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Supplement of

Bottom RedOx Model (BROM v.1.1): a coupled benthic–pelagic model for simulation of water and sediment biogeochemistry

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Section S1: run-time input file for BROM-transport (brom.yaml)

```
# IMPORTANT !!!! _ <TAB> is NOT allowed here, used <Space> only !!!!
# Each entry must have 6 spaces before the parameter name
instances:
  brom:
    initialization:
##---Paramters for grid-------(see io_ascii.f90/make_vert_grid for a grid diagram)----------------
      water_layer_thickness: 95.  # Thickness of the water column [m] (may overriden by netCDF input, see below)
      k_wat_bbl: 18               # Number of levels above the water/BBL boundary  (may be overriden by netCDF input, see below)
      bbl_thickness: 0.5          # Thickness of the high-resolution layer overlying the sediments (model "benthic boundary layer") [m] (default = 0.5 m)
                             #   This should be thinner than the full viscous+logarithmic layer, but thicker than the viscous layer
                             #   Typical thicknesses for full viscous+logarithmic layer are 1 m and 10 m for deep sea and shelf respectively (Wimbush 2012)
      hz_bbl_min: 0.02            # Minimum allowed layer thickness in the BBL near the SWI [m] (default = 0.02 m)
      hz_sed_min: 0.0005          # Minimum layer thickness in the sediments near the SWI [m] (default = 0.0005 m)
      hz_sed_max: 0.01            # Maximum layer thickness deeper in the sediments [m] (default = 0.01 m)
      k_min: 1                  # Minimum k number defining the layer that is in contact with the atmosphere (default = 1)
      k_points_below_water: 17    # Number of levels below the water/BBL boundary (default = 20)
      i_min: 1                  # Minimum i number (default = 1)
      i_water: 1                # Number of i for water column (default = 1)
      i_max: 1                  # Maximum i number  (default = 1)
#Note: (i_min,i_water,i_max) should be (1,1,1) for 1D applications
#
#
##---Boundary conditions-----------------------------------------------------------------------
#
#Here we set the type of boundary condition using bctype_top_<variable name> and bctype_bottom_<variable name>
#     0 to use surface fluxes from FABM where parameterized, otherwise no flux (default, does not need to be explicitly set)
#     1 for constant Dirichlet, specified by bc_top_<variable name> or bc_bottom_<variable name>
#       E.g. bctype_bottom_niva_brom_bio_O2: 1
#            bc_bottom_niva_brom_bio_O2: 0.
#     2 for sinusoidal Dirichlet, specified by bcpar_top_<variable name> or bcpar_bottom_<variable name>
#            The model is: phi(t) = a1 + a2*sin(omega*(day-a3)) where omega = 2*pi/365
#                          => max(phi(t)) = a1+a2, min(phi(t)) = a1-a2, mean(phi(t)) = a1, peak at 91.25+a3 days
#            Model parameters are specified by a1top_<variable name> etc.
#       E.g. bctype_top_niva_brom_bio_NO3: 2
#            a1top_niva_brom_bio_NO3: 3.0
#            a2top_niva_brom_bio_NO3: 3.0
#            a3top_niva_brom_bio_NO3: 60.
#     3 for arbitrary Dirichlet, read from netCDF file (see I/O options to specify netCDF variable names)
#
#      bctype_bottom_niva_brom_bio_O2: 1
#      bc_bottom_niva_brom_bio_O2: 0.
#
      bctype_top_niva_brom_redox_SO4: 1
      bc_top_niva_brom_redox_SO4: 25000.
      bctype_bottom_niva_brom_redox_SO4: 1
      bc_bottom_niva_brom_redox_SO4: 25000.
#
      bctype_top_niva_brom_redox_Mn4: 1
      bc_top_niva_brom_redox_Mn4: 20.E-4
#
      bctype_top_niva_brom_redox_Fe3: 1
      bc_top_niva_brom_redox_Fe3: 5.E-4
#
      bctype_top_niva_brom_carb_Alk: 1
      bc_top_niva_brom_carb_Alk: 2200.
#      bctype_bottom_niva_brom_carb_Alk: 1
#      bc_bottom_niva_brom_carb_Alk: 3200.
#
#      bctype_bottom_niva_brom_carb_DIC: 1
#      bc_bottom_niva_brom_carb_DIC: 2850.
#
#      bctype_bottom_niva_brom_bio_NH4: 1
#      bc_bottom_niva_brom_bio_NH4: 10.
#
      bctype_top_niva_brom_bio_NO3: 2
      a1top_niva_brom_bio_NO3: 1. # 3
      a2top_niva_brom_bio_NO3: 1.
      a3top_niva_brom_bio_NO3: 320.
      bctype_bottom_niva_brom_bio_NO3: 1
```

```
    bc_bottom_niva_brom_bio_NO3: 0.
#
    bctype_top_niva_brom_bio_PO4: 2
    a1top_niva_brom_bio_PO4: 0.7 #0.8
    a2top_niva_brom_bio_PO4: 0.7
    a3top_niva_brom_bio_PO4: 320. #60.
#     bctype_bottom_niva_brom_bio_PO4: 1
#     bc_bottom_niva_brom_bio_PO4: 10.
#
    bctype_top_niva_brom_redox_Si: 2
    a1top_niva_brom_redox_Si: 1.5
    a2top_niva_brom_redox_Si: 1.5
    a3top_niva_brom_redox_Si: 320.
#     bctype_bottom_niva_brom_redox_Si: 1
#     bc_bottom_niva_brom_redox_Si: 100.
#
#
##---Horizontal mixing parameters------------------------------------------------------------
#
#Here we specify horizontal mixing model using hmix_<variable name>
#    0 to assume no horizontal mixing (default, does not need to be explicitly set)
#    1 for "box model" mixing model: hmix = hmix_rate*(X_0 - X) with X_0 specified by netCDF input file and hmix_rate specified here
#
    hmix_niva_brom_bio_NO3: 0
    hmix_niva_brom_bio_NH4: 0
    hmix_niva_brom_bio_PO4: 0
    hmix_niva_brom_redox_Si: 0
    hmix_niva_brom_bio_O2: 0
#
#
##---Ice model parameters--------------------------------------------------------------------
    use_hice: 0       # 1 to use ice thickness forcing "hice" from netCDF input
#
#
##---Constant forcings-----------------------------------------------------------------------
    density: 1000.
    wind_speed: 8.    # Wind speed 10 m above sea surface [m/s] (default = 8 m/s)
    pco2_atm: 380.    # Atmospheric partial pressure of CO2 [ppm] (default = 380 ppm)
#
#
##---Surface irradiance model parameters-----------------------------------------------------
    use_Eair: 0       # 1 to use 24-hr average surface downwelling shortwave irradiance in air from netCDF input
    lat_light: 50     # Latitude of modelled site [degrees north], e.g. Hardangerfjord station H6 is at 60.228N; Sleipner=50N; Saelen=60.33N
    Io: 80.           # Theoretical maximum 24-hr average surface downwelling shortwave irradiance in air [W/m2] (default = 80 W/m2)
                      #   This should include that effect of average cloud cover (local)
    light_model: 0    # Specify light model: 0 for simple model based on ersem/light.f90
                      #                      1 for extended model accounting for other particulates in BROM
#
#
##---Light absorption model parameters ------------------------------------------------------
    Eair_to_PAR0: 0.5  # Factor to convert input or calculated surface downward irradiance Eair to surface PAR in water (default = 0.5, units dependent on Eair)
                       #   Factor of ~0.48 to convert shortwave (0.3-4 um) to PAR-band (0.4-0.7 um) in [W/m2]
                       #   Further factor of 0.8-0.95 to convert downward-in-air to net-in-water (Mobley and Boss, 2012, Figs. 2c, 4b, 8a)
                       #   Latter factor becomes 0.45-0.55 if modelling PAR in terms of photon flux (Mobley and Boss, 2012, Figs. 5b, 8b)
    k0r:  0.04        # Background PAR attenuation [m-1] (default = 0.04 m-1, from ERSEM shortwave attenuation default)
    kESS: 4e-05       # Specific PAR attenuation by silt [m^2/mg] (default = 4e-05 m^2/mg, from ERSEM shortwave attenuation default)
    ESS:  0.          # Assumed (constant) concentration of silt [mg/m^3] (default = 0. mg/m^3, from ERSEM shortwave attenuation default)
    kPhy: 0.00023     # Specific PAR attenuation by phytoplankton [m^2/mg N] (default = 0.0023 m^2/mg N, from ERSEM shortwave attenuation default)
                      #   From ERSEM Blackford (P1-P4), default = 0.0004 m^2/mg C * 5.68 mg C/mg N (Redfield ratio 106/16 mol/mol)
                      #   Note misprint "e-3" instead of "e-4" in Blackford et al. (2004) Table 1
    kPON: 0.          # Specific PAR attenuation due to PON [m^2/mg N] (default = 0. m^2/mg N)
# The following are only used if light_model = 1
    kHet: 0.          # Specific PAR attenuation due to zooplankton [m^2/mg N] (default = 0. m^2/mg N)
    kDON: 0.          # Specific PAR attenuation due to DON [m^2/mg N] (default = 0. m^2/mg N)
    kB:   0.          # Specific PAR attenuation due to bacteria [m^2/mg N] (default = 0. m^2/mg N)
    kPIV: 0.          # Specific PAR attenuation due to total particulate inorganic volume fraction (default = 0. m^-1)
#
#
##---Assumed densities for particles in the model (may be used in light/sedimentation models)------
#
# Densities are specified by rho_<full variable name> and in same units as the model concentration
# Any missing values will use the default density rho_def
    rho_def:   3.0E7                  # Default density of solid particles [mmol/m3]
    rho_niva_brom_bio_Phy: 1.5E7      # Density of (living) phytoplankton [mmolN/m3] (default = 1.4E6 mmolN/m3 from PON default)
```

```
    rho_niva_brom_bio_PON: 1.5E7        # Density of (dead) particulate organic matter [mmolN/m3] (default = 1.4E6 mmolN/m3, from: 1.23 g WW/cm3
(Alldredge, Gotschalk, 1988), mg DW/mg WW=0.18 and mg DW /mg C=2 (Link et al.,2006))
    rho_niva_brom_bio_Het: 1.5E7        # Density of (living) non-bacterial heterotrophs [mmolN/m3] (default = 1.4E6 mmolN/m3 from PON default)
    rho_niva_brom_redox_Baae: 1.5E7     # Density of (living) aerobic autotrophic bacteria [mmolN/m3] (default = 1.4E6 mmolN/m3 from PON default)
    rho_niva_brom_redox_Bhae: 1.5E7     # Density of (living) aerobic heterotrophic bacteria [mmolN/m3] (default = 1.4E6 mmolN/m3 from PON default)
    rho_niva_brom_redox_Baan: 1.5E7     # Density of (living) anaerobic autotrophic bacteria [mmolN/m3] (default = 1.4E6 mmolN/m3 from PON default)
    rho_niva_brom_redox_Bhan: 1.5E7     # Density of (living) anaerobic heterotrophic bacteria [mmolN/m3] (default = 1.4E6 mmolN/m3 from PON default)
    rho_niva_brom_redox_CaCO3: 2.80E7   # Density of calcium carbonate [mmolCa/m3] (default = 2.80E7 mmolCa/m3)
    rho_niva_brom_redox_Fe3: 3.27E7     # Density of Fe3 [mmolFe/m3] (default = 3.27E7 mmolFe/m3)
    rho_niva_brom_redox_FeCO3: 2.93E7   # Density of FeCO3 [mmolFe/m3] (default = 2.93E7 mmolFe/m3)
    rho_niva_brom_redox_FeS: 5.90E7     # Density of FeS [mmolFe/m3] (default = 5.90E7 mmolFe/m3)
    rho_niva_brom_redox_FeS2: 4.17E7    # Density of FeS2 [mmolFe/m3] (default = 4.17E7 mmolFe/m3)
    rho_niva_brom_redox_Mn4: 5.78E7     # Density of Mn4 [mmolMn/m3] (default = 5.78E7 mmolMn/m3)
    rho_niva_brom_redox_MnCO3: 3.20E7   # Density of MnCO3 [mmolMn/m3] (default = 3.20E7 mmolMn/m3)
    rho_niva_brom_redox_MnS: 4.60E7     # Density of MnS [mmolMn/m3] (default = 4.60E7 mmolMn/m3)
    rho_niva_brom_redox_S0: 6.56E7      # Density of S0 [mmolS/m3] (default = 6.56E7 mmolS/m3)
    rho_niva_brom_redox_Sipart: 4.40E7  # Density of particulate silicate [mmolSi/m3] (default = 4.40E7 mmolSi/m3)
#
#
##---Time stepping parameters-----------------------------------------------------------------
    dt:         0.0025     # Time step in [days] (default = 0.0025 days)
    freq_turb:  1          # Physical mixing time step = dt/freq_turb (default = 1)
    freq_sed:   1          # Sinking / bhc frequency (default = 1)
    year:       1998       # Selected year (for reading netCDF inputs) WARNING: This must be a year present in the netCDF file, and nc_year0 must be correctly
specified below
    days_in_yr: 365        # Number of days in repeated period (typically 365 or 366, default = 365)
    last_day:   3650       # Last day in simulation (~ days_in_yr * no. repeated years, default = 365)
    cc0:        1.0E-11    # Resilient (minimum) concentration for all variables [mmol/m3] (default = 1.0E-11 mmol/m3)
    surf_flux_with_diff: 0  # 1 to include surface fluxes in diffusion update, 0 to include in biogeochemical update (default = 0)
#
#
##---Vertical diffusivity parameters----------------------------------------------------------
    diff_method:    1      # Numerical method to treat vertical diffusion (default = 1):
                           #  0 for FTCS approach (Forward-Time Central-Space scheme)
                           #  1 for GOTM approach (semi-implicit in time) using diff_center from GOTM lake (converting input/output units)
                           #  2 for GOTM approach (semi-implicit in time) using modified version of original GOTM diff_center (no units conversion required, should
give very similar results to diff_method = 1)
                           #  Note: If diff_method>0 and bioturb_across_SWI = 1 below, only one modified GOTM subroutine can be used (diff_center2)
    cnpar:          0.6    # "Implicitness" parameter for GOTM vertical diffusion (default = 0.6):
                           #  0 => Forward Euler  (fully explicit, first-order accurate)
                           #  1 => Backward Euler (fully implicit, first-order accurate)
                           #  0.5 => Crank-Nicolson (semi-implicit, second-order accurate)
    dynamic_kz_bbl: 0      # 1 for dynamic (time-dependent) kz_bbl, 0 for static kz_bbl (default = 0)
                           #  For deep water (e.g. >500 m) a static kz_bbl may be a reasonable approximation.
                           #  For shallower water, probably better to set dynamic_kz_bbl = 1; kz in the BBL is then determined by linearly interpolating between zero at
the SWI and the value at the bottom of the hydrodynamic model input water column
    kz_bbl_type:    1      # Type of variation of eddy diffusion kz(z) assumed over the benthic boundary layer:
                           #  0 => constant = kz_bbl_max, 1 => linear (~=> log-layer for velocity, Holtappels & Lorke, 2011)
                           #  This is only used if assuming a static kz_bbl (dynamic_kz_bbl = 0)
    kz_bbl_max:     5.E-6  # Maximum eddy diffusivity in the benthic boundary layer [m2/s] (default = 1.0E-5 m2/s)
                           #  This is only used if assuming a static kz_bbl (dynamic_kz_bbl = 0)
    dbl_thickness:  0.0005 # Thickness of the diffusive boundary layer [m] (default = 0.0005 m = 0.5 mm)
                           #  Jorgensen and Revsbech (1985) quote a range 1-2 mm over the deep sea floor (Boudreau and Guinasso, 1982, Wimbush 1976)
                           #  and down to 0.1-0.2 mm over more exposed sediments (Santschi et al., 1983)
                           #  All layers within the DBL (midpoint height above SWI < dbl_thickness) have kz = kz_mol0 (no eddy diffusivity)
    kz_mol0:        1.0E-9 # Molecular diffusivity at infinite dilution [m2/s] (default = 1.0E-9 m2/s)
                           #  Cf. range (0.5-2.7)E-9 m2/s in Boudreau 1997, Table 4.8
                           #  This sets a single constant value for all variables that is subsequently corrected for viscosity and tortuosity
    mu0_musw:       0.94   # Inverse relative viscosity of saline pore water (default = 0.94 from Boudreau 1997 Table 4.10)
                           #  This relates the diffusivity in saline pore water to the infinite-dilution diffusivity
                           #  assuming the approximation from Li and Gregory (1974), see Boudreau (1997) equation 4.107
    kz_bioturb_max: 1.0E-11 # Maximum diffusivity due to bioturbation in the sediments [m2/s] (default = 1.0E-11 m2/s)
                           #  Cf. range (1-100) cm2/yr = (0.3-30)E-11 m2/s cited in Soetaert and Middelburg (2009), citing Middelburg et al. (1997)
                           #  This sets value for upper z_const_bioturb metres, then bioturbation diffusivity decays with scale z_decay_bioturb.
    z_const_bioturb: 0.01  # "Mixed layer depth" in sediments over which bioturbation diffusivity = kz_bioturb_max [m] (default = 0.02 m)
                           #  Cf. values 0.05 m and 0.01 m used by Soetaert and Middelburg (2009) for well-mixed and anoxic conditions respectively
                           #  Meire et al. (2013) use 0.05 m as a constant value
    z_decay_bioturb: 0.01  # Decay scale of bioturbation diffusivity below z_const_bioturb [m] (default = 0.01 m, following Soetaert and Middelburg, 2009)
    K_O2s:          5.0    # Half-saturation constant for the effect of oxygen on bioturbation and bioirrigation [uM] (default = 5.0 uM)
                           #  Bioturbation diffusivity and bioirrigation rate are modulated by a Michaelis-Menten function with parameter K_O2s
    bioturb_across_SWI: 1  # 1 to allow (interphase) bioturbation diffusion across the SWI (default = 1)
                           #  Bioturbation across the SWI must be interphase mixing rather than the intraphase mixing assumed within the sediments
#
#
```

```
##---Bioirrigation parameters----------------------------------------------------------------------
#
# Bioirrigation rate alpha = a1_bioirr*exp(-a2_bioirr*z_s), where z_s is depth below the SWI [m]
#
    a1_bioirr:      0.0    # Maximum rate of bioirrigation in the sediments [s^-1] (default = 0.E-5)
                    #   Schluter et al. (2000) infer a range (0-5) d^-1 = (0-6)E-5 s^-1 for a1
                    #   This range is also broadly consistent with the profiles of alpha inferred by Miele et al. (2001)
    a2_bioirr:      50.    # Decay rate with depth of bioirrigation rate [m^-1] (default = 50)
                    #   Schluter et al. (2000) infer a range (0-1) cm^1 = (0-100) m^-1 for a2
                    #   This range is also broadly consistent with the profiles of alpha inferred by Miele et al. (2001)
#
#
##---Sedimentation parameters----------------------------------------------------------------------
    w_binf:         1.0E-10 # Particulate background burial velocity deep in the sediments where phi = phi_inf [m/s] (default = 1.0E-10 m/s = 0.3 cm/year, but note
that true values are highly variable)
                    #   Soetaert et al. (1996) propose a regression model as a function of water depth:
                    #   w = 982*D^-1.548, where D is water depth in [m] and w is in cm/year, e.g. for D = 100 m, w = 0.8 cm/year = 2.5E-10 m/s
                    #   Note: Shallow particulate and solute burial velocities are inferred by assuming steady state compaction (Boudreau, 1997)
    dynamic_w_sed:  1      # 1 to enable time-dependent advective velocities in the sediments (default = 0)
                    #   This uses the modelled (reactive) particulate variables to correct the advective velocities in the sediments (see calculate_sed)
                    #   w_binf and phi_inf then define constant background components of these velocities
#
#
##---Porosity parameters---------------------------------------------------------------------------
#
#   Porosity phi = phi_inf + (phi_0-phi_inf)*exp(-z_s/z_decay_phi), where z_s is depth below the SWI [m]
#
    phi_0:          0.95   # Maximum porosity at the SWI (default = 0.95, following Soetaert et al., 1996)
    phi_inf:        0.80   # Minimum porosity deep in the sediments (default = 0.80, following Soetaert et al., 1996)
    z_decay_phi:    0.04   # Exponential decay scale for excess porosity in the upper sediments [m] (default = 0.04, following Soetaert et al., 1996)
#
#
##---I/O options----------------------------------------------------------------------------------
    input_type: 2                       # input forcing type: 0 for sinusoidal changes, 1 to read from ascii, 2 to read from netCDF (default)
    ncoutfile_name: BROM_Sleipner_out20.nc    # netCDF output file name
    outfile_name: finish.dat              # ascii output file name
    port_initial_state: 1                 # 0 to use FABM default (default), 1 to read from ascii file (icfile_name)
    icfile_name: start19.dat              # ascii initial condition file name (needed if port_initial_state = 1)
#The following are only used if reading input from netCDF (input_type = 2)
#Note: NetCDF variables (temperature, salinity, diffusivity) must have either two dimensions (depth, time) or four dimensions ((latitude, longitude, depth , time)
or (longitude, latitude, depth, time))
    nc_set_k_wat_bbl: 1                   # 1 (default) to set the no. water column layers to agree with netCDF input
                                  # 0 to use the value k_wat_bbl set above by subsampling the netCDF input
                                  # Note that in both cases the water layer thickness is determined by the netCDF input, overriding water_layer_thickness above
    nc_staggered_grid: 1                  # 1 (default) to assume a staggered input grid, (t,s) at layer midpoints, kz on layer interfaces (e.g. ROMS, GOTM)
    nc_bottom_to_top: 1                   # 1 (default) if netCDF variables are stored with vertical index increasing from bottom to top (e.g. ROMS, GOTM)
    nc_z_increasing_upward: 1             # 1 if netCDF depth variables are increasing upward (e.g. if "depth" is negative) (default = 0)
    ncinfile_name: nns_annual.nc          # netCDF input file name
    ncintime_name: time                   # netCDF time dimension name [units since nc_year0-01-01 00:00:00]
    nc_year0: 1998                        # reference year for netCDF time variable (default = 1970) WARNING: This MUST be correctly specified
    ncinz_name: z                         # netCDF depth dimension name for layer midpoints (rho points) [m]
    ncinz2_name: z1                       # netCDF depth dimension name for layer interfaces (w points) [m]
    ncinlat_name: lat                     # netCDF latitude dimension name (needed if reading 4D variables)
    ncinlon_name: lon                     # netCDF longitude dimension name (needed if reading 4D variables)
    ncinlat_sel: 1                        # Chosen latitude index (1,2,...,nlat) (needed if reading from 4D variables with nlat > 1)
    ncinlon_sel: 1                        # Chosen longitude index (1,2,...,nlon) (needed if reading from 4D variables with nlon > 1)
#
#Below we specify the names of variables in netCDF input files
#Format is <BROM internal name>: <netCDF input name>
#Can also specify a constant scale factor "fac", e.g. to convert units, or correct bias.
#BROM internal variable = fac * netCDF input variable (BROM assumes fac = 1 if not specified here)
#This factor can also be used to apply a simple stoichiometric assumption in lieu of nutrient variable data
#E.g. ncinSis_name: NO3s                  # netCDF input surface silicate variable name [uM] - here using nitrate
#    ncinSis_fac: 1.5                     # scale factor for netCDF input surface silicate - here assuming "extended Redfield ratio" Si:N = 1.5 mol Si / mol N
#
#2D physical variables used for setting BROM forcings
#These must be arrays of size [no. water column layers (= k_wat_bbl) * no. of days for all available years]
    ncint_name: temp                      # netCDF input temperature variable name [degC]
    ncins_name: salt                      # netCDF input salinity variable name [psu]
    ncinkz_name: nus                      # netCDF input vertical diffusivity variable name [m2/s]
    ncinkz_fac: 1.0                       # scale factor for netCDF input vertical diffusivity (default = 1.0)
#
#1D physical variables used for setting BROM forcings
#These must be arrays of size [no. of days for all available years]
```

```
    ncinEair_name: Eair                 # netCDF input shortwave irradiance in air at water surface [W/m2] (only used if use_Eair = 1)
    ncinEair_fac: 1.0                   # scale factor for netCDF input shortwave irradiance (default = 1.0) (only used if use_Eair = 1)
    ncinhice_name: hice                 # netCDF input ice thickness variable name [m] (only used if use_hice = 1)
    ncinhice_fac: 1.0                   # scale factor for netCDF input ice thickness (default = 1.0) (only used if use_hice = 1)
#
#Biogeochemical variables used for setting Dirichlet BCs at surface or bottom (bctype = 3)
#These must be arrays of size [1 * no. of days in repeated period (= days_in_yr)]
    ncinNH4s_name: NH4s                 # netCDF input surface ammonium variable name [uM]
    ncinNH4s_fac: 1.0                   # scale factor for netCDF input surface ammonium (default = 1.0)
    ncinNO3s_name: NO3s                 # netCDF input surface nitrate variable name [uM]
    ncinNO3s_fac: 1.0                   # scale factor for netCDF input surface nitrate (default = 1.0)
    ncinPO4s_name: PO4s                 # netCDF input surface phosphate variable name [uM]
    ncinPO4s_fac: 1.0                   # scale factor for netCDF input surface phosphate (default = 1.0)
    ncinSis_name: Sis                   # netCDF input surface silicate variable name [uM]
    ncinSis_fac: 1.0                    # scale factor for netCDF input surface silicate (default = 1.0)
    ncinAlks_name: ATs                  # netCDF input surface alkalinity variable name [uM]
    ncinAlks_fac: 1.0                   # scale factor for netCDF input surface alkalinity (default = 1.0)
#
#Biogeochemical variables used for setting horizontal mixing fluxes
#NOTE: These must be arrays of size [no. water column layers (= k_wat_bbl) * no. of days in repeated period (= days_in_yr)]
#NOTE: The depth indexing must agree with temperature and salinity inputs
#NOTE: The layer index of the mixing variable is the layer with which it mixes in the internal BROM grid
#     This is does not necessarily reflect the actual depth of the mixing variable in its external location
#NOTE: This information is only used if hmix_<variable name> is > 0, see above
    ncinNH4hmix_name: NH4_N             # netCDF input horizontal mixing ammonium variable name [uM]
    ncinNH4hmix_fac: 1.0                # scale factor for netCDF input horizontal mixing ammonium (default = 1.0)
    ncinNO3hmix_name: NO3_N             # netCDF input horizontal mixing nitrate variable name [uM]
    ncinNO3hmix_fac: 1.0                # scale factor for netCDF input horizontal mixing nitrate (default = 1.0)
    ncinPO4hmix_name: PO4_N             # netCDF input horizontal mixing phosphate variable name [uM]
    ncinPO4s_fac: 1.0                   # scale factor for netCDF input horizontal mixing phosphate (default = 1.0)
    ncinSihmix_name: NO3_N              # netCDF input horizontal mixing silicate variable name [uM]
    ncinSihmix_fac: 1.5                 # scale factor for netCDF input horizontal mixing silicate (default = 1.0)
    ncinO2hmix_name: O2_N               # netCDF input horizontal mixing oxygen variable name [uM]
    ncinO2hmix_fac: 1.0                 # scale factor for netCDF input horizontal mixing oxygen (default = 1.0)
#
#Horizontal mixing rates
#NOTE: This must be an array of size [no. water column layers (= k_wat_bbl) * no. of days in repeated period (= days_in_yr)]
#NOTE: The depth indexing must agree with temperature and salinity inputs
#NOTE: This information is only used if hmix_<variable name> is > 0, see above
    ncinhmix_rate_name: hmix_rate       # netCDF input horizontal mixing rates [day^-1]
    ncinhmix_rate_fac: 1.0              # scale factor for netCDF input horizontal mixing rate (default = 1.0)
#
#
##---Options for run-time output to screen-----------------------------------------------------------
    show_maxmin: 0                      # 1 to show the profile maximum and minimum of each variable at the end of each day (default = 0)
    show_kztCFL: 0                      # 1/2 to show the max/profile of total vertical diffusivity and associated Courant-Friedrichs-Lewy number at the end of
each day (default = 0)
    show_wCFL: 0                        # 1/2 to show the max/profile of vertical advection and associated Courant-Friedrichs-Lewy number at the end of each day
(default = 0)
    show_nan: 0                         # 1 to show the profile concentration output on NaN-termination for the offending variable (default = 1)
    show_nan_kztCFL: 2                  # 1/2 to show the max/profile of total vertical diffusivity and associated Courant-Friedrichs-Lewy number on NaN-
termination (default = 1)
    show_nan_wCFL: 1                    # 1/2 to show the max/profile of vertical advection and associated Courant-Friedrichs-Lewy number on NaN-termination
(default = 1)
#
#
## References
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```

Section S2: run-time input file for BROM-biogeochemistry (fabm.yaml)

```
# IMPORTANT !!!! _ <TAB> is NOT allowed here, used <Space> only !!!!
# Each entry must have 6 spaces before the parameter name
require_initialization: true
instances:
#-------------------------------------------------------------------------
  niva_brom_eqconst:
#-------------------------------------------------------------------------
  niva_brom_carb:
    initialization:
      Alk: 2200.
      DIC: 2100.
    coupling:
      Kc0: niva_brom_eqconst/Kc0
      Kc1: niva_brom_eqconst/Kc1
      Kc2: niva_brom_eqconst/Kc2
      Kw: niva_brom_eqconst/Kw
      Kb: niva_brom_eqconst/Kb
      Kp1: niva_brom_eqconst/Kp1
      Kp2: niva_brom_eqconst/Kp2
      Kp3: niva_brom_eqconst/Kp3
      Knh4: niva_brom_eqconst/Knh4
      Kh2s: niva_brom_eqconst/Kh2s
#      Kh2s2: niva_brom_eqconst/Kh2s2
      KSi: niva_brom_eqconst/KSi
      kso4: niva_brom_eqconst/kso4
      kflu: niva_brom_eqconst/kflu
      tot_free: niva_brom_eqconst/tot_free
#    Constants calculated: Kc0 (Weiss, 1974), Kc1, Kc2 (Roy et al., 1993), Kw, Kp1,Kp2,Kp3 (DOE, 2004),
#                          Kb (Dickson,1990), KSi(Millero,1995), Knh4, Kh2s1(Luff et al, 2001), Kh2s2(Volkov 1984)
#                          dissociation for B, F according to (Dickson et al., 2007), more references in the code.
      PO4: niva_brom_bio/PO4
      NH4: niva_brom_bio/NH4
      DON: niva_brom_bio/DON
      Si: niva_brom_redox/Si
      H2S: niva_brom_redox/H2S
      Mn3: niva_brom_redox/Mn3
      Mn4: niva_brom_redox/Mn4
      Fe3: niva_brom_redox/Fe3
      SO4: niva_brom_redox/SO4
#-------------------------------------------------------------------------
  niva_brom_bio:
    initialization:
      O2: 200.
      Phy: 0.01
      Het: 0.01
      PON: 0.01
      DON: 0.0
      NO3: 5.
      PO4: 1.
      NH4: 0.0
    parameters:
# ---- Phy  ----------
      K_phy_gro: 4.7       # Maximum specific growth rate (1/d) =0.9-1.3 (Savchuk, 2002), =3.(Gregoire, Lacroix, 2001) >!0.5 worked for Berre!<
      Iopt: 25.            # Optimal irradiance (W/m2) =50 (Savchuk, 2002)
      bm: 0.12              # Coefficient for growth dependence on t
      cm: 1.4              # Coefficient for growth dependence on t
      K_phy_mrt: 0.20       # Specific rate of mortality, (1/d) =0.3-0.6 (Savchuk, 2002), =0.05 (Gregoire, Lacroix, 2001)
      K_phy_exc: 0.10       # Specific rate of excretion, (1/d) =0.01 (Burchard et al., 2006)
# ----Het -----------
      K_het_phy_gro: 1.1    #! Max.spec. rate of grazing of Zoo on Phy, (1/d), =0.9 (Gregoire, Lacroix, 2001), =1.5 (Burchard et al., 2006)
      K_het_phy_lim: 0.5    #! Half-sat.const.for grazing of Zoo on Phy for Phy/Zoo ratio
      K_het_pom_gro: 0.50   #! Max.spec.rate of grazing of Zoo on POP and bacteria, (1/d), =1.2 (Burchard et al., 2006)
      K_het_pom_lim: 0.05   #! Half-sat.const.for grazing of Zoo on POP for POP/Zoo  ratio
      K_het_res: 0.02       #! Specific respiration rate =0.02 (Yakushev et al., 2007)
      K_het_mrt: 0.05       #! %! Maximum specific rate of mortality of Zoo (1/d) =0.05 (Gregoire, Lacroix, 2001)
      Uz: 0.5              #! Food absorbency for Zoo (nd) =0.5-0.7 (Savchuk, 2002)
      Hz: 0.5              #! Ratio betw. diss. and part. excretes of Zoo (nd), =0.5 (Gregoire, Lacroix, 2001)
      limGrazBac:  2.       #! Limiting parameter for bacteria grazing by Zoo, =2. (Yakushev et al., 2007)
# ----N -------------
      K_nox_lim: 0.1        #! Half-sat.const.for uptake of NO3+NO2 (uM) =0.5 (Gregoire, Lacroix, 2001)
      K_nh4_lim: 0.02       #! Half-sat.const.for uptake of NH4 (uM) =0.2 (Gregoire, Lacroix, 2001)
      K_psi: 1.46          #! Strength of NH4 inhibition of NO3 uptake constant (uM-1) =1.46_rk (Gregoire, Lacroix, 2001)
```

```
    K_nfix: 0.4          #! Maximum specific rate of N-fixation (1/d) =0.5 (Savchuk, 2002)
# ----P ------------
    K_po4_lim: 0.012     #! Half-sat. constant for uptake of PO4 by Phy
# ----Si------------
    K_si_lim: 0.1        #! Half-sat. constant for uptake of Si_lim by Phy
# ----Sinking-------
    Wsed: 5.0       #! Rate of sinking of detritus (m/d), =0.4 (Savchuk, 2002), =5. (Gregoire, Lacroix, 2001), =1-370 (Alldredge, Gotschalk, 1988)
    Wphy: 0.2       #! Rate of sinking of Phy (m/d), =0.1-0.5 (Savchuk, 2002)
    Whet: 1.        #! Rate of sinking of Het (m/d), =1. (Yakushev et al., 2007)
# ---- Stoichiometric coefficients ----
    r_n_p: 16.0     #! N[uM]/P[uM]
    r_o_n: 6.625    #! O2[uM]/N[uM]
    r_c_n: 8.0      #! C[uM]/N[uM]
    r_si_n: 1.0     #! Si[uM]/N[uM]
  coupling:
    NO2: niva_brom_redox/NO2
    H2S: niva_brom_redox/H2S
    Baan: niva_brom_redox/Baan
    Baae: niva_brom_redox/Baae
    Bhae: niva_brom_redox/Bhae
    Bhan: niva_brom_redox/Bhan
    Si: niva_brom_redox/Si
    Sipart: niva_brom_redox/Sipart
    DIC: niva_brom_carb/DIC
    Alk: niva_brom_carb/Alk
    Hplus: niva_brom_carb/Hplus
    Kp1: niva_brom_eqconst/Kp1
    Kp2: niva_brom_eqconst/Kp2
    Kp3: niva_brom_eqconst/Kp3
    Knh4: niva_brom_eqconst/Knh4
    KSi: niva_brom_eqconst/KSi
#-------------------------------------------------------------------------------
 niva_brom_redox:
  initialization:
    Mn2: 0.0
    Mn3: 0.0
    Mn4: 0.0
    MnS: 0.0
    MnCO3: 0.0
    Fe2: 0.0
    Fe3: 0.0
    FeS: 0.0
    FeCO3: 0.0
    NO2: 0.0
    Si: 0.0
    Sipart: 0.0
    H2S: 0.0
    S0:  0.0
    S2O3: 0.0
    SO4: 25000.
    Baae: 0.01
    Bhae: 0.01
    Baan: 0.01
    Bhan: 0.01
    CaCO3: 5.0
    CH4: 0.001
    FeS2: 0.0
  parameters:
# ---- Model parameters ------
    Wbact: 0.4       #! Rate of sinking of bacteria (Bhae,Baae,Bhan,Baan) (1/d), (Yakushev et al.,2007)
    Wm: 7.0          #! Rate of accelerated sinking of particles with settled metal hydroxides (1/d), (Yakushev et al.,2007)
# specific rates of biogeochemical processes
#---- Mn---------
    K_mn_ox1: 0.1       #! Specific rate of oxidation of Mn2 to Mn3 with O2 (1/d).
    K_mn_ox2: 0.2       #! Specific rate of oxidation of Mn3 to Mn4 with O2 (1/d)
    K_mn_rd1: 0.5       #! Specific rate of reduction of Mn4 to Mn3 with H2S (1/d)
    K_mn_rd2: 1.0       #! Specific rate of reduction of Mn3 to Mn2 with H2S (1/d)
    K_mns: 1500.        #! Conditional equilibrium constant for MnS from Mn2 with H2S (M)
    K_mns_diss: 0.0005  #! Specific rate of dissolution of MnS to Mn2 and H2S (1/d)
    K_mns_form: 0.00001 #! Specific rate of formation of MnS from Mn2 with H2S (1/d)
    K_mnco3: 1.         #! Conditional equilibrium constant %  1.8e-11 (M) (Internet)      1 uM2 for Mn2+CO3->MnCO3 (Meysman,2003)
    K_mnco3_diss: 7.e-7 #! Specific rate of dissolution of MnCO3 (1/d) =6.8e-7 (2.5 X 10-1 yr-1 (Van Cappellen, Wang, 1996) !1x10-4 yr-1) (Hunter et al, 98)
    K_mnco3_form: 0.1e-4 #! Specific rate of formation of MnCO3 (1/d) =2.7e-7  (1. X 10-4 yr-1 (Van Cappellen, Wang, 1996)!1x10-4 yr-1) (Hunter et al, 98))
    K_mnco3_ox: 0.0027  #! Specific rate of oxidation of MnCO3 with O2 (1/d)=0.0027  ( 1x10^(-6) M/yr (Van Cappellen, Wang, 1996).
```

```
    K_DON_mn: 0.001     #! Specific rate of oxidation of DON with Mn4 (1/d)
    K_PON_mn: 0.001     #! Specific rate of oxidation of PON with Mn4 (1/d)
    s_mnox_mn2: 0.01    #! threshold of Mn2 oxidation (uM Mn) (Yakushev et al.,2007)
    s_mnox_mn3: 0.01    #! threshold of Mn3 oxidation (uM Mn) (Yakushev et al.,2007)
    s_mnrd_mn4: 0.01    #! threshold of Mn4 reduciton (uM Mn) (Yakushev et al.,2007)
    s_mnrd_mn3: 0.01    #! threshold of Mn3 reduciton  (uM Mn) (Yakushev et al.,2007)
#---- Fe---------
    K_fe_ox1: 0.5         #!Specific rate of oxidation of Fe2 to Fe3  with O2 (1/d), =4. (Konovalov et al., 2006)
    K_fe_ox2: 0.001       #!0.1! Specific rate of oxidation of Fe2 to Fe3  with MnO2 (1/d) =0.74 (Konovalov et al., 2006); 3x10^6 1/(M yr) is estimated in Van
Cappellen-Wang-96
    K_fe_rd: 1.2          #!0.5! Specific rate of reduction of Fe3 to Fe2  with H2S (1/day) *=0.05 (Konovalov et al., 2006)
    K_fes: 2510.0         #!FeS equilibrium constant (Solubility Product Constant) (uM)=2510  ( 2.51x10-6 mol cm-3, Bektursuniva,11)
    K_fes_form: 5.e-4     #!Specific rate of precipitation of FeS from Fe2 with H2S (1/day)=1.e-5 (4x10-3 1/yr, Bektursunova,11)
    K_fes_diss: 1.e-6     #!Specific rate of dissollution of FeS to Fe2 and H2S  (1/day)=3.e-6 (1x10-3 1/yr, Bektursunova,11)
    K_fes_ox: 0.001       #!Specific rate of oxidation of FeS with O2 (1/day)=0.001(3x10^5 1/(M yr),(Van Cappellen, Wang, 1996)
    K_DON_fe: 0.00005     #!-0.0003 ! %  Specific rate of oxidation of DON with Fe3 (1/day)
    K_PON_fe: 0.00001     #!-0.0001 ! %  Specific rate of oxidation of PON with Fe3 (1/day)
    K_fes2_form: 1.e-6    #!specific rate of FeS2 formation by FeS oxidation by H2S (1/day)=0.000009 (10^(-4) L/mol/s (Rickard-97)
    K_fes2_ox: 4.38e-4    #!specific rate of pyrite oxidation by O2  (1/uM/d)=4.38x10^(-4) 1/micromolar/day (Wijsman et al -2002).
    s_feox_fe2: 0.001     #!threshold of Fe2 reduciton
    s_ferd_fe3: 0.01      #!threshold of Fe3 reduciton  (uM Fe)
    K_feco3: 15.          #!10. !2.e-2 ! Conditional equilibrium constant %  1.8e-11 (M) (Internet)  1 uM2 for Mn2+CO3->FeCO3 (Meysman,2003)
    K_feco3_diss: 7.e-4   #!Specific rate of dissolution of FeCO3 (1/day)=6.8e-7   !2.5 X 10-1 yr-1 (Van Cappellen, Wang, 1996) !1x10-4 yr-1 (Hunter et al, 98)
    K_feco3_form: 3.e-4   #!Specific rate of formation of FeCO3 (1/day)=2.7e-7  !! 1. X 10-4 yr-1(Van Cappellen, Wang, 1996)!1x10-4 yr-1 (Hunter et al, 98)
    K_feco3_ox: 0.0027    #!Specific rate of oxidation of FeCO3 with O2 (1/day)=0.0027  ( 1x10^(-6) M/yr (Van Cappellen, Wang, 1996).
#---- S---------
    K_hs_ox: 0.5          #! Specific rate of oxidation of H2S to S0  with O2 (1/d),  =0.1 (Gregoire, Lacroix, 2001)
    K_s0_ox: 0.02         #! 0.02 Specific rate of oxidation of S0 with O2 (1/d), (Yakushev, Neretin,1997)
    K_s2o3_ox: 0.01       #! Specific rate of oxidation of S2O3 with O2 (1/d), (Yakushev, Neretin,1997)
    K_so4_rd: 5.e-6       #! Specific rate of OM sulfate reduction with sulfate (1/d), (Yakushev, Neretin,1997)
    K_s2o3_rd: 0.001      #! Specific rate of OM sulfate reduction with thiosulfate (1/d) (Yakushev, Neretin,1997)
    K_s0_disp: 0.001      #! Specific rate of S0 dispropotionation (1/d) (Yakushev,2013)
    K_s0_no3: 0.9         #! Specific rate of oxidation of S0 with NO3 (1/d) (Yakushev,2013)
    K_s2o3_no3: 0.01      #! Specific rate of oxidation of S2O3 with NO3 (1/d) (Yakushev,2013)
    K_mnrd_hs: 1.0        #! half sat. of Mn reduction (uM S) (Yakushev,2013)
    K_ferd_hs: 1.0        #! half sat. of Fe reduction (uM S) (Yakushev,2013)
#---- N---------!
    K_DON_ox: 0.05        #! Specific rate of oxidation of DON with O2 (1/d) = 0.1(Savchuk, 2002)
    K_PON_ox: 0.002       #! Specific rate of oxidation of PON with O2 (1/d) =0.002 (Savchuk, 2002), =0.07 (Gregoire, Lacroix, 2001)
    Tda: 13.0             #! Temperature control coefficient for OM decay (Burchard et al., 2006)
    beta_da: 20.0         #! Temperature control coefficient for OM decay (Burchard et al., 2006)
    K_omox_o2: 1.0        #! Half sat. of o2 for OM mineralization (uM) (Yakushev,2013)
    K_PON_DON: 0.1        #! Specific rate of Autolysis of PON to DON (1/d), =0.02 (Burchard et al., 2006)
    K_nitrif1: 0.01       #! Spec.rate of 1st st. of nitrification, (1/d), =0.01 (Yakushev,2013) =0.1(Savchuk, 2002) =0.1 (Gregoire, Lacroix, 2001)
    K_nitrif2: 0.1        #! Spec.rate of 2d st. of nitrification, (1/d), =0.1 (Yakushev,2013)
    K_denitr1: 0.16       #! Spec.rate of 1 stage of denitrif =0.16 (Yakushev, Neretin,1997),= 0.5(Savchuk, 2002),= 0.015(Gregoire, Lacroix, 2001)
    K_denitr2: 0.25       #! Spec.rate of 2 stage of denitrif =0.22 (Yakushev, Neretin,1997)
    K_omno_no3: 0.001     #! Half sat. of no3 for OM denitr. (uM N) (Yakushev,2013)
    K_omno_no2: 0.001     #! Half sat. of no2 for OM denitr. (uM N) (Yakushev,2013)
    K_hs_no3: 0.8         #! Spec.rate of thiodenitrification (1/d), =.015 (Gregoire, Lacroix, 2001)
    K_annamox: 0.8        #! Spec.rate of Anammox (1/d),  (Gregoire, Lacroix, 2001)
#---- O2--------!
    O2s_nf: 5.            #! threshold of O2  saturation for nitrification, (uM), =10. (Gregoire, Lacroix, 2001)
    O2s_dn: 10.0          #! threshold of O2 for denitrification, anammox, Mn reduction (uM O2), =40 (0.72 mgO2/l) (Savchuk, 2002)
    s_omox_o2: 0.01       #! threshold of o2 for OM mineralization (uM O2) (Yakushev,2013)
    s_omno_o2: 25.0       #! threshold of o2 for OM denitrification (uM O2) (Yakushev,2013)
    s_omso_o2: 25.0       #! threshold of o2 for OM sulfate reduction (uM O2) (Yakushev,2013)
    s_omso_no3: 5.0       #! threshold of noX for OM sulfate reduction (uM O2) (Yakushev,2013)
    K_mnox_o2: 2.0        #! half sat. of Mn oxidation (uM O2) (Yakushev,2013)
#---- C--------!
    K_caco3_diss: 3.0     #! CaCO3 dissollution rate constant (1/d) (wide ranges are given in (Luff et al., 2001))
    K_caco3_form: 0.0002  #! CaCO3 precipitation rate constant (1/d) (wide ranges are given in (Luff et al., 2001))
    K_DON_ch4: 0.00014    #! Specific rate of methane production from DON (1/d) (Lopes et al., 2011)
    K_PON_ch4: 0.00014    #! Specific rate of methane production from PON (1/d) (Lopes et al., 2011)
    K_ch4_o2: 0.14        #! Specific rate of oxidation of CH4 with O2 (1/d) =0.14 (Lopes et al., 2011)
    K_ch4_so4: 0.0000274  #! Specific rate of oxidation of CH4 with SO4 (1/uM/day) (0.0274 m3 /mol-1 day-1 Lopes et al., 2011)
    s_omch_so4: 30.       #! threshold of of SO4 for methane production from OM (uM) (Lopes et al., 2011)
#---- Si-------!
    K_sipart_diss: 0.080  #! Si dissollution rate constant (1/d), =0.008 (Popova, Srokosz, 2009)
#---- Bacteria-!
    K_Baae_gro: 0.1       #!  Baae maximum specific growth rate (1/d) (Yakushev, 2013)
    K_Baae_mrt: 0.005     #!  Baae specific rate of mortality (1/d) (Yakushev et al., 2013)
    K_Baae_mrt_h2s: 0.899 #!  Baae increased specific rate of mortality due to H2S (1/d) (Yakushev et al., 2013)
    limBaae: 2.0          #! Limiting parameter for nutrient consumprion by Baae (nd) (Yakushev, 2013)
```

```
    K_Bhae_gro:  0.5      #!  Bhae maximum specific growth rate (1/d) (Yakushev, 2013)
    K_Bhae_mrt:  0.01     #!  Bhae specific rate of mortality (1/d) (Yakushev, 2013)
    K_Bhae_mrt_h2s: 0.799  #!  Bhae increased specific rate of mortality due to H2S (1/d)  (Yakushev, 2013)
    limBhae: 5.0          #! Limiting parameter for OM consumprion by Bhae (nd) (Yakushev, 2013)
    K_Baan_gro: 0.2       #!  Baan maximum specific growth rate (1/d) (Yakushev, 2013)
    K_Baan_mrt: 0.005     #!  Baan specific rate of mortality (1/d) (Yakushev, 2013)
    limBaan: 2.0          #! Limiting parameter for nutrient consumprion by Baan (nd) (Yakushev, 2013)
    K_Bhan_gro: 0.15      #!  Bhan maximum specific growth rate (1/d) (Yakushev, 2013)
    K_Bhan_mrt: 0.01      #!  Bhan specific rate of mortality (1/d) (Yakushev, 2013)
    K_Bhan_mrt_o2: 0.899  #!  Bhan increased specific rate of mortality due to O2 (1/d) (Yakushev, 2013)
    limBhan: 2.0          #! Limiting parameter for OM consumprion by Bhan (nd) (Yakushev, 2013)
#---- Stoichiometric coefficients ----!
    r_fe_n: 26.5          #! Fe[uM]/N[uM] (Boudreau, 1996)
    r_mn_n: 13.25         #! Mn[uM]/N[uM] (Boudreau, 1996)
    f:  0.66              #! conversion factor relating solid and dissolved species concentrations
    r_fe3_p: 2.7          #! Fe[uM]/P[uM] partitioning coeff. for Fe oxide (Yakushev et al., 2007)
    r_mn3_p: 0.67         #! Mn[uM]/P[uM] complex stoichiometric coeff. for Mn(III) (Yakusheve al., 2007)
    r_fe3_si: 3.          #! Fe[uM]/Si[uM] partitioning coeff. for Fe oxide
  coupling:
    O2: niva_brom_bio/O2    #  O2: niva_oxydep/oxy
    NH4: niva_brom_bio/NH4
    NO3: niva_brom_bio/NO3
    PO4: niva_brom_bio/PO4
    PON: niva_brom_bio/PON
    DON: niva_brom_bio/DON
    Wsed: niva_brom_bio/Wsed
    Kp1: niva_brom_eqconst/Kp1
    Kp2: niva_brom_eqconst/Kp2
    Kp3: niva_brom_eqconst/Kp3
    Knh4: niva_brom_eqconst/Knh4
    Kh2s: niva_brom_eqconst/Kh2s
    KSi: niva_brom_eqconst/KSi
    Kc0: niva_brom_eqconst/Kc0
    Alk: niva_brom_carb/Alk
    DIC: niva_brom_carb/DIC
    Hplus: niva_brom_carb/Hplus
    Om_Ca: niva_brom_carb/Om_Ca
    Om_Ar: niva_brom_carb/Om_Ar
    CO3: niva_brom_carb/CO3
    pCO2: niva_brom_carb/pCO2
    Ca: niva_brom_carb/Ca
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