Contributed Paper
doi: 10.5281/zenodo.13355

STUDY OF GAS EXCHANGE IN A WIND TUNNEL. Preliminary results.

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Mechanics and kinetics of gas exchange at the air-water interface are investigated in a wind tunnel. We propose to study the dependency of the mass-transfer coefficients on :

- wind speed in a range extending between 2 m/sec and 15 m/sec;
- Schmidt number by running experiments with helium and argon;
- water surface roughness and wave spectrum;
- bubbles and spray formation

by running experiments with gases showing different solubilities as helium, argon and N_2O.

In the smaller facility of the Institut de Mécanique Statistique de la Turbulence in Marseille, the air-water interface is 8 meters long and 0.6 meter large. The depth of water is 0.3 meter.

Gas exchange experiments are run by invasion. Gases are injected at the tracer level in the air. For each experiment, the mass transfer coefficient is computed by measuring simultaneously the variation with time of the partial pressure of the tracer gas and the kinetics of its dissolution in the liquid phase. This experimental procedure describes quite closely the phenomena occuring in natural conditions, compare to bubbling techniques often used in evasion experiments. Moreover the influence of a change of the density of the gas which could be kept responsible for a critical change of the wave pattern at the air-water interface, is negligible as the concentration of the tracer gas is at most a few per cent.

Air and water temperatures are set to maintain near neutral conditions in the tunnel.

From the wind profiles, determined for each wind speed, we compute the values of the drag coefficient and the friction velocity at the interface.

At the present time, we have preliminary results for argon experiments. Figure 1 shows the variation of k_L in cm/hour as a function of the mean wind speed. The equation of the line has been calculated taking into account the individual variance of each point, as the errors associated with each measurement are not constant due to a deficiency in our experimental procedure, which is now being changed.

In the range of wind speed investigated in our experiments, we have observed a linear relationship between the friction velocity, u_*, and the mean wind speed, u . Values of u_* are indicated on the horizontal scale of figure 1.

of the existing data describing CO_2 gas exchange in wind tunnels. The line (a) represents the results of our argon experiments. The line (b) has been calculated to change our results from argon to CO_2, assuming tentatively a square root dependency of k_L with Schmidt number

$$\left[\frac{Sc_A}{Sc_{CO_2}}\right]^{1/2} = 0.88$$

In both cases a good agreement is found between Broecker's data (2), Liss (1979) ones and ours. It is important to point out that the three groups of data have been obtained in relatively large wind tunnels, 18 meters long for the Hambourg's group and 8 meters long for Liss and us (Liss 1979 measurements have been made in the same facility at I.M.S.T. in Marseille as us).

This agreement suggests that the data do not depend on specific wave tank arrangements (Cf. discussion by H.C. Broeker p. 608 in (2)) but would rather appear better appropriate to describe natural processes occuring at the atmosphere-ocean interface, compare to other existing experimental results.

Analysis of experiments run with helium and N_2O are now in progress.

This work is made in collaboration with M. COANTIC, from I.M.S.T. in Marseille.

REFERENCES.

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and this issue.

2 - H.C. BROECKER - J. PETERMANN - W. SIEMS.
The influence of wind on CO_2 exchange in a wind wave tunnel, including the effects of monolayers.
Journal of Marine Research, 36, 4, 595-610 - 1978.

FIGURES.

FIGURE 1 -

Mass transfer coefficient k_L in cm/hour as a function of the mean wind speed u m/sec and the friction velocity u_*.

FIGURE 2 -

From Jahne and Munnich (1979). Gas transfer velocity for CO_2 as a function of friction velocity in the gas phase (u_{*g}) and in the liquid phase (u_{*L}).

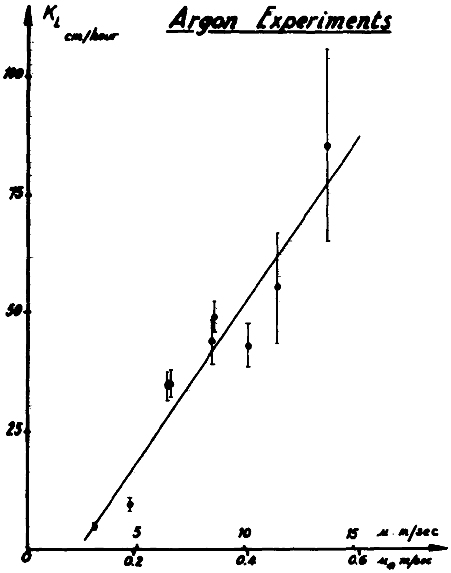
Argon Experiments
K_L cm/hour
100
75
50
25
0
5
10
15
u m/sec
0.2
0.4
0.6
u_a m/sec

Fig 1

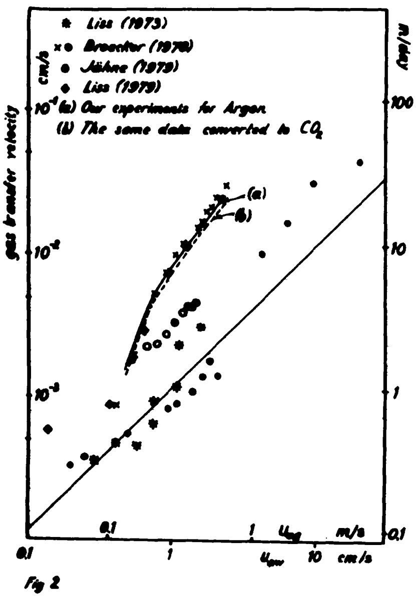
Liss (1973)
Broecker (1978)
Jähne (1979)
Liss (1979)
(a) Our experiments for Argon
(b) The same data converted to CO_2
gas transfer velocity
cm/s
m/day
(a)
(b)
10^{-1}
10^{-2}
10^{-3}
100
10
1
0.1
0.1
1
U_{ag}
m/s
0.1
1
U_{aw}
10
cm/s

Fig 2