

Introduction

• Inhalation of airborne radionuclides results in internal doses of ionizing radiation proportional to time spent in resuspended activity:[1]

$$D_{R,k} = DFI_k \times C_g \times BR \times \int_{t_0}^{t_0+T} S_f(t) dt.$$

DFI_k: inhalation dose correction factor to organ *k* [Sv/Bq inhaled]

C_g: ground activity deposit [Bq/m²]

BR: breathing rate [m³/s]

T: exposure period *t*₀ past release

• Resuspension factor *S_f* characterizes air activity concentration relative to specific surface activity deposition:

$$S_f(t) [m^{-1}] = \frac{C_a(\bar{r}^3, t) [Bq/m^3]}{C_g(\bar{r}^2, t) [Bq/m^2]}$$

• Measurements must be taken in equilibrium conditions; climate or man-made disturbances can sputter data from 10⁻¹¹ to 10⁻². [8]

• Recently, conservative regression analyses were performed upon particulate resuspension data extracted from literature. The resulting *S_f*(0) values increased from previous predictions and integrated resuspension factors (IRF) poorly replicated measured data. [2]

• To obtain better agreement with experiment, the authors applied a physical exchange model with two catenary compartments and a weighted fit inversely proportional to the uncertainty in each datum.

Methods

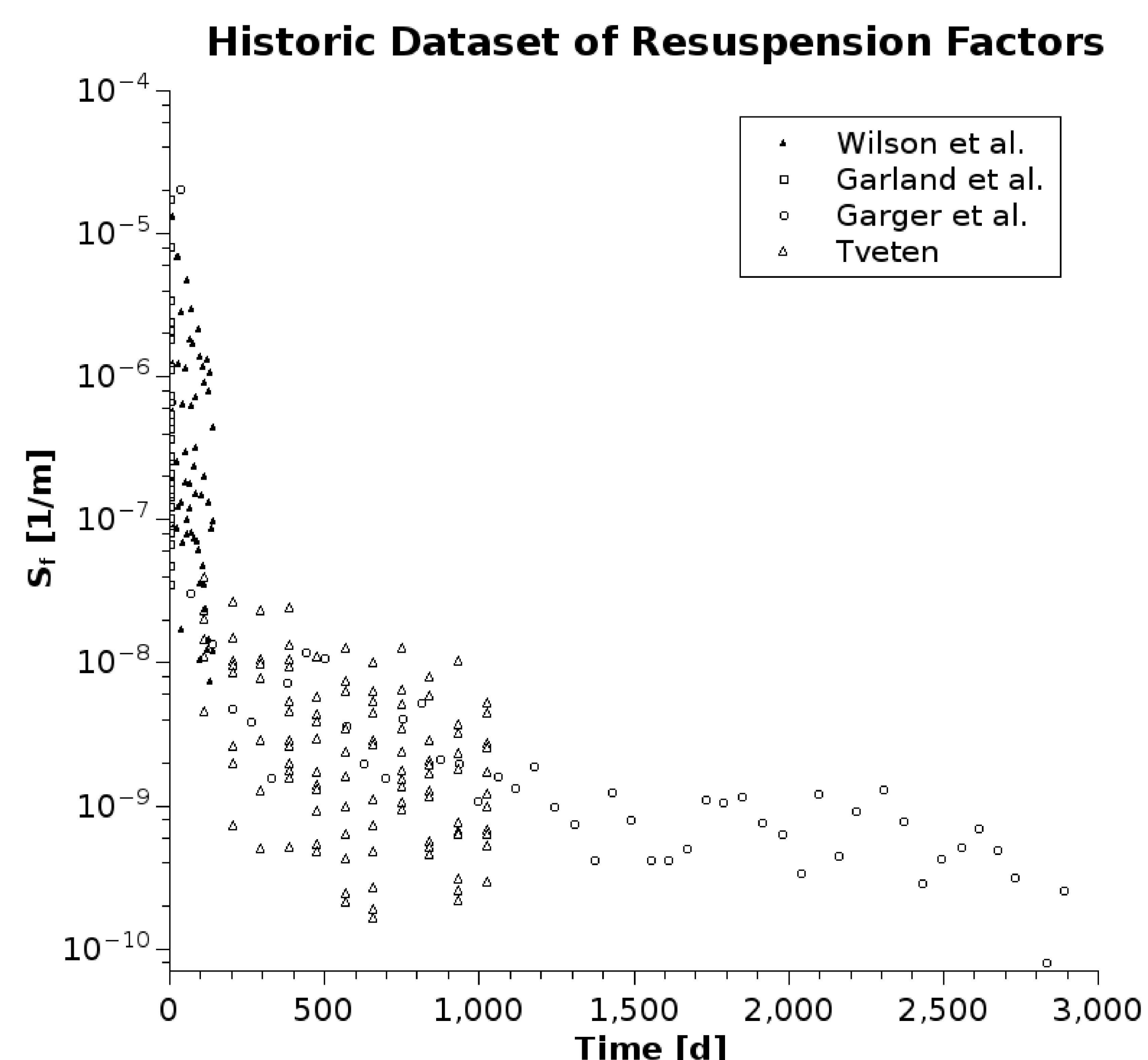


Fig 1: Semi-log scale of resuspension factors calculated from realistic and synthetic particle dispersion experiments. [2]

- Extract resuspension factor data from literature (Fig. 1). [4, 5, 6, 7, 9]
- Average measurement coincidences within roughly semi-weekly bins to increase the model resolution while sufficiently sampling the timespan of the leading decay process.
- Apply two-compartment catenary model (double-exponential) with an instrumental weighting to:
 - increase importance of data with low uncertainty,
 - decrease importance of data with high uncertainty.

Results

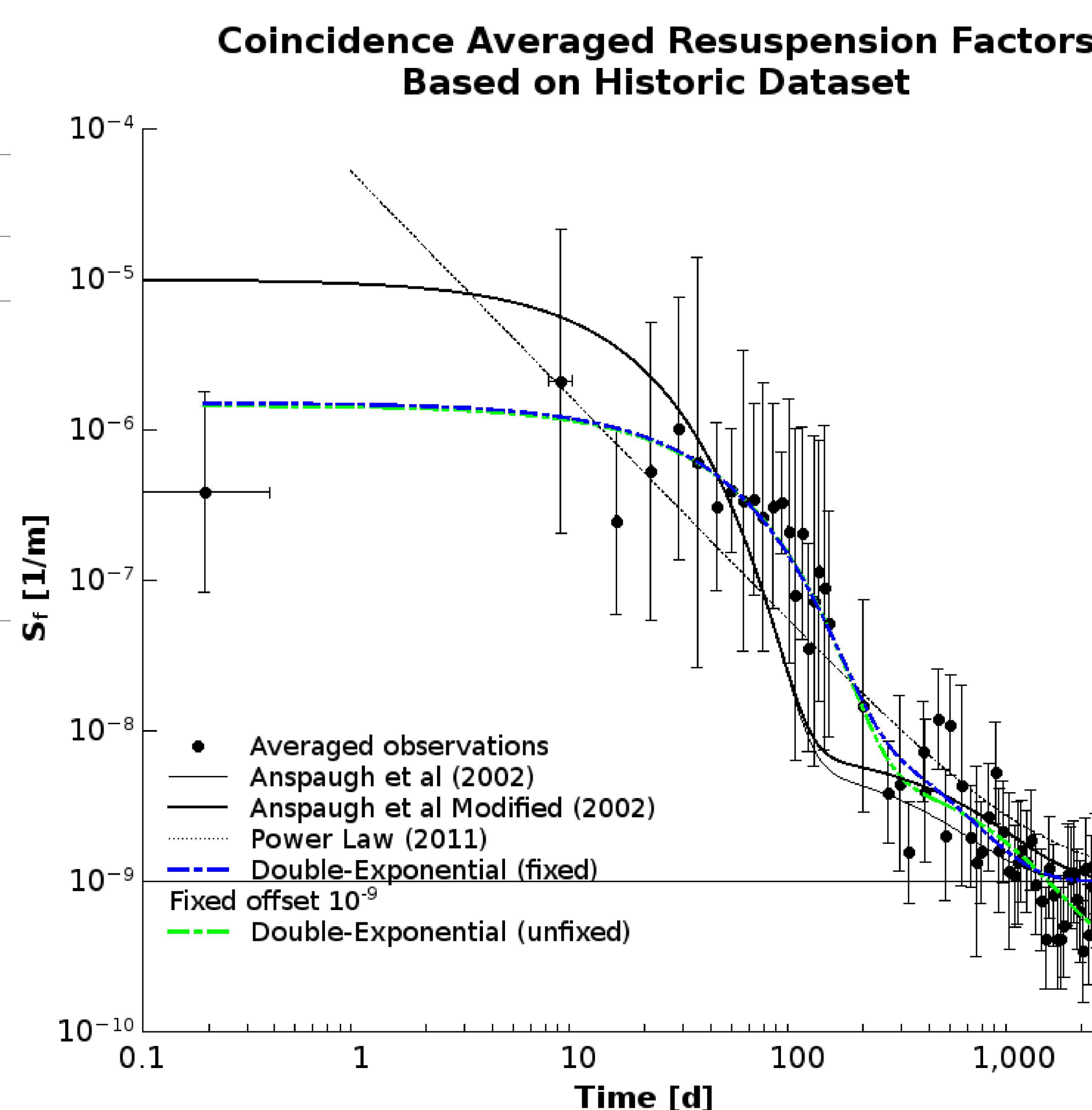
Table 1: Linear regression fit parameters with instrumental weighting in log-space.

	$S_f = C_1 e^{-t/T_1} + C_2 e^{-t/T_2} + S_0$	$w_i = 1/\sigma_{y,i}^2$
	fixed	unfixed
C ₁ [m ⁻¹]	1.50 × 10 ⁻⁶	1.45 × 10 ⁻⁶
T ₁ [d]	37.9	39.5
C ₂ [m ⁻¹]	1.37 × 10 ⁻⁸	6.12 × 10 ⁻⁹
T ₂ [d]	289	639
S ₀ [m ⁻¹]	10 ⁻⁹	3.31 × 10 ⁻¹⁰

Fig 2 (right): Log-log scale of observations averaged over local time bins in contrast to previous resuspension factor models.

Table 2: Predicted IRF of unfixed catenary model fit with net change relative to recent regression assessments of historical data.

Integration period [days]	IRF [days/m]	Relative to predicted IRF by model		
		Anspaugh et al ^[3]	Power ^[2]	Double-Exponential ^[2]
0 - 1	1.438 × 10 ⁻⁶	-85%	-97%	-24%
0 - 10	1.288 × 10 ⁻⁵	-82%	-88%	-20%
0 - 30	3.067 × 10 ⁻⁵	-76%	-74%	-10%



Discussion

- Two-compartment catenary model fit with 1/σ² weighting successfully predicted previous IRF values to within 10-24%.
- Previous models overestimate initial resuspension, underestimate rapidity of decay; IRF error decreases over time to account for this (Table 2).
- Power-law divergence has limited utility in calculating IRF (Fig. 2).
- Fixed offset 10⁻⁹ constrains models to overestimate long-lived resuspension data (Fig. 1).
- A more comprehensive *S_f*(*t*) will require sensitive plume dynamics models for predicting IRF as *t*₀ → 0.

References

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