Supplement of Geosci. Model Dev., 17, 5705–5732, 2024
https://doi.org/10.5194/gmd-17-5705-2024-supplement

Geoscientific Model Development
Open Access

Supplement of

Evaluation of the coupling of EMACv2.55 to the land surface and vegetation model JSBACHv4

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Contents

S1 Input Files

Table S1. JSBACH input file overview. *grid* corresponds to the simulation gridsize and *year* to the reference year.

Initial conditions	filename
Initial data for the Carbon Pools	cpools_vga0218_18991231_tiles.nc
Initial data for soil and land properties	ic_land_soil_*grid*_1976_tsrf_clim.nc
	jsbach_*grid*_11tiles_5layers_*year*_no-dynveg_layer_moist.nc
	jsbach_*grid*_11tiles_5layers_*year*_no-dynveg_albedo.nc
	jsbach_*grid*_11tiles_5layers_*year*_no-dynveg_cover_fract.nc
	jsbach_*grid*_11tiles_5layers_*year*_no-dynveg_cover_type.nc
	jsbach_*grid*_11tiles_5layers_*year*_no-dynveg_nn.nc
	jsbach_*grid*_11tiles_5layers_*year*_no-dynveg_soil_layer_depth.nc
	jsbach_*grid*_11tiles_5layers_*year*_no-dynveg_veg_fract.nc
	bc_land_soil_*grid*_*year*_fract_org.nc
	bc_land_soil_*grid*_*year*_nn.nc

S2 Example namelist for EMAC/JSBACH: *jsbach.nml*

The following snippets of the jsbach namelist show the default simulation setup for the JSBACH submodel.

```
! -*- f90 -*-
&CTRL
l_verbose= F     ! verbose output of model (debugging)
/
&CPL
!################################################################################
!## JSBACH switches for PROCESS in CALL ORDER FOR DEBUGGING
!## DEFAULT = .true.
!################################################################################
        L_CARBON                                     = T,
        L_FUEL                                       = T,
        L_RADIATION                                  = T,
        L_PHENOLOGY                                  = T,
        L_HYDROLOGY                                  = T,
        L_SEB                                        = T,
        L_SSE                                        = T,
        L_ASSIMILATION                               = T,
        L_TURBULENCE                                 = T,
        L_DISTURB                                    = T,
    !#FUEL
        L_update_fuel                                = .true.,
    !#DISTURBANCE
        L_update_natural_disturbances                = .true.,
    !#RADIATION
        L_update_surface_radiation                   = .true.,
    !#PHENOLOGY
        L_update_phenology_logrop                    = .true.,
        L_update_fpc                                 = .true.,
    !#HYDROLOGY
        L_update_snow_and_skin_fraction              = .true.,
        L_update_soil_properties                     = .true.,
    !#SURFACE ENERGY BALANCE
        L_update_surface_energy_land                 = .true.,
        L_update_surface_energy_lake                 = .true.,
    !#HYDROLOGY
```

```
        L_update_evaporation                           = .true.,
    !#SURFACE ENERGY BALANCE
        L_update_surface_fluxes_land                   = .true.,
        L_update_surface_fluxes_lake                   = .true.,
    !#RADIATION
        L_update_radiation_par                         = .true.,
    !#HYDROLOGY
        L_update_surface_hydrology                     = .true.,
        L_update_snow_and_skin_fraction                = .true.,
    !#SOIL and SNOW ENERGY
        L_update_soil_and_snow_properties              = .true.,
        L_update_soil_and_snow_temperature             = .true.,
    !#HYDROLOG
         L_update_soil_hydrology                       = .true.,
    !#SURFACE ENERGY BALANCE
        L_update_snowmelt_correction                   = .true.,
    !#ASSIMILATION
        L_update_assimilation_scaling_factors          = .true.,
        L_update_canopy_cond_unstressed_assimilation= .true.,
        L_update_canopy_cond_stressed_assimilation  = .true.,
        L_update_assimilation                          = .true.,
    !#HYDROLOGY
        L_update_canopy_cond_unstressed                = .true.,
        L_update_water_stress                          = .true.,
        L_update_canopy_cond_stressed                  = .true.,
    !#CARBON
    ! warning CO2 gas tracer must be present!
        L_update_C_NPP_pot_allocation                  = .true.,
    !#TURBULENCE
        L_update_humidity_scaling                      = .true.,
        L_update_roughness                             = .true.,
    !#RADIATION
        L_update_albedo                                = .true.,
    !#HYDROLOGY
        L_update_water_balance                         = .true.,
!###############################################################################
!## JSBACH logical switches
!###############################################################################
```

```
        l_freeze                                  = T,
        l_supercool                               = T,
        l_dynsnow                                 = T,
        l_heat_cap_dyn                            = T,
        l_heat_cond_dyn                           = T,
        l_ice_on_lakes                            = T,
        l_snow                                    = T,
        l_organic                                 = T,
        ltpe_closed                               = F,
        ltpe_open                                 = F,
        l_forestRegrowth                          = T,
        l_use_alb_canopy                          = T,
        l_use_alb_veg_simple                      = T,
        l_use_alb_soil_scheme                     = F,
        l_use_alb_soil_litter                     = T,
        l_use_alb_mineralsoil_const               = T,
        l_use_alb_soil_organic_C                  = T,  !T: 'linear', F: 'log'
        l_burn_pasture                            = T,
        l_use_quincy                              = F,  !QUINCY not implemented
!################################################################################
!## EMAC INPUT DATA
!################################################################################
! The following channel objects are just input.
! JSBACH will not modify them.
input_fract_lake            =   'ECHAM5',   'alake',    ! [1]
input_land_mask             =   'ECHAM5',   'slm',      ! [1]
input_slf                   =   'ECHAM5',   'slf',      ! [1]
input_fract_glacier         =   'g3b',      'glac',     ! [1]
input_press_srf             =   'g3b',      'aps',      ! [Pa]
input_t_air                 =   'e5vdiff',  'temp2',    ! [K]
input_t_acoef               =   'e5vdiff',  'zetnl',    !
    \[1]Richtmyer-morton-coefficients, t=dry static energy, q=moisture
input_t_bcoef               =   'e5vdiff',  'zftnl',    ! [J/kg]
input_t_acoef_wtr           =   'e5vdiff',  'zetnw',    ! [1]
input_t_bcoef_wtr           =   'e5vdiff',  'zftnw',    ! [J/kg]
input_t_acoef_ice           =   'e5vdiff',  'zetni',    ! [1]
input_t_bcoef_ice           =   'e5vdiff',  'zftni',    ! [J/kg]
input_q_acoef               =   'e5vdiff',  'zeqnl',    ! [1]
```

```
input_q_bcoef             =   'e5vdiff',  'zfqnl',    ! [kg/kg]
input_q_acoef_wtr         =   'e5vdiff',  'zeqnw',    ! [1]
input_q_bcoef_wtr         =   'e5vdiff',  'zfqnw',    ! [kg/kg]
input_q_acoef_ice         =   'e5vdiff',  'zeqni',    ! [1]
input_q_bcoef_ice         =   'e5vdiff',  'zfqni',    ! [kg/kg]
input_drag_srf            =   'e5vdiff',  'cfhl',     ! (neutral)/ drag coefficients,
    \was cdnl, cdnw, cdni
input_drag_wtr            =   'e5vdiff',  'cfhw',     ! [-]
input_drag_ice            =   'e5vdiff',  'cfhi',     ! [-]
input_pch                 =   'e5vdiff',  'chl',      ! surface drag [1]
input_wind_10m            =   'e5vdiff',  'wind10',   ! [m s-1]
input_cos_zenith_angle    =   'orbit',    'cossza',   ! [-]
input_declination         =   'orbit',    'dec_off',  ! [degrees, angle sun at equator]
input_rad_sw_lwtr         =   'rad01',    'soflw',    ! [W m-2]
input_rad_sw_lice         =   'rad01',    'sofli',    ! [W m-2]
input_rad_lw_lwtr         =   'rad01',    'trflw',    ! [W m-2]
input_rad_lw_lice         =   'rad01',    'trflw',    ! [W m-2]
input_q_rel_air_climbuf   =   'e5vdiff',  'rh_2m',    ! [-]
input_oro_stddev          =   'g3b',      'orostd',   ! [m]

! The following channel objects are just input.
! Only srf level is used.
input_wind_u              =   'ECHAM5',   'um1',      ! [m/s]
input_wind_v              =   'ECHAM5',   'vm1',      ! [m/s]
input_cv_rain             =   'ECHAM5',   'rsfc_2d',  ! [kg m-2 s-1]
input_ls_rain             =   'ECHAM5',   'rsfl_2d',  ! [kg m-2 s-1]
input_cv_snow             =   'ECHAM5',   'ssfc_2d',  ! [kg m-2 s-1]
input_ls_snow             =   'ECHAM5',   'ssfl_2d',  ! [kg m-2 s-1]
input_lwflx               =   'rad01',    'flxt',     ! [W m-2]
input_swflx               =   'rad01',    'flxs',     ! shortwave flux [W m-2]
input_swnirflx            =   'rad01',    'flxnir',   ! NIR flux all sky [W m-2]
input_swvisflx            =   'rad01',    'flxsw1',   ! SW1 flux all sky (VIS) [W m-2]
input_lwflx_up            =   'rad01',    'flxut',    ! longwave flux [W m-2]
input_swflx_up            =   'rad01',    'flxus',    ! shortwave flux [W m-2]


! The following channel objects exist already in MESSy.
```

```
! SURFACE did not update those variables, but JSBACH will update them (only over land and
    \lakes)
! either via calculation or according to the jsbach input files.
input_vol_heat_cap          =   'g3b',      'rgcgn',    ! Volumetric heat capacity of the
    \soil [j/m**3/K]
input_az0                   =   'g3b',      'az0',      ! roughness length orography [m]
input_fract_forest          =   'ECHAM5',   'forest',   ! forest fraction [1]
input_fract_fpc             =   'ECHAM5',   'vgrat',    ! vegetation fraction rel to land
    \[1]
input_fract_fpc_mon         =   'ECHAM5',   'vgrat',    ! vegetation fraction rel to
    \land, monthly [1]
input_latent_hflx           =   'e5vdiff',  'ahfl',     ! latent heat flux [W m-2]
input_latent_hflx_lnd       =   'e5vdiff',  'ahfll',    ! latent heat flux over land [W
    \m-2]
input_latent_hflx_wtr       =   'e5vdiff',  'ahflw',    ! latent heat flux over water [W
    \m-2]
input_latent_hflx_ice       =   'e5vdiff',  'ahfli',    ! latent heat flux over ice [W
    \m-2]
input_sensible_hflx         =   'e5vdiff',  'ahfs',     ! sensible heat flux [W m-2]
input_sensible_hflx_lnd     =   'e5vdiff',  'ahfsl',    ! sensible heat flux over land [W
    \m-2]
input_sensible_hflx_wtr     =   'e5vdiff',  'ahfsw',    ! sensible heat flux over water
    \[W m-2]
input_sensible_hflx_ice     =   'e5vdiff',  'ahfsi',    ! sensible heat flux over ice [W
    \m-2]
input_evapo_wtr             =   'e5vdiff',  'evapw',    ! evaporation over water [kg m-2
    \s-1]
input_evapo_ice             =   'e5vdiff',  'evapi',    ! evaporation over ice [kg m-2
    \s-1]
input_evapopot              =   'e5vdiff',  'evapot_2d',! potential
    \evaporation/sublimation [kg m-2 s-1]
input_evapl                 =   'e5vdiff',  'evapl_2d', ! evaporation land
input_evap                  =   'e5vdiff',  'evap',     ! evaporation

! The following channel objects exist already in MESSy and will be updated by JSBACH
! SURFACE did update them before.
input_depth_lice            =   'g3b',      'siced',    ! seaice depth [m]
input_seaice                =   'g3b',      'seaice',   ! seaice fraction rel to ocean [1]
```

```
input_seacov            =   'ECHAM5',   'seacov',   ! sea cover (fraction of grid
    \box) [1]
input_landcov           =   'ECHAM5',   'landcov',  ! land cover (fraction of grid
    \box) [1]
input_fract_lice        =   'ECHAM5',   'icecov',   ! ice cover (fract of gb) only
    \over water [1]
input_water_content     =   'g3b',      'ws',       ! Soil water content [m]
input_w_skin            =   'g3b',      'wl',       ! Water content skin reservoir
    \(soil&canopy)[m]
input_t_unfilt          =   'g3b',      'tslm',     ! T(t)    Surface temperature,
    \unfiltered [K]
input_t_old             =   'g3b',      'tslm1',    ! T(t-dt) Surface temperature
    \t-dt [K]
input_t_soil            =   'g3b',      'tsoil',    ! Temperature [K] in the five
    \soil layers [K]
input_tsi               =   'g3b',      'tsi',      ! Lake surface temperature (ice)
    \[K]
input_t_lwtr            =   'g3b',      'tsw',      ! surface temperature of water [K]
input_t                 =   'ECHAM5',   'tsurf',    ! surface temperature [K]
input_snowmelt          =   'g3b',      'snmel',    ! Snow melt [kg/m**2]
input_w_snow_can        =   'g3b',      'snc',      ! Snow depth canopy [m water
    \equivalent]
input_w_snow_soil       =   'g3b',      'sn',       ! Snow depth ground [m water
    \equivalent]
input_w_snow_lice       =   'g3b',      'sni',      ! Snow depth ice [m water
    \equivalent]
input_snow_accum        =   'g3b',      'snacl',    ! Snow budget at non-glacier
    \points [kg/m**2]
input_w_glac            =   'g3b',      'gld',      ! Glacier depth (including snow)
    \[m water equivalent]
input_runoff_glac       =   'g3b',      'rogl',     ! Glacier runoff (rain+snow/ice
    \melt) [kg/m**2]
input_adrain            =   'ECHAM5',   'adrain',   ! Drainage at non-glacier points
    \[m]
input_aros              =   'ECHAM5',   'aros',     ! atmospheric runoff  [m]
input_hcap_grnd         =   'g3b',      'grndcapc', ! Heat capacity of the uppermost
    \soil layer [J/m**2/K]
input_grnd_hflx         =   'g3b',      'grndhflx', ! Ground heat flux [J m-2 s-1]
```

```
input_evapo_skin          =   'ECHAM5',   'evwsd',    ! Evaporation from skin reservoir
    \[1]
input_hflx_cond_ice       =   'g3b',      'ahfice',   ! conductive heat flux [W m-2]
input_fract_snow_lice     =   'ECHAM5',   'cvsi',     ! snow cover over ice (fraction
    \of grid box) [1]
input_fract_snow_can      =   'ECHAM5',   'cvsc',     ! Fractional snow cover canopy [1]
input_fract_snow          =   'ECHAM5',   'cvs',      ! Fractional snow cover [1]
input_lai                 =   'ECHAM5',   'vlt',      ! leaf area index [1]
input_wsmx                =   'g3b',      'wsmx',     ! field capacity (water holding
    \capacity) of soil [m]
input_grndflux            =   'g3b',      'grndflux', ! grndflux+grndhflx*slm*dtime
    \[W/m**2]
input_cvw                 =   'ECHAM5',   'cvw',      ! Skin reservoir fraction (=
    \pwl/pwlmx, see *vdiff*)
input_runoff_hd           =   'g3b',      'runoff',   ! Total runoff non-glacier points
    \(acc.) [kg/m**2s]
input_drainage_hd         =   'ECHAM5',   'adrain',   ! Drainage at non-glacier points
    \[m/s]
input_albedo              =   'rad',      'albedo',   ! surface albedo [1]

!##############################################################################
!##JSBACH input data /pool/data/JSBACH/...
!##############################################################################
! The following channel objects exist already in MESSy.
! JSBACH will use input data and overwrite the channel objects for the first timestep.
input_lai_init            =   'import_grid','in_lai_cl_lai_clim', !initial LAI from
    \climatology [1]
! The following channel objects don't exist in MESSy.
! JSBACH will use input data and create new channel objects.
input_fract_fpc_max       =   'import_grid','in_jsb_veg_ratio_max',   ! [1]
input_rough_m             =   'import_grid','in_alb_roughness_length',! [m]
input_vol_field_cap       =   'import_grid','in_jsb_soil_field_cap',  ! [m/m]
input_cover_type_ti       =   'import_grid','in_jsb_ct_cover_type',   ! [1]
input_cover_fract_ti      =   'import_grid','in_jsb_lc_cover_fract',  ! [1]
input_w_soil_sl           =   'import_grid','in_jsb_lm_layer_moist',  ! [m]
input_soil_depth          =   'import_grid','in_jsb_soil_depth',      ! [m]
input_vol_porosity        =   'import_grid','in_jsb_soil_porosity',   ! [m/m]
input_pore_size_index     =   'import_grid','in_jsb_pore_size_index', ! [-]
```

```
input_heat_cond             =   'import_grid','in_jsb_heat_conductivity',! [J m-1 s-1 K-1]
input_hyd_cond_sat          =   'import_grid','in_jsb_hyd_cond_sat',    ! [m/s]
input_vol_p_wilt            =   'import_grid','in_jsb_wilting_point',   ! [m/m]
input_bclapp                =   'import_grid','in_jsb_bclapp',          ! [-]
input_w_soil_column         =   'import_grid','in_jsb_init_moist',      ! [m]
input_max_moist             =   'import_grid','in_jsb_maxmoist',        ! [m]
input_root_depth            =   'import_grid','in_jsb_root_depth',      ! [m]
input_matrix_pot            =   'import_grid','in_jsb_moisture_pot',    ! [m]
input_albedo_veg_vis        =   'import_grid','in_alb_albedo_veg_vis',  ! [1]
input_albedo_veg_nir        =   'import_grid','in_alb_albedo_veg_nir',  ! [1]
input_albedo_soil_vis       =   'import_grid','in_alb_albedo_soil_vis', ! [1]
input_albedo_soil_nir       =   'import_grid','in_alb_albedo_soil_nir', ! [1]
input_tclim                 =   'import_grid','in_jsb_ic_surf_temp',    ! [K]
input_tclim_sum             =   'import_grid','in_jsb_tc_tclim_sum',    ! [K]
input_tclim_max             =   'import_grid','in_jsb_tc_tclim_max',    ! [K]
input_tclim_min             =   'import_grid','in_jsb_tc_tclim_min',    ! [K]
input_tclim_idx             =   'import_grid','in_jsb_tc_tidx',         ! [-]
input_fract_org_sl          =   'import_grid','in_fosl_fract_org_sl',   ! [1]
input_NPP_pot_yDayMean      =   'import_grid','j_NPP_run_mean',         ! [mol(CO2)/m2
    \(canopy) s]
!##############################################################################
!## JSBACH Input Carbon from cpools
!##############################################################################
! Initial conditions for carbon pools, all in [mol(C)/m^2(canopy)] if not stated
    \otherwise.
input_c_green               =   'import_grid','j_Cpool_green',                  ! Green
    \carbon pool: on input last value; updated on output [mol(C)/m^2(canopy) s]:
input_c_reserve             =   'import_grid','j_Cpool_reserve',                ! C-pool
    \for carbohydrate reserve (sugars, starches) that allows plants to survive
input_c_woods               =   'import_grid','j_Cpool_woods',                  ! C-pool
    \for stems, thick roots and other (dead) structural
input_c_crop_harvest        =   'import_grid','j_Cpool_crop_harvest',           ! C-pool
    \for biomass harvested from crops [mol(C)/m^2(grid box)]
input_c_acid_ag1            =   'import_grid','j_YCpool_acid_ag1',              ! Above
    \ground litter-pool for acid soluble litter
input_c_water_ag1           =   'import_grid','j_YCpool_water_ag1',             ! - for
    \water soluble litter
```

```
input_c_ethanol_ag1         =   'import_grid','j_YCpool_ethanol_ag1',           ! - for
    \ethanol soluble litter
input_c_nonsoluble_ag1      =   'import_grid','j_YCpool_nonsoluble_ag1',        ! -
    \non-soluble soluble litter
input_c_acid_bg1            =   'import_grid','j_YCpool_acid_bg1',              ! Below
    \ground litter-pool for acid soluble litter
input_c_water_bg1           =   'import_grid','j_YCpool_water_bg1',             ! - for
    \water soluble litter
input_c_ethanol_bg1         =   'import_grid','j_YCpool_ethanol_bg1',           ! - for
    \ethanol soluble litter
input_c_nonsoluble_bg1      =   'import_grid','j_YCpool_nonsoluble_bg1',        ! - for
    \non-soluble litter
input_c_humus_1             =   'import_grid','j_YCpool_humus_1',
input_c_acid_ag2            =   'import_grid','j_YCpool_acid_ag2',
input_c_water_ag2           =   'import_grid','j_YCpool_water_ag2',
input_c_ethanol_ag2         =   'import_grid','j_YCpool_ethanol_ag2',
input_c_nonsoluble_ag2      =   'import_grid','j_YCpool_nonsoluble_ag2',
input_c_acid_bg2            =   'import_grid','j_YCpool_acid_bg2',
input_c_water_bg2           =   'import_grid','j_YCpool_water_bg2',
input_c_ethanol_bg2         =   'import_grid','j_YCpool_ethanol_bg2',
input_c_nonsoluble_bg2      =   'import_grid','j_YCpool_nonsoluble_bg2',
input_c_humus_2             =   'import_grid','j_YCpool_humus_2',
/
```

S3 Schematic of JSBACH in EMAC

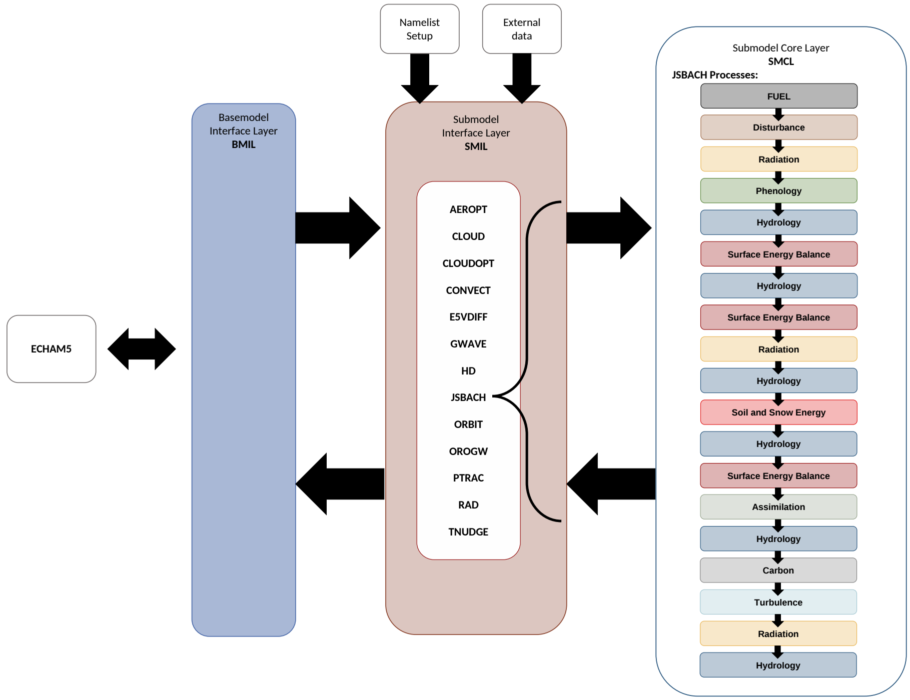

Figure S1. Schematic overview of JSBACH as new submodel in EMAC with corresponding processes.

S4 Parameter optimisation

Table S2. List of optimised parameters of the control simulation (CTRL) and the 35 Simulations with varying parameters. Simulation 1 (EMAC/SRF) is performed with the SURFACE submodel, while simulation 2 to 35 are performed with the JSBACH submodel. The simulation with the parameters used for the EMAC/JSBACH setup is indicated in bold.

Run	zasic	zinhomi	zinhoml	cmfctop	cprcon [e-04$s^2\,m^{-2}$]
1 (EMAC/SRF)	0.85 (default)	0.85 (default)	$\mathrm{zinhoml}_{\mathrm{default}}$	0.3 (default)	1 (default)
2 (CTRL)	default	default	default	default	default
3	0.8	default	default	default	default
4	default	default	default	default	default
5	0.89	default	default	default	default
6	0.91	default	default	default	default
7	default	0.8	default	default	default
8	default	default	default	default	default
9	default	0.9	default	default	default
10	default	0.95	default	default	default
11	default	1	default	default	default
12	default	default	0.7	default	default
13	default	default	0.77	default	default
14	default	default	0.8	default	default
15	default	default	0.9	default	default
16 (EMAC/JSBACH)	default	default	0.92	default	default
17	default	default	default	0.2	default
18	default	default	default	0.23	default
19	default	default	default	0.26	default
20	default	default	default	default	default
21	default	default	default	0.35	default
22	default	default	default	default	default
23	default	default	default	default	2
24	default	default	default	default	3
25	default	default	default	default	4
26	default	default	default	default	5
27	default	default	default	default	6
28	default	default	default	default	8
29	default	default	default	default	9
30	0.75	1	0.88	default	4
32	0.75	1	0.88	default	8
33	0.75	1	0.88	default	10
34	0.7	1	0.92	default	4
35	default	default	0.92	default	4

Table S3. Table of the temporally and globally averaged results ± inter annual variability as standard deviation of the CTRL and 35 Simulations with varying tuning parameters (1990 to 2010). Simulation 1 (EMAC/SRF) is performed with the SURFACE submodel, while simulation 2 to 35 are performed with the JSBACH submodel. Additionally, the corresponding reanalysis or observational results are listed as "REF". For precipitation REF refers to the GPCP monthly precipitation dataset (Adler et al. (2003)), while for the remaining variables REF refers to ERA5/ERA5-Land reanalysis datasets (Hersbach (2023);Muñoz Sabater(2019,2021)). The simulation with the parameters used for the EMAC/JSBACH setup is indicated in bold.

Run	LST [K]	TOA$_{net}$ [W m^{-2}]	TOA$_{sw}$ [W m^{-2}]	TOA$_{lw}$ [W m^{-2}]	SRF$_{net}$ [W m^{-2}]	SRF$_{sw}$ [W m^{-2}]	SRF$_{lw}$ [W m^{-2}]	HFLX$_{net}$ [W m^{-2}]	HFLX$_{sensible}$ [W m^{-2}]	HFLX$_{latent}$ [W m^{-2}]	Precip [mm day^{-1}]	ACLC	LWC [kg m^{-2}]	IWC [kg m^{-2}]	TWS [m]
REF	282.25 ± 0.27	0.45 ± 0.65	242.67 ± 0.65	-242.22 ± 0.29	105.91 ± 0.45	163.76 ± 0.54	-57.85 ± 0.31	-69.92 ± 0.57	-28.15 ± 0.68	-41.76 ± 0.43	2.7 ± 0.03	0.553 ± 0.00405	0.04707 ± 0.00098	0.02166 ± 0.00033	1.06012 ± 0.00947
1 (EMAC/SRF)	283.09 ± 0.27	3.56 ± 0.39	234.33 ± 0.27	-230.77 ± 0.34	107.92 ± 0.24	161.74 ± 0.31	-53.83 ± 0.3	-104.24 ± 0.35	-16.74 ± 0.18	-87.5 ± 0.42	2.83 ± 0.02	1.06067 ± 0.00444	0.10394 ± 0.00115	0.04972 ± 0.00068	0.34995 ± 0.00425
2 (CTRL)	280.66 ± 0.26	6.61 ± 0.5	237.22 ± 0.3	-230.61 ± 0.42	108.08 ± 0.28	165.97 ± 0.36	-57.88 ± 0.35	-110.92 ± 0.65	-11.59 ± 0.15	-99.33 ± 0.6	2.77 ± 0.02	0.6462 ± 0.0025	0.09594 ± 0.00114	0.04945 ± 0.00067	1.00362 ± 0.00761
3	280.54 ± 0.28	5.06 ± 0.51	235.54 ± 0.29	-230.48 ± 0.38	106.76 ± 0.25	164.66 ± 0.39	-57.91 ± 0.43	-111.01 ± 0.59	-11.7 ± 0.16	-99.31 ± 0.55	2.77 ± 0.02	0.6466 ± 0.0025	0.0959 ± 0.00159	0.04976 ± 0.00066	1.00345 ± 0.00823
4	280.66 ± 0.26	6.61 ± 0.5	237.22 ± 0.3	-230.61 ± 0.42	108.08 ± 0.28	165.97 ± 0.36	-57.88 ± 0.35	-110.92 ± 0.65	-11.59 ± 0.15	-99.33 ± 0.6	2.77 ± 0.02	0.6462 ± 0.0025	0.09594 ± 0.00114	0.04945 ± 0.00067	1.00362 ± 0.00761
5	280.73 ± 0.27	8.06 ± 0.43	238.78 ± 0.31	-230.72 ± 0.37	109.31 ± 0.26	167.24 ± 0.38	-57.93 ± 0.36	-110.81 ± 0.64	-11.6 ± 0.12	-99.21 ± 0.62	2.76 ± 0.02	0.646 ± 0.0022	0.09552 ± 0.00114	0.04936 ± 0.00063	1.00336 ± 0.00878
6	280.85 ± 0.29	8.63 ± 0.53	239.5 ± 0.31	-230.87 ± 0.39	109.92 ± 0.25	167.76 ± 0.4	-57.83 ± 0.37	-110.84 ± 0.64	-11.6 ± 0.15	-99.24 ± 0.65	2.76 ± 0.02	0.6453 ± 0.0022	0.09582 ± 0.00127	0.04919 ± 0.00059	1.0033 ± 0.0086
7	280.6 ± 0.29	6.67 ± 0.42	237.87 ± 0.35	-231.2 ± 0.41	108.53 ± 0.32	166.66 ± 0.39	-58.14 ± 0.37	-111.28 ± 0.61	-11.72 ± 0.14	-99.56 ± 0.59	2.77 ± 0.02	0.6465 ± 0.0027	0.09529 ± 0.00098	0.04955 ± 0.00061	1.00326 ± 0.00943
8	280.66 ± 0.26	6.61 ± 0.5	237.22 ± 0.3	-230.61 ± 0.42	108.08 ± 0.28	165.97 ± 0.36	-57.88 ± 0.35	-110.92 ± 0.65	-11.59 ± 0.15	-99.33 ± 0.6	2.77 ± 0.02	0.6462 ± 0.0025	0.09594 ± 0.00114	0.04945 ± 0.00067	1.00362 ± 0.00761
9	280.73 ± 0.27	6.35 ± 0.42	236.5 ± 0.24	-230.15 ± 0.34	107.56 ± 0.26	165.2 ± 0.3	-57.64 ± 0.35	-110.55 ± 0.6	-11.58 ± 0.11	-98.97 ± 0.58	2.76 ± 0.02	0.6462 ± 0.0018	0.09652 ± 0.00112	0.04933 ± 0.00055	1.0034 ± 0.00672
10	280.73 ± 0.27	6.48 ± 0.46	236.0 ± 0.31	-229.52 ± 0.45	107.19 ± 0.29	164.69 ± 0.34	-57.5 ± 0.33	-110.04 ± 0.59	-11.55 ± 0.14	-98.48 ± 0.58	2.74 ± 0.02	0.6465 ± 0.0028	0.09637 ± 0.00111	0.04942 ± 0.00057	1.00328 ± 0.00819
11	280.75 ± 0.26	6.34 ± 0.49	235.32 ± 0.36	-228.98 ± 0.33	106.71 ± 0.31	163.97 ± 0.43	-57.26 ± 0.39	-109.6 ± 0.58	-11.49 ± 0.14	-98.1 ± 0.55	2.73 ± 0.02	0.6474 ± 0.0024	0.09708 ± 0.00096	0.049 ± 0.00052	1.00239 ± 0.00791
12	280.58 ± 0.28	5.66 ± 0.44	236.32 ± 0.32	-230.65 ± 0.39	106.91 ± 0.33	164.94 ± 0.37	-58.02 ± 0.35	-110.57 ± 0.62	-11.59 ± 0.17	-98.97 ± 0.61	2.76 ± 0.02	0.6456 ± 0.0026	0.09557 ± 0.00096	0.04952 ± 0.00049	1.00348 ± 0.00838
13	280.57 ± 0.28	4.84 ± 0.42	235.5 ± 0.34	-230.67 ± 0.35	106.06 ± 0.27	164.01 ± 0.43	-57.95 ± 0.4	-110.55 ± 0.54	-11.63 ± 0.17	-98.93 ± 0.53	2.76 ± 0.02	0.6455 ± 0.0031	0.09529 ± 0.00108	0.04946 ± 0.00061	1.00356 ± 0.00795
14	280.53 ± 0.28	4.4 ± 0.47	235.04 ± 0.3	-230.64 ± 0.39	105.67 ± 0.24	163.47 ± 0.38	-57.8 ± 0.36	-110.57 ± 0.59	-11.65 ± 0.13	-98.92 ± 0.57	2.76 ± 0.02	0.6462 ± 0.0027	0.09533 ± 0.00104	0.04946 ± 0.00058	1.00368 ± 0.0075
15	280.55 ± 0.26	3.48 ± 0.39	234.1 ± 0.37	-230.62 ± 0.41	104.62 ± 0.29	162.42 ± 0.44	-57.79 ± 0.39	-110.5 ± 0.67	-11.57 ± 0.13	-98.93 ± 0.63	2.76 ± 0.02	0.6457 ± 0.0035	0.09531 ± 0.00098	0.04942 ± 0.00049	1.00327 ± 0.00821
16 (EMAC/JSBACH)	280.48 ± 0.23	3.23 ± 0.38	233.86 ± 0.29	-230.63 ± 0.38	104.43 ± 0.3	162.14 ± 0.34	-57.71 ± 0.35	-110.47 ± 0.67	-11.67 ± 0.14	-98.79 ± 0.61	2.76 ± 0.02	0.6464 ± 0.0028	0.09519 ± 0.0009	0.04936 ± 0.00054	1.00385 ± 0.00815
17	280.6 ± 0.23	3.89 ± 0.46	234.27 ± 0.31	-230.38 ± 0.37	105.94 ± 0.28	162.71 ± 0.38	-56.77 ± 0.37	-111.4 ± 0.58	-11.82 ± 0.14	-99.58 ± 0.55	2.78 ± 0.02	0.6578 ± 0.0025	0.09687 ± 0.00121	0.04916 ± 0.00063	1.00379 ± 0.00819
18	280.63 ± 0.23	4.81 ± 0.4	235.27 ± 0.33	-230.46 ± 0.37	106.67 ± 0.27	163.83 ± 0.41	-57.16 ± 0.41	-111.22 ± 0.6	-11.78 ± 0.15	-99.44 ± 0.58	2.77 ± 0.02	0.654 ± 0.0027	0.09656 ± 0.00118	0.04918 ± 0.0006	1.00344 ± 0.00751
19	280.64 ± 0.21	5.59 ± 0.44	236.14 ± 0.29	-230.56 ± 0.42	107.32 ± 0.24	164.77 ± 0.41	-57.45 ± 0.44	-111.11 ± 0.67	-11.72 ± 0.16	-99.39 ± 0.63	2.77 ± 0.02	0.6506 ± 0.0026	0.09622 ± 0.00136	0.04941 ± 0.00068	1.00382 ± 0.0075
20	280.66 ± 0.26	6.61 ± 0.5	237.22 ± 0.3	-230.61 ± 0.42	108.08 ± 0.28	165.97 ± 0.36	-57.88 ± 0.35	-110.92 ± 0.65	-11.59 ± 0.15	-99.33 ± 0.6	2.77 ± 0.02	0.6462 ± 0.0025	0.09594 ± 0.00114	0.04945 ± 0.00067	1.00362 ± 0.00761
21	280.69 ± 0.28	7.64 ± 0.37	238.32 ± 0.24	-230.68 ± 0.34	108.9 ± 0.26	167.18 ± 0.27	-58.27 ± 0.32	-110.69 ± 0.61	-11.6 ± 0.17	-99.09 ± 0.61	2.76 ± 0.02	0.6424 ± 0.0025	0.09519 ± 0.00094	0.04968 ± 0.00063	1.00316 ± 0.00774
22	280.66 ± 0.26	6.61 ± 0.5	237.22 ± 0.3	-230.61 ± 0.42	108.08 ± 0.28	165.97 ± 0.36	-57.88 ± 0.35	-110.92 ± 0.65	-11.59 ± 0.15	-99.33 ± 0.6	2.77 ± 0.02	0.6462 ± 0.0025	0.09594 ± 0.00114	0.04945 ± 0.00067	1.00362 ± 0.00761
23	280.49 ± 0.26	6.85 ± 0.48	241.36 ± 0.35	-234.51 ± 0.32	111.04 ± 0.22	170.57 ± 0.48	-59.53 ± 0.48	-113.5 ± 0.66	-11.91 ± 0.13	-101.59 ± 0.63	2.84 ± 0.02	0.6267 ± 0.0029	0.08383 ± 0.00098	0.03996 ± 0.00057	1.00189 ± 0.00737
24	280.41 ± 0.22	6.29 ± 0.41	242.5 ± 0.28	-236.21 ± 0.33	111.74 ± 0.26	171.84 ± 0.35	-60.09 ± 0.36	-114.76 ± 0.56	-12.06 ± 0.12	-102.7 ± 0.57	2.87 ± 0.02	0.619 ± 0.0026	0.07962 ± 0.00066	0.0366 ± 0.00056	1.0015 ± 0.00797
25	280.4 ± 0.27	5.88 ± 0.43	243.13 ± 0.32	-237.25 ± 0.33	112.06 ± 0.23	172.56 ± 0.46	-60.51 ± 0.48	-115.45 ± 0.65	-12.16 ± 0.14	-103.29 ± 0.63	2.89 ± 0.02	0.6133 ± 0.0028	0.07735 ± 0.00073	0.0349 ± 0.00056	1.00089 ± 0.00818
26	280.35 ± 0.26	5.59 ± 0.39	243.44 ± 0.29	-237.85 ± 0.36	112.25 ± 0.25	172.9 ± 0.37	-60.65 ± 0.35	-115.92 ± 0.59	-12.18 ± 0.1	-103.74 ± 0.61	2.91 ± 0.02	0.6099 ± 0.0026	0.07629 ± 0.00061	0.03385 ± 0.00087	1.00167 ± 0.00813
27	280.34 ± 0.25	5.31 ± 0.38	243.62 ± 0.31	-238.31 ± 0.29	112.33 ± 0.24	173.11 ± 0.41	-60.78 ± 0.43	-116.21 ± 0.56	-12.26 ± 0.13	-103.95 ± 0.6	2.92 ± 0.02	0.6069 ± 0.0034	0.07533 ± 0.00071	0.03305 ± 0.00042	1.0011 ± 0.00768
28	280.28 ± 0.28	5.11 ± 0.37	243.93 ± 0.37	-238.82 ± 0.28	112.48 ± 0.26	173.47 ± 0.47	-60.99 ± 0.47	-116.58 ± 0.61	-12.36 ± 0.16	-104.22 ± 0.61	2.92 ± 0.02	0.6036 ± 0.0033	0.07422 ± 0.00081	0.03216 ± 0.00043	1.00115 ± 0.00858
29	280.32 ± 0.3	4.95 ± 0.43	244.0 ± 0.35	-239.05 ± 0.35	112.49 ± 0.27	173.54 ± 0.46	-61.05 ± 0.45	-116.73 ± 0.59	-12.32 ± 0.18	-104.41 ± 0.58	2.93 ± 0.02	0.6018 ± 0.0033	0.07398 ± 0.00073	0.03186 ± 0.00042	1.00108 ± 0.00824
30	280.17 ± 0.31	0.54 ± 0.41	236.07 ± 0.28	-235.53 ± 0.36	105.78 ± 0.26	165.57 ± 0.35	-59.79 ± 0.39	-114.13 ± 0.62	-11.99 ± 0.14	-102.14 ± 0.61	2.87 ± 0.02	0.6146 ± 0.0025	0.07776 ± 0.00067	0.03467 ± 0.0005	1.00037 ± 0.00886
32	280.08 ± 0.28	-0.08 ± 0.43	237.09 ± 0.34	-237.17 ± 0.27	106.35 ± 0.23	166.66 ± 0.46	-60.31 ± 0.47	-115.27 ± 0.55	-12.13 ± 0.13	-103.13 ± 0.6	2.9 ± 0.02	0.6062 ± 0.0024	0.07447 ± 0.0008	0.03201 ± 0.00055	1.00072 ± 0.00858
33	280.07 ± 0.28	-0.19 ± 0.45	237.34 ± 0.42	-237.52 ± 0.35	106.52 ± 0.29	166.92 ± 0.52	-60.4 ± 0.42	-115.57 ± 0.61	-12.16 ± 0.14	-103.41 ± 0.58	2.91 ± 0.02	0.6028 ± 0.0037	0.07393 ± 0.00063	0.03153 ± 0.00041	1.00103 ± 0.00849
34	280.06 ± 0.25	-0.89 ± 0.36	234.44 ± 0.36	-235.33 ± 0.35	104.42 ± 0.28	164.15 ± 0.44	-59.73 ± 0.41	-114.11 ± 0.54	-12.01 ± 0.16	-102.09 ± 0.52	2.87 ± 0.01	0.6168 ± 0.0031	0.07773 ± 0.00069	0.03483 ± 0.0005	1.00153 ± 0.00794
35	280.21 ± 0.25	2.53 ± 0.44	239.73 ± 0.39	-237.2 ± 0.33	108.41 ± 0.26	168.65 ± 0.51	-60.24 ± 0.44	-114.97 ± 0.58	-12.15 ± 0.13	-102.82 ± 0.58	2.88 ± 0.02	0.6129 ± 0.003	0.0771 ± 0.00081	0.03461 ± 0.00046	1.00171 ± 0.00781

Table S4. Root mean square error (RMSE) and normalised RMSE by the range of the reference data (NRMSE) of reference data minus simulation for the analysed time period (1990 to 2010).

Run	LST [K]	TOA_{net} [W m^{-2}]	TOA_{sw} [W m^{-2}]	TOA_{lw} [W m^{-2}]	SRF_{net} [W m^{-2}]	SRF_{sw} [W m^{-2}]	SRF_{lw} [W m^{-2}]	$HFLX_{net}$ [W m^{-2}]	$HFLX_{sensible}$ [W m^{-2}]	$HFLX_{latent}$ [W m^{-2}]	Precip [mm day^{-1}]	ACLC	LWC [kg m^{-2}]	IWC [kg m^{-2}]	TWS [m]
2 (CTRL) RSME	4.88	9.044	7.131	11.839	5.6	5.441	0.909	42.858	5.205	15.966	0.092	0.02	0.042	0.027	0.06
2 (CTRL) NRMSE	0.349	0.411	0.411	1.535	0.308	0.312	0.209	1.129	1.136	1.227	0.28	0.554	2.936	10.765	0.66
3 RMSE	4.919	8.068	8.49	11.971	5.228	5.055	0.942	42.944	5.101	15.948	0.097	0.02	0.042	0.028	0.06
3 NRMSE	0.351	0.366	0.49	1.552	0.288	0.29	0.217	1.132	1.114	1.226	0.295	0.564	2.934	10.888	0.663
4 RMSE	4.88	9.044	7.131	11.839	5.6	5.441	0.909	42.858	5.205	15.966	0.092	0.02	0.042	0.027	0.06
4 NRMSE	0.349	0.411	0.411	1.535	0.308	0.312	0.209	1.129	1.136	1.227	0.28	0.554	2.936	10.765	0.66
5 RMSE	4.856	10.086	6.024	11.731	6.18	6.069	0.915	42.753	5.189	15.844	0.086	0.019	0.042	0.027	0.06
5 NRMSE	0.347	0.458	0.348	1.521	0.34	0.348	0.21	1.127	1.133	1.218	0.261	0.548	2.907	10.727	0.664
6 RMSE	4.822	10.524	5.586	11.58	6.537	6.382	0.917	42.781	5.198	15.882	0.088	0.019	0.042	0.027	0.06
6 NRMSE	0.345	0.478	0.322	1.501	0.36	0.366	0.211	1.127	1.135	1.221	0.268	0.53	2.928	10.661	0.665
7 RSME	4.9	9.08	6.651	11.261	5.789	5.76	0.961	43.206	5.073	16.191	0.099	0.02	0.027	0.042	0.06
7 NRSME	0.35	0.412	0.384	1.46	0.319	0.33	0.221	1.139	1.108	1.245	0.3	0.562	2.891	10.802	0.667
8 RMSE	4.88	9.044	7.131	11.839	5.6	5.441	0.909	42.858	5.205	15.966	0.092	0.02	0.042	0.027	0.06
8 NRMSE	0.349	0.411	0.411	1.535	0.308	0.312	0.209	1.129	1.136	1.227	0.28	0.554	2.936	10.765	0.66
9 RMSE	4.858	8.864	7.698	12.292	5.417	5.172	0.935	42.505	5.215	15.614	0.087	0.02	0.043	0.027	0.06
9 NRMSE	0.347	0.403	0.444	1.593	0.298	0.296	0.215	1.12	1.139	1.2	0.264	0.554	2.976	10.716	0.661
10 RMSE	4.858	8.95	8.106	12.909	5.318	5.058	0.968	42.013	5.241	15.133	0.076	0.02	0.043	0.027	0.06
10 NRMSE	0.347	0.406	0.468	1.674	0.293	0.29	0.222	1.107	1.144	1.163	0.232	0.562	2.965	10.751	0.664
11 RMSE	4.851	8.861	8.676	13.442	5.223	4.981	1.098	41.593	5.297	14.757	0.07	0.021	0.043	0.027	0.061
11 NRMSE	0.347	0.402	0.501	1.743	0.288	0.285	0.252	1.096	1.157	1.134	0.213	0.585	3.014	10.584	0.673
12 RMSE	4.904	8.424	7.847	11.798	5.259	5.11	0.925	42.521	5.201	15.616	0.087	0.019	0.042	0.027	0.06
12 NRMSE	0.35	0.383	0.453	1.529	0.29	0.293	0.213	1.121	1.135	1.2	0.265	0.538	2.91	10.789	0.663
13 RMSE	4.909	7.938	8.519	11.782	5.161	4.983	0.932	42.506	5.167	15.565	0.085	0.019	0.042	0.027	0.06
13 NRMSE	0.351	0.36	0.491	1.527	0.284	0.285	0.214	1.12	1.128	1.196	0.26	0.535	2.891	10.766	0.661
14 RMSE	4.925	7.706	8.913	11.809	5.162	4.98	0.914	42.523	5.147	15.564	0.086	0.02	0.042	0.027	0.06
14 NRMSE	0.352	0.35	0.514	1.531	0.284	0.285	0.21	1.121	1.124	1.196	0.263	0.554	2.894	10.767	0.659
15 RMSE	4.916	7.277	9.732	11.834	5.317	5.154	0.926	42.457	5.219	15.569	0.085	0.019	0.042	0.027	0.06
15 NRMSE	0.351	0.33	0.561	1.534	0.293	0.295	0.213	1.119	1.139	1.197	0.257	0.541	2.892	10.75	0.665
16 (EMAC/JSBACH) RMSE	4.939	7.175	9.943	11.822	5.367	5.225	0.919	42.426	5.123	15.439	0.084	0.02	0.042	0.027	0.06
16 (EMAC/JSBACH) NRMSE	0.353	0.326	0.574	1.533	0.296	0.299	0.211	1.118	1.118	1.187	0.255	0.559	2.884	10.728	0.658
17 RMSE	4.897	7.46	9.58	12.068	5.159	5.08	1.414	43.32	4.976	16.21	0.102	0.031	0.043	0.027	0.06
17 NRMSE	0.35	0.339	0.553	1.564	0.284	0.291	0.325	1.142	1.086	1.246	0.311	0.867	3.001	10.651	0.659
18 RMSE	4.886	7.923	8.713	11.983	5.215	4.976	1.159	43.144	5.019	16.072	0.098	0.027	0.043	0.027	0.06
18 NRMSE	0.349	0.36	0.503	1.553	0.287	0.285	0.267	1.137	1.096	1.235	0.296	0.763	2.979	10.657	0.662
19 RMSE	4.881	8.376	7.986	11.892	5.349	5.078	1.03	43.044	5.074	16.026	0.097	0.024	0.043	0.027	0.06
19 NRMSE	0.349	0.38	0.461	1.542	0.295	0.291	0.237	1.134	1.108	1.232	0.296	0.671	2.956	10.749	0.658
20 RMSE	4.88	9.044	7.131	11.839	5.6	5.441	0.909	42.858	5.205	15.966	0.092	0.02	0.042	0.027	0.06
20 NRSME	0.349	0.411	0.411	1.535	0.308	0.312	0.209	1.129	1.136	1.227	0.28	0.554	2.936	10.765	0.66
21 RSME	4.869	9.771	6.328	11.77	5.967	6.029	0.991	42.64	5.193	15.73	0.086	0.016	0.042	0.027	0.06
21 NRSME	0.348	0.444	0.365	1.526	0.329	0.345	0.228	1.124	1.134	1.209	0.261	0.455	2.883	10.853	0.665
22 RSME	4.88	9.044	7.131	11.839	5.6	5.441	0.909	42.858	5.205	15.966	0.092	0.02	0.042	0.027	0.06
22 NRSME	0.349	0.411	0.411	1.535	0.308	0.312	0.209	1.129	1.136	1.227	0.28	0.554	2.936	10.765	0.66
23 RSME	4.935	9.206	4.79	8.052	7.276	8.439	1.936	45.337	4.89	18.198	0.151	0.007	0.03	0.018	0.061
23 NRSME	0.353	0.418	0.276	1.044	0.401	0.483	0.445	1.195	1.068	1.399	0.458	0.198	2.099	7.021	0.678
24 RSME	4.965	8.823	4.604	6.443	7.79	9.486	2.422	46.54	4.746	19.287	0.184	0.011	0.026	0.014	0.062
24 NRSME	0.355	0.401	0.266	0.835	0.429	0.543	0.557	1.226	1.036	1.483	0.559	0.316	1.809	5.697	0.683
25 RSME	4.969	8.561	4.626	5.488	8.026	10.118	2.827	47.213	4.649	19.878	0.203	0.016	0.024	0.013	0.062
25 NRSME	0.355	0.389	0.267	0.711	0.442	0.579	0.65	1.244	1.015	1.528	0.615	0.453	1.653	5.024	0.689
26 RSME	4.987	8.377	4.666	4.949	8.176	10.407	2.944	47.659	4.635	20.322	0.217	0.019	0.023	0.012	0.062
26 NRSME	0.356	0.38	0.269	0.642	0.45	0.596	0.677	1.256	1.012	1.562	0.66	0.541	1.58	4.618	0.681
27 RSME	4.992	8.209	4.7	4.545	8.235	10.59	3.077	47.941	4.557	20.531	0.226	0.022	0.022	0.011	0.062
27 NRSME	0.357	0.373	0.271	0.589	0.453	0.607	0.707	1.263	0.995	1.578	0.686	0.621	1.514	4.293	0.686
28 RSME	5.016	8.089	4.777	4.111	8.355	10.912	3.28	48.299	4.46	20.798	0.236	0.025	0.021	0.01	0.062
28 NRSME	0.358	0.367	0.276	0.533	0.46	0.625	0.754	1.273	0.974	1.599	0.716	0.709	1.438	3.944	0.687
29 RSME	5.001	8.001	4.794	3.931	8.362	10.975	3.338	48.444	4.494	20.98	0.24	0.027	0.021	0.01	0.062
29 NRSME	0.357	0.363	0.277	0.51	0.46	0.629	0.767	1.277	0.981	1.613	0.73	0.758	1.421	3.825	0.687
30 RSME	5.061	6.618	8.048	7.085	5.16	5.29	2.148	45.935	4.814	18.735	0.18	0.015	0.024	0.012	0.063
30 NRSME	0.362	0.301	0.464	0.918	0.284	0.303	0.494	1.21	1.051	1.44	0.547	0.42	1.681	4.933	0.696
32 RSME	5.096	6.641	7.234	5.55	5.176	5.763	2.639	47.032	4.675	19.72	0.213	0.023	0.021	0.01	0.063
32 NRSME	0.364	0.302	0.417	0.72	0.285	0.33	0.607	1.239	1.021	1.516	0.646	0.639	1.455	3.888	0.692
33 RSME	5.103	6.652	7.05	5.239	5.196	5.901	2.715	47.327	4.649	19.994	0.221	0.026	0.02	0.009	0.062
33 NRSME	0.365	0.302	0.407	0.679	0.286	0.338	0.624	1.247	1.015	1.537	0.67	0.731	1.417	3.696	0.688
34 RSME	5.106	6.75	9.431	7.269	5.368	4.993	2.097	45.914	4.795	18.691	0.182	0.013	0.024	0.013	0.062
34 NRSME	0.365	0.307	0.544	0.942	0.296	0.286	0.482	1.21	1.047	1.437	0.554	0.367	1.678	4.995	0.682
35 RSME	5.044	6.939	5.466	5.533	5.733	6.987	2.575	46.752	4.658	19.413	0.194	0.016	0.024	0.012	0.062
35 NRSME	0.36	0.315	0.315	0.717	0.316	0.4	0.592	1.232	1.017	1.492	0.59	0.463	1.636	4.909	0.68

Table S5. Selection of newly available output variables and diagnostics of the JSBACH submodel.

JSBACH Process Variable	Additional information
Radiation	
Surface albedo	Available in the visible and near infrared range for soil, snow, ice, water, canopy and separately for each Plant Functional Type (PFT).
Photosynthetic active radiation (PAR)	Available are total, direct and diffuse parts for each canopy layer and PFT.
Fraction of absorbed PAR	Available are total, direct and diffuse parts for each canopy layer and PFT.
Surface Energy Balance	
Surface temperature	Available for land, ice, water, snow, five soil and three snow levels.
Sensible and latent heatflux	Available for land, ice and water.
Heat capacity of soil	Available for land and water.
Turbulence	
Surface roughness length	Available for Orography, momentum and heat. All are available for each PFT.
Soil and Snow Energy	
Ground heat conductivity	Available for each soil and snow layer.
Ground heat capacity	Available for each soil and snow layer.
Ground heat flux	Available for each soil and snow layer.
Volumetric soil field capacity	Available for each soil layer.
Volumetric porosity of ground	Available for each soil layer.
Density of snow on soil	Available for each snow layer.
Snow depth	Available for each snow layer.
Thawing depth	Available for each snow layer.
Assimilation	
CO2 concentration at surface level	
Dark respiration	Available for each canopy level and PFT.
Disturbance	
Fraction of burned foliage projective cover (FPC)	Available for each PFT.
Fraction of damaged FPC from wind	Available for each PFT.
Amount of carbon relocated by wind and fire damage	

Table S6. Selection of newly available output variables and diagnostics of the JSBACH submodel.

JSBACH Process		
	Variable	Additional information
Hydrology		
	Fraction of organic material in soil layers	
	Volume fraction of frozen water	Available for each soil layer.
	Wet (skin reservoir) fraction	Available for each soil layer and canopy level.
	Water and ice content	Available for each soil and snow layer and the total columns.
	Water content in root zone	
	Water stress factor of canopy	
	Depth of each soil layer that can be saturated with water	
	Rooted depth per soil layer (until rooting depth)	
	Volumetric permanent wilting point	
	Evapotranspiration	Available for land, water, ice, vegetation, soil, snow and skin reservoir.
	Humidity at lowest atmospheric level	
	Surface drag coefficients	Available for land, water and ice.
Carbon		
	Plant carbon pools	Available for carbohydrate reserve (sugars, starches) that allows plants to survive. Additional for stems, thick roots and other (dead) structural matter and last for biomass harvested from crops.
	A bove ground and below ground litter carbon pools	Available for green and woody litter, plus acid, water and ethanol soluble litter and non soluble litter.
	Gross assimilation	Available for each canopy layer and PFT.
	Soil heterotrophic respiration	Available for each canopy layer and PFT.
	Gross primary productivity	Available for each canopy layer and PFT.
	Net primary productivity	Available for each canopy layer and PFT.
Phenology		
	Leaf area index (LAI)	Available for each canopy layer and PFT.
Fuel		
	Amount of fuel available for fire	Available for each PFT.