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Comments on the Ventilation Coefficient

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Abstract
The ventilation coefficient has to do with an atmospheric area's ability to disperse pollutants. The ventilation coefficient is denoted by f, where $f \geq 1$. For a small ice particle, $f = 1$, because the Reynolds number is effectively zero. Beard and Pruppacher (1971) [1] fitted data from small water drops falling at terminal velocity through a vertical wind tunnel. They got two empirical formulas, which will be shared in Introduction. These equations are for the mean ventilation coefficient f for vapor diffusion. They involve the Reynolds number and the Schmidt number. The Reynolds number N_{Re} is the following:

$$N_{Re} = (U^*d)/v.$$

The Schmidt number is:

$$N_{Sc} = v/D_v.$$

Beard and Pruppacher's empirical equations have in them the Reynolds number and Schmidt number. Nomenclature is omitted.

Keywords: Reynolds Number, Schmidt Number, Ventilation Coefficient, Empirical Formula

Introduction

For Beard and Pruppacher's empirical equations, they are found in Wang (2013) [2] page 237:

$$f = 1.00 + 0.108\,(N_{sc}^{1/3}N_{Re}^{1/2})^2 \text{ for } N_{sc}^{1/3}N_{Re}^{1/2} < 1.4 \tag{1}$$

and,

$$f = 0.78 + 0.308\,(N_{sc}^{1/3}N_{Re}^{1/2}) \text{ for } 51.4 > N_{sc}^{1/3}N_{Re}^{1/2} \geq 1.4 \tag{2}$$

Results

The reason the ventilation coefficient goes to one for small ice particles is because the Reynolds number, N_{re}, goes to zero as there is very little or no falling velocity of the particle, as is shown by Wang (2013) [2] in Fig 9.3, page 238, where the particle size is small and the falling velocity is U. U is small, making N_{re} disappear. Thus, for small ice particles $f = 1$. In Fig 5.5.7 page 212 of Khain and Pinsky (2018) [3] we see that the ventilation coefficient rises somewhat linearly from 1 with drop radius and $N_{sc}^{1/3}N_{Re}^{1/2}$. We see from the Internet (with AI – Reference 8) that the radius of the newly formed ice particle is so small that it will have a very small velocity U giving it a Reynolds number of zero.

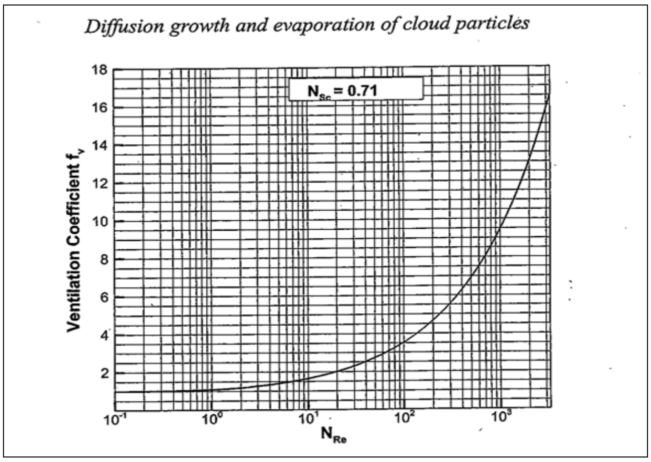

Fig 9.3: The ventilation coefficient as a function of Reynolds number for a water drop falling in air assuming that the Schmidt number $N_{Sc} = 0.71$

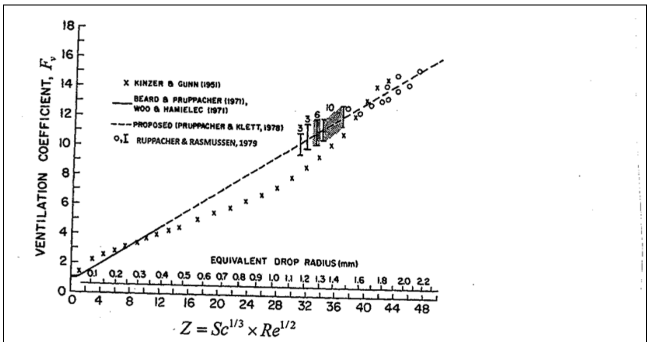

Figure 5.5.7 The dependencies of ventilation coefficient $F_v(Z)$. The dependencies $F_v(Z)$ calculated for large Re are extrapolated for moderate values of Re. The results of laboratory experiments are denoted by symbols. Drop size range in laboratory experiments by Pruppacher and Rasmussen (1979) is 1, 100 μm $\le r_0 \le$ 2, 500 μm ($29.7 \le Z \le 51.4$). Drop size range in laboratory experiments by Beard and Pruppacher (1971) is 60 μm $\le r_0 \le$ 400 μm ($1.4 \le Z \le 12.3$) (from Pruppacher and Rasmussen, 1979; American Meteorological Society©; used with permission).

Discussion

As we see in the definition of ventilation coefficient, VC, is the product of wind speed U and height Z_i and the units are m^2/s.

$$VC = U \times Z_i \tag{3}$$

VC represents the ability of a part of an atmosphere to disperse pollutants. According to Reference 8) we have High Pollution Potential (< 6,000 m^2/s): Values falling below this threshold indicate stagnant air conditions where emissions cannot properly disperse, leading to dangerous pollutant accumulation near the surface. Good Dispersion Capacity (≥ 6,000 m^2/s): Higher values signal that pollutants will be quickly diluted and carried away, resulting in healthier surface air quality.

We can see in both figures (5.5.7 and 9.3) that the ventilation coefficient goes from 1 to about 16.

Conclusion

One teacher I'd like to mention is Frances Leibold who taught us Geometry when I was a Sophomore at ACALANES HIGH SCHOOL in Lafayette, California. In all of her classes I was her #1 student because I was the class recorder and had access to all of the scores.

Acknowledgements

To remember God, a Spiritual song comes to mind and the lyrics are: "Lord I keep so busy working for the Kingdom, ain't got time to die!" Also, when I was going to Our Lady of Refuge Catholic Church in Pacific Beach, San Diego, they said, We share eternal life with the Virgin Mary.

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