

Name: BALTEX water and heat balances

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Comments: This files contains estimated water and heat balance components for the BALTEX/Bridge period as well as longer periods.

References:

Omstedt, A. and C., Nohr (2004). Calculating the water and heat balances of the Baltic Sea using ocean modelling and available meteorological, hydrological and ocean data. Tellus 56A, 400-414.

Table 1. Estimated annual mean volume flows for the Baltic Sea (order of magnitude).

The flows are denoted by: inflow ( $Q_i$ ), outflow ( $Q_o$ ), net precipitation (P-E), river runoff ( $Q_r$ ), the volume change due to ice advection from the Baltic Sea ( $Q_{ice}$ ), the volume change due to land uplift ( $Q_{rise}$ ), the groundwater inflow ( $Q_g$ ), the volume changes due to thermal expansion ( $Q_T$ ) and salt contraction ( $Q_S$ ).  $A_s$  denotes the Baltic Sea surface area.

| $Q_i$<br>( $m^3s^{-1}$ ) | $Q_o$<br>( $m^3s^{-1}$ ) | $Q_o-Q_i$<br>( $m^3s^{-1}$ ) | (P-E) $A_s$<br>( $m^3s^{-1}$ ) | $Q_r$<br>( $m^3s^{-1}$ ) | $Q_{ice}$<br>( $m^3s^{-1}$ ) | $Q_{rise}$<br>( $m^3s^{-1}$ ) | $Q_g$<br>( $m^3s^{-1}$ ) | $Q_T$<br>( $m^3s^{-1}$ ) | $Q_S$<br>( $m^3s^{-1}$ ) |
|--------------------------|--------------------------|------------------------------|--------------------------------|--------------------------|------------------------------|-------------------------------|--------------------------|--------------------------|--------------------------|
| $10^5$                   | $-10^5$                  | $-10^4$                      | $10^3$                         | $10^4$                   | $-10^2$                      | $-10^1$                       | $10^2$                   | $\pm 10^2$               | $\pm 10^1$               |

Table 2. Mean water balance for the Baltic Sea (the Belt Sea and the Kattegat excluded) average. Unit:  $10^3 \text{ m}^3 \text{ s}^{-1}$ . The flows are denoted as: River runoff ( $Q_r$ ), net precipitation (P-E), inflow ( $Q_i$ ), outflow ( $Q_o$ ), and storage change.  $A_s$  denotes the Baltic Sea surface area.

| AUTHOR  | $Q_i$<br>( $\text{m}^3\text{s}^{-1}$ ) | $Q_o$<br>( $\text{m}^3\text{s}^{-1}$ ) | $Q_o-Q_i$<br>( $\text{m}^3\text{s}^{-1}$ ) | $Q_r$<br>( $\text{m}^3\text{s}^{-1}$ ) | $A_s(P-E)$<br>( $\text{m}^3\text{s}^{-1}$ ) | Storage change<br>( $\text{m}^3\text{s}^{-1}$ ) | PERIOD                             |
|---------|--|--|--|--|---|---|------------------------------------|
| Present | 38.44                                  | 56.32                                  | 17.88                                      | 14.88                                  | 2.05  | -0.95   | BALTEX/ <i>BRIDGE</i><br>2000–2002 |
| Present | 42.75                                  | 59.41                                  | 16.76                                      | 14.96                                  | 1.70  | -0.11   | 1979–2002                          |

Table 3. Estimated annual mean heat fluxes for the Baltic Sea (order of magnitude). The fluxes are denoted as: net heat flux ( $F_n$ ), sun radiation to the open water surface ( $F_s^o$ ), heat flow from water to ice ( $F_w^i$ ), sun radiation through ice ( $F_s^i$ ), the heat fluxes associated with precipitation in the form of rain ( $F_{prec}$ ) and snow ( $F_{snow}$ ), the heat sink associated with ice advection from the Baltic Sea ( $F_{ice}$ ), heat flows associated with river runoff and ground water flow  $F_r$  and  $F_g$ , the heat fluxes associated with inflows ( $F_i$ ) and outflows ( $F_o$ ), and the total heat loss to the atmosphere ( $F_{loss}$ ). The fluxes are positive when going from the water to the atmosphere.

| $F_n$  | $F_s^o$       | $F_w^i$       | $F_s^i$       | $F_{prec}$    | $F_{snow}$    | $F_{ice}$     | $F_r$         | $F_g$         | $F_o-F_i$     | $F_{loss}$    |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| (Wm)   | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) | ( $Wm^{-2}$ ) |
| $10^2$ | $-10^2$       | $10^0$        | $-10^0$       | $10^{-1}$     | $10^{-1}$     | $-10^{-1}$    | $10^{-1}$     | $10^{-1}$     | $10^0$        | $-10^0$       |

Table 4. Mean heat balance of the Baltic Sea (the Belt Sea and the Kattegat excluded).

The fluxes are positive when going from the water to the atmosphere. The fluxes are denoted as: sensible heat ( $F_h$ ), latent heat ( $F_e$ ), net long-wave radiation ( $F_l$ ), sun radiation to the open water surface ( $F_s^o$ ), sun radiation through ice ( $F_s^i$ ), heat flow from water to ice ( $F_w^i$ ), and net heat loss  $F_{loss} = (1-A_i)(F_h+F_e+F_l+F_s^o) + A_i(F_s^i + F_w^i)$ , where  $A_i$  is the ice concentration.

| AUTHOR  | $F_h$<br>( $Wm^{-2}$ ) | $F_e$<br>( $Wm^{-2}$ ) | $F_l$<br>( $Wm^{-2}$ ) | $F_s^o$<br>( $Wm^{-2}$ ) | $F_w^i$<br>( $Wm^{-2}$ ) | $F_s^i$<br>( $Wm^{-2}$ ) | $F_{loss}$<br>( $Wm^{-2}$ ) | PERIOD                     |
|---------|------------------------|------------------------|------------------------|--------------------------|--------------------------|--------------------------|-----------------------------|----------------------------|
| Present | 10                     | 37                     | 37                     | -88                      | 3                        | -0                       | -0                          | BALTEX/BRIDGE<br>2000–2002 |
| Present | 9                      | 35                     | 36                     | -85                      | 4                        | -0                       | -1                          | 1970–2002                  |

Table 5. A comparison between fluxes calculated by the PROBE-Baltic model and the HIRLAM-BALTEX model. For details of the nomenclature see Table 3.

| AUTHOR                            | $F_h$<br>( $Wm^{-2}$ ) | $F_e$<br>( $Wm^{-2}$ ) | $F_l$<br>( $Wm^{-2}$ ) | $F_s^o$<br>( $Wm^{-2}$ ) | $F_{loss}$<br>( $Wm^{-2}$ ) | PERIOD    |
|-----------------------------------|------------------------|------------------------|------------------------|--------------------------|-----------------------------|-----------|
| Fortelius<br>(2002, pers<br>com.) | 7                      | 44                     | 54                     | -123                     | -18                         | 1999–2000 |
| Present                           | 7                      | 38                     | 38                     | -88                      | -5                          | 1999–2000 |

**Appendix A. Calculated major components in the water and heat balances during the BALTEX/*BRIDGE* period**

Table 6. Monthly mean water balance for the Baltic Sea (the Belt Sea and the Kattegat excluded). The flows are denoted as: difference between outflows and inflows ( $Q_o-Q_i$ ), river runoff ( $Q_r$ ), net precipitation (P-E), storage change, and  $A_s$  the Baltic Sea surface area.

| Year | Month | $Q_o-Q_i$<br>( $10^3 \text{ m}^3 \text{ s}^{-1}$ ) | $Q_r$<br>( $10^3 \text{ m}^3 \text{ s}^{-1}$ ) | $A_s(P-E)$<br>( $10^3 \text{ m}^3 \text{ s}^{-1}$ ) | Storage change<br>( $10^3 \text{ m}^3 \text{ s}^{-1}$ ) |
|------|-------|--|--|---|---|
| 1999 | 10    | 9.98   | 10.59  | -2.02   | -1.41   |
| 1999 | 11    | 1.53   | 10.37  | -4.96   | 3.88  |
| 1999 | 12    | 10.31  | 10.65  | 0.29  | 0.63  |
| 2000 | 1     | 4.67   | 10.87  | -1.19   | 5.00  |
| 2000 | 2     | 24.27  | 12.48  | 2.49  | -9.30   |
| 2000 | 3     | 40.99  | 14.56  | 1.96  | -24.47  |
| 2000 | 4     | 30.67  | 19.27  | 4.68  | -6.73   |
| 2000 | 5     | -0.57  | 21.24  | 1.99  | 23.80   |
| 2000 | 6     | 16.50  | 17.76  | 5.36  | 6.62  |
| 2000 | 7     | 26.25  | 18.54  | 8.23  | 0.52  |
| 2000 | 8     | 21.66  | 17.78  | -1.93   | -5.81   |
| 2000 | 9     | 36.66  | 13.74  | -8.05   | -30.96  |
| 2000 | 10    | -15.26   | 11.37  | 2.02  | 28.64   |
| 2000 | 11    | 26.68  | 14.47  | 5.79  | -6.42   |
| 2000 | 12    | 2.22   | 14.44  | 0.52  | 12.74   |
| 2001 | 1     | 36.31  | 12.16  | -0.45   | -24.60  |
| 2001 | 2     | 4.91   | 12.01  | -0.89   | 6.21  |
| 2001 | 3     | 38.54  | 12.60  | 0.42  | -25.52  |
| 2001 | 4     | 3.91   | 17.48  | 6.31  | 19.87   |
| 2001 | 5     | 10.50  | 21.39  | 2.13  | 13.02   |
| 2001 | 6     | 23.94  | 16.91  | 5.89  | -1.14   |
| 2001 | 7     | 8.30   | 15.26  | 1.43  | 8.39  |
| 2001 | 8     | 11.70  | 15.76  | 0.44  | 4.49  |
| 2001 | 9     | 37.04  | 16.56  | 3.44  | -17.03  |
| 2001 | 10    | -18.62   | 14.98  | -1.40   | 32.19   |
| 2001 | 11    | 17.59  | 14.11  | -6.88   | -10.36  |
| 2001 | 12    | 5.54   | 11.82  | -6.19   | 0.09  |
| 2002 | 1     | -9.57  | 12.16  | 4.03  | 25.76   |
| 2002 | 2     | 16.89  | 12.01  | 5.94  | 1.06  |
| 2002 | 3     | 59.75  | 12.60  | 2.33  | -44.82  |

Table 7. Monthly mean heat balance of the Baltic Sea (the Belt Sea and the Kattegat excluded). The fluxes are positive when going from the water to the atmosphere. The fluxes are denoted as: sensible heat ( $F_h$ ), latent heat ( $F_e$ ), net long-wave radiation ( $F_l$ ), sun radiation to the open water surface ( $F_s^o$ ), heat flow from water to ice ( $F_w^i$ ), net heat loss ( $F_{loss}$ ), and  $A_i$  the calculated Baltic Sea monthly mean ice coverage.

| YEAR | MND | $F_h$<br>( $Wm^{-2}$ ) | $F_e$<br>( $Wm^{-2}$ ) | $F_l$<br>( $Wm^{-2}$ ) | $F_s^o$<br>( $Wm^{-2}$ ) | $F_w^i$<br>( $Wm^{-2}$ ) | $F_{loss}$<br>( $Wm^{-2}$ ) | $A_i$ |
|------|-----|------------------------|------------------------|------------------------|--------------------------|--------------------------|-----------------------------|-------|
| 1999 | 10  | 23                     | 70                     | 45                     | -34                      | 0                        | 104                         | 0     |
| 1999 | 11  | 26                     | 54                     | 45                     | -10                      | 0                        | 115                         | 0     |
| 1999 | 12  | 48                     | 61                     | 51                     | -4                       | 0                        | 157                         | 0     |
| 2000 | 1   | 20                     | 36                     | 42                     | -8                       | 6                        | 97                          | 0.14  |
| 2000 | 2   | 5                      | 17                     | 32                     | -22                      | 10                       | 41                          | 0.29  |
| 2000 | 3   | 5                      | 23                     | 33                     | -56                      | 9                        | 13                          | 0.30  |
| 2000 | 4   | -11                    | 5                      | 28                     | -112                     | 7                        | -83                         | 0.17  |
| 2000 | 5   | -17                    | 14                     | 36                     | -189                     | 0                        | -155                        | 0     |
| 2000 | 6   | -18                    | 17                     | 29                     | -200                     | 0                        | -170                        | 0     |
| 2000 | 7   | -5                     | 25                     | 26                     | -170                     | 0                        | -124                        | 0     |
| 2000 | 8   | 4                      | 50                     | 39                     | -141                     | 0                        | -49                         | 0     |
| 2000 | 9   | 15                     | 73                     | 55                     | -94                      | 0                        | 49                          | 0     |
| 2000 | 10  | 10                     | 43                     | 35                     | -34                      | 0                        | 54                          | 0     |
| 2000 | 11  | 19                     | 39                     | 32                     | -9                       | 0                        | 80                          | 0     |
| 2000 | 12  | 32                     | 43                     | 44                     | -4                       | 0                        | 115                         | 0     |
| 2001 | 1   | 31                     | 41                     | 42                     | -7                       | 0                        | 107                         | 0     |
| 2001 | 2   | 39                     | 41                     | 45                     | -24                      | 15                       | 116                         | 0.22  |
| 2001 | 3   | 9                      | 19                     | 31                     | -49                      | 11                       | 20                          | 0.38  |
| 2001 | 4   | -8                     | 6                      | 26                     | -100                     | 10                       | -67                         | 0.18  |
| 2001 | 5   | -17                    | 12                     | 37                     | -190                     | 0                        | -158                        | 0     |
| 2001 | 6   | -16                    | 11                     | 29                     | -197                     | 0                        | -173                        | 0     |
| 2001 | 7   | -6                     | 38                     | 35                     | -201                     | 0                        | -134                        | 0     |
| 2001 | 8   | 4                      | 56                     | 39                     | -143                     | 0                        | -45                         | 0     |
| 2001 | 9   | 16                     | 62                     | 37                     | -75                      | 0                        | 40                          | 0     |
| 2001 | 10  | 13                     | 45                     | 37                     | -34                      | 0                        | 62                          | 0     |
| 2001 | 11  | 41                     | 82                     | 53                     | -11                      | 0                        | 165                         | 0     |
| 2001 | 12  | 65                     | 65                     | 53                     | -4                       | 1                        | 180                         | 0.02  |
| 2002 | 1   | 18                     | 25                     | 29                     | -6                       | 10                       | 75                          | 0.27  |
| 2002 | 2   | 5                      | 20                     | 30                     | -22                      | 9                        | 42                          | 0.28  |
| 2002 | 3   | 1                      | 17                     | 33                     | -59                      | 7                        | -1                          | 0.27  |