1 Ocean Dynamics (DYN)

1.1 The WAD test cases (*usrdef_zgr.F90*)

This section contains details of the seven test cases that can be run as part of the WAD_TEST_CASES configuration. All the test cases are shallow (less than 10m deep), basins or channels with 4m high walls and some of topography that can wet and dry up to 2.5m above sea-level. The horizontal grid is uniform with a 1km resolution and measures 52km by 34km. These dimensions are determined by a combination of code in the *usrdef_nam.F90* module located in the WAD_TEST_CASES/MY_SRC directory and setting read in from the namusr_def namelist. The first six test cases are closed systems with no rotation or external forcing and motion is simply initiated by an initial ssh slope. The seventh test case introduces and open boundary at the right-hand end of the channel which is forced with sinousoidally varying ssh and barotropic velocities.

```
!
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   rn_dx = 1000.0
   rn_dz = 1.0
   nn_wad_test = 1
/
```

The nn_wad_test parameter can takes values 1 to 7 and it is this parameter that determines which of the test cases will be run. Most cases can be run with the default settings but the simple linear slope cases (tests 1 and 5) can be run with lower values of rn_wdmin1. Any recommended changes to the default namelist settings will be stated in the individual subsections.

Test case 7 requires additional `namelist_cfg` changes to activate the open boundary and lengthen the duration of the run (in order to demonstrate the full forcing cycle). There is also a simple python script which needs to be run in order to generate the boundary forcing files. Full details are given in subsection (1.1.7).

1.1.1 WAD test case 1 : A simple linear slope

The first test case is a simple linear slope (in the x-direction, uniform in y) with an adverse SSH gradient that, when released, creates a surge up the slope. The parameters are chosen such that the surge rises above sea-level before falling back and oscillating towards an equilibrium position. This case can be run with rn_wdmin1 values as low as 0.075m. I.e. the following change may be made to the default values in `namelist_cfg` (for this test only):

```
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   nn_wad_test = 1
/
!-----------------------------------------------------------------------
&namwad   !   Wetting and drying
!-----------------------------------------------------------------------
   rn_wdmin1          =  0.075    ! Minimum wet depth on dried cells
/
```

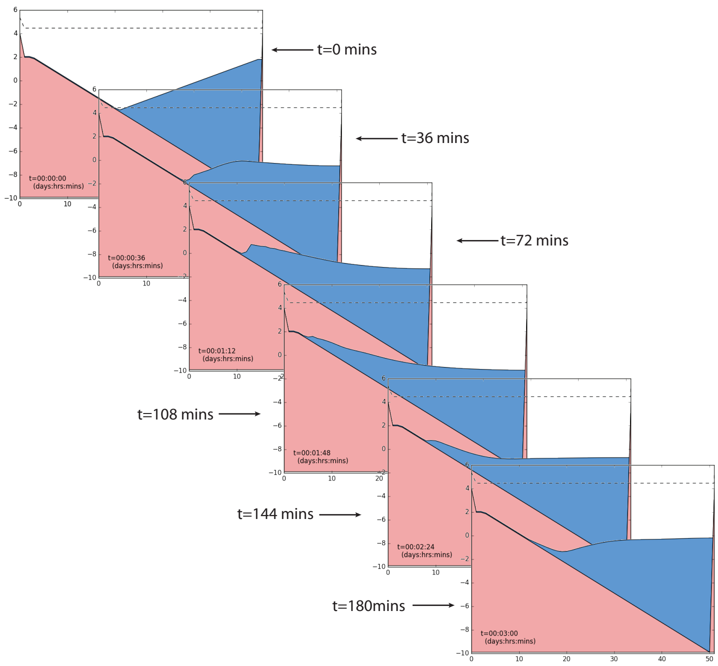

Figure 1.1: The evolution of the sea surface height in WAD_TEST_CASE 1 from the initial state (t=0) over the first three hours of simulation. Note that in this time-frame the resultant surge reaches to nearly 2m above sea-level before retreating.

1.1.2 WAD test case 2 : A parabolic channel

The second and third test cases use a closed channel which is parabolic in x and uniform in y. Test case 2 uses a gentler initial SSH slope which nevertheless demonstrates the ability to wet and dry on both sides of the channel. This solution requires values of rn_wdmin1 at least 0.3m (*Q.: A function of the maximum topographic slope?*)

```
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   nn_wad_test = 2
/
```

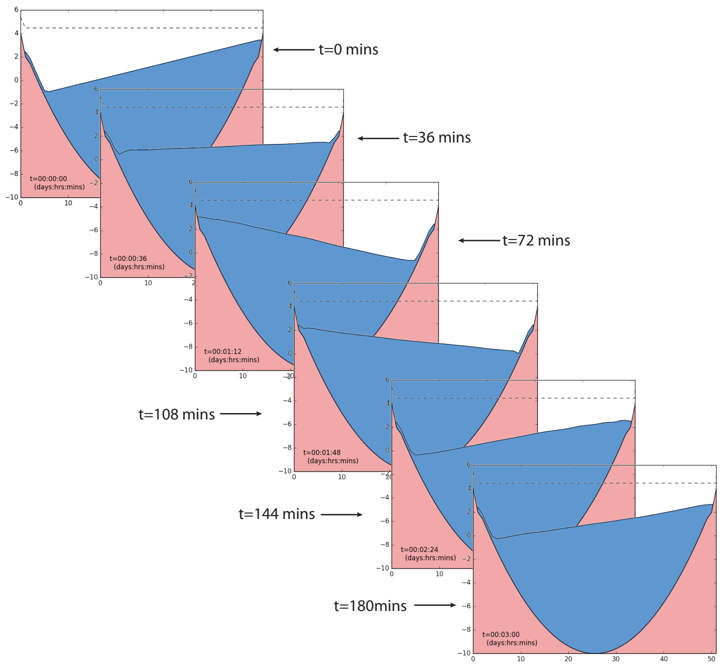

Figure 1.2: The evolution of the sea surface height in WAD_TEST_CASE 2 from the initial state (t=0) over the first three hours of simulation. Note that in this time-frame the resultant sloshing causes wetting and drying on both sides of the parabolic channel.

1.1.3 WAD test case 3 : A parabolic channel (extreme slope)

Similar to test case 2 but with a steeper initial SSH slope. The solution is similar but more vigorous.

```
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   nn_wad_test = 3
/
```

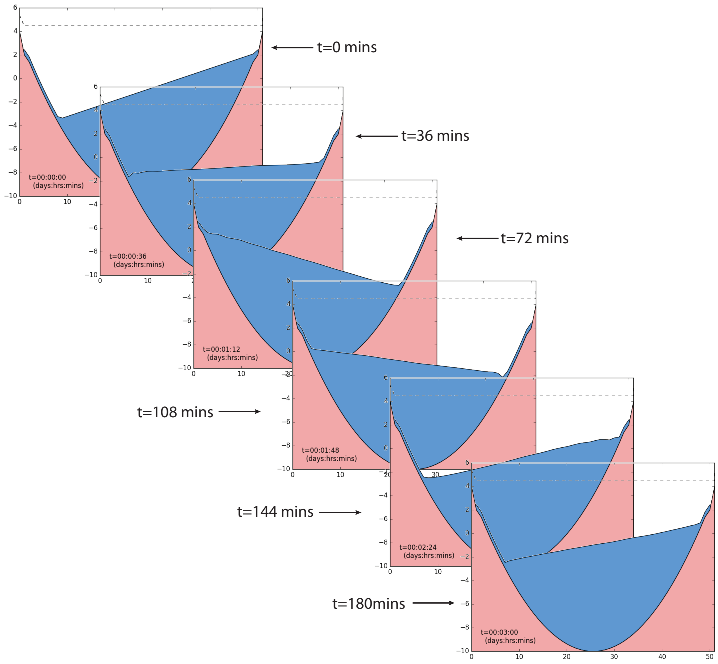

Figure 1.3: The evolution of the sea surface height in WAD_TEST_CASE 3 from the initial state (t=0) over the first three hours of simulation. Note that in this time-frame the resultant sloshing causes wetting and drying on both sides of the parabolic channel.

1.1.4 WAD test case 4 : A parabolic bowl

Test case 4 includes variation in the y-direction in the form of a parabolic bowl. The initial condition is now a raised bulge centred over the bowl. Figure 1.4 shows a cross-section of the SSH in the X-direction but features can be seen to propagate in all directions and interfere when return paths cross.

```
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   nn_wad_test = 4
/
!-----------------------------------------------------------------------
&namwad  !   Wetting and drying
!-----------------------------------------------------------------------
   rn_wdmin1         =  0.45    ! Minimum wet depth on dried cells
/
```

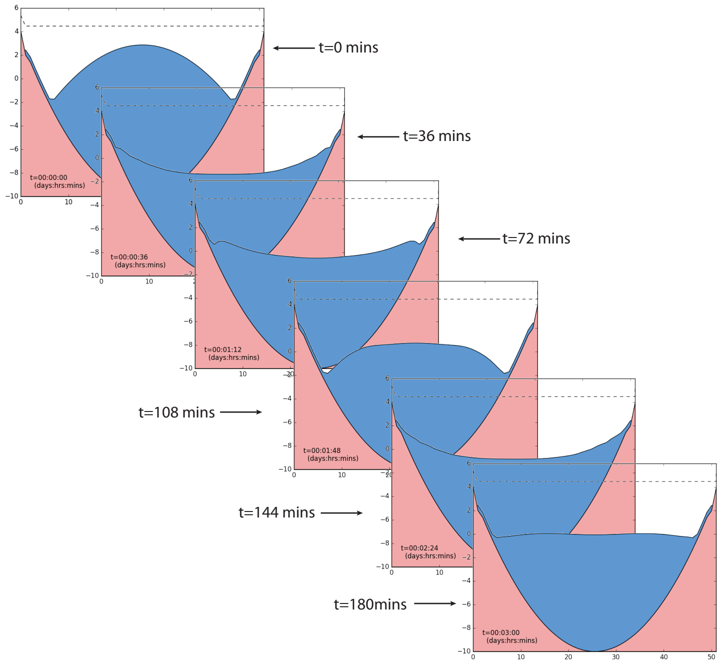

Figure 1.4: The evolution of the sea surface height in WAD_TEST_CASE 4 from the initial state (t=0) over the first three hours of simulation. Note that this test case is a parabolic bowl with variations occurring in the y-direction too (not shown here).

1.1.5 WAD test case 5 : A double slope with shelf channel

Similar in nature to test case 1 but with a change in slope and a mid-depth shelf.

```
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   nn_wad_test = 5
/
!-----------------------------------------------------------------------
&namwad  !   Wetting and drying
!-----------------------------------------------------------------------
   rn_wdmin1          =  0.15    ! Minimum wet depth on dried cells
/
```

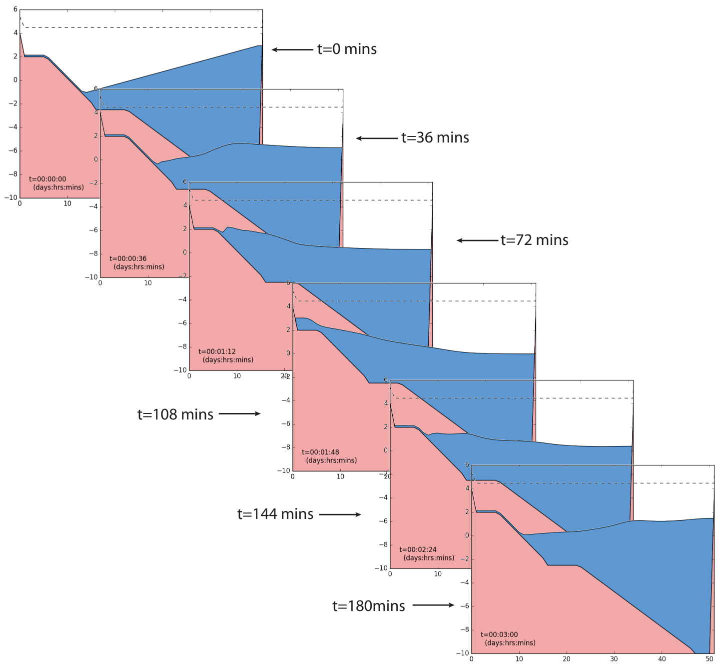

Figure 1.5: The evolution of the sea surface height in WAD_TEST_CASE 5 from the initial state (t=0) over the first three hours of simulation. The surge resulting in this case wets to the full depth permitted (2.5m above sea-level) and is only halted by the 4m high side walls.

1.1.6 WAD test case 6 : A parabolic channel with central bar

Test cases 1 to 5 have all used uniform T and S conditions. The dashed line in each plot shows the surface salinity along the y=17 line which remains satisfactorily constant. Test case 6 introduces variation in salinity by taking a parabolic channel divided by a central bar (gaussian) and using two different salinity values in each half of the channel. This step change in salinity is initially enforced by the central bar but the bar is subsequently over-topped after the initial SSH gradient is released. The time series in this case shows the SSH evolution with the water coloured according to local salinity values. Encroachment of the high salinity (red) waters into the low salinity (blue) basin can clearly be seen.

```
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   nn_wad_test = 6
/
```

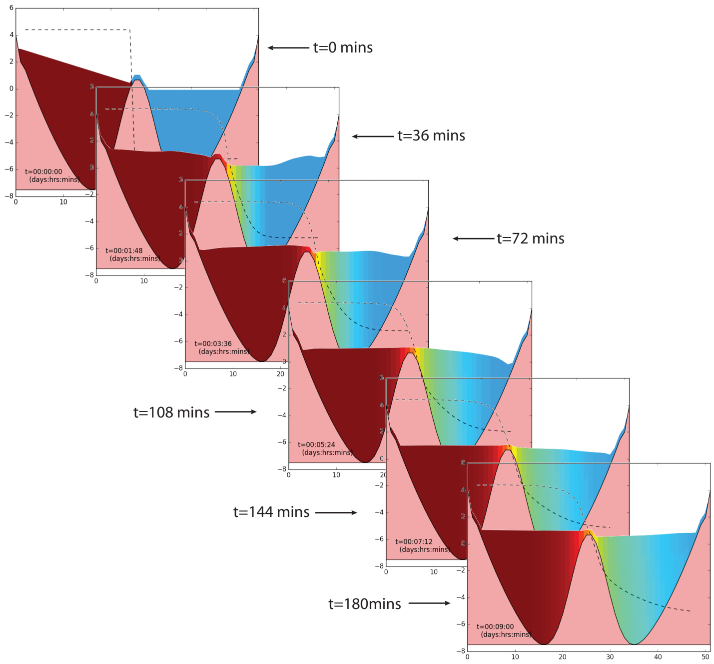

Figure 1.6: The evolution of the sea surface height in WAD_TEST_CASE 6 from the initial state (t=0) over the first three hours of simulation. Water is coloured according to local salinity values. Encroachment of the high salinity (red) waters into the low salinity (blue) basin can clearly be seen although the largest influx occurs early in the sequence between the frames shown.

1.1.7 WAD test case 7 : A double slope with shelf, open-ended channel

Similar in nature to test case 5 but with an open boundary forced with a sinusoidally varying ssh. This test case has been introduced to emulate a typical coastal application with a tidally forced open boundary. The bathymetry and setup is identical to test case 5 except the right hand end of the channel is now open and has simple ssh and barotropic velocity boundary conditions applied at the open boundary. Several additional steps and namelist changes are required to run this test.

```
!-----------------------------------------------------------------------
&namusr_def
!-----------------------------------------------------------------------
   nn_wad_test = 7
/
!-----------------------------------------------------------------------
&namrun        !   parameters of the run
!-----------------------------------------------------------------------
   nn_itend    =      9600  !  last  time step
/
!-----------------------------------------------------------------------
&nambdy        !  unstructured open boundaries
!-----------------------------------------------------------------------
    ln_bdy         = .true.
    nb_bdy         = 1                    !  number of open boundary sets
/
!-----------------------------------------------------------------------
&namwad  !   Wetting and drying
!-----------------------------------------------------------------------
   rn_wdmin1         =  0.150   ! Minimum wet depth on dried cells
/
```

In addition, the boundary condition files must be generated using the python script provided.

```
python ./makebdy_tc7.py
```

will create the following boundary files for this test (assuming a suitably configured python environment: python2.7 with netCDF4 and numpy):

```
bdyssh_tc7_m12d30.nc   bdyuv_tc7_m12d30.nc
bdyssh_tc7_m01d01.nc   bdyuv_tc7_m01d01.nc
bdyssh_tc7_m01d02.nc   bdyuv_tc7_m01d02.nc
bdyssh_tc7_m01d03.nc   bdyuv_tc7_m01d03.nc
```

These are sufficient for up to a three day simulation; the script is easily adapted if longer periods are required.

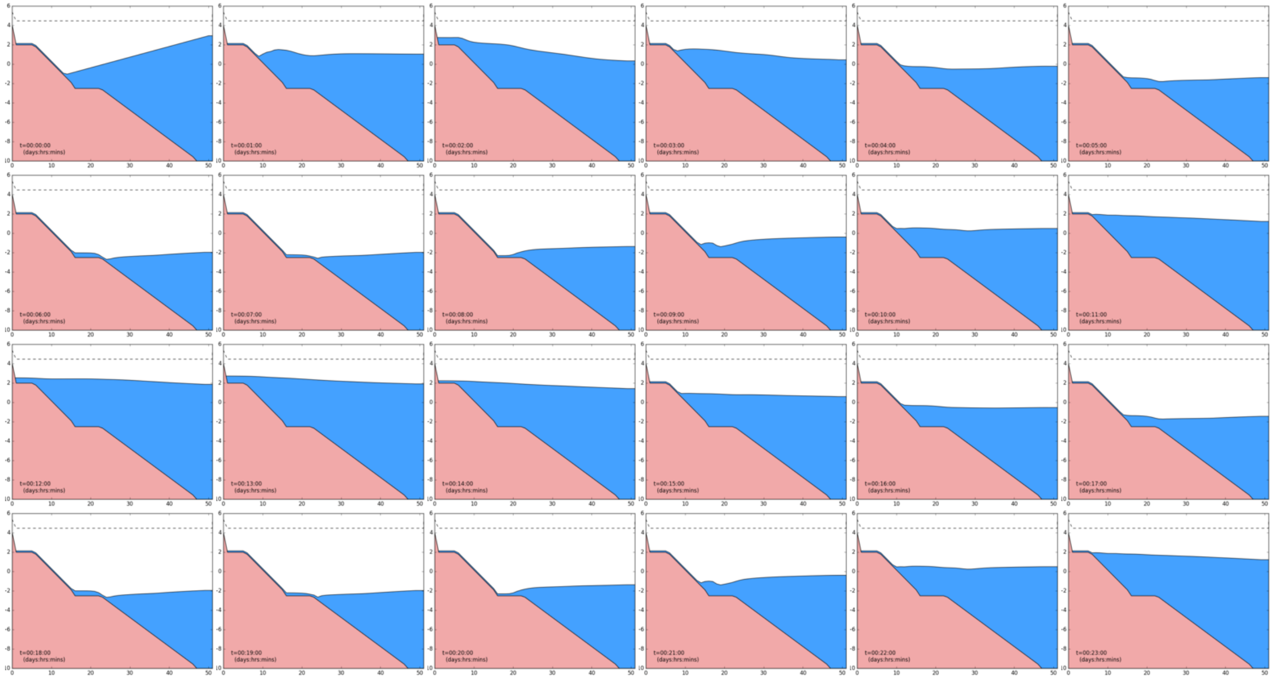

Figure 1.7: The evolution of the sea surface height in WAD_TEST_CASE 7 from the initial state (t=0) over the first 24 hours of simulation. After the initial surge the solution settles into a simulated tidal cycle with an amplitude of 5m. This is enough to repeatedly wet and dry both shelves.