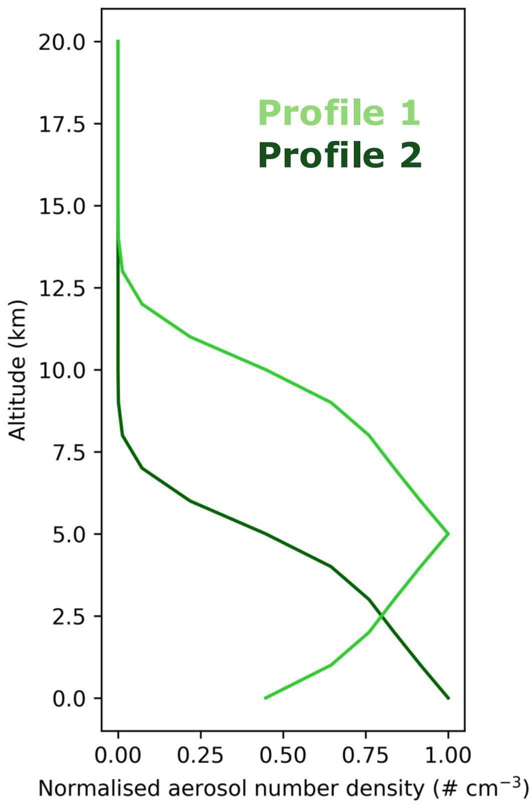

Figure S2: The two vertical profile of dust aerosol number density used in this work (profile 1, light green curve: peaking at 5 km altitude; profile 2, dark green curve: peaking at surface). The dust aerosol number density profiles are normalised (1.0 # cm-3 at the respective maxima in the two profiles) so to better visualise their vertical shape.

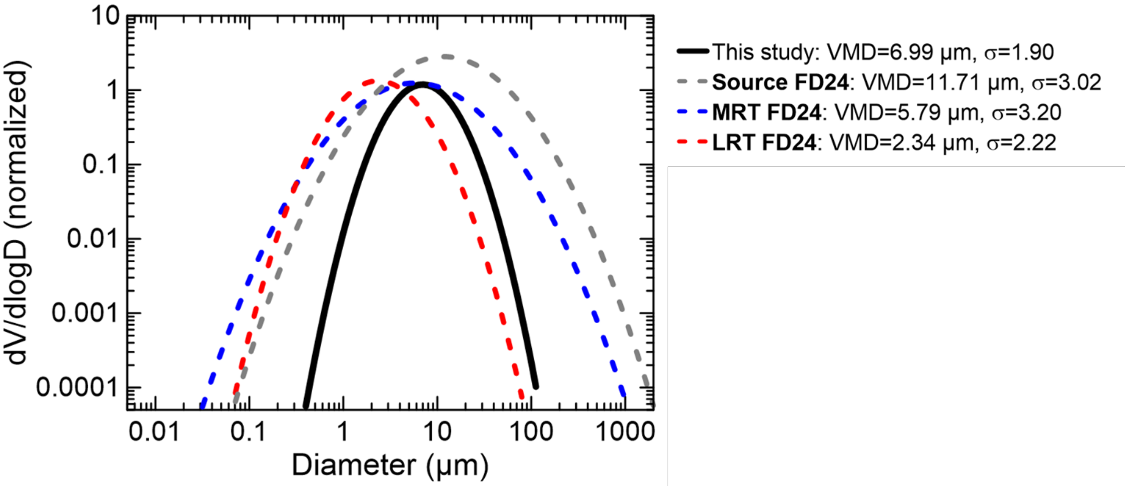

Figure S3. Input Size distribution used in this paper (black line) compared to the climatological synthesis of dust size distribution determined in Formenti and Di Biagio (2024) (FD24), based on observations from ground-based and aircraft platforms. The volume median diameter (VMD) and width (σ) of the lognormal function describing these size distributions are indicated.

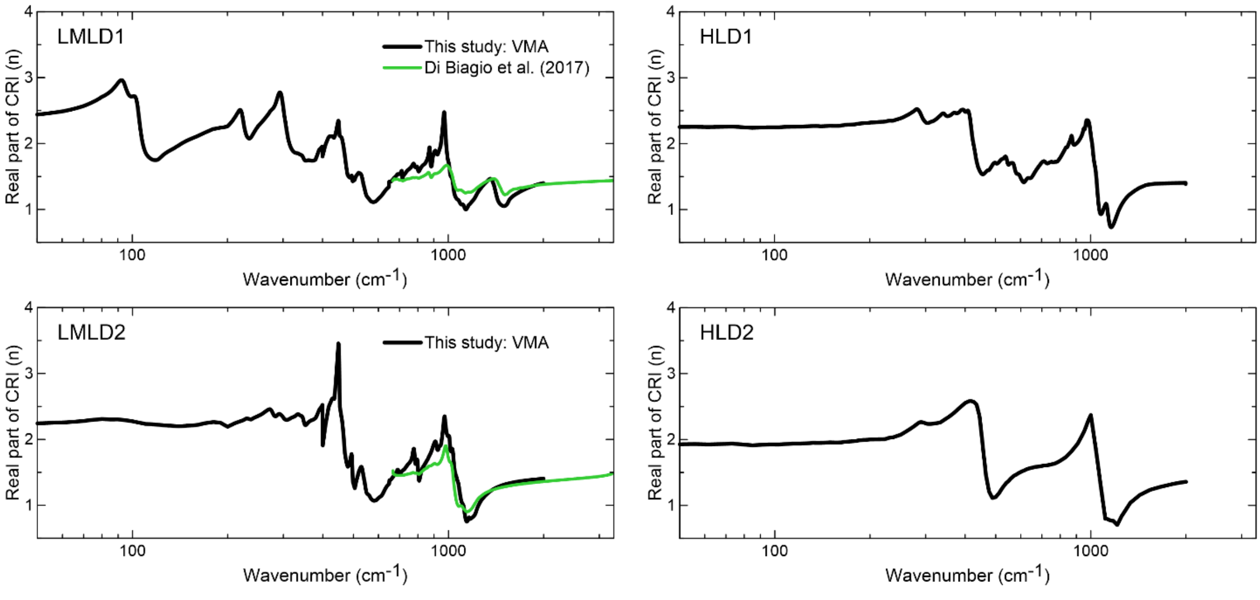

Figure S4. The spectral real part of the complex refractive indices calculated using the VMA method (in black) compared with the experimental measurements from Di Biagio et al. (2017) for LMLD1 and LMLD2 (in green).