OUTPUTS NEEDED FOR BUDGETS

2D (to be defined in file_def.xml)

The minimum for fluxes at the interfaces:
Heat => qt_oce, qt_ice, hfxin, hfxout, hflx_rnf_cea, hflx_isf_cea, hflx_icb_cea, hflx_cal_cea
Salt => sfx
Freshwater => emp_oce, emp_ice, empmr, friver (or runoffs), iceberg_cea, iceshelf_cea, calving_cea, vfxice, vfxsnw, vfxsub, vfxspr, vfxsub_err

To be more precise, we can also output:
Heat => qemp_oce, qemp_ice, hflx_rain_cea, hflx_evap_cea, hflx_snow_cea, hflx_snow_ai_cea, hflx_snow_ao_cea
Freshwater => rain, snow_ao_cea, snow_ai_cea, evap_ao_cea, subl_ai_cea

Nb:
rain = total rain
snow_ao_cea = snow over ocean
snow_ai_cea = snow over ice
evap_ao_cea = evaporation (over ocean)
subl_ai_cea = sublimation (over ice)

1D => Check conservation with integrated outputs

[
key_diaar5 needs to be activated in cpp_keys
ln_diahsb = true (ocean namelist)
ln_limdiaout = true (ice namelist)
Be careful, these diags are CPU expensive (needs global sums)
The simulation must start from an initial state and not from a restart (if ln_diahsb was not set to true initially)
]

all of "bg", "ibg", "sbg", "sc"

- Ocean freshwater budget : bgvolssh (= bgvole3t) must be close to 0 [in km3]
- Ocean freshwater forcing = bgfrcvol [km3]

- Ocean heat budget : bgheatco & bgtemper must be close to 0 [in 1e20J & degC]
- Ocean heat forcing = bgfrcsal [pss]

- Ocean salt budget : bgsaltco & bgsaline must be close to 0 [in pss*km3 & pss]
- Ocean salt forcing = bgfrcsal [degC]

FRESHWATER BUDGET

[
Units are usually different in the code and in the outputs.
For ice, the fluxes are expressed in m/day, equivalent ice (of density 917 kg/m3)
For snow, the fluxes are expressed in m/day, equivalent snow (of density 330 kg/m3)
(i.e. vfxspr, vfxsnw, vfxsub, vfxsub_err)
For ocean, the fluxes are expressed in kg/m2/s
It will certainly be changed soon following CMIP6 conventions
]
[sign convention emp = positive upward
wfx = positive downward (i.e. out of the ice/snow system)]

Freshwater budget of the ice-ocean system [in kg/m2/s]
D(vol_oce + vol_ice + vol_snow)/Dt =
emp_oce + emp_ice - friver(runoffs) - iceberg_cea - iceshelf_cea

Freshwater budget in the ocean [in kg/m2/s] = ocean mass change
In the code: emp_oce ==> E - P - calving
- wfx_ice - wfx_snw - wfx_err_sub ==> sea-ice melting/freezing
+ snow melting or falling into ocean + error sub
- rnf ==> river runoff + icerbergs
+ fwfisf ==> ice-shelves melting (<0)
In outputs: emp_oce
- vfxice * 917 / 86400 - (vfxsnw + vfxsub_err) * 330 / 86400
- runoffs [or friver]
- iceshelf_cea

Note: empmr = emp_oce
- vfxice * 917 / 86400 - (vfxsnw + vfxsub_err) * 330 / 86400
- runoffs [or friver]

Freshwater budget in the ice [in kg/m2/s] = ice mass change
In the code: wfx_ice ==> sea-ice melting/freezing
+ wfx_snw ==> snow melting or falling into ocean
+ wfx_sub ==> sublimation (really seen by the ice/snow,
thus slightly different from the one imposed by atm.)
+ wfx_spr ==> snow precip on sea-ice
In outputs: vfxice * 917 / 86400
+ (vfxsnw + vfxsub + vfxspr) * 330 / 86400

Freshwater flux at the interface [ice/snow]-ocean [in kg/m2/s]
In the code: wfx_ice + wfx_snw + wfx_err_sub
In outputs: vfxice * 917 / 86400 + (vfxsnw + vfxsub_err) * 330 / 86400

Freshwater flux at the interface [ice/snow]-atm. [in kg/m2/s]
In the code: wfx_sub + wfx_spr = emp_ice + wfx_err_sub
In outputs: (vfxsub + vfxspr) * 330 / 86400 = emp_ice + vfxsub_err * 330 / 86400

Freshwater flux at the interface ocean-atm. [in kg/m2/s]
In the code: emp_oce + calving - wfx_err_sub
In outputs: emp_oce + calving_cea - vfxsub_err * 330 / 86400

Notes

- wfx_ice = wfx_bog + wfx_bom + wfx_sum + wfx_sni + wfx_opw + wfx_dyn + wfx_res
  (+ wfx_lam, only trunk version)
- emp_ice = sublimation - snow precip (over ice)
- wfx_err_sub (<0) is a small correction resulting from the difference between sublimation imposed by the atm. and what really sublimates. wfx_err_sub = (wfx_sub - evap_ice) is an evaporation term for the ocean.

Distribution of freshwater flux

- iceberg = 50% of the Antarctic freshwater is distributed along an icebergs map (climatology)
- iceshelf = 50% of the Antarctic freshwater is distributed along the coast
- calving = calving in the Northern Hemisphere is uniformly distributed (tests are also ongoing for a distribution along the coasts)
- friver (or runoffs) = freshawter flux from rivers + icebergs

HEAT BUDGET

[W/m2]
[sign convention = positive downward]

Heat fluxes at the interfaces:

atm.-ice	qt_ice = (qns_ice + qsr_ice) * iceconc + qemp_ice
atm.-ocean	qt_oce = (qns_oce + qsr_oce) * (1 - iceconc) + qemp_oce
atm.-[ice/ocean]	hfxin = qt_oce + qt_ice
ocean-[ice/atm.]	hfxout = qns + qsr
ocean-land	hflx_rnf_cea ==> iceberg melting + rivers: sensible heat (at SST if not specified)
	hflx_isf_cea ==> ice-shelf melting: latent (<0) + sensible heat (T=-1.9deg)
	hflx_icb_cea ==> iceberg melting: latent heat loss from ocean (<0)
	hflx_cal_cea ==> calving: latent heat loss from ocean (<0)

Change of ocean heat content:

dT_oce = hflx_isf_cea [in sbcisf.F90] ==> ice shelf melting latent+sensible
+ hflx_rnf [in sbcrnf.F90] ==> iceberg + rivers sensible heat (at SST)
+ qns [in trasbc.F90] ==> the rest of non-solar not "used" in sea-ice
(i.e. latent+sensible+LW+ hflx_cal_cea + hflx_icb_cea)
+ qsr [in traqsr.F90] ==> solar flux not "used" to melt sea-ice

Change of ice heat content:

dT_ice = hfxin - hfxout

Note:

qemp_oce and qemp_ice are heat fluxes associated with heat content of precip/evap (sensible flux) + latent heat loss for the phase change (ex. snow=>water)

Clem's comment:

Heat budget is not easy to diagnose because things are mixed up. This will need to be revised.
For exemple:

1) icebergs heat flux is both in hflx_rnf_cea (sensible) and hflx_icb_cea (latent).
2) icebergs melt at SST, calving is considered at 0deg, ice-shelf melt at -1.9deg.

SALT BUDGET

[Units differ in the code and in the outputs]
[sign convention = positive downward]

Salt flux at the interface ice-ocean (sum of several processes)

In the code [1.e-3 kg/m2/s]: sfx = sfx_bog + sfx_bom + sfx_sum + sfx_sni + sfx_opw + sfx_sub + sfx_dyn + sfx_bri + sfx_res (+ sfx_lam, only trunk version)

In outputs [1.e-3 kg/m2/day]: sfx