Prioritisation of CABLE updates

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The following is a (personal) review of the current CABLE tickets in an attempt to scope and prioritise the effort needed to "finalise" a version of CABLE for use within CMIP6. The prioritisation is based on an (incomplete) understanding of the requirements for CABLE within ACCESS as committed to the NESP projects (i.e. GCM simulations in contrast to ESM simulations). Consequently aspects which

- involve identified bugs in the science code,
- involve the coupled model or coupling between CABLE and the UM, or
- involve capability enhancements to the biophysics of the CABLE,

are given more weight than enhancement affecting the offline code or the biochemistry. This review/proposed development line is understood to be a first step in confirming the version of CABLE to be used in CMIP6 and a prerequisite for future work on determining a suitable CABLE configuration.

An attempt has been made to identify clear connections between Tickets (numbers in brackets). The areas of work have been grouped into aspects which are "trivial" (e.g. one-line bug fixes) requiring minimal testing, stand-alone developments (which require more extensive testing but should be implemented easily) and complex science developments (where multiple lines of development need to assessed for mutual compatibility prior to implementation).

Recommendation 1: A call to the community for new/urgent Tickets is undertaken to ensure that the community is fully aware of current work, imminent developments and expected time lines.

Trivial updates:

The following is list of easy modifications to the current trunk. These can (?) be implemented without the need for switches. In the biophysics code

67 An order of operations issue in the screen level calculations (addressed in #139).

117 initialisation of variables in photosynthesis code for numerical/compiler reasons.

120 Bugs within the soil moisture code using the default soil-snow scheme.

122 Fix to correction term evaluation in cable_cbm (duplicated by #135, addressed in #137, #139)

136 consistency of conditions of usage of latent heats between cable_canopy and cable_soilsnow (addressed in #137, #139)

138 bug fix on the calculation of u* (covered in #139 and #152)

147 bug fix to the diffuse albedo

154 science refinement to the calculation of screen level variables over tall canopies.

In the biochemistry code

142 POP and PO-LUC updates

144 CASA and SLI updates

Recommendation 2: 9 of these 10 Tickets should form the focus of the initial stage of the next trunk update/merge process. The exception is #136 which should wait until #137 is addressed.

The following are CABLE code issues which are trivial in nature but need further discussion as to the appropriate way forward (switches may be needed for testing/backwards compatibility):

70 initialisation of wetness factors %owetfac and %wetfac (has links to #97)

106 initialisation of soil moisture variables (see also #96). While addressing this issue we should also make frozen_limit (and other terms) a C% type parameter (#141)

134 consistency and usage of canopy wetness factor %fwet

148 heights used to force CABLE - with implications for dust and aerosol sources/sinks in Earth system simulations.

Discussions with Haverd suggest that issue #148 could be extended to consider whether offline forcing needs to be modified depending on canopy height etc (as per BIOS2) – but this is out of scope at the current time. A one or two line code bug fix is suggested by #148 and is the minimum needed to be implemented.

The following are important CABLE-ACCESS coding and/or configuration issues which should be trivial in nature to address but need further discussion as to the appropriate way forward:

37 hardwired indices for lakes, glaciers etc. – also the hardwired biome indices in the LUC code.

40 hardwired root distribution in coupled CABLE.

68 hardwired soil type and hence other soil parameter fields in coupled CABLE (see #125)

81 updates to the PFT look-up table.

CABLE can probably accommodate #37 and #40 for CMIP6 (but not for implementation in the JULES repository). #68, #81 and #125 will be needed for ACCESS CM2.

Important stand-alone development(s):

132 updated coupling interface routine for the "implicit" call to CABLE within ACCESS

This is a critical update (if not numerically important) to the methodology whereby CABLE is coupled to the UM within ACCESS. The code set needs to be reviewed in light of the migration from UM8.5 to v10.6+JULES.

Ticket 132 has two options – the first is an upgrade to the existing coupling and is the minimum required. The second revises the order operations between the calls to the CABLE (land) and JULES (sea and sea-ice) parts of the surface forcing. This is strictly necessary to ensure that the sea and sea-ice components of mixed grid cells are being forced as per the original intent of JULES. The coupling sequencing used in ACCESS1.3 is strictly incorrect. Neither option has been tested within v10.x of the UM.

Recommendation 3: This (2-part) update should be tested as a stand-alone development to ACCESS using simple AMIP-style simulations. This is switchable by design.

There are also CABLE developments for urban and inland water surfaces (Thatcher) that may merit merging with the trunk prior to CMIP6 and any configuration decisions (Recommendation 1).

Complex developments:

There are two areas of science development which will require a higher degree of care when updating the CABLE trunk. These are characterised by i) multiple developers acting on the same/similar parts of the code and ii) a need to assess both the code/configuration and the embedded science for consistency. On ii) this may require additional logic, i.e. explicit prevention of switch combinations, to be implemented as part of configuration decisions.

Soil energy balance and hydrology

This collection of code updates all involve the soil temperature/moisture calculations and/or the interface to the plant transpiration calculations. It includes issues/code sets raised in #65 and #95 around water availability influencing transpiration extraction (not just the rooting profile); #97 - the Dekker hydrology scheme and its interface with SLI; #137 around moisture conservation (in soilsnow); #139 around the soil energy balance (soilsnow in ACCESS); and #152 around the sequencing of the soil calculations in coupled simulations (soilsnow in ACCESS). These developments also need to be considered alongside the current implementation of the Medlyn stomatal conductance model (#56) and the Haverd fw_soil switch (#129), alongside the prescription of the rooting profile (#40) and how SLI will/could operate within ACCESS.

It is not known if solutions to #40, #65 and #95 exist or been implemented (e.g. it appears that #65 has been, this needs following up). It is critical that the water extraction/photosynthesis decoupling issue is resolved via model structure or configuration choice (e.g. #95, #129). The science embedded in the Dekker hydrology represents a key science advance from earlier versions of ACCESS and clearly merits prioritisation. #137 (or something similar) is critical and #139 important. #152, while beneficial, will require careful testing and review, and possibly a partial or staged implementation.

Importantly the various developments to the soil energy balance and hydrology are not just technical updates and/or configuration decisions (both are however needed) but also scientific. Critically this is an opportunity to review and ensure that the resulting science package is complete and credible. For instance the current implementation of the Haverd litter scheme is incomplete in that it did not include necessary changes to the within_canopy subroutine and screen level diagnostic calculations (see #139).

Potential issues that should be considered during the merge that have been identified (so far) are:

- Effort has been taken to interweave the litter scheme (in SLI and soilsnow) and the new soil hydrology schemes. A similar effort is required for the intersection with #137, #139 and #152. The two set of developments both act on the soil energy balance and hence interface with the canopy energy balance and screen level diagnostics calculations. Changes to the model structure are also proposed in #139 and #152 which would need to be reflected in the updated hydrology scheme.
- A review of how SLI would time step within ACCESS is required – in particular this involves consideration of the correction terms (#139) and how SLI sub-time steps. This both a science and technical domain (e.g. efficiency and parallelisation in ACCESS) issue.
- The Medlyn stomatal model, the Haverd fw_soil switch and the extraction of water from different soil layers (#95, #129) all appear to be addressing similar issues around transpiration and transpiration allocation. They may not be compatible technically or scientifically.

- The litter scheme and the soil porosity component of #97 appear to address similar issues around soil evaporation. They may not be compatible (as currently coded) technically or scientifically.
- We need to be mindful of how the Dekker hydrology scheme interacts with the UM. This includes sourcing necessary input fields (NB the interface been updated in v10.6/JULES), ACCESS soil ancillary files (#68, #125) and interaction with the coupled model via the runoff.

The consolidation and merge process, in particular switches and the order of implementation (e.g. sequentially or via a new CMIP6 branch), between the various developments and into the trunk clearly needs careful consideration. Some of the issues to resolve would not be immediately relevant if an early call around the use of SLI within CMIP6 is made. For example point 2 is immediately of lower priority if SLI is not going to be used; and most of #137, 139 and 152 is irrelevant if SLI is the only soil scheme to be used.

Recommendation 4: A biogeophys review The community needs to dedicate some specific time and resources to a) reviewing the two sets of proposed code enhancements (#95 and #137-139-152 set) for coding and science conflicts and b) to review how the new hydrology, the Medlyn conductance, Haverd fw_soil and water availability weighted transpiration fit together. On part a) we may need a consolidation ticket prior to a merge with the trunk. On part b) further work may be needed and the issues avoided in the interim (e.g. CMIP6) through the CABLE configuration.

CASA and other ESM updates

This collection of code updates all involve CASA and associated land-cover attributes within CABLE. It includes issues/code developments raised in #82 carbon conservation (and offline/online code differences[1]); #114 a new nitrogen module; #115 negative NPP fixes; and #116 a fix to address oscillatory behaviour in the carbon pools. Much of these developments are captured in #146.

(Perhaps) The primary reason for caution here surrounds ensuring internal consistency with other parts of CABLE and the plans for CASA within ACCESS for CMIP6 and as part of ACCESS-ESM. In the latter case this includes the use (or not) of endogenous phenology and the land-cover change methodology (either through POP-LUC or the existing code #88).

Recommendation 5: A biogeochem review The community needs to dedicate some specific time to reviewing which of the ticketed CASA updates, and any other ESM updates in development – see e.g. #40, need to implemented for CMIP6. Structural (#146) and coupled i/o updates are particularly important.

GLACE configuration

#96 noted the need for a particular non-standard capability for ACCESS arising from the GLACE-type experiments envisaged in LS3MIP (links to #106). A proposed solution was devised for ACCESS1.4 however with the update to v10.6/JULES this needs to be revisited. This is a primarily a technical development but one which deserves specific mention as it is tied to ACCESS and CMIP. Whether such a development is required as part of the configuration for the main CMIP6 experiments, or can wait, is a matter for discussion.

[1] During this process at least one code issue (initialisation of pwbmin in the offline code) was identified. This, and any other issues, identified do not appear to have been ticketed.

Concluding comments

Each of the suggested updates will have to go through the testing to be accepted into the trunk – this review does not preclude that necessity only attempts to order the process. The above suggests a 7 stage process to prioritise and progress the envisaged updates:

1. A community call for updates envisaged for inclusion in CMIP6 – to include hard time lines and criteria.
2. A cable trunk update for the majority of the "trivial" bug fixes (offline testing sufficing?)
3. AMIP style testing of the #132 revised coupling.
4. A biogeophys review – leading to recommendation for a consolidated biogeophys update and merge with the trunk.
5. A biogeochem review – leading to a recommendation for a consolidated biogeochem update and merge with the trunk.
6. Testing of the updated CABLE, tagging and a decision on configuration for CMIP6.
7. Development and implementation of the necessary i/o for GLACE-type simulations within ACCESS (with the science of CABLE fixed at the tagged version).

Stages 1-3 and the review parts of stages 4 and 5 can proceed in parallel.

This staging, in particular items 4-5, is necessarily constrained by time, the mandated testing and documentation requirements for inclusion in the CABLE trunk, resourcing (people and computing) and the overall requirements/plans for the CMIP6 submissions (e.g. necessary capability, desired performance criteria, benchmarking). If the time lines for confirming an ACCESS configuration are tight then stages 4-5 may need to be deferred.