Partitioning of the Transfer Resistance between Air and Water

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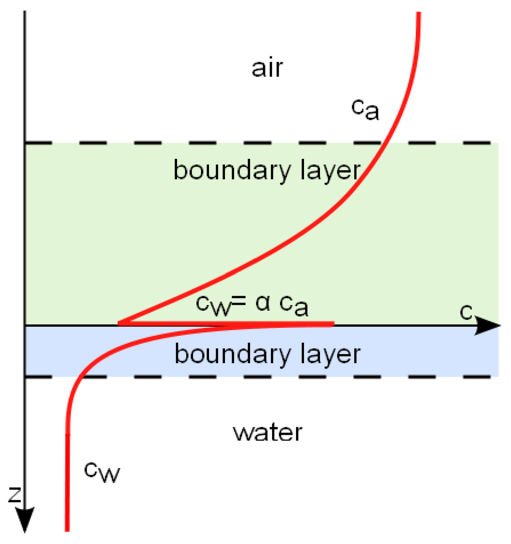
Gas Transfer through the Boundary Layers



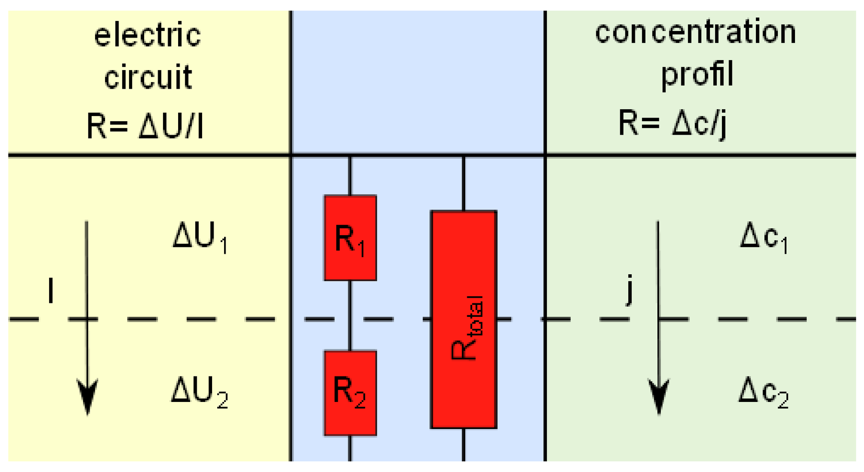
- **Molecular diffusion** is the dominant process
- **Concentration jump** at the interface

$$R_{total} = \frac{\Delta c}{j}$$

R: transfer resistance
c: concentration
j: gas flux
α: solubility

Partitioning equation:

$$R_{total} = R_{air} + \frac{\tilde{R}_{water}}{\alpha}$$



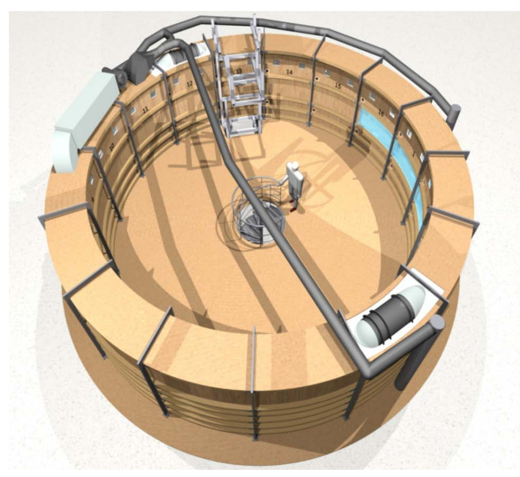
- Transfer resistances of different phases are added like an **electric circuit** [1]

➢ **Never tested experimentally**

How to Get Transfer Resistances

Measurement procedure

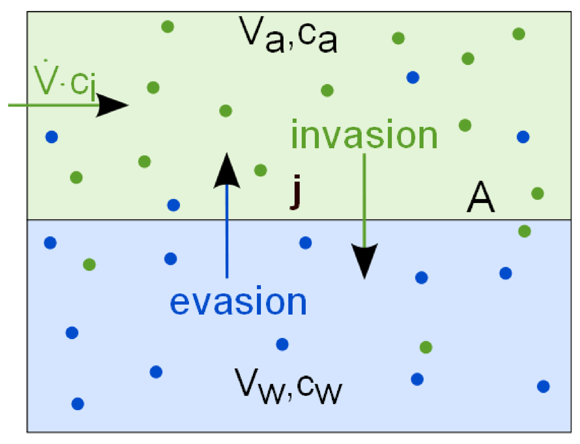
- Conducted at *the* ***Aeolotron***, an annular wind-wave facility
- **10 tracers**, in a broad spectrum of solubilities were measured simultaneously
- **Reference wind speed** varied between 0.7 m/s and 8.4 m/s
- Measurements with clean surface and the **surfactant** *Triton X-100*



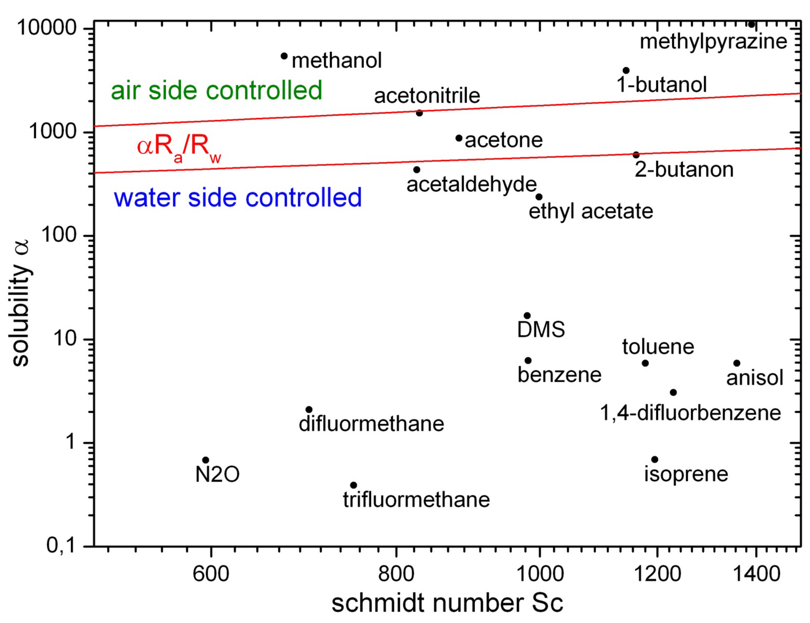
The *Aeolotron* wind- wave facility has a radius of approximately 5 m.

Box model

- Concentrations in air and water have been monitored by FTIR **spectroscopy** and TOF mass spectroscopy (TOF see E. Mesarchaki)
- The transfer resistance *R* was obtained by a **box model** [2]



Extended Schmidt number scaling method



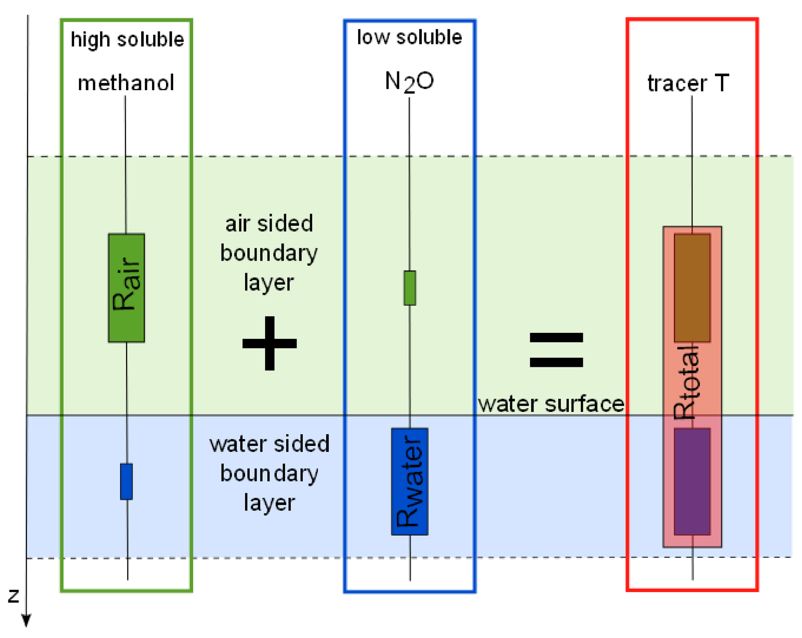
- Tracers with a very **high solubility** are controlled by the air side
- Tracers with a very **low solubility** are controlled by the water side

- **methanol** (α = 5470) as the reference tracer for the air sided resistance (R_{water} neglected):

$$R_{T,air} = \left(\frac{D_{M,air}}{D_{T,air}}\right)^{2/3} R_{M,total}$$

- N_2O (α = 0,6) as the reference tracer for the water sided resistance (R_{air} neglected):

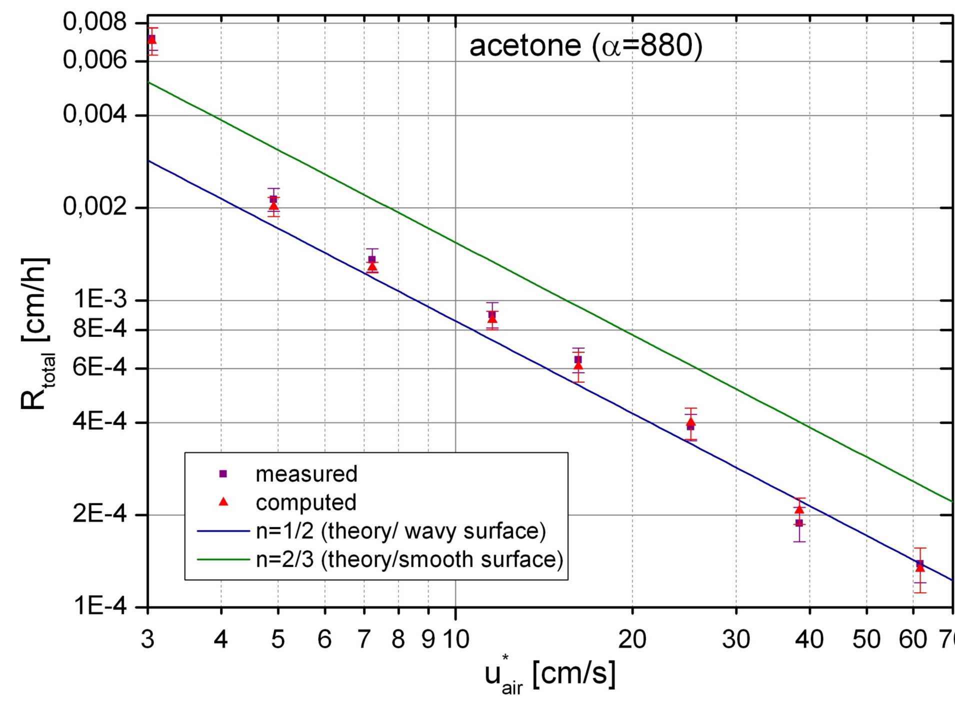
$$\tilde{R}_{T,water} = \left(\frac{D_{N,water}}{D_{T,water}}\right)^{n} \tilde{R}_{N,total}$$



D: Diffusion constant
n: Schmidt number exponent (see K. Richter)

Partitioning of the Transfer Resistance

Experimental testing of the partitioning equation by Liss & Slater



- Measured and computed transfer resistances show good agreement

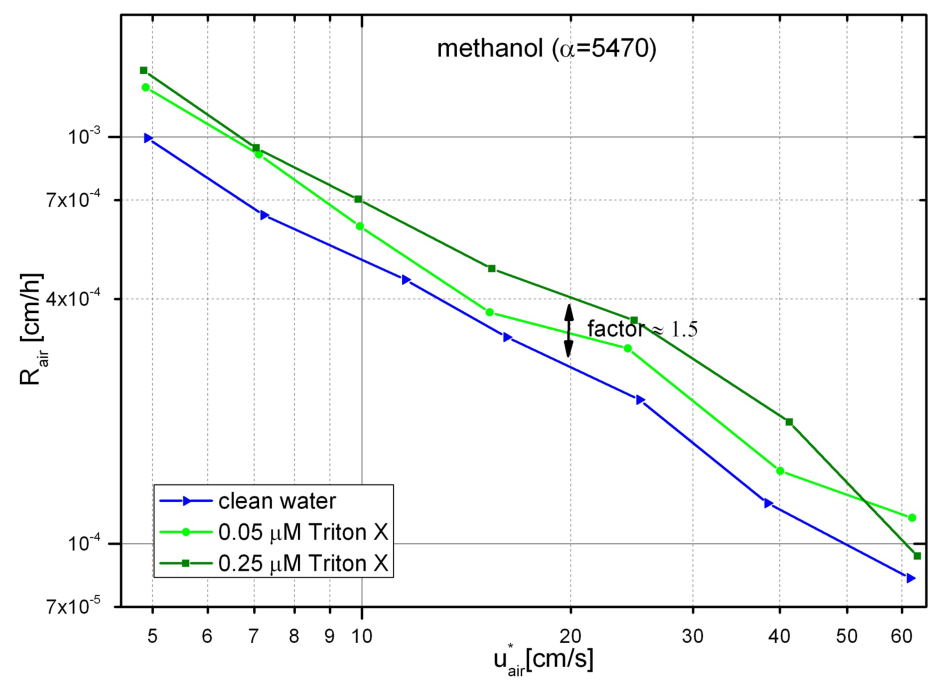
➢ **Partitioning equation is experimentally shown**

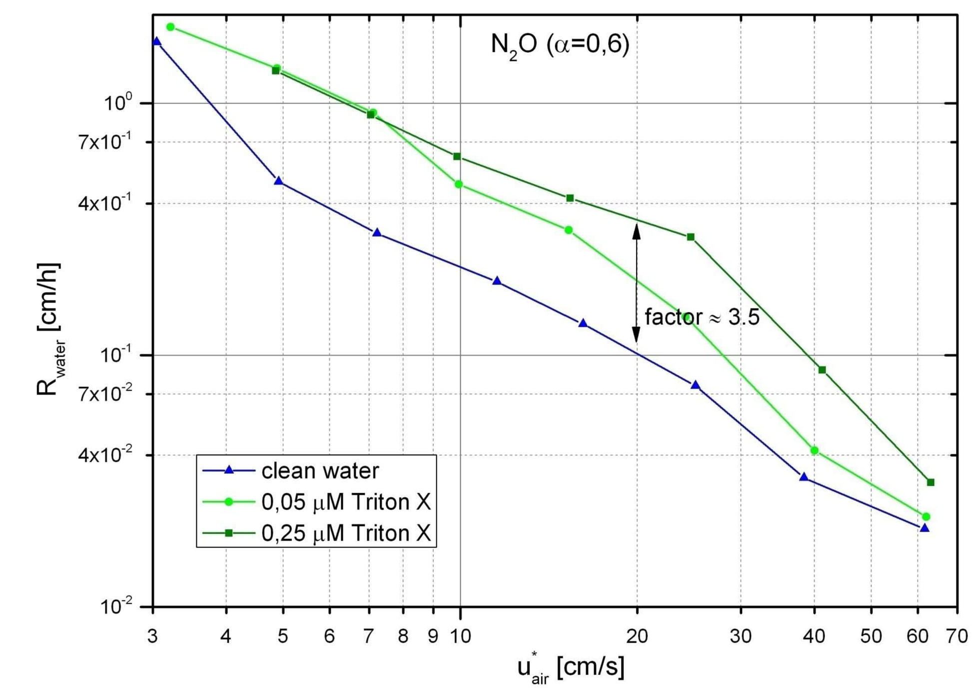
- Comparison with the Deacon model [3] shows the transition of the Schmidt number exponent

➢ **Values agree with theory**

➢ **It is possible to compute the transfer resistance of any tracer, if the solubility and diffusion constants are known**

Effect of a surfactant for the different parts of the transfer resistance





In the left figure the effect of the surfactant for the air sided part on the transfer resistance and in the right figure the effect on the water sided part is shown.

- The water sided part of the transfer resistance is more influenced by the surfactant
- At high friction velocities the transfer resistances for clean and surfactant covered water surfaces are nearly equal

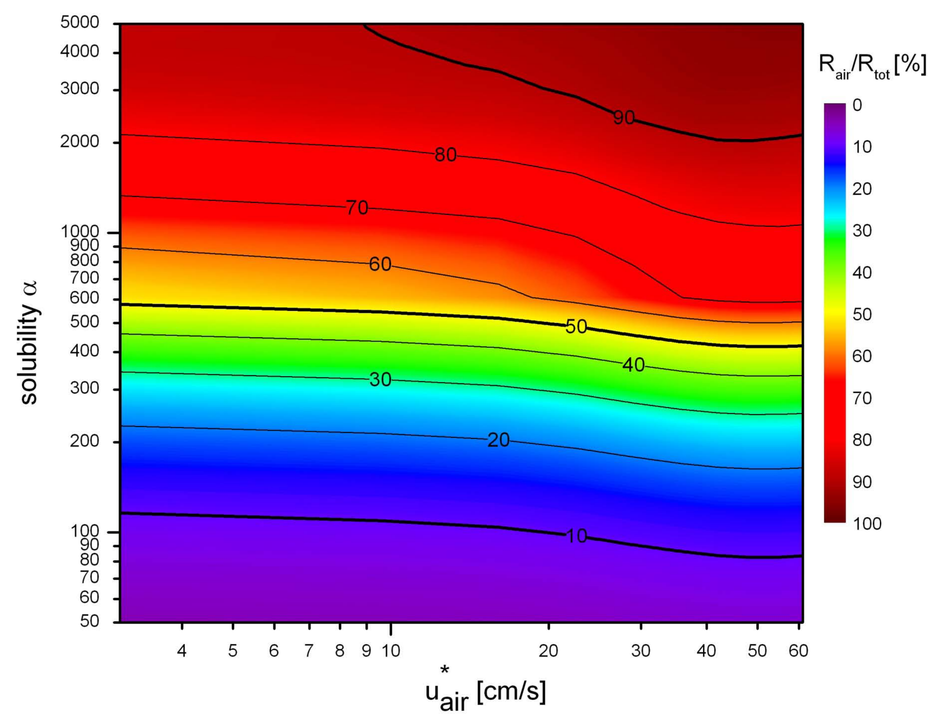
➢ **At high friction velocities the surface film begins to break open**

Dependency of equal partitioning on solubility and friction velocity

Clean water:

- Linear interpolation of the air sided part of the resistances for different tracers in dependency of the friction velocity and solubility

➢ **The equal partitioning depends on both, the friction velocity and the solubility**

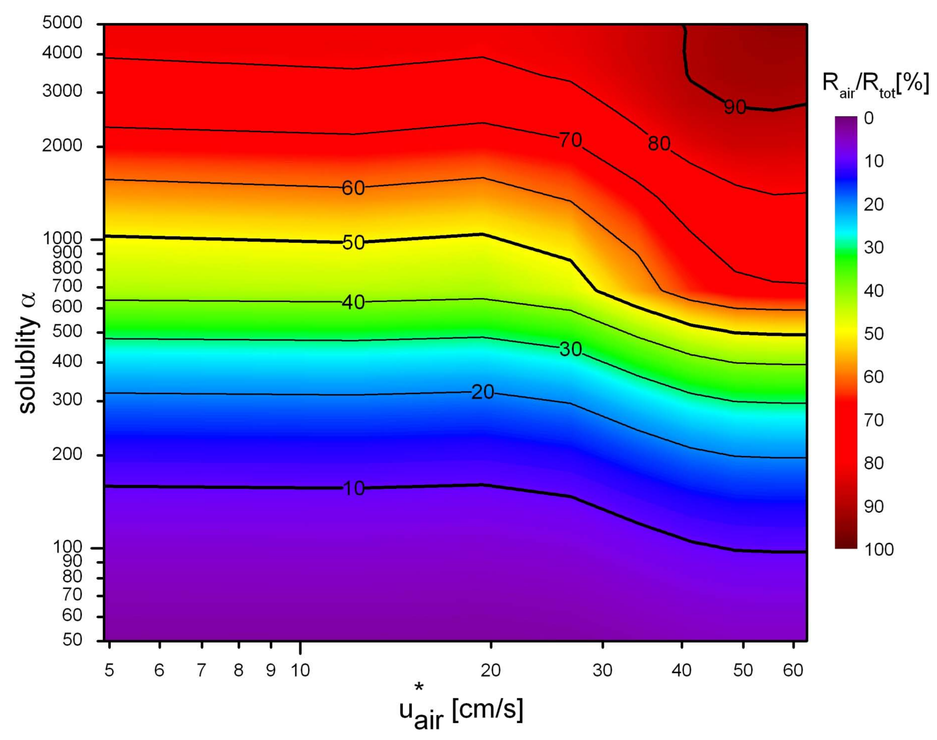


The dependency of partitioning on the friction velocity and solubility for clean water.

Water with 0.25 µMolar *Triton X-100*:

- The surfactant has an effect on the equal partitioning
- At low friction velocities the effect is the largest

➢ **Surfactants influence the partitioning to higher solubilities**



The dependency of partitioning on the friction velocity and solubility with a surfactant.

References:
[1] P. S. Liss and P. G. Slater; Flux of gases across the air-sea interface; Nature 1974
[2] C. Kräuter; Aufteilung des Transferwiderstandes zwischen Luft und Wasser beim Austausch flüchtiger Substanzen mittlerer Löslichkeit zwischen Ozean und Atmosphäre; Diploma thesis; Institute for Environmental Physics; 2011
[3] E.L. Deacon; Gas transfer to and across an air-water interface; Tellus 1977