Supplementary Materials

**Table S1. Variables and constants**. Their names, notations, units and value or observed range given as [1%, 99%] of their distributions upon simulations with the Level 4 data or B the Baltic experiment data. a given in m∙h−1. b given in cm∙h−1.z only for observations at height z. Values observed during c storms or d fresh water discharges were outside the [1%, 99%] range.

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| **Name/Description** | **Symbol** | **Unit** | **Value (or Range)** |
| Bunsen’s solubility coefficient | β | dimensionless | 6381–9972 |
| Wave age | β | dimensionless | 0.54–1.04 B |
| gas concentration in the air | Ca | mol m‑3 | 0.161–0.171 |
| Drag coefficient | CD | dimensionless | 0.0008–0.0044 |
| Specific heat of air | cp | J g-1 K-1 | 1.005 |
| Phase speed of the peak of the wave spectrum | cp | m s−1 | 4.4–7.9 B |
| gas concentration in the water | Cw | mol m‑3 | 0.052–0.120 |
| air-water gas flux | F | mmol m‑2∙d−1 | 6.5–39.9 B |
| peak angular frequency of wind-waves | fp | rad s−1 | 0.67–4.97 c |
| gravitational acceleration | g | m s−2 | 9.80665 |
| significant wave height | Hs | m | 0.04–2.51 c |
| transfer velocity (air-side) | ka | m∙s−1 (m h−1) | 22.6–262.3 a,c |
| bubble generated transfer velocity | kbublle | m∙s−1 (cm h−1) | 0.039–15.6 b,c |
| transfer velocity (water-side) | kw | m∙s−1 (cm h−1) | 2.1–36.1 b,c |
| wind generated transfer velocity | Kwind | m∙s−1 (cm h−1) | 2.42–28.1 b,c |
| Henry constant (Ca/Cw form) | kH | dimensionless | 1.02–1.41:CO2  28.8–36.1:CH4  1.34–1.91:N2O |
| Henry constant (Cw/pa form)  (at 25 °C and 0 ppt) | kHcp | mol L‑1∙atm−1 | 0.034:CO2  0.0014:CH4  0.025:N2O |
| Monin-Obukhov’s length | L | dimensionless | −5.88 × 10−3–0.48 |
| peak wave length | Lp | s | 1.96–137.4 c |
| molar mass of the air | Ma | g mol−1 | 28.97 |
| molar mass of the gas | Mg | g mol−1 | 44.01:CO2  16.043:CH4  44.013:N2O |
| molar mass of the water | Ms | g mol−1 | 18.01 |
| air pressure | P | atm | 0.995–1.009 |
| gas partial pressure in the air | pa | ppm | 381–401 B |
| gas partial pressure in the water | pw | ppm | 122–282 B |
| specific humidity | q | g Kg−1 | 0.005–0.013 z |
| ideal gas law constant | R | Pa m3 mol−1 K−1 | 8.314472 |
| wave breaking parameter (Reynolds number) | RH | dimensionless | 139–7.1 × 104 |
| bulk Richardson number | Rib | dimensionless | −2.9315–0.0003 |
| liquid water mixing ratio | rL | dimensionless | - |
| water vapour mixing ratio at saturation | rsat | dimensionless | - |
| salinity | S | ppt | 31.9–39.2 d |
| Schmidt number of the air | Sca | dimensionless | 0.829–0.853 |
| Schmidt number of the water | Scw | dimensionless | 588–1108 |
| air temperature | Ta | °C | 7.79–20.52 z |
| air temperature | Tka | K | 280.9–293.7 z |
| air potential temperature | Tp | K | 279.5–292.8 z |
| air virtual potential temperature | Tv | K | 280.5–294.8 z |
| water surface temperature | Tw (or SST) | °C | 10–21.8 |
| water temperature | Tkw | K | 283.2–295 |
| Wind velocity at height z m | uz | m s−1 | 0.66–11.96 c |
| wind velocity at height 10 m | u10 | m s−1 | 0.64–11.73 c |
| friction velocity | u\* | m s−1 | 0.043–0.497 c |
| liquid molar volume at boiling point | Vb | L mol−1 | 35:CO2  35:CH4  35:N2O |
| molar volume of ideal gases | Videal | L mol−1 | 22.4136 |
| molar volume of real gases | Vm | L mol−1 | 22.3:CO2  22.3:CH4  22.2432:N2O |
| whitecap cover | W | dimensionless | 4.6 × 10−5–0.018 |
| height (in the atmosphere) | z | m | 11.89–13.73 |
| roughness length | z0 | m | 6.76 × 10−6–10−2 |
| chemical enhancement factor | αCh | m s−1 | 1.846–2.793 |
| von Kármàn’s constant | κ | dimensionless | 0.4 |
| kinematic viscosity of air | υa | m2 s−1 | 1.4 × 10−5–1.5 × 10−5 |
| kinematic viscosity of water | υw | m2 s−1 | 1.23 × 10−6–1.33 × 10−6 |
| atmospheric stability | ψm | dimensionless | −6.087–8.42 × 10−4 |
| temperature dependency of solubility | −ΔsolnH/R |  | 2400:CO2  1700:CH4  2600:N2O |

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