Precursor control for coupled atmosphere-ocean runs with PALM

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(revised version)

1 Concept

The main concept behind the precursor control is to run both models, atmospheric and ocean versions of PALM seperately until an individual time level. From this time onwards, both models shall run coupled and transfer data at the sea surface.

2 User Instructions

2.1 Starting Coupled Runs

To provide these precursor runs (herafter **PR**) there are two solutions implemented. The first one is to start atmosphere and ocean as follows:

mrun -d examplerun ... -X8 -r "d3# ... restart"   (atmospheric run)
mrun -d examplerun ... -X8 -r "d3o# ... restart" -y   (oceanic run)

followed by a restart run:

mrun -d examplerun ... -X16 -r "d3f d3of ... " -Y "8 8"   (coupled restart run)

where examplerun refers to the name of the job and the number of processors in the coupled run has to be set according to the PRs. In this example 8 processors were used for each PR, and 16 for the coupled restart with a distribution of 8 to the atmosphere and 8 to the ocean. Currently only one-to-one topologies are supported. All input files have to contain the new parameter `coupling_start_time` which has to be set in the following way (e.g.):

atmospheric PR
`end_time = 3600.0,`
`coupling_start_time = 3600.0`
oceanic PR
`end_time = 40000.0,`
`coupling_start_time = 40000.0`
coupled restart run: atmosphere
`end_time = 23600.0,`
`coupling_start_time = 3600.0`
coupled restart run: ocean

```
end_time = 60000.0,
coupling_start_time = 40000.0
```

This means that

```
        time_since_reference_point = end_time - coupling_start_time
```

has to be equal $0s$ in the PRs and equal (here 20000.0s) in both restart input files.

The other solution can be started more simply but may cause an unbalanced workload and is only useful if restarts are not allowed:
mrun -d examplerun ... -X16 "d3# d3o# ... " -Y "8 8"

   The input files in this case have to be prepared as follows:
coupled run: atmosphere
```
end_time = 23600.0,
coupling_start_time = 3600.0
```
coupled run: ocean
```
end_time = 60000.0,
coupling_start_time = 40000.0
```


In this case `time_since_reference_point` has to be equal in both, atmosphere and ocean.

3 Data Output

The data output will be according to the settings in `.mrun.config`. The main difference is, that now negative times occur during the PRs. The coupling starts at $time = 0s$, positive times refer to the coupled run, while negative times refer to the PRs. In the `run_control` file the time will start at $0s$ and will not show negative times.

4 Restart runs

The user settings for `restart_time` have to be used as usual but won't be initiated before the coupling is active (`time_since_reference_point` > 0.0) and refers not to `simulated_time`.

5 Detailed program code changes

5.1 New variables

`coupling_start_time` - A (`control_parameters, inipar`) REAL parameter that sets the time after the coupling should start.
`time_since_reference_point` - A (`control_parameters`) REAL variable that replaces `simulated_time` during data output.
`run_coupled` - A (`control_parameters`) LOGICAL variable which is .TRUE. if the model runs in coupled mode, otherwise .FALSE..

5.1.1 Explanation of changes in source code

The most important change was made implementing the `coupling_start_time` variable which is internally set to

$$\text{coupling\_start\_time} = simulated\_time - coupling\_start\_time$$

after each timestep. This means coupling_start_time will refer to a negative value if simulated_time is lower than coupling_start_time. In this case PALM knows that it shall not use the surface coupler ($run\_coupled = .FALSE.$). When output_time reaches 0, the PR is finished, PALM will write out binary data for the restart and then terminate if restarts are allowed. For making coupled restarts easier, in oceanic runs the flag parameter "_O" is used now during the PRs. Due to this, PALM will recognise the restart data from the atmospheric and oceanic model easily and can initialize a coupled run.

The run control header file will give output of `coupling_start_time` if it's value is nonzero.

5.1.2 Restrictions

- Restarts forced by users won't take effect during the PRs and are now related to `time_since_reference_point`.

- It's not possible to set Neumann boundary conditions for `bc_pt_b`.

- PRs have not been tested with coupling via MPI-2 yet.

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