3.5. Using Icepack in other models

This section documents how to use Icepack in other models.

3.5.1. Overview

Icepack is a column physics package designed to be used in other broader sea ice models, such as CICE, SIS, or even in ocean models. Icepack includes options for simulating sea ice thermodynamics, mechanical redistribution (ridging) and associated area and thickness changes. In addition, the model supports a number of tracers, including thickness, enthalpy, ice age, first-year ice area, deformed ice area and volume, melt ponds, and biogeochemistry.

Icepack is called on a grid point by grid point basis. All data is passed in and out of the model via subroutine interfaces. Fortran "use" statements are not encouraged for accessing data inside the Icepack model.

Icepack does not contain any parallelization or I/O. The driver of Icepack is expected to support those features. Icepack can be called concurrently across multiple MPI tasks. Icepack should also be thread safe.

3.5.2. Icepack Initialization

The subroutine icepack_configure should be called before any other icepack interfaces are called. This subroutine initializes the abort flag and a few other important defaults. We recommend that call be implemented as:

```
call icepack_configure()  ! initialize icepack
call icepack_warnings_flush(nu_diag)
if (icepack_warnings_aborted()) call my_abort_method()
```

The 2nd and 3rd line above are described further in Error Messages and Aborts.

3.5.3. Error Messages and Aborts

Icepack does not understand the I/O (file units) or computing environment (MPI, etc). It provides an interface that allows the driver to write error messsages and check for an abort flag. If Icepack fails, it will make error messages available thru that interface and it will set an abort flag that can be queried by the driver. To best use those features, it's recommended that after every icepack interface call, the user add the following:

```
call icepack_warnings_flush(nu_diag)
if (icepack_warnings_aborted()) call my_abort_method()
```

icepack_warnings_flush is a public interface in icepack that writes any warning or error messages generated in icepack to the driver file unit number defined by nu_diag. The function icepack_warnings_aborted queries the internal icepack abort flag and returns true if icepack generated an abort error. my_abort_method represents method that stops the driver model from running. That interface or command is driver dependent.

3.5.4. Calling Sequence

TBD

3.5.5. Public Interfaces

The section documents each of the public interfaces in Icepack. The interfaces are available via a use statement to icepack_intfc. For example:

```
use icepack_intfc, only: icepack_step_radiation
```

3.5.5.1. icepack_init_parameters

subroutine **icepack_init_parameters**([*puny_in*[, *bignum_in*[, *pi_in*[, *secday_in*[, *rhos_in*[, *rhoi_in*[, *rhow_in*[, *cp_air_in*[, *emissivity_in*[, *cp_ice_in*[, *cp_ocn_in*[, *depresst_in*[, *dragio_in*[, *albocn_in*[, *gravit_in*[, *viscosity_dyn_in*[, *tocnfrz_in*[, *rhofresh_in*[, *zvir_in*[, *vonkar_in*[, *cp_wv_in*[, *stefan_boltzmann_in*[, *ice_ref_salinity_in*[, *tffresh_in*[, *lsub_in*[, *lvap_in*[, *timelt_in*[, *tsmelt_in*[, *iceruf_in*[, *cf_in*[, *pstar_in*[, *cstar_in*[, *kappav_in*[, *kice_in*[, *kseaice_in*[, *ksno_in*[, *zref_in*[, *hs_min_in*[, *snowpatch_in*[, *rhosi_in*[, *sk_l_in*[, *saltmax_in*[, *phi_init_in*[, *min_salin_in*[, *salt_loss_in*[, *min_bgc_in*[, *dsin0_frazil_in*[, *hi_ssl_in*[, *hs_ssl_in*[, *awtvdr_in*[, *awtidr_in*[, *awtvdf_in*[, *awtidf_in*[, *qqqice_in*[, *tttice_in*[, *qqqocn_in*[, *tttocn_in*[, *ktherm_in*[, *conduct_in*[, *fbot_xfer_type_in*, *calc_tsfc_in*[, *dts_b_in*, *update_ocn_f_in*[, *ustar_min_in*[, *a_rapid_mode_in*[, *rac_rapid_mode_in*[, *aspect_rapid_mode_in*[, *dsdt_slow_mode_in*[, *phi_c_slow_mode_in*[, *phi_i_mushy_in*[,

shortwave_in[, *albedo_type_in*[, *albsnowi_in*[, *albicev_in*[, *albicei_in*[, *albsnowv_in*[, *ahmax_in*[, *r_ice_in*[, *r_pnd_in*[, *r_snw_in*[, *dt_mlt_in*, *rsnw_mlt_in*, *kalg_in*[, *kstrength_in*, *krdg_partic_in*, *krdg_redist_in*[, *mu_rdg_in*[, *atmbndy_in*[, *calc_strair_in*[, *formdrag_in*[, *highfreq_in*[, *natmiter_in*[, *tfrz_option_in*[, *kitd_in*, *kcatbound_in*[, *hs0_in*[, *frzpnd_in*[, *dpscale_in*[, *rfracmin_in*[, *rfracmax_in*[, *pndaspect_in*[, *hs1_in*[, *hp1_in*[, *bgc_flux_type_in*[, *z_tracers_in*[, *scale_bgc_in*[, *solve_zbgc_in*[, *modal_aero_in*[, *skl_bgc_in*[, *solve_zsal_in*[, *grid_o_in*[, *l_sk_in*[, *initbio_frac_in*[, *grid_os_in*[, *l_sks_in*[, *dedd_algae_in*[, *phi_snow_in*[, *heat_capacity_in*[, *t_max_in*[, *fsal_in*[, *fr_resp_in*[, *algal_vel_in*[, *r_dfe2dust_in*[, *dustfe_sol_in*[, *op_dep_min_in*[, *fr_graze_s_in*[, *fr_graze_e_in*[, *fr_mort2min_in*[, *fr_dfe_in*, *k_nitrif_in*, *t_iron_conv_in*, *max_loss_in*, *max_dfe_doc1_in*, *fr_resp_s_in*, *y_sk_dms_in*, *t_sk_conv_in*, *t_sk_ox_in*, *frazil_scav_in*]]])

Parameters:
- **puny_in** *[real,in,]*
- **bignum_in** *[real,in,]*
- **pi_in** *[real,in,]*
- **secday_in** *[real,in,]*
- **rhos_in** *[real,in,]* :: density of snow (kg/m^3)
- **rhoi_in** *[real,in,]*
- **rhow_in** *[real,in,]*
- **cp_air_in** *[real,in,]* :: specific heat of air (J/kg/K)
- **emissivity_in** *[real,in,]* :: emissivity of snow and ice
- **cp_ice_in** *[real,in,]* :: specific heat of fresh ice (J/kg/K)
- **cp_ocn_in** *[real,in,]*
- **depresst_in** *[real,in,]* :: Tf:brine salinity ratio (C/ppt)
- **dragio_in** *[real,in,]*
- **albocn_in** *[real,in,]*
- **gravit_in** *[real,in,]* :: gravitational acceleration (m/s^2)
- **viscosity_dyn_in** *[real,in,]*
- **tocnfrz_in** *[real,in,]* :: freezing temp of seawater (C)
- **rhofresh_in** *[real,in,]* :: density of fresh water (kg/m^3)
- **zvir_in** *[real,in,]* :: rh2o/rair - 1.0
- **vonkar_in** *[real,in,]* :: von Karman constant
- **cp_wv_in** *[real,in,]*
- **stefan_boltzmann_in** *[real,in,]*
- **ice_ref_salinity_in** *[real,in,]* :: (ppt)
- **tffresh_in** *[real,in,]*
- **lsub_in** *[real,in,]* :: latent heat, sublimation freshwater (J/kg)
- **lvap_in** *[real,in,]*
- **timelt_in** *[real,in,]* :: melting temperature, ice top surface (C)
- **tsmelt_in** *[real,in,]*
- **iceruf_in** *[real,in,]* :: ice surface roughness (m)
- **cf_in** *[real,in,]* :: ratio of ridging work to PE change in ridging
- **pstar_in** *[real,in,]*
- **cstar_in** *[real,in,]* :: constant in Hibler strength formula
- **kappav_in** *[real,in,]* :: vis extnctn coef in ice, wvlngth<700nm (1/m)
- **kice_in** *[real,in,]*
- **kseaice_in** *[real,in,]* :: thermal conductivity of sea ice (W/m/deg)
- **ksno_in** *[real,in,]*
- **zref_in** *[real,in,]*
- **hs_min_in** *[real,in,]* :: min snow thickness for computing zTsn (m)
- **snowpatch_in** *[real,in,]*
- **rhosi_in** *[real,in,]* :: average sea ice density (kg/m2)
- **sk_l_in** *[real,in,]* :: skeletal layer thickness (m)
- **saltmax_in** *[real,in,]* :: max salinity at ice base for BL99 (ppt)
- **phi_init_in** *[real,in,]*
- **min_salin_in** *[real,in,]* :: threshold for brine pocket treatment
- **salt_loss_in** *[real,in,]*
- **min_bgc_in** *[real,in,]* :: fraction of ocean bgc concentration in surface melt
- **dsin0_frazil_in** *[real,in,]* :: bulk salinity reduction of newly formed frazil
- **hi_ssl_in** *[real,in,]*
- **hs_ssl_in** *[real,in,]* :: visible, direct
- **awtvdr_in** *[real,in,]*
- **awtidr_in** *[real,in,]* :: near IR, direct ! diagnostics
- **awtvdf_in** *[real,in,]*
- **awtidf_in** *[real,in,]* :: near IR, diffuse
- **qqqice_in** *[real,in,]* :: for qsat over ice
- **tttice_in** *[real,in,]*
- **qqqocn_in** *[real,in,]* :: for qsat over ocn
- **tttocn_in** *[real,in,]* :: for qsat over ocn
- **ktherm_in** *[integer,in,]* :: type of thermodynamics
- **conduct_in** *[character,in,]* :: 'MU71' or 'bubbly'
- **fbot_xfer_type_in** *[character,in,]* :: transfer coefficient type for ice-ocean heat flux
- **calc_tsfc_in** *[real]* :: if false, Tsfc is computed elsewhere and
- **dts_b_in** *[real,in,]* :: zsalinity timestep
- **update_ocn_f_in** *[real]* :: include fresh water and salt fluxes for frazil
- **ustar_min_in** *[real,in,]* :: minimum friction velocity for ice-ocean heat flux
- **a_rapid_mode_in** *[real,in,]* :: channel radius for rapid drainage mode (m)
- **rac_rapid_mode_in** *[real,in,]*
- **aspect_rapid_mode_in** *[real,in,]* :: aspect ratio for rapid drainage mode (larger=wider)
- **dsdt_slow_mode_in** *[real,in,]*
- **phi_c_slow_mode_in** *[real,in,]* :: liquid fraction porosity cutoff for slow mode
- **phi_i_mushy_in** *[real,in,]* :: liquid fraction of congelation ice
- **shortwave_in** *[character,in,]* :: shortwave method, 'ccsm3' or 'dEdd'
- **albedo_type_in** *[character,in,]* :: albedo parameterization, 'ccsm3' or 'constant'

Call to: `icepack_recompute_constants()`, `icepack_warnings_aborted()`

3.5.5.2. icepack_query_parameters

subroutine **`icepack_query_parameters`**([*puny_out*[, *bignum_out*[, *pi_out*[, *rad_to_deg_out*[, *secday_out*[, *c0_out*[, *c1_out*[, *c1p5_out*[, *c2_out*[, *c3_out*[, *c4_out*[, *c5_out*[, *c6_out*[, *c8_out*[, *c10_out*[, *c15_out*[, *c16_out*[, *c20_out*[, *c25_out*[, *c100_out*[, *c180_out*[, *c1000_out*[, *p001_out*[, *p01_out*[, *p1_out*[, *p2_out*[, *p4_out*[, *p5_out*[, *p6_out*[, *p05_out*[, *p15_out*[, *p25_out*[, *p75_out*[, *p333_out*[, *p666_out*[, *spval_const_out*[, *pih_out*[, *piq_out*[, *pi2_out*[, *rhos_out*[, *rhoi_out*[, *rhow_out*[, *cp_air_out*[, *emissivity_out*[, *cp_ice_out*[, *cp_ocn_out*[, *depresst_out*[, *dragio_out*[, *albocn_out*[, *gravit_out*[, *viscosity_dyn_out*[, *tocnfrz_out*[, *rhofresh_out*[, *zvir_out*[, *vonkar_out*[, *cp_wv_out*[, *stefan_boltzmann_out*[, *ice_ref_salinity_out*[, *tffresh_out*[, *lsub_out*[, *lvap_out*[, *timelt_out*[, *tsmelt_out*[, *iceruf_out*[, *cf_out*[, *pstar_out*[, *cstar_out*[, *kappav_out*[, *kice_out*[, *kseaice_out*[, *ksno_out*[, *zref_out*[, *hs_min_out*[, *snowpatch_out*[, *rhosi_out*[, *sk_l_out*[, *saltmax_out*[, *phi_init_out*[, *min_salin_out*[, *salt_loss_out*[, *min_bgc_out*[, *dsin0_frazil_out*[, *hi_ssl_out*[, *hs_ssl_out*[, *awtvdr_out*[, *awtidr_out*[, *awtvdf_out*[, *awtidf_out*[, *qqqice_out*[, *tttice_out*[, *qqqocn_out*[, *tttocn_out*, *update_ocn_f_out*[, *lfresh_out*[, *cprho_out*[, *cp_out*[, *ustar_min_out*[, *a_rapid_mode_out*[, *ktherm_out*[, *conduct_out*[, *fbot_xfer_type_out*, *calc_tsfc_out*[, *dts_b_out*[, *rac_rapid_mode_out*[, *aspect_rapid_mode_out*[, *dsdt_slow_mode_out*[, *phi_c_slow_mode_out*[, *phi_i_mushy_out*[, *shortwave_out*[, *albedo_type_out*[, *albicev_out*[, *albicei_out*[, *albsnowv_out*[, *albsnowi_out*[, *ahmax_out*[, *r_ice_out*[, *r_pnd_out*[, *r_snw_out*[, *dt_mlt_out*, *rsnw_mlt_out*[, *dedd_algae_out*, *kalg_out*[, *kstrength_out*, *krdg_partic_out*, *krdg_redist_out*[, *mu_rdg_out*[, *atmbndy_out*[, *calc_strair_out*[, *formdrag_out*[, *highfreq_out*[, *natmiter_out*[, *tfrz_option_out*[, *kitd_out*, *kcatbound_out*[, *hs0_out*[, *frzpnd_out*[, *dpscale_out*[, *rfracmin_out*[, *rfracmax_out*[, *pndaspect_out*[, *hs1_out*[, *hp1_out*[, *bgc_flux_type_out*[, *z_tracers_out*[, *scale_bgc_out*[, *solve_zbgc_out*[, *modal_aero_out*[, *skl_bgc_out*[, *solve_zsal_out*[, *grid_o_out*[, *l_sk_out*[, *initbio_frac_out*[, *grid_os_out*[, *l_sks_out*[, *phi_snow_out*[, *heat_capacity_out*[, *fr_resp_out*[, *algal_vel_out*[, *r_dfe2dust_out*[, *dustfe_sol_out*[, *t_max_out*[, *fsal_out*[, *op_dep_min_out*[, *fr_graze_s_out*[, *fr_graze_e_out*[, *fr_mort2min_out*, *fr_resp_s_out*[, *fr_dfe_out*, *k_nitrif_out*, *t_iron_conv_out*, *max_loss_out*, *max_dfe_doc1_out*, *y_sk_dms_out*, *t_sk_conv_out*, *t_sk_ox_out*, *frazil_scav_out*]]])

Parameters:
- **puny_out** *[real,out,]* :: a small number
- **bignum_out** *[real,out,]*
- **pi_out** *[real,out,]* :: pi
- **rad_to_deg_out** *[real,out,]*
- **secday_out** *[real,out,]*
- **c0_out** *[real,out,]*
- **c1_out** *[real,out,]*
- **c1p5_out** *[real,out,]*
- **c2_out** *[real,out,]*
- **c3_out** *[real,out,]*
- **c4_out** *[real,out,]*
- **c5_out** *[real,out,]*
- **c6_out** *[real,out,]*
- **c8_out** *[real,out,]*
- **c10_out** *[real,out,]*
- **c15_out** *[real,out,]*
- **c16_out** *[real,out,]*
- **c20_out** *[real,out,]*
- **c25_out** *[real,out,]*
- **c100_out** *[real,out,]*
- **c180_out** *[real,out,]*
- **c1000_out** *[real,out,]*
- **p001_out** *[real,out,]*
- **p01_out** *[real,out,]*
- **p1_out** *[real,out,]*
- **p2_out** *[real,out,]*
- **p4_out** *[real,out,]*
- **p5_out** *[real,out,]*
- **p6_out** *[real,out,]*
- **p05_out** *[real,out,]*
- **p15_out** *[real,out,]*
- **p25_out** *[real,out,]*
- **p75_out** *[real,out,]*
- **p333_out** *[real,out,]*
- **p666_out** *[real,out,]*
- **spval_const_out** *[real,out,]*
- **pih_out** *[real,out,]*
- **piq_out** *[real,out,]*
- **pi2_out** *[real,out,]*
- **rhos_out** *[real,out,]* :: density of snow (kg/m^3)
- **rhoi_out** *[real,out,]*
- **rhow_out** *[real,out,]*
- **cp_air_out** *[real,out,]* :: specific heat of air (J/kg/K)
- **emissivity_out** *[real,out,]* :: emissivity of snow and ice
- **cp_ice_out** *[real,out,]* :: specific heat of fresh ice (J/kg/K)
- **cp_ocn_out** *[real,out,]*
- **depresst_out** *[real,out,]* :: Tf:brine salinity ratio (C/ppt)
- **dragio_out** *[real,out,]*
- **albocn_out** *[real,out,]*
- **gravit_out** *[real,out,]* :: gravitational acceleration (m/s^2)
- **viscosity_dyn_out** *[real,out,]*
- **tocnfrz_out** *[real,out,]* :: freezing temp of seawater (C)
- **rhofresh_out** *[real,out,]* :: density of fresh water (kg/m^3)
- **zvir_out** *[real,out,]* :: rh2o/rair - 1.0
- **vonkar_out** *[real,out,]* :: von Karman constant
- **cp_wv_out** *[real,out,]*
- **stefan_boltzmann_out** *[real,out,]*
- **ice_ref_salinity_out** *[real,out,]* :: (ppt)
- **tffresh_out** *[real,out,]*
- **lsub_out** *[real,out,]* :: latent heat, sublimation freshwater (J/kg)
- **lvap_out** *[real,out,]*
- **timelt_out** *[real,out,]* :: melting temperature, ice top surface (C)
- **tsmelt_out** *[real,out,]*
- **iceruf_out** *[real,out,]* :: ice surface roughness (m)
- **cf_out** *[real,out,]* :: ratio of ridging work to PE change in ridging
- **pstar_out** *[real,out,]*
- **cstar_out** *[real,out,]* :: constant in Hibler strength formula
- **kappav_out** *[real,out,]* :: vis extnctn coef in ice, wvlngth<700nm (1/m)
- **kice_out** *[real,out,]*
- **kseaice_out** *[real,out,]* :: thermal conductivity of sea ice (W/m/deg)
- **ksno_out** *[real,out,]*
- **zref_out** *[real,out,]*

Call to: `icepack_recompute_constants()`, `icepack_warnings_aborted()`

3.5.5.3. icepack_write_parameters

subroutine **`icepack_write_parameters`**(*iounit*)

Parameters: **iounit** *[integer,in]* :: unit number for output

3.5.5.4. icepack_recompute_constants

subroutine **`icepack_recompute_constants`**()

Called from: `icepack_init_parameters()`, `icepack_query_parameters()`

3.5.5.5. icepack_compute_tracers

3.5.5.6. icepack_query_tracer_sizes

3.5.5.7. icepack_write_tracer_sizes

3.5.5.8. icepack_init_tracer_flags

3.5.5.9. icepack_query_tracer_flags

3.5.5.10. icepack_write_tracer_flags

3.5.5.11. icepack_init_tracer_indices

3.5.5.12. icepack_query_tracer_indices

3.5.5.13. icepack_write_tracer_indices

3.5.5.14. icepack_init_tracer_numbers

3.5.5.15. icepack_query_tracer_numbers

3.5.5.16. icepack_write_tracer_numbers

3.5.5.17. icepack_init_itd

subroutine **`icepack_init_itd`**(*ncat*, *hin_max*)

Parameters:
- **ncat** *[integer,in]* :: number of thickness categories
- **hin_max** (ncat + 1) *[real,out]* :: minimum ice thickness, m

Call to: `icepack_warnings_add()`, `icepack_warnings_setabort()`

3.5.5.18. icepack_init_itd_hist

subroutine **`icepack_init_itd_hist`**(*ncat*, *hin_max*, *c_hi_range*)

Options: **ncat** *[integer,in,optional/default=(len(hin_max)-1)]* :: number of thickness categories

Parameters:
- **hin_max** (ncat + 1) *[real,in]* :: category limits (m)
- **c_hi_range** (ncat) *[character,out]* :: string for history output

Call to: `icepack_warnings_add()`

3.5.5.19. icepack_aggregate

subroutine **`icepack_aggregate`**(*ncat*, *aicen*, *trcrn*, *vicen*, *vsnon*, *aice*, *trcr*, *vice*, *vsno*, *aice0*, *ntrcr*, *trcr_depend*, *trcr_base*, *n_trcr_strata*, *nt_strata*)

Parameters:
- **ncat** *[integer,in]* :: number of thickness categories
- **aicen** (*) *[real,in]* :: concentration of ice
- **trcrn** (,) *[real,inout]* :: ice tracers
- **vicen** (*) *[real,in]*
- **vsnon** (*) *[real,in]* :: volume per unit area of snow (m)
- **aice** *[real,out]* :: concentration of ice
- **trcr** (*) *[real,out]* :: ice tracers
- **vice** *[real,out]*
- **vsno** *[real,out]* :: volume per unit area of snow (m)
- **aice0** *[real,out]* :: concentration of open water
- **ntrcr** *[integer,in]* :: number of tracers in use
- **trcr_depend** (*) *[integer,in]* :: = 0 for aicen tracers, 1 for vicen, 2 for vsnon
- **trcr_base** (,) *[real,in]* :: = 0 or 1 depending on tracer dependency
- **n_trcr_strata** (*) *[integer,in]* :: number of underlying tracer layers
- **nt_strata** (,) *[integer,in]* :: indices of underlying tracer layers

Call to: `icepack_warnings_aborted()`

3.5.5.20. icepack_step_ridge

subroutine **`icepack_step_ridge`**(*dt*, *ndtd*, *nilyr*, *nslyr*, *nblyr*, *ncat*, *hin_max*, *rdg_conv*, *rdg_shear*, *aicen*, *trcrn*, *vicen*, *vsnon*, *aice0*, *trcr_depend*, *trcr_base*, *n_trcr_strata*, *nt_strata*, *dardg1dt*, *dardg2dt*, *dvirdgdt*, *opening*, *fpond*, *fresh*, *fhocn*, *n_aero*, *faero_ocn*, *aparticn*, *krdgn*, *aredistn*, *vredistn*, *dardg1ndt*, *dardg2ndt*, *dvirdgndt*, *araftn*, *vraftn*, *aice*, *fsalt*, *first_ice*, *fzsal*, *flux_bio*[, *closing*])

Parameters:
- **dt** *[real,in]* :: time step
- **ndtd** *[integer,in]* :: for proper averaging over thermo timestep
- **nilyr** *[integer,in]*
- **nslyr** *[integer,in]* :: number of snow layers
- **nblyr** *[integer,in]* :: number of bio layers
- **hin_max** (ncat + 1) *[real,inout]* :: category limits (m)
- **rdg_conv** *[real,inout]* :: convergence term for ridging (1/s)
- **rdg_shear** *[real,inout]*
- **aicen** (*) *[real,inout]* :: concentration of ice
- **trcrn** (,) *[real,inout]* :: tracers
- **vicen** (*) *[real,inout]*
- **vsnon** (*) *[real,inout]* :: volume per unit area of snow (m)
- **aice0** *[real,inout]*
- **trcr_depend** (*) *[integer,in]* :: = 0 for aicen tracers, 1 for vicen, 2 for vsnon
- **trcr_base** (,) *[real,in]* :: = 0 or 1 depending on tracer dependency
- **n_trcr_strata** (*) *[integer,in]* :: number of underlying tracer layers
- **nt_strata** (,) *[integer,in]* :: indices of underlying tracer layers
- **dardg1dt** *[real,inout]* :: rate of area loss by ridging ice (1/s)
- **dardg2dt** *[real,inout]*
- **dvirdgdt** *[real,inout]* :: rate of ice volume ridged (m/s)
- **opening** *[real,inout]*
- **fpond** *[real,inout]* :: fresh water flux to ponds (kg/m^2/s)
- **fresh** *[real,inout]*
- **fhocn** *[real,inout]*
- **n_aero** *[integer,in]* :: number of aerosol tracers
- **faero_ocn** (*) *[real,inout]* :: aerosol flux to ocean (kg/m^2/s)
- **aparticn** (*) *[real,inout]* :: participation function
- **krdgn** (*) *[real,inout]*
- **aredistn** (*) *[real,inout]* :: redistribution function: fraction of new ridge area
- **vredistn** (*) *[real,inout]*
- **dardg1ndt** (*) *[real,inout]*
- **dardg2ndt** (*) *[real,inout]* :: rate of area gain by new ridges (1/s)
- **dvirdgndt** (*) *[real,inout]*
- **araftn** (*) *[real,inout]* :: rafting ice area
- **vraftn** (*) *[real,inout]*
- **aice** *[real,inout]* :: sea ice concentration
- **fsalt** *[real,inout]* :: salt flux to ocean (kg/m^2/s)
- **first_ice** (*) *[logical,inout]* :: true until ice forms
- **fzsal** *[real,inout]* :: zsalinity flux to ocean(kg/m^2/s)
- **flux_bio** (*) *[real,inout]* :: all bio fluxes to ocean
- **closing** *[real,inout,]* :: rate of closing due to divergence/shear (1/s)

Options: **ncat** *[integer,in,optional/default=(len(hin_max)-1)]* :: number of thickness categories

Call to: `ridge_ice()`, `icepack_warnings_aborted()`, `cleanup_itd()`

3.5.5.21. icepack_ice_strength

subroutine **`icepack_ice_strength`**(*ncat*, *aice*, *vice*, *aice0*, *aicen*, *vicen*, *strength*)

Parameters:
- **ncat** *[integer,in]* :: number of thickness categories
- **aice** *[real,in]* :: concentration of ice
- **vice** *[real,in]*
- **aice0** *[real,in]* :: concentration of open water
- **aicen** (*) *[real,in]* :: concentration of ice
- **vicen** (*) *[real,in]* :: volume per unit area of ice (m)
- **strength** *[real,inout]* :: ice strength (N/m)

Call to: `asum_ridging()`, `icepack_warnings_aborted()`, `ridge_itd()`

3.5.5.22. icepack_prep_radiation

subroutine **icepack_prep_radiation**(*ncat*, *nilyr*, *nslyr*, *aice*, *aicen*, *swvdr*, *swvdf*, *swidr*, *swidf*, *alvdr_ai*, *alvdf_ai*, *alidr_ai*, *alidf_ai*, *scale_factor*, *fswsfcn*, *fswintn*, *fswthrun*, *fswpenln*, *sswabsn*, *iswabsn*)

Parameters:
- **ncat** *[integer,in]* :: number of ice thickness categories
- **nilyr** *[integer,in]*
- **nslyr** *[integer,in]* :: number of snow layers
- **aice** *[real,in]* :: ice area fraction
- **aicen** (*) *[real,in]* :: ice area fraction in each category
- **swvdr** *[real,in]*
- **swvdf** *[real,in]* :: sw down, visible, diffuse (W/m^2)
- **swidr** *[real,in]*
- **swidf** *[real,in]* :: sw down, near IR, diffuse (W/m^2)
- **alvdr_ai** *[real]*
- **alvdf_ai** *[real]*
- **alidr_ai** *[real]* :: near-ir, direct (fraction)
- **alidf_ai** *[real]* :: near-ir, diffuse (fraction)
- **scale_factor** *[real,inout]* :: shortwave scaling factor, ratio new:old
- **fswsfcn** (*) *[real,inout]* :: SW absorbed at ice/snow surface (W m-2)
- **fswintn** (*) *[real,inout]*
- **fswthrun** (*) *[real,inout]* :: SW through ice to ocean (W/m^2)
- **fswpenln** (,) *[real,inout]* :: visible SW entering ice layers (W m-2)
- **sswabsn** (,) *[real,inout]* :: SW radiation absorbed in snow layers (W m-2)
- **iswabsn** (,) *[real,inout]*

3.5.5.23. icepack_step_radiation

subroutine **icepack_step_radiation**(*dt*, *ncat*, *n_algae*, *tr_zaero*, *nblyr*, *ntrcr*, *nbtrcr_sw*, *nilyr*, *nslyr*, *n_aero*, *n_zaero*, *dedd_algae*, *nlt_chl_sw*, *nlt_zaero_sw*, *swgrid*, *igrid*, *fbri*, *aicen*, *vicen*, *vsnon*, *tsfcn*, *alvln*, *apndn*, *hpndn*, *ipndn*, *aeron*, *zbion*, *trcrn*, *tlat*, *tlon*, *calendar_type*, *days_per_year*, *nextsw_cday*, *yday*, *sec*, *kaer_tab*, *waer_tab*, *gaer_tab*, *kaer_bc_tab*, *waer_bc_tab*, *gaer_bc_tab*, *bcenh*, *modal_aero*, *swvdr*, *swvdf*, *swidr*, *swidf*, *coszen*, *fsnow*, *alvdrn*, *alvdfn*, *alidrn*, *alidfn*, *fswsfcn*, *fswintn*, *fswthrun*, *fswpenln*, *sswabsn*, *iswabsn*, *albicen*, *albsnon*, *albpndn*, *apeffn*, *snowfracn*, *dhsn*, *ffracn*, *l_print_point*[, *initonly*])

Parameters:
- **dt** *[real,in]* :: time step (s)
- **ncat** *[integer,in]* :: number of ice thickness categories
- **n_algae** *[integer,in]*
- **tr_zaero** *[logical,in]*
- **nblyr** *[integer,in]*
- **ntrcr** *[integer,in]*
- **nbtrcr_sw** *[integer,in]*
- **nilyr** *[integer,in]*
- **nslyr** *[integer,in]* :: number of snow layers
- **n_aero** *[integer,in]*
- **n_zaero** *[integer,in]* :: number of zaerosols
- **dedd_algae** *[logical,in]*
- **nlt_chl_sw** *[integer,in]*
- **nlt_zaero_sw** (*) *[integer,in]* :: index for zaerosols
- **swgrid** (*) *[real,in]* :: grid for ice tracers used in dEdd scheme
- **igrid** (*) *[real,in]* :: biology vertical interface points
- **fbri** (*) *[real,in]* :: brine fraction
- **aicen** (*) *[real,in]* :: ice area fraction in each category
- **vicen** (*) *[real,in]*
- **vsnon** (*) *[real,in]* :: snow volume in each category (m)
- **tsfcn** (*) *[real,in]*
- **alvln** (*) *[real,in]* :: level-ice area fraction
- **apndn** (*) *[real,in]*
- **hpndn** (*) *[real,in]* :: pond depth (m)
- **ipndn** (*) *[real,in]*
- **aeron** (,) *[real,in]* :: aerosols (kg/m^3)
- **zbion** (,) *[real,inout]* :: zaerosols (kg/m^3) and chla (mg/m^3)
- **trcrn** (,) *[real,in]* :: tracers
- **tlat** *[real,in]*
- **tlon** *[real,in]* :: latitude and longitude (radian)
- **calendar_type** *[character,in]* :: differentiates Gregorian from other calendars
- **days_per_year** *[integer,in]* :: number of days in one year
- **nextsw_cday** *[real,in]* :: julian day of next shortwave calculation
- **yday** *[real,in]* :: day of the year
- **sec** *[integer,in]* :: elapsed seconds into date
- **kaer_tab** (,) *[real,in]* :: aerosol mass extinction cross section (m2/kg)
- **waer_tab** (,) *[real,in]*
- **gaer_tab** (,) *[real,in]* :: aerosol asymmetry parameter (cos(theta))
- **kaer_bc_tab** (,) *[real,in]* :: aerosol mass extinction cross section (m2/kg)
- **waer_bc_tab** (,) *[real,in]*
- **gaer_bc_tab** (,) *[real,in]* :: aerosol asymmetry parameter (cos(theta))
- **bcenh** (,,*) *[real,in]*
- **modal_aero** *[logical,in]* :: .true. use modal aerosol optical treatment
- **swvdr** *[real,in]*
- **swvdf** *[real,in]* :: sw down, visible, diffuse (W/m^2)
- **swidr** *[real,in]*
- **swidf** *[real,in]* :: sw down, near IR, diffuse (W/m^2)
- **coszen** *[real,inout]* :: cosine solar zenith angle, < 0 for sun below horizon
- **fsnow** *[real,in]*
- **alvdrn** (*) *[real,inout]* :: visible, direct albedo (fraction)
- **alvdfn** (*) *[real,inout]* :: visible, diffuse (fraction)
- **alidrn** (*) *[real,inout]*
- **alidfn** (*) *[real,inout]*
- **fswsfcn** (*) *[real,inout]* :: SW absorbed at ice/snow surface (W m-2)
- **fswintn** (*) *[real,inout]*
- **fswthrun** (*) *[real,inout]* :: SW through ice to ocean (W/m^2)
- **fswpenln** (,) *[real,inout]* :: visible SW entering ice layers (W m-2)
- **sswabsn** (,) *[real,inout]* :: SW radiation absorbed in snow layers (W m-2)
- **iswabsn** (,) *[real,inout]*
- **albicen** *[real]*
- **albsnon** *[real]* :: snow
- **albpndn** *[real]*
- **apeffn** *[real]* :: effective pond area used for radiation calculation
- **snowfracn** (*) *[real,inout]*
- **dhsn** (*) *[real,inout]* :: depth difference for snow on sea ice and pond ice
- **ffracn** (*) *[real,inout]* :: albedo components for history
- **l_print_point** *[logical,in]* :: flag for printing diagnostics
- **initonly** *[logical]* :: flag to indicate init only, default is false

Call to: `compute_shortwave_trcr()`, `icepack_warnings_aborted()`, `run_dedd()`, `shortwave_ccsm3()`, `icepack_warnings_add()`, `icepack_warnings_setabort()`

3.5.5.24. icepack_init_hbrine

subroutine **icepack_init_hbrine**(*bgrid*, *igrid*, *cgrid*, *icgrid*, *swgrid*, *nblyr*, *nilyr*, *phi_snow*)

Parameters:
- **bgrid** (nblyr + 2) *[real,out]* :: zsalinity grid points
- **igrid** (nblyr + 1) *[real,out]* :: ice top
- **cgrid** (nilyr + 1) *[real,out]* :: CICE vertical grid top point
- **icgrid** (nilyr + 1) *[real,out]*
- **swgrid** (nilyr + 1) *[real,out]* ::
  - swgrid(1)
- **nblyr** *[integer,in]* :: number of bio layers
- **nilyr** *[integer,in]* :: number of ice layers
- **phi_snow** *[real,inout]* :: porosity at the ice-snow interface

3.5.5.25. icepack_init_zsalinity

subroutine **icepack_init_zsalinity**(*nblyr*, *ntrcr_o*, *rayleigh_criteria*, *rayleigh_real*, *trcrn*, *nt_bgc_s*, *ncat*, *sss*)

Parameters:
- **nblyr** *[integer,in]* :: number of biolayers
- **ntrcr_o** *[integer,in]*
- **rayleigh_criteria** *[logical,inout]* :: no ice initial condition
- **rayleigh_real** *[real,inout]*
- **trcrn** (,) *[real,inout]* :: bgc subset of trcrn
- **nt_bgc_s** *[integer,in]* :: zsalinity index
- **ncat** *[integer,in]* :: number of categories
- **sss** *[real,in]*

3.5.5.26. icepack_init_bgc

subroutine **icepack_init_bgc**(*ncat*, *nblyr*, *nilyr*, *ntrcr_o*, *cgrid*, *igrid*, *ntrcr*, *nbtrcr*, *sicen*, *trcrn*, *sss*, *ocean_bio_all*)

Parameters:
- **ncat** *[integer,in,]* :: number of thickness categories
- **ntrcr_o** *[integer,in]*
- **cgrid** (nilyr + 1) *[real,inout]* :: CICE vertical coordinate
- **igrid** (nblyr + 1) *[real,inout]* :: biology vertical interface points
- **ntrcr** *[integer,in]* :: number of tracers in use
- **nbtrcr** *[integer,in]* :: number of bio tracers in use
- **sicen** (nilyr,ncat) *[real,in]* :: salinity on the cice grid
- **trcrn** (,) *[real,inout]* :: subset of tracer array (only bgc)
- **sss** *[real,in]* :: sea surface salinity (ppt)
- **ocean_bio_all** (*) *[real,inout]* :: fixed order, all values even for tracers false

Options:
- **nblyr** *[integer,in,optional/default=(len(igrid)-1)]* :: number of bio layers
- **nilyr** *[integer,in,optional/default=(len(cgrid)-1)]*

Call to: `icepack_warnings_aborted()`

3.5.5.27. icepack_init_zbgc

subroutine **icepack_init_zbgc**([*r_si2n_in*[, *r_s2n_in*[, *r_fe2c_in*[, *r_fe2n_in*[, *r_c2n_in*[, *r_c2n_don_in*[, *r_chl2n_in*[, *f_abs_chl_in*[, *r_fe2don_in*[, *r_fe2doc_in*[, *chlabs_in*[, *alpha2max_low_in*[, *beta2max_in*[, *mu_max_in*[, *fr_graze_in*[, *mort_pre_in*[, *mort_tdep_in*[, *k_exude_in*[, *k_nit_in*[, *k_am_in*[, *k_sil_in*[, *k_fe_in*[, *f_don_in*[, *kn_bac_in*[, *f_don_am_in*[, *f_doc_in*[, *f_exude_in*[, *k_bac_in*[, *grow_tdep_in*[, *zbgc_frac_init_in*[, *zbgc_init_frac_in*[, *tau_ret_in*[, *tau_rel_in*[, *bgc_tracer_type_in*[, *fr_resp_in*[, *algal_vel_in*[, *r_dfe2dust_in*[, *dustfe_sol_in*[, *t_max_in*[, *op_dep_min_in*[, *fr_graze_s_in*[, *fr_graze_e_in*[, *fr_mort2min_in*[, *fr_dfe_in*[, *k_nitrif_in*[, *t_iron_conv_in*[, *max_loss_in*[, *max_dfe_doc1_in*[, *fr_resp_s_in*[, *y_sk_dms_in*[, *t_sk_conv_in*[, *t_sk_ox_in*[, *fsal_in*]])

Parameters:
- **r_si2n_in** (*) *[real]* :: algal Sil to N (mole/mole)
- **r_s2n_in** (*) *[real]* :: algal S to N (mole/mole)
- **r_fe2c_in** (*) *[real]* :: algal Fe to carbon (umol/mmol)
- **r_fe2n_in** (*) *[real]* :: algal Fe to N (umol/mmol)
- **r_c2n_in** (*) *[real]* :: algal C to N (mole/mole)
- **r_c2n_don_in** (*) *[real]* :: increase compare to algal R_Fe2C
- **r_chl2n_in** (*) *[real]* :: 3 algal chlorophyll to N (mg/mmol)
- **f_abs_chl_in** (*) *[real]* :: to scale absorption in Dedd
- **r_fe2don_in** (*) *[real]* :: Fe to N of DON (nmol/umol)
- **r_fe2doc_in** (*) *[real]* :: Fe to C of DOC (nmol/umol)
- **chlabs_in** (*) *[real]* :: chla absorption 1/m/(mg/m^3)
- **alpha2max_low_in** (*) *[real]* :: light limitation (1/(W/m^2))
- **beta2max_in** (*) *[real]* :: light inhibition (1/(W/m^2))
- **mu_max_in** (*) *[real]* :: maximum growth rate (1/d)
- **fr_graze_in** (*) *[real]* :: fraction of algae grazed
- **mort_pre_in** (*) *[real]* :: mortality (1/day)
- **mort_tdep_in** (*) *[real]* :: T dependence of mortality (1/C)
- **k_exude_in** (*) *[real]* :: algal carbon exudation rate (1/d)
- **k_nit_in** (*) *[real]* :: nitrate half saturation (mmol/m^3)
- **k_am_in** (*) *[real]* :: ammonium half saturation (mmol/m^3)
- **k_sil_in** (*) *[real]* :: silicon half saturation (mmol/m^3)
- **k_fe_in** (*) *[real]* :: iron half saturation or micromol/m^3
- **f_don_in** (*) *[real]* :: fraction of spilled grazing to DON
- **kn_bac_in** (*) *[real]* :: Bacterial degredation of DON (1/d)
- **f_don_am_in** (*) *[real]* :: fraction of remineralized DON to Am
- **f_doc_in** (*) *[real]* :: fraction of mort_N that goes to each doc pool
- **f_exude_in** (*) *[real]* :: fraction of exuded carbon to each DOC pool
- **k_bac_in** (*) *[real]* :: Bacterial degredation of DOC (1/d)
- **grow_tdep_in** (*) *[real]* :: T dependence of growth (1/C)
- **zbgc_frac_init_in** (*) *[real]* :: initializes mobile fraction
- **zbgc_init_frac_in** (*) *[real]* :: fraction of ocean tracer concentration in new ice
- **tau_ret_in** (*) *[real]* :: retention timescale (s), mobile to stationary phase
- **tau_rel_in** (*) *[real]* :: release timescale (s), stationary to mobile phase
- **bgc_tracer_type_in** (*) *[real]* :: described tracer in mobile or stationary phases
- **fr_resp_in** *[real]* :: frac of algal growth lost due to respiration
- **algal_vel_in** *[real]* :: 0.5 cm/d(m/s) Lavoie 2005 1.5 cm/day
- **r_dfe2dust_in** *[real]* :: g/g (3.5% content) Tagliabue 2009
- **dustfe_sol_in** *[real]* :: solubility fraction
- **t_max_in** *[real]* :: maximum temperature (C)
- **op_dep_min_in** *[real]* :: Light attenuates for optical depths exceeding min
- **fr_graze_s_in** *[real]* :: fraction of grazing spilled or slopped
- **fr_graze_e_in** *[real]* :: fraction of assimilation excreted
- **fr_mort2min_in** *[real]* :: fractionation of mortality to Am
- **fr_dfe_in** *[real]* :: fraction of remineralized nitrogen
- **k_nitrif_in** *[real]* :: nitrification rate (1/day)
- **t_iron_conv_in** *[real]* :: desorption loss pFe to dFe (day)
- **max_loss_in** *[real]* :: restrict uptake to % of remaining value
- **max_dfe_doc1_in** *[real]* :: max ratio of dFe to saccharides in the ice (nM Fe/muM C)
- **fr_resp_s_in** *[real]* :: DMSPd fraction of respiration loss as DMSPd
- **y_sk_dms_in** *[real]* :: fraction conversion given high yield
- **t_sk_conv_in** *[real]* :: Stefels conversion time (d)
- **t_sk_ox_in** *[real]* :: DMS oxidation time (d)
- **fsal_in** *[real]* :: salinity limitation factor (1)

Call to: `n()`

3.5.5.28. icepack_biogeochemistry

subroutine **`icepack_biogeochemistry`**(*dt*, *ntrcr*, *nbtrcr*, *upno*, *upnh*, *idi*, *iki*, *zfswin*, *zsal_tot*, *darcy_v*, *grow_net*, *pp_net*, *hbri*, *dhbr_bot*, *dhbr_top*, *zoo*, *fbio_snoice*, *fbio_atmice*, *ocean_bio*, *first_ice*, *fswpenln*, *bphi*, *btiz*, *ice_bio_net*, *snow_bio_net*, *fswthrun*, *rayleigh_criteria*, *sice_rho*, *fzsal*, *fzsal_g*, *bgrid*, *igrid*, *icgrid*, *cgrid*, *nblyr*, *nilyr*, *nslyr*, *n_algae*, *n_zaero*, *ncat*, *n_doc*, *n_dic*, *n_don*, *n_fed*, *n_fep*, *meltbn*, *melttn*, *congeln*, *snoicen*, *sst*, *sss*, *fsnow*, *meltsn*, *hin_old*, *flux_bio*, *flux_bio_atm*, *aicen_init*, *vicen_init*, *aicen*, *vicen*, *vsnon*, *aice0*, *trcrn*, *vsnon_init*, *skl_bgc*)

Parameters:
- **dt** *[real,in]* :: time step
- **ntrcr** *[integer,in]*
- **nbtrcr** *[integer,in]*
- **upno** *[real,inout]* :: nitrate uptake rate (mmol/m^2/d) times aice
- **upnh** *[real,inout]* :: ammonium uptake rate (mmol/m^2/d) times aice
- **idi** *[integer]* :: igrid Diffusivity (m^2/s)
- **iki** *[integer]*
- **zfswin** *[real]*
- **zsal_tot** *[real,inout]*
- **darcy_v** (*) *[real,inout]*
- **grow_net** *[real,inout]* :: Specific growth rate (/s) per grid cell
- **pp_net** *[real,inout]*
- **hbri** *[real,inout]* :: brine height, area-averaged for comparison with hi (m)
- **dhbr_bot** (*) *[real,inout]* :: brine bottom change
- **dhbr_top** (*) *[real,inout]*
- **zoo** (,) *[real,inout]* :: N losses accumulated in timestep (ie. zooplankton/bacteria)
- **fbio_snoice** (*) *[real,inout]*
- **fbio_atmice** (*) *[real,inout]* :: fluxes from atm to ice
- **ocean_bio** (*) *[real,inout]* :: contains all the ocean bgc tracer concentrations
- **first_ice** (*) *[logical,inout]* :: distinguishes ice that disappears (e.g. melts)
- **fswpenln** (,) *[real,in]* :: visible SW entering ice layers (W m-2)
- **bphi** *[real]*
- **btiz** *[real]* :: layer temperatures interpolated on bio grid (C)
- **ice_bio_net** (*) *[real,inout]* :: depth integrated tracer (mmol/m^2)
- **snow_bio_net** (*) *[real,inout]*
- **fswthrun** (*) *[real,in]* :: SW through ice to ocean (W/m^2)
- **rayleigh_criteria** *[logical,inout]* :: .true. means Ra_c was reached
- **sice_rho** (*) *[real,inout]*
- **fzsal** *[real,inout]* :: Total flux of salt to ocean at time step for conservation
- **fzsal_g** *[real,inout]*
- **bgrid** (*) *[real,inout]* :: biology nondimensional vertical grid points
- **igrid** (*) *[real,inout]*
- **icgrid** (*) *[real,inout]*
- **cgrid** (*) *[real,inout]* :: CICE vertical coordinate
- **nblyr** *[integer,in]*
- **nilyr** *[integer,in]*
- **nslyr** *[integer,in]*
- **n_algae** *[integer,in]*
- **n_zaero** *[integer,in]*
- **ncat** *[integer,in]*
- **n_doc** *[integer,in]*
- **n_dic** *[integer,in]*
- **n_don** *[integer,in]*
- **n_fed** *[integer,in]*
- **n_fep** *[integer,in]*
- **meltbn** (*) *[real,in]*
- **melttn** (*) *[real,in]* :: top melt in category n (m)
- **congeln** (*) *[real,in]* :: congelation ice formation in category n (m)
- **snoicen** (*) *[real,in]*
- **sst** *[real,in]* :: sea surface temperature (C)
- **sss** *[real,in]*
- **fsnow** *[real,in]* :: snowfall rate (kg/m^2 s)
- **meltsn** (*) *[real,in]*
- **hin_old** (*) *[real,inout]* :: old ice thickness
- **flux_bio** (*) *[real,inout]* :: all bio fluxes to ocean
- **flux_bio_atm** (*) *[real,in]* :: all bio fluxes to ice from atmosphere
- **aicen_init** (*) *[real,in]*
- **vicen_init** (*) *[real,in]* :: initial ice volume (m), for linear ITD
- **aicen** (*) *[real,in]* :: concentration of ice
- **vicen** (*) *[real,in]*
- **vsnon** (*) *[real,in]* :: volume per unit area of snow (m)
- **aice0** *[real,in]* :: open water area fraction
- **trcrn** *[real]* :: tracers
- **vsnon_init** (*) *[real,in]*
- **skl_bgc** *[logical,in]* :: if true, solve skeletal biochemistry

Call to: `n()`, `preflushing_changes()`, `icepack_warnings_aborted()`, `compute_micros()`, `compute_micros_mushy()`, `update_hbrine()`

3.5.5.29. icepack_init_OceanConcArray

subroutine **`icepack_init_oceanconcarray`**(*max_nbtrcr*, *max_algae*, *max_don*, *max_doc*, *max_dic*,

max_aero, *max_fe*, *nit*, *amm*, *sil*, *dmsp*, *dms*, *algaln*, *doc*, *don*, *dic*, *fed*, *fep*, *zaeros*, *ocean_bio_all*, *hum*)

Options:
- **max_nbtrcr** *[integer,in,optional/default=len(ocean_bio_all)]* :: maximum number of bio tracers
- **max_algae** *[integer,in,optional/default=len(algaln)]* :: maximum number of algal types
- **max_don** *[integer,in,optional/default=len(don)]*
- **max_doc** *[integer,in,optional/default=len(doc)]* :: maximum number of dissolved organic carbon types
- **max_dic** *[integer,in,optional/default=len(dic)]*
- **max_aero** *[integer,in,optional/default=len(zaeros)]*
- **max_fe** *[integer,in,optional/default=len(fed)]* :: maximum number of iron types

Parameters:
- **nit** *[real,in]* :: PON
- **amm** *[real,in]* :: Am
- **sil** *[real,in]* :: Sil
- **dmsp** *[real,in]* :: DMSPd
- **dms** *[real,in]* :: DMS
- **algaln** (max_algae) *[real,in]* :: chl
- **doc** (max_doc) *[real,in]* :: doc
- **don** (max_don) *[real,in]* :: don
- **dic** (max_dic) *[real,in]* :: dic
- **fed** (max_fe) *[real,in]* :: fed
- **fep** (max_fe) *[real,in]* :: fep
- **zaeros** (max_aero) *[real,in]* :: zaero
- **ocean_bio_all** (max_nbtrcr) *[real,inout]* :: fixed order, all values even for tracers false
- **hum** *[real,in]* :: humics

3.5.5.30. icepack_init_ocean_conc

subroutine **icepack_init_ocean_conc**(*amm*, *dmsp*, *dms*, *algaln*, *doc*, *dic*, *don*, *fed*, *fep*, *hum*, *nit*, *sil*, *zaeros*, *max_dic*, *max_don*, *max_fe*, *max_aero*[, *cton*[, *cton_don*]])

Parameters:
- **amm** *[real,out]* :: ISPOL < 1 mmol/m^3
- **dmsp** *[real,out]*
- **dms** *[real,out]* :: DMS
- **algaln** (*) *[real,out]* :: ISPOL, Lannuzel 2013(Phaeocystis)
- **doc** (*) *[real,out]*
- **dic** (*) *[real,out]* :: DIC
- **don** (*) *[real,out]*
- **fed** (*) *[real,out]* :: c1 (nM) Lannuzel2007 DFe,
- **fep** (*) *[real,out]* :: (nM) van der Merwe 2011
- **hum** *[real,out]* :: mmol C/m^3
- **nit** *[real,out]* :: nitrate
- **sil** *[real,out]* :: silicate
- **zaeros** (*) *[real,out]* :: BC and dust
- **max_dic** *[integer,in]*
- **max_don** *[integer,in]*
- **max_fe** *[integer,in]* :: ki, max_fe
- **max_aero** *[integer,in]*
- **cton** (*) *[real,inout,]* :: carbon to nitrogen ratio for algae
- **cton_don** (*) *[real,inout,]* :: nitrogen to carbon ratio for proteins

3.5.5.31. icepack_atm_boundary

subroutine **icepack_atm_boundary**(*sfctype*, *tsf*, *pott*, *uatm*, *vatm*, *wind*, *zlvl*, *qa*, *rhoa*, *strx*, *stry*, *tref*, *qref*, *delt*, *delq*, *lhcoef*, *shcoef*, *cdn_atm*, *cdn_atm_ratio_n*[, *uvel*[, *vvel*[, *uref*]]])

Parameters:
- **sfctype** *[character,in]* :: ice or ocean
- **tsf** *[real,in]* :: surface temperature of ice or ocean
- **pott** *[real,in]*
- **uatm** *[real,in]* :: x-direction wind speed (m/s)
- **vatm** *[real,in]*
- **wind** *[real,in]* :: wind speed (m/s)
- **zlvl** *[real,in]*
- **qa** *[real,in]* :: specific humidity (kg/kg)
- **rhoa** *[real,in]* :: air density (kg/m^3)
- **strx** *[real,inout]*
- **stry** *[real,inout]* :: y surface stress (N)
- **tref** *[real,inout]* :: reference height temperature (K)
- **qref** *[real,inout]*
- **delt** *[real,inout]* :: potential T difference (K)
- **delq** *[real,inout]*
- **lhcoef** *[real,inout]* :: transfer coefficient for latent heat
- **shcoef** *[real,inout]* :: transfer coefficient for sensible heat
- **cdn_atm** *[real,inout]* :: neutral drag coefficient
- **cdn_atm_ratio_n** *[real,inout]* :: ratio drag coeff / neutral drag coeff
- **uvel** *[real,in,]* :: x-direction ice speed (m/s)
- **vvel** *[real,in,]* :: y-direction ice speed (m/s)
- **uref** *[real,out,]* :: reference height wind speed (m/s)

Called from: `icepack_step_therm1()`

Call to: `atmo_boundary_const()`, `icepack_warnings_aborted()`, `atmo_boundary_layer()`

3.5.5.32. icepack_ocn_mixed_layer

subroutine **icepack_ocn_mixed_layer**(*alvdr_ocn*, *swvdr*, *alidr_ocn*, *swidr*, *alvdf_ocn*, *swvdf*, *alidf_ocn*, *swidf*, *sst*, *flwout_ocn*, *fsens_ocn*, *shcoef*, *flat_ocn*, *lhcoef*, *evap_ocn*, *flw*, *delt*, *delq*, *aice*, *fhocn*, *fswthru*, *hmix*, *tf*, *qdp*, *frzmlt*, *dt*)

Parameters:
- **alvdr_ocn** *[real,in]* :: visible, direct (fraction)
- **swvdr** *[real,in]* :: sw down, visible, direct (W/m^2)
- **alidr_ocn** *[real,in]*
- **swidr** *[real,in]* :: sw down, near IR, direct (W/m^2)
- **alvdf_ocn** *[real,in]* :: visible, diffuse (fraction)
- **swvdf** *[real,in]*
- **alidf_ocn** *[real,in]*
- **swidf** *[real,in]*
- **sst** *[real,inout]*
- **flwout_ocn** *[real,inout]* :: outgoing longwave radiation (W/m^2)
- **fsens_ocn** *[real,inout]*
- **shcoef** *[real,in]*
- **flat_ocn** *[real,inout]* :: latent heat flux (W/m^2)
- **lhcoef** *[real,in]* :: transfer coefficient for latent heat
- **evap_ocn** *[real,inout]*
- **flw** *[real,in]* :: incoming longwave radiation (W/m^2)
- **delt** *[real,in]*
- **delq** *[real,in]* :: specific humidity difference (kg/kg)
- **aice** *[real,in]*
- **fhocn** *[real,in]*
- **fswthru** *[real,in]* :: shortwave penetrating to ocean (W/m^2)
- **hmix** *[real,in]* :: mixed layer depth (m)
- **tf** *[real,in]*
- **qdp** *[real,inout]* :: deep ocean heat flux (W/m^2), negative upward
- **frzmlt** *[real,inout]* :: freezing/melting potential (W/m^2)
- **dt** *[real,in]* :: time step (s)

3.5.5.33. icepack_init_orbit

subroutine **icepack_init_orbit**([*iyear_ad_in*[, *eccen_in*[, *obliqr_in*[, *lambm0_in*[, *mvelpp_in*[, *obliq_in*[, *mvelp_in*[, *decln_in*[, *eccf_in*[, *log_print_in*]]]]]]]]]])

Parameters:
- **iyear_ad_in** *[integer,in,]* :: Year to calculate orbit for
- **eccen_in** *[real,in,]* :: Earth's orbital eccentricity
- **obliqr_in** *[real,in,]* :: Earth's obliquity in radians
- **lambm0_in** *[real,in,]* :: Mean longitude of perihelion at the
- **mvelpp_in** *[real,in,]* :: Earth's moving vernal equinox longitude
- **obliq_in** *[real,in,]* :: obliquity in degrees
- **mvelp_in** *[real,in,]* :: moving vernal equinox long
- **decln_in** *[real,in,]* :: solar declination angle in radians
- **eccf_in** *[real,in,]* :: earth orbit eccentricity factor
- **log_print_in** *[logical,in,]* :: Flags print of status/error

Call to: `shr_orb_params()`, `icepack_warnings_aborted()`

3.5.5.34. icepack_query_orbit

subroutine **`icepack_query_orbit`**([*iyear_ad_out*[, *eccen_out*[, *obliqr_out*[, *lambm0_out*[, *mvelpp_out*[, *obliq_out*[, *mvelp_out*[, *decln_out*[, *eccf_out*[, *log_print_out*]]]]]]]]]])

Parameters:
- **iyear_ad_out** *[integer,out,]* :: Year to calculate orbit for
- **eccen_out** *[real,out,]* :: Earth's orbital eccentricity
- **obliqr_out** *[real,out,]* :: Earth's obliquity in radians
- **lambm0_out** *[real,out,]* :: Mean longitude of perihelion at the
- **mvelpp_out** *[real,out,]* :: Earth's moving vernal equinox longitude
- **obliq_out** *[real,out,]* :: obliquity in degrees
- **mvelp_out** *[real,out,]* :: moving vernal equinox long
- **decln_out** *[real,out,]* :: solar declination angle in radians
- **eccf_out** *[real,out,]* :: earth orbit eccentricity factor
- **log_print_out** *[logical,out,]* :: Flags print of status/error

Call to: `shr_orb_params()`, `icepack_warnings_aborted()`

3.5.5.35. icepack_step_therm1

subroutine **`icepack_step_therm1`**(*dt*, *ncat*, *nilyr*, *nslyr*, *n_aero*, *aicen_init*, *vicen_init*, *vsnon_init*, *aice*, *aicen*, *vice*, *vicen*, *vsno*, *vsnon*, *uvel*, *vvel*, *tsfc*, *zqsn*, *zqin*, *zsin*, *alvl*, *vlvl*, *apnd*, *hpnd*, *ipnd*, *iage*, *fy*, *aerosno*, *aeroice*, *uatm*, *vatm*, *wind*, *zlvl*, *qa*, *rhoa*, *tair*, *tref*, *qref*, *uref*, *cdn_atm_ratio*, *cdn_ocn*, *cdn_ocn_skin*, *cdn_ocn_floe*, *cdn_ocn_keel*, *cdn_atm*, *cdn_atm_skin*, *cdn_atm_floe*, *cdn_atm_pond*, *cdn_atm_rdg*, *hfreebd*, *hdraft*, *hridge*, *distrdg*, *hkeel*, *dkeel*, *lfloe*, *dfloe*, *strax*, *stray*, *strairxt*, *strairyt*, *pott*, *sst*, *sss*, *tf*, *strocnxt*, *strocnyt*, *fbot*, *tbot*, *tsnice*, *frzmlt*, *rside*, *fsnow*, *frain*, *fpond*, *fsurf*, *fsurfn*, *fcondtop*, *fcondtopn*, *fcondbot*, *fcondbotn*, *fswsfcn*, *fswintn*, *fswthrun*, *fswabs*, *flwout*, *sswabsn*, *iswabsn*, *flw*, *fsens*, *fsensn*, *flat*, *flatn*, *evap*, *evaps*, *evapi*, *fresh*, *fsalt*, *fhocn*, *fswthru*, *flatn_f*, *fsensn_f*, *fsurfn_f*, *fcondtopn_f*, *faero_atm*, *faero_ocn*, *dhsn*, *ffracn*, *meltt*, *melttn*, *meltb*, *meltbn*, *melts*, *meltsn*, *congel*, *congeln*, *snoice*, *snoicen*, *dsnown*, *lmask_n*, *lmask_s*, *mlt_onset*, *frz_onset*, *yday*[, *prescribed_ice*])

Parameters:

- **dt** *[real,in]* :: time step
- **ncat** *[integer,in]* :: number of thickness categories
- **nilyr** *[integer,in]*
- **nslyr** *[integer,in]* :: number of snow layers
- **n_aero** *[integer,in]* :: number of aerosol tracers in use
- **aicen_init** (*) *[real,inout]* :: fractional area of ice
- **vicen_init** (*) *[real,inout]*
- **vsnon_init** (*) *[real,inout]* :: volume per unit area of snow (m)
- **aice** *[real,inout]* :: sea ice concentration
- **aicen** (*) *[real,inout]* :: m
- **vice** *[real,inout]*
- **vicen** (*) *[real,inout]* :: volume per unit area of ice (m)
- **vsno** *[real,inout]* :: volume per unit area of snow (m)
- **vsnon** (*) *[real,inout]*
- **uvel** *[real,in]*
- **vvel** *[real,in]* :: y-component of velocity (m/s)
- **tsfc** (*) *[real,inout]* :: ice/snow surface temperature, Tsfcn
- **zqsn** (,) *[real,inout]* :: snow layer enthalpy (J m-3)
- **zqin** (,) *[real,inout]*
- **zsin** (,) *[real,inout]* :: internal ice layer salinities
- **alvl** (*) *[real,inout]*
- **vlvl** (*) *[real,inout]* :: level ice volume fraction
- **apnd** (*) *[real,inout]*
- **hpnd** (*) *[real,inout]* :: melt pond depth (m)
- **ipnd** (*) *[real,inout]*
- **iage** (*) *[real,inout]* :: volume-weighted ice age
- **fy** (*) *[real,inout]*
- **aerosno** (,,*) *[real,inout]* :: snow aerosol tracer (kg/m^2)
- **aeroice** (,,*) *[real,inout]* :: ice aerosol tracer (kg/m^2)
- **uatm** *[real,inout]* :: wind velocity components (m/s)
- **vatm** *[real,inout]*
- **wind** *[real,inout]* :: wind speed (m/s)
- **zlvl** *[real,inout]*
- **qa** *[real,inout]*
- **rhoa** *[real,inout]* :: air density (kg/m^3)
- **tair** *[real,inout]* :: air temperature (K)
- **tref** *[real,inout]*
- **qref** *[real,inout]* :: 2m atm reference spec humidity (kg/kg)
- **uref** *[real,inout]*
- **cdn_atm_ratio** *[real,inout]*
- **cdn_ocn** *[real,inout]*
- **cdn_ocn_skin** *[real,inout]* :: skin drag coefficient
- **cdn_ocn_floe** *[real,inout]*
- **cdn_ocn_keel** *[real,inout]* :: keel drag coefficient
- **cdn_atm** *[real,inout]* :: atm drag coefficient
- **cdn_atm_skin** *[real,inout]* :: neutral skin drag coefficient
- **cdn_atm_floe** *[real,inout]*
- **cdn_atm_pond** *[real,inout]* :: neutral pond edge drag coefficient
- **cdn_atm_rdg** *[real,inout]*
- **hfreebd** *[real,inout]* :: freeboard (m)
- **hdraft** *[real,inout]*
- **hridge** *[real,inout]* :: ridge height
- **distrdg** *[real,inout]*
- **hkeel** *[real,inout]* :: keel depth
- **dkeel** *[real,inout]*
- **lfloe** *[real,inout]* :: floe length
- **dfloe** *[real,inout]*
- **strax** *[real,in]*
- **stray** *[real,in]*
- **strairxt** *[real,inout]* :: stress on ice by air, x-direction
- **strairyt** *[real,inout]*
- **pott** *[real,inout]*
- **sst** *[real,inout]*
- **sss** *[real,inout]*
- **tf** *[real,inout]* :: freezing temperature (C)
- **strocnxt** *[real,inout]* :: ice-ocean stress, x-direction
- **strocnyt** *[real,inout]*
- **fbot** *[real,inout]* :: ice-ocean heat flux at bottom surface (W/m^2)
- **tbot** *[real,inout]*
- **tsnice** *[real,inout]* :: snow ice interface temperature (deg C)
- **frzmlt** *[real,inout]*
- **rside** *[real,inout]* :: fraction of ice that melts laterally

Call to: `frzmlt_bottom_lateral()`, `icepack_warnings_aborted()`, `neutral_drag_coeffs()`, `icepack_atm_boundary()`, `thermo_vertical()`, `icepack_warnings_add()`

3.5.5.36. icepack_step_therm2

subroutine **icepack_step_therm2**(*dt*, *ncat*, *n_aero*, *nltrcr*, *nilyr*, *nslyr*, *hin_max*, *nblyr*, *aicen*, *vicen*, *vsnon*, *aicen_init*, *vicen_init*, *trcrn*, *aice0*, *aice*, *trcr_depend*, *trcr_base*, *n_trcr_strata*, *nt_strata*, *tf*, *sss*, *salinz*, *rside*, *meltl*, *frzmlt*, *frazil*, *frain*, *fpond*, *fresh*, *fsalt*, *fhocn*, *update_ocn_f*, *bgrid*, *cgrid*, *igrid*, *faero_ocn*, *first_ice*, *fzsal*, *flux_bio*, *ocean_bio*, *frazil_diag*[, *frz_onset*[, *yday*]])

Parameters:
- **dt** *[real,in]* :: time step
- **n_aero** *[integer,in]* :: number of aerosol tracers
- **nltrcr** *[integer,in]*
- **nslyr** *[integer,in]* :: number of snow layers
- **hin_max** (ncat + 1) *[real,inout]* :: category boundaries (m)
- **aicen** (*) *[real,inout]* :: concentration of ice
- **vicen** (*) *[real,inout]*
- **vsnon** (*) *[real,inout]* :: volume per unit area of snow (m)
- **aicen_init** (*) *[real,inout]* :: initial concentration of ice
- **vicen_init** (*) *[real,inout]*
- **trcrn** (,) *[real,inout]* :: tracers
- **aice0** *[real,inout]*
- **aice** *[real,inout]* :: sea ice concentration
- **trcr_depend** (*) *[integer,in]* :: = 0 for aicen tracers, 1 for vicen, 2 for vsnon
- **trcr_base** (,) *[real,in]* :: = 0 or 1 depending on tracer dependency
- **n_trcr_strata** (*) *[integer,in]* :: number of underlying tracer layers
- **nt_strata** (,) *[integer,in]* :: indices of underlying tracer layers
- **tf** *[real,in]*
- **sss** *[real,in]* :: sea surface salinity (ppt)
- **salinz** (*) *[real,in]* :: initial salinity profile
- **rside** *[real,in]*
- **meltl** *[real,inout]* :: lateral ice melt (m/step–>cm/day)
- **frzmlt** *[real,in]* :: freezing/melting potential (W/m^2)
- **frazil** *[real,inout]*
- **frain** *[real,inout]* :: rainfall rate (kg/m^2 s)
- **fpond** *[real,inout]*
- **fresh** *[real,inout]* :: fresh water flux to ocean (kg/m^2/s)
- **fsalt** *[real,inout]*
- **fhocn** *[real,inout]* :: net heat flux to ocean (W/m^2)
- **update_ocn_f** *[logical,in]* :: if true, update fresh water and salt fluxes
- **bgrid** (nblyr + 2) *[real,in]* :: biology nondimensional vertical grid points
- **cgrid** (nilyr + 1) *[real,in]* :: CICE vertical coordinate
- **igrid** (nblyr + 1) *[real,in]* :: biology vertical interface points
- **faero_ocn** (*) *[real,inout]*
- **first_ice** (*) *[logical,inout]* :: true until ice forms
- **fzsal** *[real,inout]*
- **flux_bio** (*) *[real,inout]* :: all bio fluxes to ocean
- **ocean_bio** (*) *[real,in]* :: ocean concentration of biological tracer
- **frazil_diag** *[real,inout]* :: frazil ice growth diagnostic (m/step–>cm/day)
- **frz_onset** *[real,inout,]* :: day of year that freezing begins (congel or frazil)
- **yday** *[real,in,]* :: day of year

Options:
- **ncat** *[integer,in,optional/default=(len(hin_max)-1)]* :: number of thickness categories
- **nilyr** *[integer,in,optional/default=(len(cgrid)-1)]*
- **nblyr** *[integer,in,optional/default=(len(bgrid)-2)]* :: number of bio layers

Call to: `aggregate_area()`, `icepack_warnings_aborted()`, `linear_itd()`, `add_new_ice()`, `lateral_melt()`, `reduce_area()`, `cleanup_itd()`

3.5.5.37. icepack_ice_temperature

function **icepack_ice_temperature**(*qin*, *sin*)

Parameters:
- **qin** *[real,in]*
- **sin** *[real,in]*

Return: **tin** *[real]*

Call to: `calculate_tin_from_qin()`

3.5.5.38. icepack_snow_temperature

function **icepack_snow_temperature**(*qin*)

Parameters: **qin** *[real,in]*

Return: **tsn** *[real]*

3.5.5.39. icepack_liquidus_temperature

function **icepack_liquidus_temperature**(*sin*)

Parameters: **sin** *[real,in]*
Return: **tmlt** *[real]*
Called from: icepack_sea_freezing_temperature()

3.5.5.40. icepack_sea_freezing_temperature

function **icepack_sea_freezing_temperature**(*sss*)

Parameters: **sss** *[real,in]* :: deg C
Return: **tf** *[real]*
Call to: icepack_liquidus_temperature()

3.5.5.41. icepack_enthalpy_snow

function **icepack_enthalpy_snow**(*ztsn*)

Parameters: **ztsn** *[real,in]*
Return: **qsn** *[real]*

3.5.5.42. icepack_init_thermo

subroutine **icepack_init_thermo**(*nilyr*, *sprofile*)

Parameters:
- **nilyr** *[integer,in]* :: number of ice layers
- **sprofile** (*) *[real,out]* :: vertical salinity profile

3.5.5.43. icepack_init_trcr

subroutine **icepack_init_trcr**(*tair*, *tf*, *sprofile*, *tprofile*, *tsfc*, *nilyr*, *nslyr*, *qin*, *qsn*)

Parameters:
- **tair** *[real,in]* :: air temperature (C)
- **tf** *[real,in]* :: default
- **sprofile** (*) *[real,in]* :: vertical salinity profile (ppt)
- **tprofile** (*) *[real,in]* :: vertical temperature profile (C)
- **tsfc** *[real,out]* :: surface temperature (C)
- **nilyr** *[integer,in]* :: number of ice layers
- **nslyr** *[integer,in]* :: number of snow layers
- **qin** (*) *[real,out]* :: ice enthalpy profile (J/m3)
- **qsn** (*) *[real,out]* :: snow enthalpy profile (J/m3)

3.5.5.44. icepack_warnings_clear

subroutine **icepack_warnings_clear**()

Called from: icepack_warnings_flush()

3.5.5.45. icepack_warnings_print

subroutine **icepack_warnings_print**(*iounit*)

Parameters: **iounit** *[integer,in]*
Called from: icepack_warnings_flush()
Call to: icepack_warnings_getone()

3.5.5.46. icepack_warnings_flush

subroutine **icepack_warnings_flush**(*iounit*)

Parameters: **iounit** *[integer,in]*
Call to: icepack_warnings_print(), icepack_warnings_clear()

3.5.5.47. icepack_warnings_aborted

function **icepack_warnings_aborted**([*instring*])

Parameters: **instring** *[character,in,]*
Return: **icepack_warnings_aborted** *[logical]*

Called from: icepack_atm_boundary(), compute_micros_mushy(), compute_micros(), rebin(), shift_ice(), cleanup_itd(), zap_small_areas(), zap_snow_temperature(), zerolayer_check(), icepack_aggregate(), ridge_ice(), ridge_shift(), icepack_ice_strength(), icepack_step_ridge(), icepack_init_orbit(), icepack_query_orbit(), compute_coszen(), icepack_init_parameters(), icepack_query_parameters(), shortwave_ccsm3(), run_dedd(), shortwave_dedd(), compute_dedd(), compute_shortwave_trcr(), icepack_step_radiation(), linear_itd(), lateral_melt(), add_new_ice(), icepack_step_therm2(), thermo_vertical(), thickness_changes(), icepack_step_therm1(), add_new_ice_bgc(), adjust_tracer_profile(), icepack_init_bgc(), icepack_biogeochemistry()

Call to: icepack_warnings_add()