User Manual for Dike-Groyne Module of FVCOM

Step 1: Create an original mesh

An ordinary triangular mesh should be firstly created, and the structures of dikes and groynes need be specified as node strings in the mesh module of SMS software (version 8.1 or above is recommended). The mesh in SMS is shown in Fig.1.

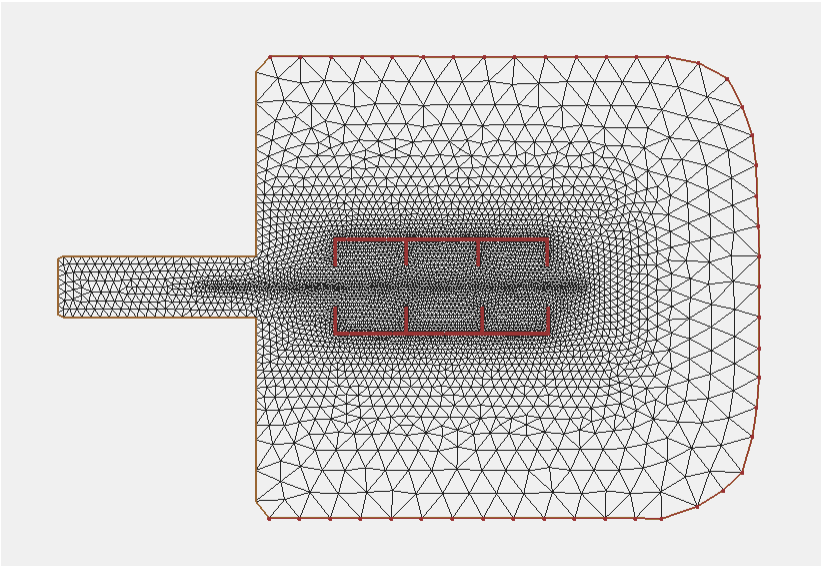

Fig.1 Mesh and dikes node strings of an idealized estuary.

There are two groups of dikes and groynes in this idealized estuary, and they are spatially separated, which then could be allocated into separate CPU domains to increase the computation speed.

The mesh file should be specified as 2dm format, which could be configured under generic model in SMS. The grd format (fort.14) is not supported in this utility. We specified this mesh as *casename_no_dike.2dm*.

Step 2: Split mesh along dikes and groynes

The mesh information should be given in the main program of source code in *split_mesh* directory, such as that in Fig.2.

```
CASENAME='tst'
FNAME1='./tst_no_dike.2dm'
FNAME2='tst_dam.2dm'
NGL= 9250
MGL= 4688

ISSpherical = .FALSE.
```

Fig.2 Mesh information specification in virtual_dike_mesh.f90

Then, the node information for the dikes and groynes should be given in

casename_ns.dat in *step2_split_mesh* directory. The original node string information in 2dm-formated mesh file is shown as Fig.3.

```
13938 ND    4687 2.66249000e+005 1.54823919e+005 1.00000000e+001
13939 ND    4688 2.66249000e+005 1.55125339e+005 1.00000000e+001
13940 NS     3429    3428    3234    3029    2814    2584    2583    2349    2111    2110
13941 NS     2109    2108    2107    2106    2105    2104    2103    2102    2101    2100
13942 NS     2099    2098    2097    2096    2095    2094    2093    2092    2091    2090
13943 NS     2089    2323    2322    2321    2320    2083    2082    2081    2080    2079
13944 NS     2078    2077    2076    2075    2074    2073    2072    2071    2070    2069
13945 NS     2300    2299    2298    2064    2295    2294    2293    2292    2059    2289
13946 NS     2056    2055    2054    2053    2052    2051    2050    2049    2048    2047
13947 NS     2046    2045    2044    2043    2042    2041    2040    2039    2038    2269
13948 NS     2268    2511    2749    2968    3174    3368   -3366
13949 NS     3277    3092    2881    2882    2658    2413    2164    1935    1736    1737
13950 NS     1938    1939    1940    1941    1942    1943    1944    1945    1946    1947
13951 NS     2178    2179    2180    2181    2182    2183    2184    2185    2186    2187
13952 NS     2188    2189    2190    2191    2192    2193    2194    2195    2196    2197
13953 NS     2198    2199    2200    2201    2202    2203    2204    2205    2206    2207
13954 NS     2208    2209    2210    2211    1982    2214    2215    2216    2217    2218
13955 NS     2219    2220    2221    2222    2223    2224    2225    2226    1996    2229
13956 NS     2230    2231    2001    2002    2003    2004    2005    2006    2007    2240
13957 NS     2484    2723    2944    3154    3347    3348   -3535
13958 NS     2189    2437    2681    2903    3114    3307    3494    3665   -3825
13959 NS     2215    2462    2703    2925    3135    3328    3515    3686   -3846
13960 NS     2323    2560    2792    3009    3215    3408    3589    3753   -3910
13961 NS     2294    2534    2770    2988    3195    3388    3570    3734   -3891
13962 NS        1       2       3       4       5       6       7       8       9      10
13963 NS       11      12      13      14      15      16      17      18      19      20
13964 NS       21      22      23      24      25      26      27      28      29      30
13965 NS       31      32      33      34      35      36      37      38      39      40
13966 NS       41      42      43      44     -45
13967 BEGPARAMDEF
```

Fig.3 Original format for the node strings in SMS 2dm-format mesh file.

The node strings for dikes and groynes are included from line 13940 to line 13961. The node string from line 13962-13966 indicates the open boundary in this idealized estuary.

Copy these node string lines to *casename_ns.dat*, and replace the blanks with zero. The final format of casename_ns.dat is shown as Fig.4.

```
  1 NS     3429    3428    3234    3029    2814    2584    2583    2349    2111    2110
  2 NS     2109    2108    2107    2106    2105    2104    2103    2102    2101    2100
  3 NS     2099    2098    2097    2096    2095    2094    2093    2092    2091    2090
  4 NS     2089    2323    2322    2321    2320    2083    2082    2081    2080    2079
  5 NS     2078    2077    2076    2075    2074    2073    2072    2071    2070    2069
  6 NS     2300    2299    2298    2064    2295    2294    2293    2292    2059    2289
  7 NS     2056    2055    2054    2053    2052    2051    2050    2049    2048    2047
  8 NS     2046    2045    2044    2043    2042    2041    2040    2039    2038    2269
  9 NS     2268    2511    2749    2968    3174    3368   -3366       0       0       0
 10 NS     3277    3092    2881    2882    2658    2413    2164    1935    1736    1737
 11 NS     1938    1939    1940    1941    1942    1943    1944    1945    1946    1947
 12 NS     2178    2179    2180    2181    2182    2183    2184    2185    2186    2187
 13 NS     2188    2189    2190    2191    2192    2193    2194    2195    2196    2197
 14 NS     2198    2199    2200    2201    2202    2203    2204    2205    2206    2207
 15 NS     2208    2209    2210    2211    1982    2214    2215    2216    2217    2218
 16 NS     2219    2220    2221    2222    2223    2224    2225    2226    1996    2229
 17 NS     2230    2231    2001    2002    2003    2004    2005    2006    2007    2240
 18 NS     2484    2723    2944    3154    3347    3348   -3535       0       0       0
 19 NS     2189    2437    2681    2903    3114    3307    3494    3665   -3825       0
 20 NS     2215    2462    2703    2925    3135    3328    3515    3686   -3846       0
 21 NS     2323    2560    2792    3009    3215    3408    3589    3753   -3910       0
 22 NS     2294    2534    2770    2988    3195    3388    3570    3734   -3891       0
```

Fig.4 Final format of casename_ns.dat

Compile the source code in *split_mesh*, and link the executable *./xsplit* in

step2_split_mesh directory, and run this program to split this mesh along the dikes and groynes. Some temporary files will be produced, and the final result for this step is *casename_dike.2dm*.

The dikes and groynes in *casename_dike.2dm* is shown in Fig.5, indicating inserted solid coastline along the dikes and groynes.

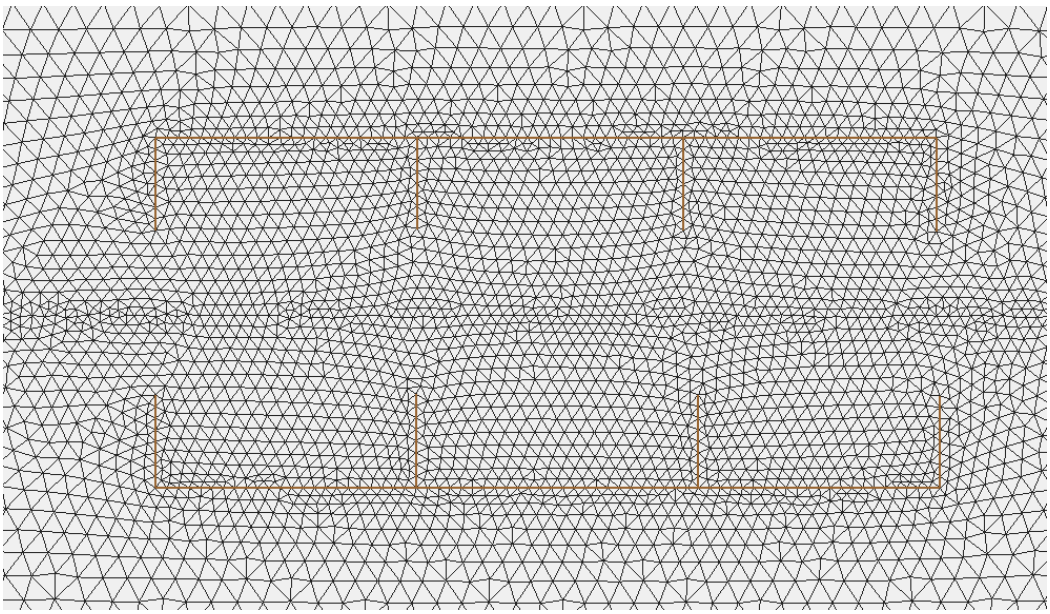

Fig.5 The boundaries for dikes and groynes after mesh splitting.

Step 3: Renumber the mesh and generate the input file

Copy the node string information and other mesh information in *casename_no_dike.2dm* (Fig.3) to *casename_dike.2dm*.

Select the open boundary node string, and renumber the whole mesh with new node numbers and cell numbers.

Save the mesh into *casename_dike_renumbered.2dm*.

Copy or link the *casename_dike_renumbered.2dm* to *step3_generate_files* directory.

Copy the node string information in *casename_dike_renumbered.2dm* to *casename_ns_after_renumber.dat* file.

Insert a new column after 'NS' column in *casename_ns_after_renumber.dat* file to specify the domain marks. The file format for *casename_ns_after_renumber.dat* file is shown in Fig.6.

It should be noted all spatially connected dikes/groynes should be allocated in one CPU domain. To increase the computation speed under parallel environment, these nodes and cells of dikes and groynes should be allocated as many CPUs as possible if they are spatially separated.

1	NS	1	2707	2706	2630	2546	2452	2349	2348	2255	2109	2108
2	NS	1	2107	2106	2105	2104	2103	2102	2101	2100	2099	2098
3	NS	1	2097	2096	2095	2094	2093	2092	2091	2090	2089	2088
4	NS	1	2087	4384	2253	2252	2251	2081	2080	2079	2078	2077
5	NS	1	2076	2075	2074	2073	2072	2071	2070	2069	2068	2067
6	NS	1	2250	2249	2248	2062	2247	4662	2245	2244	2057	2243
7	NS	1	2054	2053	2052	2051	2050	2049	2048	2047	2046	2045
8	NS	1	2044	2043	2042	2041	2040	2039	2038	2037	2036	2242
9	NS	1	2241	2347	2450	2544	2629	2705	-2703	0	0	0
10	NS	1	4384	4596	4522	4456	4392	4330	4268	4201	-4124	0
11	NS	1	4662	4255	4254	4187	4186	4185	4184	4104	-4103	0
12	NS	2	2673	2746	2812	2883	2958	3029	3108	3192	3278	3369
13	NS	2	3368	3367	3366	3365	3364	3452	3531	3609	3687	3768
14	NS	2	3767	3847	3921	3998	4073	4072	4071	4150	4225	4291
15	NS	2	4353	2174	4785	4784	4783	4782	4781	4780	4779	4832
16	NS	2	4864	4880	4889	4888	4881	4865	4834	4833	4786	4709
17	NS	2	4708	4707	4706	4705	4704	4703	2198	4226	4151	4076
18	NS	2	4075	4074	3999	3922	3848	3774	3694	3616	3541	3540
19	NS	2	3539	3538	3463	3458	3462	3461	3460	3459	3381	3289
20	NS	2	3203	3119	3040	2968	2895	2823	-2756	0	0	0
21	NS	2	2174	4413	4350	4287	4220	4219	4143	4142	-4141	0
22	NS	2	2198	4550	4482	4419	4357	4294	4232	4160	-4085	0

Fig.6 File format of *casename_ns_after_renumber.dat*.

Specify the mesh information in *generate_thin_dam_inputs.f90* as Fig.7.

```
implicit none

CASENAME='tst'
FNAME1='./tst_dike_renumbered.2dm'
NGL= 9250
MGL= 4890

above_msl= -5.0 ! dike top is 5.0m deep below the mean sea level

CALL READ_MESH
CALL READ_NODESTRING
CALL READ_THINDAM
```

Fig.7 Mesh specification in *generate_thin_dam_inputs.f90*.

The variable *above_msl* indicates the elevation of dike/groyne top above the mean sea level. In this experiment example, the dike/groyne height is 5m, which means the dike top is located in the middle of water column (uniform 10m-depth bathymetry).

Besides of this uniform value of *above_msl*, some special configuration of dike/groyne height can be given in this utility, such as *casename_ns_adding.dat*, *casename_ns_submerged.dat* and *casename_ns_linear_groyne.dat*. For this idealized experiment, these files could be left blank.

The final input files for dikes and groynes will be generated into *casename_dam_cell.dat* and *casename_dam_node.dat*.

Step 4: Run the dike-groyne model

Copy or link the *casename_dam_cell.dat* and *casename_dam_node.dat* to *step4_final_model/input* directory.

Create the *casename_grd.dat*, *casename_dep.dat* and *casename_cor.dat*

according to *casename_dike_renumbered.2dm*. Copy them into *input* directory.

Run the model with

./fvcom –casename=tst for serial computation, or

mpiexec –n 10 ./fvcom –casename=tst for parallel running.

User can check the domain specification with Pseudocolor plotting of variable *partition* in model result *tst_0001.nc* as shown in Fig.8. The software VisIt is recommended.

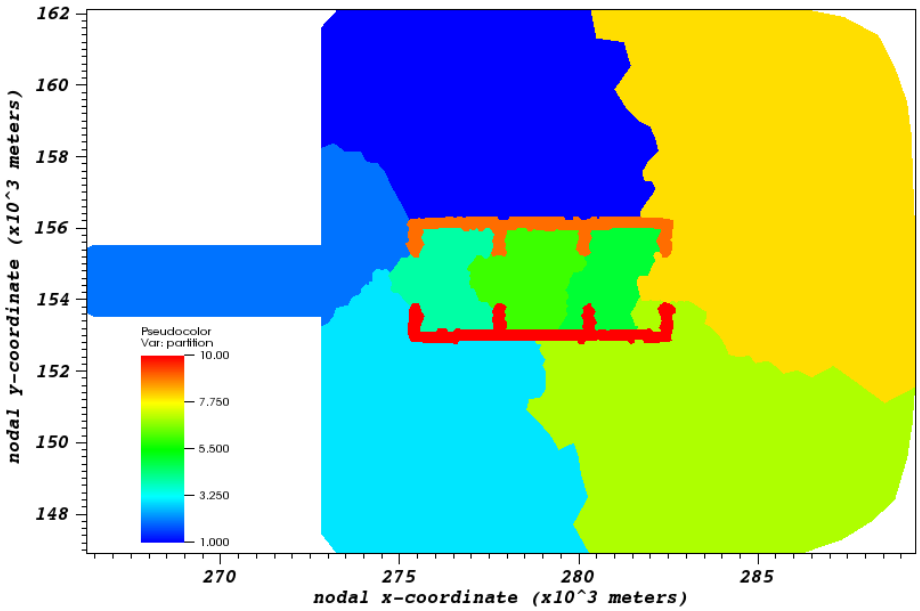

Fig.8 Domain decomposition with dike-groyne module in FVCOM.

The model details could be referred to:

Ge, J., Chen, C., Qi, J., Ding, P., & Beardsley, R. C. (2012). A dike-groyne algorithm in a terrain-following coordinate ocean model (FVCOM): Development, validation and application. *Ocean Modelling*, 47(C), 26–40. doi:10.1016/j.ocemod.2012.01.006

Chen C., R. C. Beardsley, G. Cowles, J. Qi, Z. Lai,G. Gao, D. Stuebe, Q. Xu, P. Xue, J. Ge, S. Hu, R. Ji, R Tian, H. Huang, L. Wu, H. Lin, Y. Sun and L. Zhao, (2013). An Unstructured Grid, Finite-Volume Community Ocean Model FVCOM User Manual, SMAST/UMASSD-13-0701

Regarding any questions and suggestions about the dike-groyne module, users can contact with:

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