Optimisation work for GENIE `cupcake`

Ian Ross

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Not yet done:

- Tracer reorganisation
- BIOGEM array-to-vector reorganisation

1 "Everything allocatable"

General guidelines:

1. Rationalise coordinate dimension size variables before doing anything else – all this `maxi` vs. `imax` stuff is just confusing and unnecessary.
2. Convert arrays to `ALLOCATABLE` in small groups and do a little test to make sure you're not screwing things up!
3. Initialise all allocated arrays to zero: the original fixed-size arrays are mostly defined as `SAVE` and there are some places that seem to rely on them being zeroed.
4. Be careful about using the `maxi` and `maxj` coordinate dimensions before they're properly initialised! This is especially possible in the various `initialise_...` routines.
5. Some modules haven't been fully organised as F90 modules, so that also needs to be done: mostly it's a matter of putting the initialisation, step and tear-down routines into a single module.

1.1 `gemlite`

These need to be redefined *not* to be `PARAMETER`s:

```
INTEGER,PARAMETER::n_i = ilon1_ocn
INTEGER,PARAMETER::n_j = ilat1_ocn
INTEGER,PARAMETER::n_k = inl1_ocn
```

Most are already `ALLOCATABLE`, except for:

```
INTEGER,DIMENSION(n_i,n_j)::goldstein_k1
REAL,DIMENSION(n_k)::goldstein_dz
REAL,DIMENSION(n_k)::goldstein_dza
REAL,DIMENSION(0:n_j)::goldstein_sv
```

- Needed to set up `gemlite` as a proper F90 module in order to have calling interfaces that will work with assumed-shape arrays.
- Tracer counts! (Probably like more or less all the other biogeochemistry modules.)

The `maxisles` variable is used in the following allocations:

```
  ALLOCATE(lpisl(mpi,maxisles))   ; lpisl = 0
  ALLOCATE(ipisl(mpi,maxisles))   ; ipisl = 0
  ALLOCATE(jpisl(mpi,maxisles))   ; jpisl = 0
  ALLOCATE(npi(maxisles))         ; npi = 0
  ALLOCATE(psisl(0:maxi,0:maxj,maxisles))          ; psisl = 0.0
  ALLOCATE(ubisl(2,0:maxi+1,0:maxj,maxisles))      ; ubisl = 0.0
  ALLOCATE(erisl(maxisles,maxisles+1))             ; erisl = 0.0
  ALLOCATE(psibc(maxisles))                        ; psibc = 0.0
```

All now allocated to the exact number of islands.

1.2 goldsteinseaice

These need to be redefined *not* to be PARAMETERs:

```
INTEGER, PARAMETER :: maxi = GOLDSTEINNLONS
INTEGER, PARAMETER :: maxj = GOLDSTEINNLATS
INTEGER, PARAMETER :: maxk = GOLDSTEINNLEVS
```

All defined in gold_seaice_lib.f90; all need to be made ALLOCATABLE:

```
INTEGER :: k1(0:maxi+1,0:maxj+1)
REAL, DIMENSION(0:maxj) :: s, c, sv, cv
REAL :: ds(maxj), dsv(1:maxj-1), rds2(2:maxj-1), u(2,0:maxi,0:maxj)
REAL, DIMENSION(0:maxj) :: rc, rcv, cv2, rc2
REAL :: rds(maxj), rdsv(1:maxj-1)
REAL, DIMENSION(maxj) :: asurf
REAL, DIMENSION(2,maxi,maxj) :: varice, varice1, dtha, varicedy, variceth
REAL, DIMENSION(maxi,maxj) :: tice, albice
REAL, DIMENSION(2,maxi,maxj) :: haavg, dthaavg
REAL, DIMENSION(maxi,maxj) :: ticeavg, albiceavg, fxdelavg ,fwdelavg
```

as do the following from gold_seaice_netcdf.f90:

```
REAL, DIMENSION(maxi) :: nclon1, nclon2, nclon3
REAL, DIMENSION(maxj) :: nclat1, nclat2, nclat3
```

Need to be careful not to use coordinate size variables in subroutine argument definitions *before they're assigned values!* The Fortran compiler doesn't help you to spot this, so it produces weird run-time errors.

1.3 ents

Same as in other modules:

```
INTEGER, PARAMETER :: maxi=GOLDSTEINNLONS, maxj=GOLDSTEINNLATS
```

(Also the usual maxi/imax, maxj/jmax duplication.)
All defined in gold_seaice_lib.f90; all need to be made ALLOCATABLE:

```
INTEGER :: ents_k1(maxi,maxj)
REAL :: ents_lat(maxj)
REAL, DIMENSION(maxi,maxj) :: Cveg, Csoil, fv, epsv
REAL, DIMENSION(maxi,maxj) :: leaf, respveg, respsoil, photo
REAL, DIMENSION(maxi,maxj) :: sphoto, srveg, sleaf, srsoil, sCveg1, &
  & sCsoil1, sfv1, sepsv1, sfx0a, sfx0o, sfxsens, sfxlw, sevap, &
  & spptn, srelh, sbcap, salbs, ssnow, sz0
REAL :: stqld(2,maxi,maxj)
REAL, DIMENSION(2,maxi,maxj) :: tqld, tqldavg
REAL, DIMENSION(maxi,maxj) :: bcap, bcapavg, snowavg, z0avg, &
  albsavg, z0, evapavg, pptnavg, runavg, fvfv
REAL :: fxavg(7,maxi,maxj)
```

Some cases where initialisation is really needed: all the fixed-size arrays were defined as `SAVE` so they got initialised automatically.

1.4 embm

```
INTEGER, PARAMETER :: maxi=GOLDSTEINNLONS, maxj=GOLDSTEINNLATS
INTEGER, PARAMETER :: maxk=GOLDSTEINNLEVS, maxl=2
INTEGER, PARAMETER :: maxnyr=400
INTEGER, PARAMETER :: en_ntimes_max=2000
```

Here, `maxl` isn't used, but these `maxnyr` and `en_ntimes_max` things will require some attention.

```
INTEGER :: k1(0:maxi+1,0:maxj+1)
INTEGER :: ku(2,maxi,maxj), mk(maxi+1,maxj)
REAL :: dt(maxk), ds(maxj), dsv(1:maxj-1), rds2(2:maxj-1), &
     & dz(maxk), s(0:maxj), c(0:maxj), dzu(2,maxk), &
     & tau(2,maxi,maxj), drag(2,maxi+1,maxj), dztau(2,maxi,maxj), &
     & diff(2), ec(4), sv(0:maxj)
REAL :: cv(0:maxj), dza(maxk), dztav(2,maxi,maxj), &
     & tau0(maxi,maxj), dztav0(maxi,maxj), &
     & tau1(maxi,maxj), dztav1(maxi,maxj), tsa0(maxj)
REAL :: rc(0:maxj), rcv(1:maxj-1), rdphi, rds(maxj), rdsv(1:maxj-1), &
     & cv2(1:maxj-1), rc2(0:maxj), rtv(maxi,maxj), rtv3(maxi,maxj), &
     & rdz(maxk), rdza(maxk)
REAL :: us_dztau(2, maxi, maxj), us_dztav(2, maxi, maxj)
REAL :: asurf(maxj)
REAL :: tq(2,maxi,maxj), tq1(2,maxi,maxj), qsata(maxi,maxj), &
     & qsato(maxi,maxj), co2(maxi,maxj), ch4(maxi,maxj), n2o(maxi,maxj), &
     & varice(2,maxi,maxj), varice1(2,maxi,maxj), &
     & tqa(2,maxi,maxj), solfor(maxj,maxnyr)
REAL :: albcl(maxi,maxj), fxsw(maxi,maxj), fxplw(maxi,maxj), &
     & fx0a(maxi,maxj), fx0o(maxi,maxj), fxsen(maxi,maxj), &
     & pmeadj(maxi,maxj), pptn(maxi,maxj), evap(maxi,maxj), &
     & usurf(maxi,maxj), fxlata(maxi,maxj), fxlato(maxi,maxj), &
     & fxlw(maxi,maxj), diffa(2,2,maxj), betam(2), betaz(2), hatmbl(2), &
     & ca(maxi,maxj), qb(maxi,maxj), qbsic(maxi,maxj)
REAL :: fx0sic(maxi,maxj), fx0neto(maxi,maxj), fwfxneto(maxi,maxj), &
     & evapsic(maxi,maxj), tsfreez(maxi,maxj)
REAL :: uatm(2,maxi,maxj)
REAL :: tqavg(2,maxi,maxj), fxlatavg(maxi,maxj), fxsenavg(maxi,maxj), &
     & fxswavg(maxi,maxj), fxlwavg(maxi,maxj), fwpptavg(maxi,maxj), &
     & fwevpavg(maxi,maxj)
REAL :: fx0avg(4,maxi,maxj), fwavg(2,maxi,maxj)
REAL :: albo(maxj,maxnyr), palb(maxi,maxj), palbavg(maxi,maxj)
REAL :: lice_vect(maxi,maxj,en_ntimes_max)
REAL, DIMENSION(maxi,maxj) :: d18o_ice_thresh, d18o_orog_min, d18o_orog_grad
REAL :: uatml(2,maxi,maxj,maxnyr)
REAL, DIMENSION(maxi,maxj,maxnyr) :: usurfl, tncep, pncep, rhncep, atm_alb
REAL, DIMENSION(maxi,maxj) :: chl, cel
REAL, DIMENSION(maxi,maxj) :: q_pa, rq_pa, q_pa_avg, rq_pa_avg
INTEGER, DIMENSION(maxi,maxj) :: iroff, jroff
```

The `maxnyr` (400) and `en_ntimes_max` (2000) things are used in the following allocations:

```
  ALLOCATE(solfor(maxj,maxnyr))
  ALLOCATE(albo(maxj,maxnyr))
  ALLOCATE(uatml(2,maxi,maxj,maxnyr))
  ALLOCATE(usurfl(maxi,maxj,maxnyr))
  ALLOCATE(tncep(maxi,maxj,maxnyr))
```

```
ALLOCATE(pncep(maxi,maxj,maxnyr))
ALLOCATE(rhncep(maxi,maxj,maxnyr))
ALLOCATE(atm_alb(maxi,maxj,maxnyr))

REAL :: orbitall_vect(en_ntimes_max,5) [local]
ALLOCATE(orog_vect(maxi,maxj,en_ntimes_max)) ; orog_vect = 0.0
ALLOCATE(lice_vect(maxi,maxj,en_ntimes_max)) ; lice_vect = 0.0
```

Now removed and replaced with more appropriate allocations where required.

1.5 atchem

```
INTEGER,PARAMETER::n_i = ilon1_atm
INTEGER,PARAMETER::n_j = ilat1_atm
INTEGER,PARAMETER::n_phys_atm = 15
```

The `n_phys_atm` variable will be dealt with in the "tracers" stuff.

```
real,dimension(n_atm,n_i,n_j) :: atm
real,dimension(n_atm,n_i,n_j) :: fatm
real,dimension(n_phys_atm,n_i,n_j) :: phys_atm
real,dimension(n_atm,n_i,n_j) :: atm_slabbiosphere
```

1.6 rokgem

```
INTEGER,PARAMETER :: n_i = ilon1_rok
INTEGER,PARAMETER :: n_j = ilat1_rok
INTEGER,PARAMETER :: n_phys_rok = 08
INTEGER,PARAMETER :: n_phys_ocnrok = 06
INTEGER,PARAMETER :: n_io = ilon1_rok
INTEGER,PARAMETER :: n_jo = ilat1_rok
INTEGER,PARAMETER :: n_ko = inl1_ocn
```

Some are already `ALLOCATABLE`...

```
real,dimension(n_phys_rok,n_i,n_j)::phys_rok
REAL,DIMENSION(n_phys_ocnrok,n_io,n_jo) :: phys_ocnrok
INTEGER,DIMENSION(ilon1_ocn,ilat1_ocn) :: goldstein_k1
INTEGER :: landmask(n_i,n_j)
REAL :: runoff_drainage(n_i+2,n_j+2)
INTEGER :: runoff_drainto(n_i,n_j,2)
REAL :: runoff_coast(n_i,n_j)
REAL :: total_calcium_flux(n_i,n_j)
REAL :: total_calcium_flux_Ca(n_i,n_j)
REAL :: total_calcium_flux_Si(n_i,n_j)
REAL :: weather_fCaCO3_2D(n_i,n_j)
REAL :: weather_fCaSiO3_2D(n_i,n_j)
REAL :: orogeny(n_i,n_j)
REAL :: regimes_calib(n_i,n_j)
REAL :: ref_T0_2D(n_i,n_j)
REAL :: ref_R0_2D(n_i,n_j)
REAL :: ref_P0_2D(n_i,n_j)
REAL :: data_T_2D(n_i,n_j)
REAL :: data_R_2D(n_i,n_j)
REAL :: data_P_2D(n_i,n_j)
REAL :: calibrate_T_2D(n_i,n_j)
REAL :: calibrate_R_2D(n_i,n_j)
REAL :: calibrate_P_2D(n_i,n_j)
```

1.7 goldstein

```
INTEGER, PARAMETER :: maxi=GOLDSTEINNLONS, maxj=GOLDSTEINNLATS
INTEGER, PARAMETER :: maxk=GOLDSTEINNLEVS, maxl=GOLDSTEINNTRACS
INTEGER, PARAMETER :: maxnyr=720
INTEGER, PARAMETER :: mpxi=maxi, mpxj=maxj+1
INTEGER, PARAMETER :: maxisles=GOLDSTEINMAXISLES, mpi=2 * (maxi + maxj)

INTEGER :: k1(0:maxi+1,0:maxj+1), ku(2,maxi,maxj), mk(maxi+1,maxj)
INTEGER :: ips(maxj), ipf(maxj), ias(maxj), iaf(maxj)
INTEGER :: lpisl(mpi,maxisles), ipisl(mpi,maxisles), jpisl(mpi,maxisles)
INTEGER :: npi(maxisles)
REAL :: dt(maxk), ds(maxj), dsv(1:maxj-1), rds2(2:maxj-1)
REAL :: dz(maxk), u(3,0:maxi,0:maxj,maxk), ts(maxl,0:maxi+1,0:maxj+1,0:maxk+1)
REAL :: s(0:maxj), c(0:maxj), dzu(2,maxk), tau(2,maxi,maxj)
REAL :: drag(2,maxi+1,maxj), dztau(2,maxi,maxj)
REAL :: ratm(mpxi*mpxj,mpxi+1), ub(2,0:maxi+1,0:maxj)
REAL :: rho(0:maxi+1,0:maxj+1,0:maxk), ts1(maxl,0:maxi+1,0:maxj+1,0:maxk+1)
REAL :: sv(0:maxj)
REAL :: cv(0:maxj), dza(maxk), dztav(2,maxi,maxj), gb(mpxi*mpxj)
REAL :: gap(mpxi*mpxj,2*mpxi+3), cost(maxi,maxj), rh(3,0:maxi+1,0:maxj+1)
REAL :: gbold(mpxi*mpxj), tau0(maxi,maxj), dztav0(maxi,maxj)
REAL :: tau1(maxi,maxj), dztav1(maxi,maxj), tsa0(maxj), t0
REAL :: fw_hosing(maxi,maxj), rhosing(maxi,maxj), zro(maxk), zw(0:maxk)
REAL :: dzg(maxk,maxk), z2dzg(maxk,maxk), rdzg(maxk,maxk)
REAL :: fw_anom(maxi,maxj), fw_anom_rate(maxi,maxj)
REAL :: psi(0:maxi,0:maxj)
REAL :: u1(3,0:maxi,0:maxj,maxk)
REAL, DIMENSION(0:maxj) :: rc, rc2
REAL, DIMENSION(maxi,maxj) :: rtv, rtv3
REAL, DIMENSION(1:maxj-1) :: rcv, rdsv, cv2
REAL :: rds(maxj), rdz(maxk), rdza(maxk)
REAL :: bp(maxi+1,maxj,maxk), sbp(maxi+1,maxj)
INTEGER :: icosd(maxi,maxj)
REAL :: asurf(maxj)
REAL :: tsavg(maxl,0:maxi+1,0:maxj+1,0:maxk+1)
REAL :: uavg(3,0:maxi,0:maxj,maxk), rhoavg(0:maxi+1,0:maxj+1,0:maxk)
REAL :: fx0avg(5,maxi,maxj), fwavg(4,maxi,maxj), windavg(4,maxi,maxj)
REAL :: psisl(0:maxi,0:maxj,maxisles), ubisl(2,0:maxi+1,0:maxj,maxisles)
REAL :: erisl(maxisles,maxisles+1), psibc(maxisles)
REAL :: ts_store(maxl,maxi,maxj,maxk)
REAL :: albcl(maxi,maxj)
REAL, DIMENSION(maxi,maxj) :: &
     & evap_save1, late_save1, sens_save1, evap_save2, late_save2, sens_save2
REAL, DIMENSION(maxi,maxj) :: &
     & mldpebuoy, mldpeconv, mldpelayer1, mldketau, mldemix, mld
REAL, DIMENSION(maxk) :: mlddec, mlddecd
INTEGER :: mldk(maxi,maxj)
REAL :: ediff1(maxi,maxj,maxk-1), diffmax(maxk)
REAL :: ssmax(maxk-1)
LOGICAL :: getj(maxi,maxj)
```

1.8 sedgem

Need to merge `sedgem.f90`, `initialise_sedgem.f90` and `end_sedgem.f90`.

```
INTEGER, PARAMETER :: n_i = ilon1_sed
INTEGER, PARAMETER :: n_j = ilat1_sed
```

```
INTEGER, PARAMETER :: n_phys_sed = 14
INTEGER, PARAMETER :: n_opt_sed = 26
```

Almost everything is already allocatable. Should be pretty easy to do.

1.9 `biogem`

```
INTEGER,PARAMETER::n_i = ilon1_ocn
INTEGER,PARAMETER::n_j = ilat1_ocn
INTEGER,PARAMETER::n_k = inl1_ocn
INTEGER,PARAMETER::n_phys_ocn = 21
INTEGER,PARAMETER::n_phys_ocnatm = 25
INTEGER,PARAMETER::n_data_max = 32767
INTEGER,PARAMETER::n_opt_misc = 14
INTEGER,PARAMETER::n_opt_atm = 01
INTEGER,PARAMETER::n_opt_bio = 06
INTEGER,PARAMETER::n_opt_force = 08
INTEGER,PARAMETER::n_opt_data = 30
INTEGER,PARAMETER::n_opt_select = 05
INTEGER,PARAMETER::n_diag_bio = 09
INTEGER,PARAMETER::n_diag_geochem = 07
INTEGER,PARAMETER::n_diag_misc_2D = 07
```

Lots of arrays...

2 Tracer reorganisation

Tracer counts

Tracer counts are defined in `common/gem_cmn.f90` as `PARAMETER`s:

```
INTEGER,PARAMETER::n_atm = 19
INTEGER,PARAMETER::n_ocn = 95
INTEGER,PARAMETER::n_sed = 79
```

and also in `wrappers/genie_control.f90`:

```
INTEGER, PARAMETER :: intrac_atm_max=19, intrac_ocn_max=95, intrac_sed_max=79
```

Instead, these *maximum* tracer counts should be kept as `PARAMETER`s while the *actual* tracer counts are determined from the `atm_select`, `ocn_select` and `sed_select` arrays:

```
INTEGER, PARAMETER :: &
  & n_atm_max = 19, n_ocn_max = 95, n_sed_max = 79

...

n_atm = COUNT(atm_select)
n_ocn = COUNT(ocn_select)
n_sed = COUNT(sed_select)
```

and index mapping arrays should be defined as:

```
INTEGER, DIMENSION(:), ALLOCATABLE :: &
  & idx_to_atm, idx_to_ocn, idx_to_sed
INTEGER, DIMENSION(n_atm_max) :: atm_to_idx
INTEGER, DIMENSION(n_ocn_max) :: ocn_to_idx
INTEGER, DIMENSION(n_sed_max) :: sed_to_idx
```

one set giving the mapping from the index into tracer arrays to the tracer ID (all the existing `io_...` constants) and the other giving the mapping from the tracer ID to the index into tracer arrays (with a default value of −1 for unused tracers). These things should all be set up immediately after the main GENIE namelist is read so that all of the array sizes are assigned before any of the sub-modules are initialised.

Some of this sort of thing has already been partially done in `common/gem_util.f90` and `common/gem_cmn.f90`. That stuff should be cleaned up and used for this. There should be one common set of tracer index maps for each tracer type (atmosphere, ocean, sediment) across all modules.

General principles

The basic procedure will be something like this:

1. Globally rename all `ia_...`, `io_...`, `is_...` constants to `ias_...`, `ios_...`, `iss_...` (the "`s`" is for "select"). From now on, I'll use the atmosphere version of these things as a proxy for all three types.

2. TEST

3. Introduce new `ia_...` *variables* that will refer to the actual locations of these species in the dynamics arrays. References to `atm_select` will still use the `ias_...` constant index values.

4. Work out what sort of mapping is needed between the constant `ias_...` values and the variable `ia_...` values.

5. Come up with better names for `n_atm` and `n_l_atm`.

6. Set up tracer counting, `ia_...` variable assignment, mapping calculations in GENIE initialisation (rework existing code in `gem_cmn.f90` and `gem_util.f90`).

7. TEST

8. Replace all array sizing based on `n_atm` by `n_l_atm`. Statically sized arrays all become ALLOCATABLE. Record which arrays these are and check up on each use site to make sure that there are no problems (e.g. with slices or the whole array being used in a way that won't work any more).

9. Replace indexing into dynamics arrays with `ia_...` versions.

10. TEST

11. Do the same for the sediment and ocean tracers. (Do them in atmosphere, sediment, ocean order because the number of occurrences of `ia_...`, `is_...` and `io_...` are respectively 290, 1117 and 2745!

12. Think about replacing `ipa_...`, `ipo_...` and similar indexing schemes with F90 derived types.

2.1 Atmospheric tracers

Atmospheric tracer indexing

Index variables

Indexes:

Name	Index	
ia_T	1	Temperature
ia_q	2	Specific humidity
ia_pCO2	3	pCO_2
ia_pCO2_13C	4	^{13}C (pCO_2)
ia_pCO2_14C	5	^{14}C (pCO_2)
ia_pO2	6	pO_2
ia_pO2_18O	7	^{18}O (pO_2)
ia_pN2	8	pN_2
ia_pN2_15N	9	^{15}N (pN_2)
ia_pCH4	10	pCH_4
ia_pCH4_13C	11	^{13}C (pCH_4)
ia_pCH4_14C	12	^{14}C (pCH_4)
ia_pSF6	13	Halo-carbon
ia_pN2O	14	pN_2
ia_pN2O_15N	15	^{15}N (pN_2)
ia_pH2S	16	pH_2S
ia_pH2S_34S	17	pH_2S
ia_pCFC11	18	Halo-carbon
ia_pCFC12	19	Halo-carbon

Occurrences:

File	Count	ias	Rename	Alloc	Check
atchem/atchem.f90	6	Yes			
atchem/atchem_box.f90	29	Yes			
atchem/atchem_data.f90	8	Yes			
biogem/biogem_box.f90	22	Yes			
biogem/biogem_data_netCDF.f90	18	Yes			
biogem/biogem.f90	71	Yes			
biogem/biogem_data_ascii.f90	22	Yes			
biogem/biogem_data.f90	9	Yes			
gemlite/gemlite.f90	14	Yes			
rokgem/rokgem_data_netCDF.f90	1	Yes			
rokgem/rokgem_box.f90	27	Yes			
common/gem_carbchem.f90	2	Yes			
common/gem_cmn.f90	20	Yes			
common/gem_util.f90	38	Yes			

Index mapping

Arrays defined using `n_atm_all` (+ means should be able to switch to `ia_...` indexing without problems, `?` means unsure, `X` means potential problems, – means that this array *should* be dimensioned as `n_atm_all`, `R` means replace with an equivalent array dimensioned as `n_atm` and set up appropriately):

```
atchem.f90 (initialise_atchem):
+  ALLOCATE(atm(n_atm_all,n_i,n_j),STAT=alloc_error)
+  ALLOCATE(fatm(n_atm_all,n_i,n_j),STAT=alloc_error)
+  ALLOCATE(atm_slabbiosphere(n_atm_all,n_i,n_j),STAT=alloc_error)

atchem.f90 (step_atchem):
+  REAL,DIMENSION(n_atm_all)::loc_atm_tot
+  REAL,DIMENSION(n_atm_all,n_i,n_j)::locij_fatm
+  REAL,DIMENSION(n_atm_all)::loc_fracdecay_atm

atchem_box.f90 (sub_calc_terrCO2exchange):
+  REAL,DIMENSION(n_atm_all),intent(inout)::dum_fatm

atchem_box.f90 (sub_calc_wetlands_CH4):
+  REAL,DIMENSION(n_atm_all),intent(inout)::dum_fatm

atchem_box.f90 (sub_calc_generate_14C):
+  REAL,DIMENSION(n_atm_all),intent(inout)::dum_fatm

atchem_lib.f90 (module):
-  REAL,DIMENSION(n_atm_all)::atm_init

atchem_data.f90 (sub_data_load_rst):
X  integer,DIMENSION(n_atm_all)::loc_conv_iselected_ia

genie_global.f90 (allocate_genie_global):
+  ALLOCATE(genie_sfcatm(n_atm_all,ilon1_atm,ilat1_atm),STAT=status)
+  ALLOCATE(genie_sfxsumatm(n_atm_all,ilon1_atm,ilat1_atm),STAT=status)
+  ALLOCATE(genie_sfcatm1(n_atm_all,ilon1_ocn,ilat1_ocn),STAT=status)
+  ALLOCATE(genie_sfxatm1(n_atm_all,ilon1_ocn,ilat1_ocn),STAT=status)
+  ALLOCATE(genie_sfcatm_lnd(n_atm_all,ilon1_lnd,ilat1_lnd),STAT=status)
+  ALLOCATE(genie_sfxatm_lnd(n_atm_all,ilon1_lnd,ilat1_lnd),STAT=status)
+  ALLOCATE(genie_sfxsumatm1_gem(n_atm_all,ilon1_ocn,ilat1_ocn),STAT=status)
+  ALLOCATE(genie_atm1(n_atm_all,ilon1_atm,ilat1_atm),STAT=status)

biogem.f90 (fun_calc_ocnatm_flux):
+  REAL,dimension(n_atm_all)::fun_calc_ocnatm_flux
+  REAL,dimension(n_atm_all)::loc_focnatm,loc_fatmocn
+  REAL,dimension(n_atm_all)::loc_dflux

biogem_lib.f90 (module):
?  REAL,DIMENSION(n_atm_all)::par_atm_force_scale_time
?  REAL,DIMENSION(n_atm_all)::par_atm_force_scale_val
?  LOGICAL, DIMENSION(n_atm_all) :: ocnatm_airsea_eqm
?  REAL,DIMENSION(n_atm_all)::int_ocnatm_sig
?  REAL,DIMENSION(n_atm_all)::int_focnatm_sig
?  REAL,DIMENSION(n_atm_all)::int_diag_airsea_sig
?  REAL,DIMENSION(n_atm_all)::int_diag_forcing_sig
?  REAL,DIMENSION(n_atm_all,2,n_data_max)::force_restore_atm_sig
?  REAL,DIMENSION(n_atm_all)::force_restore_atm_sig_x
?  REAL,DIMENSION(n_atm_all)::force_restore_atm_tconst
?  INTEGER,DIMENSION(n_atm_all,2)::force_restore_atm_sig_i
?  LOGICAL,DIMENSION(n_atm_all)::force_restore_atm_select
```

```
?  REAL,DIMENSION(n_atm_all,2,n_data_max)::force_flux_atm_sig
?  REAL,DIMENSION(n_atm_all)::force_flux_atm_sig_x
?  INTEGER,DIMENSION(n_atm_all,2)::force_flux_atm_sig_i
?  LOGICAL,DIMENSION(n_atm_all)::force_flux_atm_select
?  LOGICAL,DIMENSION(n_atm_all)::force_flux_atm_scale
?  integer,DIMENSION(n_atm_all)::force_atm_uniform
?  integer,DIMENSION(n_atm_all)::force_atm_point_i
?  integer,DIMENSION(n_atm_all)::force_atm_point_j

rokgem_box.f90 (sub_glob_avg_weath):
+  REAL :: loc_force_flux_weather_a(n_atm_all)
+  REAL :: loc_force_flux_weather_a_land(n_atm_all,n_i,n_j)

rokgem_box.f90 (sub_2D_weath):
+  REAL :: loc_force_flux_weather_a_land(n_atm_all,n_i,n_j)

gem_cmn.f90 (module):
-  LOGICAL,DIMENSION(n_atm_all)::atm_select
-? integer,DIMENSION(n_atm_all)::atm_type
-? integer,DIMENSION(n_atm_all)::atm_dep
-  CHARACTER(len=16),DIMENSION(n_atm_all)::string_atm
-  CHARACTER(len=128),DIMENSION(n_atm_all)::string_longname_atm
X  CHARACTER(len=16),DIMENSION(n_atm_all)::string_atm_tname
X  CHARACTER(len=128),DIMENSION(n_atm_all)::string_atm_tlname
-  CHARACTER(len=12),DIMENSION(n_atm_all)::string_atm_unit
-? REAL,DIMENSION(n_atm_all,2)::atm_mima
X  INTEGER,DIMENSION(n_atm_all)::conv_ia_lselected
X  INTEGER,DIMENSION(n_atm_all)::ia2l
X  real,DIMENSION(n_atm_all,n_ocn)::conv_ocn_atm
X  real,DIMENSION(n_ocn,n_atm_all)::conv_atm_ocn
X  integer,DIMENSION(0:n_atm_all,0:n_ocn)::conv_ocn_atm_i
X  integer,DIMENSION(0:n_ocn,0:n_atm_all)::conv_atm_ocn_i
?  REAL,DIMENSION(n_atm_all)::const_lambda_atm
-  real,dimension(4,n_atm_all)::par_Sc_coef
-  real,dimension(6,n_atm_all)::par_bunsen_coef
```

Removed: `conv_iselected_ia`, `conv_ia_lselected`, `l2ia`, `ia2l` (replaced by `ia_ias` and `ias_ia` index maps).

Array dimension names

Rename `n_atm` to `n_atm_all` and rename `n_l_atm` to `n_atm`. Also replace `intrac_atm_max` by `n_atm_all` and remove the redundant tracer count definition from `genie_control.f90` (adding imports of `gem_cmn` as necessary).

Atmospheric tracer arrays

The tricky thing here is tracing through all the references to different permutations of the tracer arrays in different places. The best way to deal with it is to do a couple of related arrays at a time and retest.

Other arrays

As well as the main tracer arrays, there are some module-local arrays that can also be trimmed down:

```
  biogem/biogem.f90:66: ALLOCATE(ocnatm_airsea_pv(n_atm_all,n_i,n_j),STAT=alloc_error)
  biogem/biogem.f90:68: ALLOCATE(ocnatm_airsea_solconst(n_atm_all,n_i,n_j),STAT=alloc_er
  biogem/biogem.f90:98: ALLOCATE(diag_forcing(n_atm_all,n_i,n_j),STAT=alloc_error)
biogem/biogem.f90:156: ALLOCATE(force_restore_atm(n_atm_all,n_i,n_j),STAT=alloc_error)
biogem/biogem.f90:158: ALLOCATE(force_restore_atm_I(n_atm_all,n_i,n_j),STAT=alloc_error)
```

```
biogem/biogem.f90:160: ALLOCATE(force_restore_atm_II(n_atm_all,n_i,n_j),STAT=alloc_error
biogem/biogem.f90:165: ALLOCATE(force_flux_atm(n_atm_all,n_i,n_j),STAT=alloc_error)
biogem/biogem.f90:167: ALLOCATE(force_flux_atm_I(n_atm_all,n_i,n_j),STAT=alloc_error)
biogem/biogem.f90:169: ALLOCATE(force_flux_atm_II(n_atm_all,n_i,n_j),STAT=alloc_error)
  rokgem/rokgem_box.f90:480: REAL :: loc_force_flux_weather_a_land(n_atm_all,n_i,n_j)
  rokgem/rokgem_box.f90:1426: REAL :: loc_force_flux_weather_a_land(n_atm_all,n_i,n_j)
```

Diagnosing breakages

After the changes so far, the following test jobs are broken:

```
cover/ridgwell-schmidt-2010      [01m 05s]  [FIXED]
cover/ocean-geochem-spin-up      [01m 44s]  [FIXED]
cover/ridgwell-hargreaves-2007   [03m 01s]  [FIXED]
cover/gem-adapt-auto             [03m 02s]  [FIXED]
cover/ocean-geochem-spin-up-2    [03m 07s]  [FIXED]
cover/calcium-isotopes           [04m 57s]  [FIXED]
cover/ridgwell-schmidt-2010-mud  [08m 58s]  [FIXED]
cover/nitrogen-no3               [11m 27s]  [FIXED]
cover/eocene-ch4                 [09m 57s]  [FIXED]
cover/fe-atmos-ch4               [10m 00s]  [FIXED]

cover/simple-corg-diagen         [10m 13s]
  sedgem/fields_sedgem_2d.nc
  biogem/biogem_series_fseaair_pO2.res
  biogem/biogem_series_focnatm_pO2.res
  biogem/biogem_series_ocn_H2S.res
  biogem/fields_biogem_3d.nc
  biogem/biogem_series_focnatm_pCO2.res
  biogem/biogem_series_focnatm_pCO2_13C.res
  biogem/fields_biogem_2d.nc
  biogem/biogem_series_fseaair_pH2S.res
```

Checks

After changing all the tracer arrays to `ALLOCATABLE` of size `n_atm`, the following references to `n_atm_all` remain. The unlabelled ones still require attention.

```
OK atchem/atchem_lib.f90:20: REAL,DIMENSION(n_atm_all)::atm_init
OK atchem/atchem_data.f90:98: INTEGER, DIMENSION(n_atm_all) :: dummy_ias_ia
OK biogem/biogem_lib.f90:462: REAL,DIMENSION(n_atm_all)::par_atm_force_scale_time
OK biogem/biogem_lib.f90:463: REAL,DIMENSION(n_atm_all)::par_atm_force_scale_val
?  biogem/biogem_lib.f90:787: LOGICAL, DIMENSION(n_atm_all) :: ocnatm_airsea_eqm
+  biogem/biogem_lib.f90:819: REAL,DIMENSION(n_atm_all)::int_ocnatm_sig
+  biogem/biogem_lib.f90:821: REAL,DIMENSION(n_atm_all)::int_focnatm_sig
+  biogem/biogem_lib.f90:838: REAL,DIMENSION(n_atm_all)::int_diag_airsea_sig
+  biogem/biogem_lib.f90:839: REAL,DIMENSION(n_atm_all)::int_diag_forcing_sig
+  biogem/biogem_lib.f90:918: REAL,DIMENSION(n_atm_all)::force_restore_atm_sig_x
+  biogem/biogem_lib.f90:919: REAL,DIMENSION(n_atm_all)::force_restore_atm_tconst
+  biogem/biogem_lib.f90:921: LOGICAL,DIMENSION(n_atm_all)::force_restore_atm_select
+  biogem/biogem_lib.f90:936: REAL,DIMENSION(n_atm_all)::force_flux_atm_sig_x
+  biogem/biogem_lib.f90:938: LOGICAL,DIMENSION(n_atm_all)::force_flux_atm_select
+  biogem/biogem_lib.f90:939: LOGICAL,DIMENSION(n_atm_all)::force_flux_atm_scale
+  biogem/biogem_lib.f90:951: integer,DIMENSION(n_atm_all)::force_atm_uniform
+  biogem/biogem_lib.f90:954: integer,DIMENSION(n_atm_all)::force_atm_point_i
+  biogem/biogem_lib.f90:957: integer,DIMENSION(n_atm_all)::force_atm_point_j
+  rokgem/rokgem_box.f90:478: REAL :: loc_force_flux_weather_a(n_atm_all)
OK common/gem_cmn.f90:36: LOGICAL,DIMENSION(n_atm_all)::atm_select
OK common/gem_cmn.f90:363: INTEGER, DIMENSION(n_atm_all) :: atm_type
```

```
OK common/gem_cmn.f90:367: INTEGER, DIMENSION(n_atm_all) :: atm_dep
OK common/gem_cmn.f90:372: CHARACTER(len=16), DIMENSION(n_atm_all) :: string_atm
OK common/gem_cmn.f90:376: CHARACTER(len=128), DIMENSION(n_atm_all) :: string_longname_a
OK common/gem_cmn.f90:379: CHARACTER(len=12), DIMENSION(n_atm_all) :: string_atm_unit
OK common/gem_cmn.f90:395: INTEGER, DIMENSION(n_atm_all) :: ias_ia
OK common/gem_cmn.f90:380: REAL, DIMENSION(n_atm_all,2) :: atm_mima
```

A few "special" arrays that it makes sense to index by the fixed tracer IDs:

```
OK common/gem_cmn.f90:24: INTEGER,PARAMETER::n_atm_all = 19
OK common/gem_cmn.f90:412: real,DIMENSION(n_atm_all,n_ocn)::conv_ocn_atm
OK common/gem_cmn.f90:413: real,DIMENSION(n_ocn,n_atm_all)::conv_atm_ocn
OK common/gem_cmn.f90:434: integer,DIMENSION(0:n_atm_all,0:n_ocn)::conv_ocn_atm_i
OK common/gem_cmn.f90:435: integer,DIMENSION(0:n_ocn,0:n_atm_all)::conv_atm_ocn_i
OK common/gem_cmn.f90:740: real,dimension(4,n_atm_all)::par_Sc_coef
OK common/gem_cmn.f90:742: real,dimension(6,n_atm_all)::par_bunsen_coef

+  biogem/biogem_lib.f90:920: INTEGER,DIMENSION(n_atm_all,2)::force_restore_atm_sig_i
+  biogem/biogem_lib.f90:937: INTEGER,DIMENSION(n_atm_all,2)::force_flux_atm_sig_i

+  biogem/biogem_lib.f90:917: REAL,DIMENSION(n_atm_all,2,n_data_max)::force_restore_atm_
+  biogem/biogem_lib.f90:935: REAL,DIMENSION(n_atm_all,2,n_data_max)::force_flux_atm_sig

OK biogem/biogem_data.f90:1832: do ias=1,n_atm_all
+  rokgem/rokgem_box.f90:921: DO k=1,n_atm_all
OK common/gem_data.f90:95: &   4,n_atm_all &
OK common/gem_data.f90:132: &   6,n_atm_all &
OK common/gem_util.f90:1290: do ia=1,n_atm_all
OK common/gem_util.f90:1299: do ia=1,n_atm_all
OK common/gem_util.f90:1719: DO ias = 1, n_atm_all
```

Diagnosing more breakages

After completing all the atmospheric tracer changes, the following test jobs are still broken:

```
cover/eocene-ch4
```

```
 ===================================================
  >>> Initialising BIOGEM ocean biogeochem. module ...
==2048== Invalid read of size 4
==2048==    at 0x47F4ED: __biogem_data_MOD_sub_check_par_biogem (biogem_data.f90:1889)
==2048==    by 0x44DE4E: __biogem_MOD_initialise_biogem (biogem.f90:471)
==2048==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2048==    by 0x402BDF: MAIN__ (genie.f90:31)
==2048==    by 0x405B97: main (genie.f90:7)
==2048==  Address 0x167be968 is 8 bytes before a block of size 32 alloc'd
==2048==    at 0x9FEAF90: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so
==2048==    by 0x4432EE: __biogem_MOD_initialise_biogem (biogem.f90:178)
==2048==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2048==    by 0x402BDF: MAIN__ (genie.f90:31)
==2048==    by 0x405B97: main (genie.f90:7)
==2048==
==2048== Invalid read of size 4
==2048==    at 0x47F762: __biogem_data_MOD_sub_check_par_biogem (biogem_data.f90:1900)
==2048==    by 0x44DE4E: __biogem_MOD_initialise_biogem (biogem.f90:471)
==2048==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2048==    by 0x402BDF: MAIN__ (genie.f90:31)
==2048==    by 0x405B97: main (genie.f90:7)
==2048==  Address 0x167beac8 is 8 bytes before a block of size 32 alloc'd
==2048==    at 0x9FEAF90: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so
```

```
==2048==    by 0x44444B: __biogem_MOD_initialise_biogem (biogem.f90:195)
==2048==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2048==    by 0x402BDF: MAIN__ (genie.f90:31)
==2048==    by 0x405B97: main (genie.f90:7)
==2048==
  <<< Initialisation complete
 ======================================================
 ======================================================
  >>> Initialising ATCHEM atmospheric chem. module ...
  <<< Initialisation complete
 ======================================================



cover/fe-atmos-ch4

  <<< Initialisation complete
 ======================================================
 ======================================================
  >>> Initialising BIOGEM ocean biogeochem. module ...
==2046== Invalid read of size 4
==2046==    at 0x47F4ED: __biogem_data_MOD_sub_check_par_biogem (biogem_data.f90:1889)
==2046==    by 0x44DE4E: __biogem_MOD_initialise_biogem (biogem.f90:471)
==2046==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2046==    by 0x402BDF: MAIN__ (genie.f90:31)
==2046==    by 0x405B97: main (genie.f90:7)
==2046==  Address 0x1d57e0d8 is 8 bytes before a block of size 28 alloc'd
==2046==    at 0x9FEAF90: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so
==2046==    by 0x4432EE: __biogem_MOD_initialise_biogem (biogem.f90:178)
==2046==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2046==    by 0x402BDF: MAIN__ (genie.f90:31)
==2046==    by 0x405B97: main (genie.f90:7)
==2046==
==2046== Invalid read of size 4
==2046==    at 0x47F762: __biogem_data_MOD_sub_check_par_biogem (biogem_data.f90:1900)
==2046==    by 0x44DE4E: __biogem_MOD_initialise_biogem (biogem.f90:471)
==2046==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2046==    by 0x402BDF: MAIN__ (genie.f90:31)
==2046==    by 0x405B97: main (genie.f90:7)
==2046==  Address 0x1d57e238 is 8 bytes before a block of size 28 alloc'd
==2046==    at 0x9FEAF90: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so
==2046==    by 0x44444B: __biogem_MOD_initialise_biogem (biogem.f90:195)
==2046==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2046==    by 0x402BDF: MAIN__ (genie.f90:31)
==2046==    by 0x405B97: main (genie.f90:7)
==2046==
  <<< Initialisation complete
 ======================================================
 ======================================================
  >>> Initialising ATCHEM atmospheric chem. module ...
  <<< Initialisation complete


cover/simple-corg-diagen

  <<< Initialisation complete
 ======================================================
 ======================================================
  >>> Initialising BIOGEM ocean biogeochem. module ...
```

```
==2047== Invalid read of size 4
==2047==    at 0x47F4ED: __biogem_data_MOD_sub_check_par_biogem (biogem_data.f90:1889)
==2047==    by 0x44DE4E: __biogem_MOD_initialise_biogem (biogem.f90:471)
==2047==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2047==    by 0x402BDF: MAIN__ (genie.f90:31)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==  Address 0x158b7198 is 8 bytes before a block of size 24 alloc'd
==2047==    at 0x9FEAF90: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so
==2047==    by 0x4432EE: __biogem_MOD_initialise_biogem (biogem.f90:178)
==2047==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2047==    by 0x402BDF: MAIN__ (genie.f90:31)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==
==2047== Invalid read of size 4
==2047==    at 0x47F762: __biogem_data_MOD_sub_check_par_biogem (biogem_data.f90:1900)
==2047==    by 0x44DE4E: __biogem_MOD_initialise_biogem (biogem.f90:471)
==2047==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2047==    by 0x402BDF: MAIN__ (genie.f90:31)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==  Address 0x2148efb8 is 8 bytes before a block of size 24 alloc'd
==2047==    at 0x9FEAF90: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so
==2047==    by 0x44444B: __biogem_MOD_initialise_biogem (biogem.f90:195)
==2047==    by 0x6FAE31: __genie_ini_wrappers_MOD_initialise_biogem_wrapper (genie_ini_w
==2047==    by 0x402BDF: MAIN__ (genie.f90:31)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==
  <<< Initialisation complete
 ============================================================
 ============================================================
  >>> Initialising ATCHEM atmospheric chem. module ...
  <<< Initialisation complete
 ============================================================


==2047==
==2047== Conditional jump or move depends on uninitialised value(s)
==2047==    at 0xE28C578: __printf_fp (in /usr/lib/libc-2.21.so)
==2047==    by 0xE287406: vfprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2B2BE8: vsnprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2911D1: snprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xD8B41E8: write_float (write_float.def:1289)
==2047==    by 0xD8AD6CB: formatted_transfer_scalar_write (transfer.c:1764)
==2047==    by 0xD8AD6CB: formatted_transfer (transfer.c:2002)
==2047==    by 0x4A7162: __biogem_data_ascii_MOD_sub_data_save_global_av (biogem_data_as
==2047==    by 0x41F3C5: __biogem_MOD_diag_biogem_timeslice (biogem.f90:2653)
==2047==    by 0x6FB6C6: __genie_loop_wrappers_MOD_diag_biogem_timeslice_wrapper (genie_
==2047==    by 0x4041E9: MAIN__ (genie.f90:268)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==
==2047== Use of uninitialised value of size 8
==2047==    at 0xE28CA82: __printf_fp (in /usr/lib/libc-2.21.so)
==2047==    by 0xE287406: vfprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2B2BE8: vsnprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2911D1: snprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xD8B41E8: write_float (write_float.def:1289)
==2047==    by 0xD8AD6CB: formatted_transfer_scalar_write (transfer.c:1764)
==2047==    by 0xD8AD6CB: formatted_transfer (transfer.c:2002)
==2047==    by 0x4A7162: __biogem_data_ascii_MOD_sub_data_save_global_av (biogem_data_as
```

```
==2047==    by 0x41F3C5: __biogem_MOD_diag_biogem_timeslice (biogem.f90:2653)
==2047==    by 0x6FB6C6: __genie_loop_wrappers_MOD_diag_biogem_timeslice_wrapper (genie_
==2047==    by 0x4041E9: MAIN__ (genie.f90:268)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==
==2047== Use of uninitialised value of size 8
==2047==    at 0xE284948: __mpn_lshift (in /usr/lib/libc-2.21.so)
==2047==    by 0xE28CA86: __printf_fp (in /usr/lib/libc-2.21.so)
==2047==    by 0xE287406: vfprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2B2BE8: vsnprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2911D1: snprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xD8B41E8: write_float (write_float.def:1289)
==2047==    by 0xD8AD6CB: formatted_transfer_scalar_write (transfer.c:1764)
==2047==    by 0xD8AD6CB: formatted_transfer (transfer.c:2002)
==2047==    by 0x4A7162: __biogem_data_ascii_MOD_sub_data_save_global_av (biogem_data_as
==2047==    by 0x41F3C5: __biogem_MOD_diag_biogem_timeslice (biogem.f90:2653)
==2047==    by 0x6FB6C6: __genie_loop_wrappers_MOD_diag_biogem_timeslice_wrapper (genie_
==2047==    by 0x4041E9: MAIN__ (genie.f90:268)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==
==2047== Use of uninitialised value of size 8
==2047==    at 0xE28494B: __mpn_lshift (in /usr/lib/libc-2.21.so)
==2047==    by 0xE28CA86: __printf_fp (in /usr/lib/libc-2.21.so)
==2047==    by 0xE287406: vfprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2B2BE8: vsnprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xE2911D1: snprintf (in /usr/lib/libc-2.21.so)
==2047==    by 0xD8B41E8: write_float (write_float.def:1289)
==2047==    by 0xD8AD6CB: formatted_transfer_scalar_write (transfer.c:1764)
==2047==    by 0xD8AD6CB: formatted_transfer (transfer.c:2002)
==2047==    by 0x4A7162: __biogem_data_ascii_MOD_sub_data_save_global_av (biogem_data_as
==2047==    by 0x41F3C5: __biogem_MOD_diag_biogem_timeslice (biogem.f90:2653)
==2047==    by 0x6FB6C6: __genie_loop_wrappers_MOD_diag_biogem_timeslice_wrapper (genie_
==2047==    by 0x4041E9: MAIN__ (genie.f90:268)
==2047==    by 0x405B97: main (genie.f90:7)
==2047==
```

Still broken: `simple-corg-diagen`

```
sedgem/fields_sedgem_2d.nc                  [FINAL OUTPUT ONLY]
biogem/fields_biogem_3d.nc
  ocn_DIC_13C                                1.5 ->
  ocn_H2S                                   49.5 ->
  carb_H                                    49.5 ->
  carb_fug_CO2                              99.5 ->
  carb_conc_CO2                             49.5 ->
  carb_conc_CO3                             49.5 ->
  carb_conc_HCO3                            99.5 ->
  carb_ohm_cal                              99.5 ->
  carb_ohm_arg                              49.5 ->
  carb_dCO3_cal                             49.5 ->
  carb_dCO3_arg                             49.5 ->
  phys_u                                     1.5 -> ?
  phys_v                                     1.5 -> ?
  carb_d13C_CO32                             1.5 -> ***
biogem/biogem_series_fseaair_pO2.res        55.5 ->
biogem/biogem_series_focnatm_pO2.res        49.5 ->
biogem/biogem_series_ocn_H2S.res            29.5 ->
biogem/biogem_series_focnatm_pCO2.res       29.5 ->
```

```
biogem/biogem_series_focnatm_pCO2_13C.res   29.5 ->
biogem/fields_biogem_2d.nc
  atm_dpCO2                                 49.5 ->
biogem/biogem_series_fseaair_pH2S.res       29.5 ->
```

Careful comparison of the results for a long (5000 year) simulation here seems to indicate that the differences are small and are probably due to compiler reordering of floating point operations somewhere. (I can't be definite about that, but the differences in the results are definitely all below the threshold of scientific significance, so I don't want to spend any more time trying to track down precisely what's going on here.)

2.2 Sediment tracers

Step 1: name changes and indexing setup

1. Global replace of `n_sed` with `nt_sed_all`.
2. Global replace of `n_l_sed` with `nt_sed`.
3. Global replace of `is_...` tracer indexes with `iss_...`.
4. Add `is_...` variables and set up initialisation.
5. Indexing for `string_sed` and friends.
6. Global replace `intrac_sed_max` with `nt_sed_all`.

Step 2: array definitions

References to `nt_sed_all`:

```
wrappers/genie_global.f90:
OK    14: USE gem_cmn, ONLY: nt_sed_all
 +  1045: ALLOCATE(genie_sfcsed(nt_sed_all,ilon1_sed,ilat1_sed),STAT=status)
 +  1047: ALLOCATE(genie_sfxsumsed(nt_sed_all,ilon1_sed,ilat1_sed),STAT=status)
 +  1049: ALLOCATE(genie_sfxsumsed1(nt_sed_all,ilon1_ocn,ilat1_ocn),STAT=status)
 +  1051: ALLOCATE(genie_sfcsed1(nt_sed_all,ilon1_ocn,ilat1_ocn),STAT=status)
 +  1053: ALLOCATE(genie_sfxsed1(nt_sed_all,ilon1_ocn,ilat1_ocn),STAT=status)

wrappers/genie_loop_wrappers.f90:
 ?   176: & nt_sed_all, ilon1_ocn, ilat1_ocn, ilon1_sed, ilat1_sed, &
 ?   190: CALL cpl_flux_sedsed1(nt_sed_all, ilon1_ocn, ilat1_ocn, &

sedgem/sedgem_data.f90:
 ?   213: integer,DIMENSION(nt_sed_all)::loc_is_iss
 ?   664: do is=1,nt_sed_all
 +   982: REAL,DIMENSION(nt_sed_all)::loc_sed
 +  1121: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_sed_coretop
 +  1122: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_sed_preservation
 +  1127: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_fsed
 +  1128: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_fdis
 +  1708: ALLOCATE(loc_sed_save(nt_sed_all,n_i,n_j,0:n_sed_tot),STAT=alloc_error)
 +  2072: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_sed_coretop
 +  2073: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_sed_preservation

sedgem/sedgem_data_netCDF.f90:
 +   281: real,dimension(nt_sed_all)::loc_sed
 +  1231: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_sed_coretop
 +  1232: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_sed_preservation
 ?  1425: DO is=1,nt_sed_all
 ?  1548: DO is=1,nt_sed_all

sedgem/sedgem.f90:
 +    69: ALLOCATE(sed(nt_sed_all,n_i,n_j,n_sed_tot),STAT=alloc_error)
 +    71: ALLOCATE(sed_top(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +    77: ALLOCATE(sed_fsed(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +    79: ALLOCATE(sed_fdis(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +    93: ALLOCATE(sed_fsed_OLD(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +    95: ALLOCATE(sed_fdis_OLD(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +   247: REAL,DIMENSION(nt_sed_all)::loc_fracdecay_sed
 +   255: real,DIMENSION(nt_sed_all,n_i,n_j)::loc_sfxsumsed_OLD

sedgem/sedgem_box.f90:
 +    78: REAL,DIMENSION(nt_sed_all)::loc_new_sed
 +    79: REAL,DIMENSION(nt_sed_all)::loc_dis_sed
 +    80: REAL,DIMENSION(nt_sed_all)::loc_exe_sed
 ?   635: do is=1,nt_sed_all
 ?   639: do is=1,nt_sed_all
 ?   643: do is=1,nt_sed_all
 +   735: REAL,DIMENSION(nt_sed_all)::loc_new_sed
 +   736: REAL,DIMENSION(nt_sed_all)::loc_dis_sed
 +   737: REAL,DIMENSION(nt_sed_all)::loc_exe_sed
 ?  1091: do is=1,nt_sed_all
 ?  1095: do is=1,nt_sed_all
 ?  1099: do is=1,nt_sed_all
 +  1156: REAL,DIMENSION(nt_sed_all)::loc_new_sed
 +  1157: REAL,DIMENSION(nt_sed_all)::loc_dis_sed
 +  1158: REAL,DIMENSION(nt_sed_all)::loc_exe_sed
 +  1563: REAL,INTENT(inout),DIMENSION(nt_sed_all)::dum_sed_dis
 +  1564: REAL,INTENT(in),DIMENSION(nt_sed_all)::dum_sed_new
 +  1565: REAL,INTENT(in),DIMENSION(nt_sed_all)::dum_sed_top
 +  1737: REAL,INTENT(inout),DIMENSION(nt_sed_all)::dum_sed_dis
 +  1738: REAL,INTENT(in),DIMENSION(nt_sed_all)::dum_sed_new
```

```
 +  1739: REAL,INTENT(in),DIMENSION(nt_sed_all)::dum_sed_top
 +  1940: REAL,INTENT(inout),DIMENSION(nt_sed_all,0:par_n_sed_mix)::dum_sed
 +  1941: REAL,INTENT(inout),DIMENSION(nt_sed_all)::dum_sed_top

sedgem/sedgem_lib.f90:
 +   322: real,DIMENSION(nt_sed_all)::conv_sed_cm3_mol
 +   323: real,DIMENSION(nt_sed_all)::conv_sed_mol_cm3
 +   324: real,DIMENSION(nt_sed_all)::conv_sed_cm3_g
 +   325: real,DIMENSION(nt_sed_all)::conv_sed_g_cm3
 +   326: real,DIMENSION(nt_sed_all)::conv_sed_mask
 +   397: REAL,INTENT(in),DIMENSION(nt_sed_all)::dum_sed
 +   412: REAL,INTENT(in),DIMENSION(nt_sed_all)::dum_sed
 +   496: REAL,DIMENSION(nt_sed_all,n_i,n_j)::fun_sed_coretop
 +   501: REAL,DIMENSION(nt_sed_all,n_i,n_j)::loc_sed

biogem/biogem_box.f90:
 +   361: real,dimension(nt_sed_all,n_k)::loc_bio_part_DOM
 +   362: real,dimension(nt_sed_all,n_k)::loc_bio_part_RDOM
 +  1528: real,dimension(nt_sed_all,n_k)::loc_bio_part
 +  2299: real,dimension(nt_sed_all,n_k)::loc_bio_part
 +  3503: real,dimension(nt_sed_all,n_i,n_j,n_k)::loc_bio_part

biogem/biogem.f90:
 +    72: ALLOCATE(bio_part(nt_sed_all,n_i,n_j,n_k),STAT=alloc_error)
 +    76: ALLOCATE(bio_settle(nt_sed_all,n_i,n_j,n_k),STAT=alloc_error)
 +    78: ALLOCATE(bio_part_red(nt_sed_all,nt_sed_all,n_i,n_j),STAT=alloc_error)
 +   109: ALLOCATE(int_bio_part_timeslice(nt_sed_all,n_i,n_j,n_k),STAT=alloc_error)
 +   111: ALLOCATE(int_bio_settle_timeslice(nt_sed_all,n_i,n_j,n_k),STAT=alloc_error)
 +   129: ALLOCATE(int_sfcsed1_timeslice(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +   131: ALLOCATE(int_focnsed_timeslice(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +   200: ALLOCATE(force_flux_sed(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +   202: ALLOCATE(force_flux_sed_I(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +   204: ALLOCATE(force_flux_sed_II(nt_sed_all,n_i,n_j),STAT=alloc_error)
 +   593: REAL,DIMENSION(nt_sed_all,n_i,n_j,n_k)::locijk_fpart
 +   603: REAL,DIMENSION(nt_sed_all,n_i,n_j)::locij_focnsed
 +   608: REAL,DIMENSION(nt_sed_all)::loc_fracdecay_sed
 +  2417: REAL,DIMENSION(nt_sed_all,n_i,n_j)::locij_focnsed
 +  2701: REAL,DIMENSION(nt_sed_all,n_i,n_j)::locij_focnsed

biogem/biogem_lib.f90:
 +   820: REAL,DIMENSION(nt_sed_all)::int_fexport_sig
 +   822: REAL,DIMENSION(nt_sed_all)::int_focnsed_sig
 +   834: REAL,DIMENSION(nt_sed_all)::int_ocnsed_sig
 +   943: REAL,DIMENSION(nt_sed_all,2,n_data_max)::force_flux_sed_sig
 +   944: REAL,DIMENSION(nt_sed_all)::force_flux_sed_sig_x
 +   945: INTEGER,DIMENSION(nt_sed_all,2)::force_flux_sed_sig_i
 +   946: LOGICAL,DIMENSION(nt_sed_all)::force_flux_sed_select
 +   947: LOGICAL,DIMENSION(nt_sed_all)::force_flux_sed_scale
 +   953: integer,DIMENSION(nt_sed_all)::force_sed_uniform
 +   956: integer,DIMENSION(nt_sed_all)::force_sed_point_i
 +   959: integer,DIMENSION(nt_sed_all)::force_sed_point_j
 +  1266: REAL,DIMENSION(nt_sed_all,n_i,n_j,n_k)::fun_lib_conv_vsedTOsed

biogem/biogem_data.f90:
 +   449:  integer,DIMENSION(nt_sed_all)::loc_is_iss
 ?   729:  real,dimension(1:n_ocn,1:nt_sed_all)::loc_conv_sed_ocn
 ?   730:  integer,dimension(0:n_ocn,0:nt_sed_all)::loc_tracerrelationships
 ?  1914: do is=1,nt_sed_all
 ?  1971: do is=1,nt_sed_all

common/gem_cmn.f90:
OK    26: INTEGER,PARAMETER::nt_sed_all = 79
OK    38: LOGICAL,DIMENSION(nt_sed_all)::sed_select
```

```
OK   447: INTEGER, DIMENSION(nt_sed_all) :: sed_type
OK   451: INTEGER, DIMENSION(nt_sed_all) :: sed_dep
OK   455: CHARACTER(len=16), DIMENSION(nt_sed_all) :: string_sed
OK   459: CHARACTER(len=128), DIMENSION(nt_sed_all) :: string_longname_sed
OK   467: CHARACTER(len=12), DIMENSION(nt_sed_all) :: string_sed_unit
OK   468: REAL, DIMENSION(nt_sed_all,2) :: sed_mima
OK   479: INTEGER, DIMENSION(nt_sed_all) :: iss_is
 ?   490: real,DIMENSION(nt_sed_all,n_ocn)::conv_ocn_sed
 ?   491: real,DIMENSION(n_ocn,nt_sed_all)::conv_sed_ocn
 ?   494: real,DIMENSION(nt_sed_all,n_ocn)::conv_DOM_POM
 ?   495: real,DIMENSION(n_ocn,nt_sed_all)::conv_POM_DOM
 ?   496: real,DIMENSION(nt_sed_all,n_ocn)::conv_RDOM_POM
 ?   497: real,DIMENSION(n_ocn,nt_sed_all)::conv_POM_RDOM
 ?   498: real,DIMENSION(n_ocn,nt_sed_all)::conv_sed_ocn_N
 ?   499: real,DIMENSION(n_ocn,nt_sed_all)::conv_sed_ocn_S
 ?   500: real,DIMENSION(n_ocn,nt_sed_all)::conv_sed_ocn_meth
 ?   512: integer,DIMENSION(0:nt_sed_all,0:n_ocn)::conv_ocn_sed_i
 ?   513: integer,DIMENSION(0:n_ocn,0:nt_sed_all)::conv_sed_ocn_i
 ?   516: integer,DIMENSION(0:nt_sed_all,0:n_ocn)::conv_DOM_POM_i
 ?   517: integer,DIMENSION(0:n_ocn,0:nt_sed_all)::conv_POM_DOM_i
 ?   518: integer,DIMENSION(0:nt_sed_all,0:n_ocn)::conv_RDOM_POM_i
 ?   519: integer,DIMENSION(0:n_ocn,0:nt_sed_all)::conv_POM_RDOM_i
 ?   520: integer,DIMENSION(0:n_ocn,0:nt_sed_all)::conv_sed_ocn_i_N
 ?   521: integer,DIMENSION(0:n_ocn,0:nt_sed_all)::conv_sed_ocn_i_S
 ?   522: integer,DIMENSION(0:n_ocn,0:nt_sed_all)::conv_sed_ocn_i_meth
 ?   784: REAL,DIMENSION(nt_sed_all)::const_lambda_sed

common/initialise_gem.f90
 ?    62: do is=1,nt_sed_all

common/gem_util.f90:
 ?  1268: do is=1,nt_sed_all
 ?  1277: do is=1,nt_sed_all
 ?  1312: do is=1,nt_sed_all
 ?  1321: do is=1,nt_sed_all
 ?  1334: do is=1,nt_sed_all
 ?  1343: do is=1,nt_sed_all
 ?  1355: do is=1,nt_sed_all
 ?  1367: do is=1,nt_sed_all
 ?  1379: do is=1,nt_sed_all
 ?  1399: real,dimension(1:n_ocn,1:nt_sed_all),INTENT(in)::dum_conv_sed_ocn
 ?  1403: integer,dimension(0:n_ocn,0:nt_sed_all)::fun_recalc_tracerrelationships_i
 ?  1409: integer,dimension(0:n_ocn,0:nt_sed_all)::loc_conv_sed_ocn_i
 ?  1418: do is=1,nt_sed_all
 ?  1443: real,dimension(n_ocn,nt_sed_all),INTENT(in)::dum_sed_ocn
 ?  1461: do is=1,nt_sed_all
 ?  1483: integer,dimension(0:n_ocn,0:nt_sed_all),INTENT(in)::dum_sed_ocn_i
 ?  1505: do is=1,nt_sed_all
 ?  1528: real,dimension(nt_sed_all,n_ocn),INTENT(in)::dum_ocn_sed
 ?  1547: do is=1,nt_sed_all
 ?  1568: integer,dimension(0:nt_sed_all,0:n_ocn),INTENT(in)::dum_ocn_sed_i
 ?  1587: do is=1,nt_sed_all
 ?  2074: do iss = 1, nt_sed_all
```

References to `nt_sed`:

```
sedgem/sedgem_data.f90:
 ?   212:  integer::loc_nt_sed

sedgem/sedgem_data.f90:
 ?   299:  DO l=1,nt_sed
 ?   366:  & loc_nt_sed,
 ?   367:  & (loc_is_iss(l),l=1,loc_nt_sed),
 ?   368:  & (sed(loc_is_iss(l),:,:,:),l=1,loc_nt_sed),
```

```
 ?   369:  & (sed_top(loc_is_iss(l),:,:),l=1,loc_nt_sed),
 ?   371:  & (dum_sfxsumsed(is_iss(l),:,:),l=1,loc_nt_sed)
 ?   632:  DO l=1,nt_sed
 ?  1127: REAL, DIMENSION(nt_sed,n_i,n_j) :: loc_fsed
 ?  1128: REAL, DIMENSION(nt_sed,n_i,n_j) :: loc_fdis
 ?  1153: do is = 1, nt_sed
 ?  1691: integer::loc_l,loc_nt_sed
 ?  1889: DO l=1,nt_sed
 ?  1908: DO l=1,nt_sed
 ?  1948: DO l=1,nt_sed
 ?  1956: loc_nt_sed = loc_l
 ?  1976: & (trim(string_sed(loc_is_iss(loc_l))),loc_l=1,loc_nt_sed)
 ?  1988: & (loc_sed_save(loc_is_iss(loc_l),i,j,o),loc_l=1,loc_nt_sed)
 ?  2000: & (loc_sed_save(loc_is_iss(loc_l),i,j,o),loc_l=1,loc_nt_sed)
 ?  2012: & (loc_sed_save(loc_is_iss(loc_l),i,j,o),loc_l=1,loc_nt_sed)
 ?  2086: DO l=1,nt_sed
 ?  2115: DO l=1,nt_sed
 ?  2140: DO l=1,nt_sed
 ?  2165: DO l=1,nt_sed
 ?  2245: DO l=1,nt_sed

sedgem/sedgem_data_netCDF.f90:
 ?   117: DO l=1,nt_sed
 ?   175: DO l=1,nt_sed
 ?   417: DO l=1,nt_sed
 ?   533: DO l=1,nt_sed
 ?   548: DO l=1,nt_sed
 ?   601: DO l=1,nt_sed
 ?   620: DO l=1,nt_sed
 ?   662: DO l=1,nt_sed
 ?   679: DO l=1,nt_sed
 ?   724: DO l=1,nt_sed
 ?   742: DO l=1,nt_sed
 ?   756: DO l=1,nt_sed
 ?   916: DO l=1,nt_sed
 ?   997: DO l=1,nt_sed
 ?  1252: DO l=1,nt_sed
 ?  1312: DO l=1,nt_sed
 ?  1340: DO l=1,nt_sed
 ?  1368: DO l=1,nt_sed

sedgem/sedgem.f90:
 ?   221: n_sedcore_tracer = nt_sed
 ?   288: DO l=1,nt_sed
 ?   521: DO l=1,nt_sed
 ?   767: & nt_sed,
 ?   768: & (is_iss(l),l=1,nt_sed),              &
 ?   769: & (sed(is_iss(l),:,:,:),l=1,nt_sed),   &
 ?   770: & (sed_top(is_iss(l),:,:),l=1,nt_sed), &
 ?   977: DO l=1,nt_sed

sedgem/sedgem_box.f90:
 ?   117: DO l=1,nt_sed
 ?   189: DO l=1,nt_sed
 ?   216: DO l=1,nt_sed
 ?   233: DO l=1,nt_sed
 ?   260: DO l=1,nt_sed
 ?   304: DO l=1,nt_sed
 ?   325: DO l=1,nt_sed
 ?   359: DO l=1,nt_sed
 ?   384: DO l=1,nt_sed
 ?   573: DO l=1,nt_sed
 ?   581: DO l=1,nt_sed
```

```
 ?   612: DO l=1,nt_sed
 ?   758: DO l=1,nt_sed
 ?   876: DO l=1,nt_sed
 ?   883: DO l=1,nt_sed
 ?  1042: DO l=1,nt_sed
 ?  1050: DO l=1,nt_sed
 ?  1170: DO l=1,nt_sed
 ?  1238: DO l=1,nt_sed
 ?  1265: DO l=1,nt_sed
 ?  1290: DO l=1,nt_sed
 ?  1310: DO l=1,nt_sed
 ?  1329: DO l=1,nt_sed
 ?  1489: DO l=1,nt_sed
 ?  1497: DO l=1,nt_sed
 ?  1528: DO l=1,nt_sed
 ?  1689: DO l=1,nt_sed
 ?  1707: DO l=1,nt_sed
 ?  1830: DO l=1,nt_sed
 ?  1858: DO l=1,nt_sed
 ?  1948: REAL,DIMENSION(nt_sed,0:par_n_sed_mix)::loc_sed
 ?  1949: REAL,DIMENSION(nt_sed)::loc_sed_top
 ?  1951: REAL,DIMENSION(nt_sed)::loc_exe
 ?  1952: REAL,DIMENSION(nt_sed,0:par_n_sed_mix)::loc_dsed
 ?  1953: REAL,DIMENSION(nt_sed)::loc_dsed_top
 ?  2012: DO l=1,nt_sed
 ?  2057: DO l=1,nt_sed

sedgem/sedgem_lib.f90:
 ?   518: DO l=1,nt_sed

biogem/biogem_box.f90:
 ?  1196: DO l=1,nt_sed
 ?  1208: DO l=1,nt_sed
 ?  1247: DO l=1,nt_sed
 ?  1259: DO l=1,nt_sed
 ?  1316: DO l=1,nt_sed
 ?  1542: DO l=3,nt_sed
 ?  1643: DO l=1,nt_sed
 ?  1660: DO l=3,nt_sed
 ?  2301: real,dimension(n_l_ocn,nt_sed)::loc_conv_ls_lo
 ?  2390: DO ls=1,nt_sed
 ?  2441: real,dimension(n_l_ocn,nt_sed)::loc_conv_ls_lo
 ?  2446: real,dimension(1:nt_sed,1:n_k)::loc_bio_part_TMP
 ?  2447: real,dimension(1:nt_sed,1:n_k)::loc_bio_part_OLD
 ?  2448: real,dimension(1:nt_sed,1:n_k)::loc_bio_part
 ?  2450: real,dimension(1:nt_sed,1:n_k)::loc_bio_settle
 ?  2451: real,dimension(1:nt_sed)::loc_bio_part_remin
 ?  2718: DO l=1,nt_sed
 ?  2778: DO l=1,nt_sed
 ?  2786: DO ls=1,nt_sed
 ?  2843: DO l=1,nt_sed
 ?  2870: DO l=1,nt_sed
 ?  3538: DO l=1,nt_sed

biogem/biogem_data_netCDF.f90:
 ?    98: DO is = 1, nt_sed
 ?   130: DO is = 1, nt_sed
 ?  1576: DO is = 1, nt_sed
 ?  1651: DO is = 1, nt_sed
 ?  2180: DO is = 1, nt_sed
 ?  2217: DO is = 1, nt_sed
 ?  2776: DO is = 1, nt_sed
 ?  2853: DO is = 1, nt_sed
```

```
 ?  2945: DO is = 1, nt_sed

biogem/biogem.f90:
 ?   391: allocate(vbio_part(n)%mk(1:nt_sed,1:n_k),STAT=alloc_error)
 ?   393: allocate(vdbio_part(n)%mk(1:nt_sed,1:n_k),STAT=alloc_error)
 ?   620: real,dimension(n_l_ocn,nt_sed)::loc_conv_ls_lo                !
 ?   758: DO l=1,nt_sed
 ?   864: DO l=1,nt_sed
 ?   921: DO ls=1,nt_sed
 ?  1252: DO l=1,nt_sed
 ?  1753: DO l=1,nt_sed
 ?  1778: DO l=1,nt_sed
 ?  1829: DO l=1,nt_sed
 ?  2028: vbio_part(n)%mk(1:nt_sed,k) = vbio_part(n)%mk(1:nt_sed,k) + vdbio_part(n)%mk(1:nt_sed,k
 ?  2029: vbio_part(n)%mk(1:nt_sed,k) = loc_Sratio*vbio_part(n)%mk(1:nt_sed,k)
 ?  2102: DO l=1,nt_sed
 ?  2285: DO l=1,nt_sed
 ?  2329: & nt_sed,
 ?  2330: & (is_iss(l),l=1,nt_sed),
 ?  2331: & (bio_part(is_iss(l),:,:,:),l=1,nt_sed)
 ?  2464: DO l=1,nt_sed
 ?  2786: DO l=1,nt_sed
 ?  2841: DO l=1,nt_sed
 ?  2854: DO l=1,nt_sed
 ?  2954: DO l=1,nt_sed

biogem/biogem_data_ascii.f90:
 ?   109: DO l=1,nt_sed
 ?   198: DO l=1,nt_sed
 ?   291: DO l=1,nt_sed
 ?   958: DO l=1,nt_sed
 ?  1099: DO l=1,nt_sed
 ?  1199: DO l=1,nt_sed
 ?  1813: DO l=1,nt_sed
 ?  2109: DO l=1,nt_sed
 ?  2141: DO l=1,nt_sed

biogem/biogem_lib.f90:
 ?  1096: allocate(fun_lib_init_vsed(n)%mk(1:nt_sed,1:n_k))
 ?  1204: allocate(fun_lib_conv_sedTOvsed(n)%mk(1:nt_sed,1:n_k))
 ?  1219: DO l=1,nt_sed
 ?  1279: DO l=1,nt_sed

biogem/biogem_data.f90:
 ?   447: integer::loc_n_l_ocn,loc_nt_sed
 ?   512: DO l=1,nt_sed
 ?   539: & loc_nt_sed,
 ?   540: & (loc_is_iss(l),l=1,loc_nt_sed),
 ?   541: & (bio_part(loc_is_iss(l),:,:,:),l=1,loc_nt_sed)
 ?  1723: DO l=1,nt_sed
 ?  2027: DO l=1,nt_sed
 ?  3020: DO l=1,nt_sed

gemlite/gemlite.f90:
 ?   493:  DO l=1,nt_sed

common/gem_cmn.f90:
OK   472:  integer::nt_sed

common/initialise_gem.f90:
 ?    33: ALLOCATE(conv_ls_lo(n_l_ocn,nt_sed),STAT=alloc_error)
 ?    34: ALLOCATE(conv_lD_lP(nt_sed,n_l_ocn),STAT=alloc_error)
 ?    35: ALLOCATE(conv_lP_lD(n_l_ocn,nt_sed),STAT=alloc_error)
```

```
 ?    36: ALLOCATE(conv_lRD_lP(nt_sed,n_l_ocn),STAT=alloc_error)
 ?    37: ALLOCATE(conv_lP_lRD(n_l_ocn,nt_sed),STAT=alloc_error)
 ?    38: ALLOCATE(conv_ls_lo_N(n_l_ocn,nt_sed),STAT=alloc_error)
 ?    39: ALLOCATE(conv_ls_lo_S(n_l_ocn,nt_sed),STAT=alloc_error)
 ?    40: ALLOCATE(conv_ls_lo_meth(n_l_ocn,nt_sed),STAT=alloc_error)
 ?    41: ALLOCATE(conv_ls_lo_i(0:n_l_ocn,0:nt_sed),STAT=alloc_error)
 ?    42: ALLOCATE(conv_lD_lP_i(0:nt_sed,0:n_l_ocn),STAT=alloc_error)
 ?    43: ALLOCATE(conv_lP_lD_i(0:n_l_ocn,0:nt_sed),STAT=alloc_error)
 ?    44: ALLOCATE(conv_lRD_lP_i(0:nt_sed,0:n_l_ocn),STAT=alloc_error)
 ?    45: ALLOCATE(conv_lP_lRD_i(0:n_l_ocn,0:nt_sed),STAT=alloc_error)
 ?    46: ALLOCATE(conv_ls_lo_i_N(0:n_l_ocn,0:nt_sed),STAT=alloc_error)
 ?    47: ALLOCATE(conv_ls_lo_i_S(0:n_l_ocn,0:nt_sed),STAT=alloc_error)
 ?    48: ALLOCATE(conv_ls_lo_i_meth(0:n_l_ocn,0:nt_sed),STAT=alloc_error)

common/gem_util.f90:
 ?  1447: real,dimension(n_l_ocn,nt_sed)::fun_conv_sedocn2lslo
 ?  1452: real,dimension(n_l_ocn,nt_sed)::loc_lslo
 ?  1487: integer,dimension(0:n_l_ocn,0:nt_sed)::fun_conv_sedocn2lslo_i
 ?  1492: integer,dimension(0:n_l_ocn,0:nt_sed)::loc_lslo_i
 ?  1532: real,dimension(nt_sed,n_l_ocn)::fun_conv_ocnsed2lols
 ?  1537: real,dimension(nt_sed,n_l_ocn)::loc_lols
 ?  1572: integer,dimension(0:nt_sed,0:n_l_ocn)::fun_conv_ocnsed2lols_i
 ?  1577: integer,dimension(0:nt_sed,0:n_l_ocn)::loc_lols_i
 ?  2033: nt_sed = l
 ?  2034: ALLOCATE(is_iss(nt_sed))
```

2.3 Ocean tracers