# Final (?) set of updates to CABLE within ACCESS-CM2

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This contains a brief overview and motivation for four interrelated changes to the coupling between the UM and CABLE – following on from CABLE Ticket #132 (both parts) and other issues identified during the process of ‘debugging’ ACCESS.

## 1: Definition of Trad

The UM radiation scheme assumes a single emissivity for each surface tile. CABLE however permits (at least) two. For climate simulations it is paramount that the upwelling longwave radiation from the surface is appropriate. Consequently two linked changes are needed within i) the suite configuration and ii) cable\_cbm.

* the PFT emissivities within the suite configuration (as used in the radiation scheme) need to be 1.
* the definition of rad%trad in cable\_cbm needs to be modified to incorporate the values of the soil and leaf emissivities, i.e.

so that gives the correct upwards longwave radiation once .

The code changes are included in cable\_cbm\_trad.F90. rad%trad is left unmodified for non-UM applications.

## 2: Coastal tiles

JULES and CABLE function in fundamentally different means – especially with regards to the function within UM’s boundary layer scheme. JULES operates as a baseline estimate (explicit part) then increments (implicit part). CABLE operates as a full calculation in both explicit and implicit parts of the boundary-layer scheme.

ACCESS, however, seeks to use CABLE for land points and JULES for sea and sea-ice points – and use both for coastal grid cells. In order to operate as a full calculation each time CABLE in ACCESS 1.3

* did a full set of calculations on the implicit part
* switched off the JULES increment for land points

The method used to switch off the JULES increment used was to set variable gamma\_1 = 0.0 within routine im\_sf\_pt2 when CABLE was being used. Unfortunately gamma\_1 is defined on the UM grid cell, not a land surface tile grid. Consequently, on coastal grid cells the JULES increment for sea and sea-ice was also switched off.

To correct this and return to the intent of the JULES sea and sea-ice exchange scheme

* gamma\_1 should be left unmodified.
* subsequent variables (apart, bpart, ftl\_surft, fqw\_surft, dtstar\_surft) that depend on gamma\_1 should be modified to take the value if gamma\_1 =0 (as per ACCESS1.3)

The code changes are included in im\_sf\_pt2\_cable\_coastal.F90.

Background information is provided within CABLE Ticket #132 however the details of the implementation are different given changes since the earlier version of the UM within which that Ticket was developed.

It may be possible to simplify this implementation further, and indeed remove the need for a cable specific version of im\_sf\_pt2, by specifying the UM variable rhokh\_1 to be an array of zeros at the interface within sf\_impl2\_cable.F90

## 3: CASA lockout

A key change from ACCESS1.3 to ACCESS-CM2 is that the UM now calls the cable\_implicit part of the code base twice per time step. If cable\_implicit\_driver were retained as per ACCESS1.3 this would update all prognostic variables twice per time step, i.e. the soil temperature, moisture would evolve with (approximately) twice the rate of change as desired. Earlier assessments of the physical model (UM v8.5), led to the development of an approach to unpick the double update for the soil variables (the prognostic bank structure) – however carbon cycle variables (bgc and CASA) were left untouched. ESM developers (Haverd and Ziehn) agree the double call is incorrect and needs to be resolved.

bgcvariables - bgc%cplant and bgc%csoil – have now been incorporated into the same approach (see earlier Jan 2018 updates to the PB structure within cable\_implicit\_driver) – however the CASA variables have not.

In order to address this issue either the full set of CASA state variables needs to incorporated into the PB structure (cumbersome and expensive) or an alternate approach devised. Since the CASA forms separate code base, with clean interfaces, the alternate approach suggested is that the carbon cycle routines bgcdriver, sumcflux and casapoolunpk are only called on the second call to cable\_implicit\_driver each time step. CASA variables the increment once per time step and evolve according to the same fluxes that are passed to the UM.

The code changes are incorporated in cable\_implicit\_driver\_PB\_revcoupling\_CASAlockout.f90

## 4: Revised coupling

The primary focus of Ticket #132 was to adjust the meteorological conditions (met%tk and met%qv) used to drive CABLE on the implicit part of the UM boundary-layer scheme so as to use physically plausible conditions. Background information is provided with the documentation of Ticket #132. The precise method used has varied through time given the changes in the interface routines form ACCESS1.3 through UMv8.5 to ACCESS-CM2. The implementation did not have major consequences in ACCESS1.3 or v8.5

This development has been implemented on a cable\_user% logical flag – l\_revised\_coupling - set within cable\_common to default to false. Additional UM variables are needed (ctctq1, ftl\_1 and fqw\_1 mapped onto CABLE tiles) for this development. The revised coupling adjusts the forcing air temperature and humidity used to

where are the values used in the explicit time part of the code base, are the increments supplied from the downsweep of the boundary-layer scheme (bdy\_impl3), are the *grid-cell averaged* surface fluxes of temperature and water, and is a coupling coefficient [see bdy\_impl3 and bdy\_impl4].

The code changes are incorporated in cable\_implicit\_driver\_PB\_revcoupling\_CASAlockout.F90 (the main code), cable\_common\_revcoupling.F90, cable\_implicit\_main\_revcoupling.F90 and sf\_impl2\_cable\_revcoupling.F90 (the latter two are for variable passing only). Activating the new code requires a new line within the cable namelist.

Cable\_implicit\_driver\_PB\_revcoupling\_CASAlockout.F90 includes changes needed for changes 3 and 4 – the code needed for each separate change is easy to discern.

Finally note that one aspect of Ticket #132 – the need to move cable\_implicit\_driver prior to im\_sf\_pt2 within sf\_impl2\_cable (the difference between v1.2 and v1.3 in the JULES-UMv8.5 codesets) – has been determined to be not necessary given the restructure of the UM.

## 5: Testing

Each of these code changes (and the previous change to the PB structure) should result in only minor (or even trivial) differences in the ACCESS-CM2 performance in the monthly (or longer) averages. The diurnal cycle and extremes may be more sensitive to these changes. Basic tests – compilation, short run tests – should be sufficient at this stage. Change 3 requires CASA to be active; Change 4 will need a namelist change to test (should be bitwise reproducible if l\_revised\_coupling = .false.).