Memo

To
To whom it may concern

Date
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Reference
003

Number of pages
15

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D-Flow 1D NetCDF-format; CF-1.7 UGRID-1.0 Deltares-0.81

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1 Agreements

The following agreements are made for the attributes of a variable

Units

The units are presented according the Climate and Format convention,see http://cfconventions.org/Data/cf-standard-names/41/build/cf-standard-name-table.html, see column "canonical units". Because the unit of Chézy does not fulfill the SI unit convention, the power of the length is not an integer ($C = [m^{\frac{1}{2}}/s] \equiv [m^{1/2}/s] \equiv [\sqrt{m}/s]$), we choose to represent the unit of Chézy by [m(0.5) s-1], [m1/2 s-1] or [m(1/2) s-1].

long_name

Long names should start with a capital character, because these names are used by labeling plots. See http://cfconventions.org/Data/cf-conventions/cf-conventions-1.7/cf-conventions.html#long-name

2 Keyword definition for 1D networks

Table 1: 1D network topology

Required topology attributes	Value	Example
cf_role	mesh_topology	
topology_dimension	1	
edge_dimension		nNetworkBranches
edge_geometry		network1D_geometry
edge_node_connectivity		network1D_edge_nodes
node_coordinates		network1D_nodes_x ␣ network1D_nodes_y
node_dimension		nNetworkNodes
Optional attributes		
long_name		Network topology

Table 2: 1D network geometry, referenced by the value of the attribute **edge_geometry** *attribute as defined in* Table 1

Required geometry attributes	Value	Example
geometry_type	multiline	
geometry_length		network1D_geom_length
node_coordinates		network1D_geom_x ␣ network1D_geom_y
node_count		nGeometryNodes
part_node_count		network1D_part_node_count
Optional attributes		
long_name		Network Geometry
node_name		Node name
edge_name		Branch name

Table 3: 1D computational mesh

Required mesh attributes	Value	Example
cf_role	mesh_topology	
topology_dimension	1	
coordinate_space	*defined by* Table 1	
branch_length		mesh1D_branch_length
edge_dimension		nMesh1DEdges
edge_node_connectivity		mesh1D_edge_nodes
node_coordinates		mesh1D_nodes_branch_id ␣
		mesh1D_nodes_branch_offset
node_dimension		nMesh1DNodes

Optional attributes

long_name		Mesh 1D
node_name		Mesh 1D node name
edge_name		Mesh 1D branch name

Vragen:

1. Bij geometry definition is het **count** en op andere plaatsen is het **dimension**. Wat kiezen we?
2. Is het attribute **edge_geometry** de enige entry naar de geometry? Kan een netwerk zonder geometry bestaan?
3. Twee lengten van een branch opgegeven, voor de geometry en de mesh. Willen we dit of zijn deze per definitie gelijk? Indien er geen geometry is opgegeven dan moet de branch lengte bij het mesh worden opgenomen.
4. Naamgevingen, branch namen in de geometrie kunnen verschillen van de naamgevingen in het rooster.
5. Naamgeving variabele: **part_node_count** vs. **edge_node_count** vs. **branch_node_count** . Wat kiezen we?
6. Lokatienamen moet ook volgens de offset worden gedefinieerd. Bijv. het Oranjekanaal dat uitkomt in de Nieuwe Waterweg ligt op 12 km vanaf het splitsing bij Het Scheur. En niet gerelateerd aan water, maar wel interessant voor de scheepvaart, Dirkzwager ligt op 6 km van Het Scheur.

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3   Network1D (map) nc-file

```
...

double s1(time, nMeshNodes):
    coordinates = 'mesh1D_node_x mesh1D_node_y'
    location = 'node' // /
    long_name = 'Water level'
    mesh = 'mesh1D'   //  this is UGRID location pointing to mesh1D topology
    standard_name = 'sea_surface_height_above_geoid'
    units = 'm'
double u(time, nMeshEdges)
    coordinates = 'mesh1D_edge_x mesh1D_edge_y' // this is CF location sufficient to plot marke
    location = 'edge' // /
    long_name = 'Velocity along branch'
    mesh = 'mesh1D'   //  this is UGRID location pointing to mesh1D topology
    standard_name = 'sea_water_speed' // not quite correct because it's not the magnitude,
                                      but signed scalar velocity
    units = 'm s-1'

...
```

4   D-Flow 1D history nc-file

To be added station locations, see for an example the D-Flow FM history file.

```
...

double s1(time=ntimes, stations=nstations);
    coordinates = "station_x station_y"
    long_name = "Water level"
    standard_name = "sea_surface_height_above_geoid"
    units = "m"
double u(time=ntimes, stations=nstations);
    coordinates = "station_xu station_yu"
    long_name = "Velocity along branch"
    standard_name = "sea_water_speed"
    units = "m s-1"

...
```

📌 **Note:** The coordinates of the station does not necessarily have the same coordinates as the mesh or network.

Date
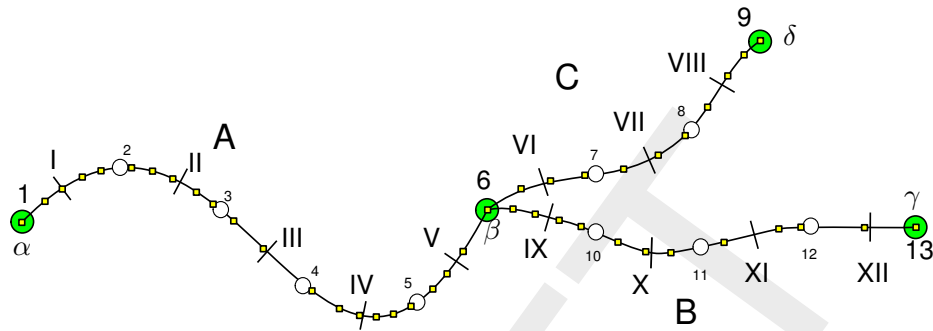generated: 2018-12-22

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5 Example based on Figure 1

Figure 1: Simple 1D network;
3 branches (A, B, C),
4 network nodes (green circles, α, β, γ, δ);
13 nodes (open circles + green circles, ζ-points, latin numbers),
12 edges (u-points; roman numbers), 44 network nodes (yellow squares)

Dimensions

nNetworkBranches = 3; A, B, C
nNetworkNodes = 4; α, β, γ, δ
nBranchPointsTotal = 46; yellow squares per branch (including both end points)
nGeomPoints = 44; yellow squares (total number of distinct points)
nMeshNodes = 13 (13=6+5+4-(3-1); 3 branches are connected to node 6)
nMeshEdges = 12 (12=5+4+3); edges are between ζ-points

5.1 Network nodes

network1D_nodes_x(nNetworkNodes)
```
-187.96667, 2195.7333, 4071.4928, 3445.4246
```

network1D_nodes_y(nNetworkNodes)
```
720.81667, 708.71667, 690.94861, 1540.1838
```

network1D_edge_nodes(nNetworkBranches,Two)
```
  I:  1   2
 II:  2   3
III:  2   4
```

5.2 Geometry

network1D_part_node_count(nNetworkBranches)
```
22, 13, 11
```

So the branches contain the following geometry points:

```
Branch A: 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
          18, 19, 20, 21, 22, 23, 24, 2;
Branch B: 2, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 3;
Branch C: 2, 36, 37, 38, 39, 40, 41, 42, 43, 44, 4.
```

Note that the node number 2 appear three times in this array.

network1D_geom(nNetworkBranches)
The three geometry lengths (the offset of the end point of a branch)

```
length_A, ..., length_C
```

The offset is in general not equal to the euclidical length between the nodes on the branch

network1D_geom_x(nNetworkNodes)
```
x_1, ..., x_46
```

network1D_geom_y(nNetworkNodes)
```
y_1, ..., y_46
```

6 Numerical discretization

mesh1D_node_branch_id(nMeshNodes)
```
 A, A, A, A, A, A, C, C, C, B, B, B, B
```

mesh1D_node_branch_offset(nMeshNodes)
```
0, 500, 1000, 1500, 2000, 2500 (on branche A, 6 nodes)
700, 1400, 2100 (on branche B, 4 nodes; without node 6)
400, 800, 1200, 1600 (on branche C, 3 nodes; without node 6)
```
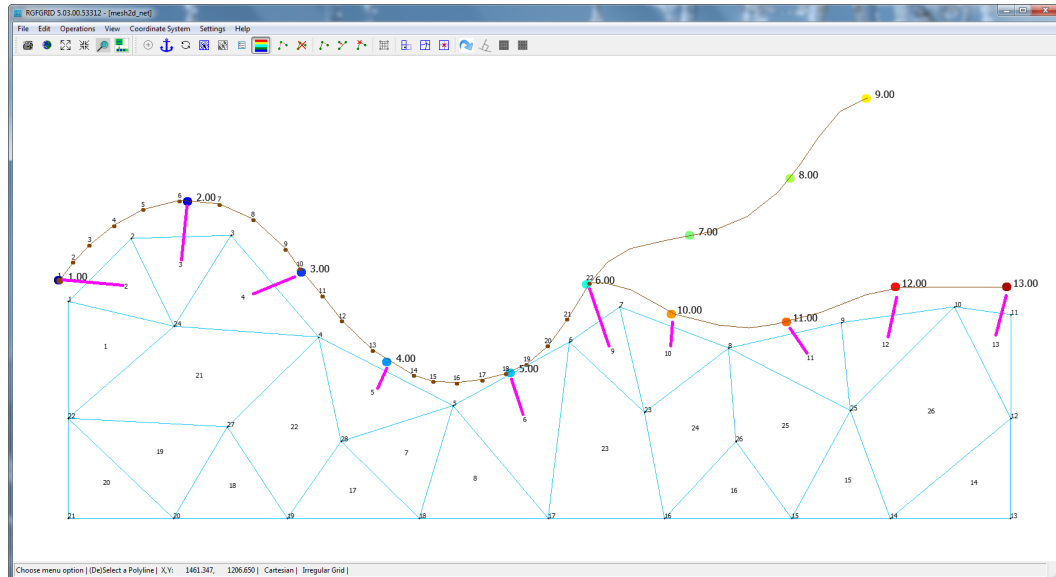
mesh1D_edge_nodes(nMeshEdges,Two)

```
   I:  1   2
  II:  2   3
 III:  3   4
  IV:  4   5
   V:  5   6
  VI:  6   7
 VII:  7   8
VIII:  8   9
  IX:  6  10
   X: 10  11
  XI: 11  12
 XII: 12  13
```

7 Example based on Figure 2

Figure 2: Composite mesh (1D and 2D),
1D Mesh*: coloured dots (=computational 1D mesh), ζ-points; numbered dots, 1d network geometry for branch A (Figure 1).*
2D Mesh*: light blue with node and face numbers.*
1D2D connections are pink coloured.

1D2D-links

1D2D-links are defined between de computational nodes of the 1D Mesh (ζ-points) and the faces of the 2D Mesh (ζ-points). The link table for Figure 2 read:

Table 4: 1D2D Link table based on Figure 2

1d node	2d face
1	2
2	3
3	4
4	5
5	6
6	9
10	10
11	11
12	12
13	13

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8 Example of ncdump-file based on Figure 2

Begin ncdump output:

```
netcdf ugrid_1d2d_map {
dimensions:
nNetworkBranches = 3 ;
nNetworkNodes = 4 ;
nGeometryNodes = 46 ;
nMesh1DNodes = 13 ;
nMesh1DEdges = 12 ;
max_nMesh2D_face_nodes = 4 ;
nMesh2D_edge = 53 ;
nMesh2D_face = 26 ;
nMesh2D_node = 28 ;
nlinks_1d2d = 10 ;
time = UNLIMITED ; // (2 currently)
Two = 2 ;
variables:
uint network1D ;
network1D:cf_role = "mesh_topology" ;
network1D:edge_dimension = "nNetworkBranches" ;
network1D:edge_geometry = "network1D_geometry" ;
network1D:edge_node_connectivity = "network1D_edge_nodes" ;
network1D:long_name = "Network topology" ;
network1D:node_coordinates = "network1D_nodes_x network1D_nodes_y" ;
network1D:node_dimension = "nNetworkNodes" ;
network1D:topology_dimension = 1 ;
double network1D_nodes_x(nNetworkNodes) ;
network1D_nodes_x:standard_name = "projection_x_coordinate" ;
network1D_nodes_x:long_name = "x-coordinates of the network connection nodes" ;
network1D_nodes_x:units = "m" ;
double network1D_nodes_y(nNetworkNodes) ;
network1D_nodes_y:standard_name = "projection_y_coordinate" ;
network1D_nodes_y:long_name = "y-coordinates of the network connection nodes" ;
network1D_nodes_y:units = "m" ;
uint network1D_geometry(nNetworkBranches) ;
network1D_geometry:geometry_type = "multiline" ;
network1D_geometry:long_name = "1D Geometry" ;
network1D_geometry:node_count = "nGeometryNodes" ;
network1D_geometry:part_node_count = "network1D_part_node_count" ;
network1D_geometry:node_coordinates = "network1D_geom_x network1D_geom_y" ;
uint network1D_edge_nodes(nNetworkBranches, Two) ;
network1D_edge_nodes:cf_role = "edge_node_connectivity" ;
network1D_edge_nodes:long_name = "start and end nodes of each branch in the network" ;
network1D_edge_nodes:start_index = 1 ;
uint network1D_part_node_count(nNetworkBranches) ;
network1D_part_node_count:long_name = "number of geometry nodes per branch" ;
double network1D_geom_x(nGeometryNodes) ;
network1D_geom_x:cf_role = "geometry_x_node" ;
network1D_geom_x:standard_name = "projection_x_coordinate" ;
network1D_geom_x:long_name = "x-coordinates of the branch geometries" ;
network1D_geom_x:units = "m" ;
double network1D_geom_y(nGeometryNodes) ;
network1D_geom_y:cf_role = "geometry_y_node" ;
network1D_geom_y:standard_name = "projection_y_coordinate" ;
network1D_geom_y:long_name = "y-coordinates of the branch geometries" ;
network1D_geom_y:units = "m" ;
uint mesh1D ;
mesh1D:cf_role = "mesh_topology" ;
mesh1D:coordinate_space = "network1D" ;
mesh1D:edge_dimension = "nMesh1DEdges" ;
mesh1D:edge_node_connectivity = "mesh1D_edge_nodes" ;
mesh1D:long_name = "Mesh 1D" ;
mesh1D:node_coordinates = "mesh1D_nodes_branch_id mesh1D_nodes_branch_offset" ;
```

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```
mesh1D:node_dimension = "nMesh1DNodes" ;
mesh1D:topology_dimension = 1 ;
uint mesh1D_nodes_branch_id(nMesh1DNodes) ;
mesh1D_nodes_branch_id:cf_role = "feature_index" ;
mesh1D_nodes_branch_id:long_name = "Number of branch on which node is located" ;
double mesh1D_nodes_branch_offset(nMesh1DNodes) ;
mesh1D_nodes_branch_offset:cf_role = "coordinate_on_feature" ;
mesh1D_nodes_branch_offset:long_name = "Offset along the branch at which the node is located" ;
mesh1D_nodes_branch_offset:units = "m" ;
uint Mesh2D ;
Mesh2D:cf_role = "mesh_topology" ;
Mesh2D:edge_coordinates = "Mesh2D_edge_x Mesh2D_edge_y" ;
Mesh2D:edge_dimension = "nMesh2D_edge" ;
Mesh2D:edge_face_connectivity = "Mesh2D_edge_faces" ;
Mesh2D:edge_node_connectivity = "Mesh2D_edge_nodes" ;
Mesh2D:face_coordinates = "Mesh2D_face_x Mesh2D_face_y" ;
Mesh2D:face_dimension = "nMesh2D_face" ;
Mesh2D:face_edge_connectivity = "Mesh2D_face_edges" ;
Mesh2D:face_face_connectivity = "Mesh2D_face_face" ;
Mesh2D:face_node_connectivity = "Mesh2D_face_nodes" ;
Mesh2D:long_name = "Mesh 2D" ;
Mesh2D:max_face_nodes_dimension = "max_nMeshFaceNodes" ;
Mesh2D:node_coordinates = "Mesh2D_node_x Mesh2D_node_y" ;
Mesh2D:node_dimension = "nMesh2D_node" ;
Mesh2D:topology_dimension = 2 ;
double Mesh2D_node_x(nMesh2D_node) ;
Mesh2D_node_x:standard_name = "projection_x_coordinate" ;
Mesh2D_node_x:units = "m" ;
double Mesh2D_node_y(nMesh2D_node) ;
Mesh2D_node_y:standard_name = "projection_y_coordinate" ;
Mesh2D_node_y:units = "m" ;
double Mesh2D_edge_x(nMesh2D_edge) ;
Mesh2D_edge_x:standard_name = "projection_x_coordinate" ;
Mesh2D_edge_x:units = "m" ;
double Mesh2D_edge_y(nMesh2D_edge) ;
Mesh2D_edge_y:standard_name = "projection_y_coordinate" ;
Mesh2D_edge_y:units = "m" ;
double Mesh2D_edge_nodes(nMesh2D_edge, Two) ;
Mesh2D_edge_nodes:cf_role = "edge_node_connectivity" ;
Mesh2D_edge_nodes:long_name = "Maps every edge to the two nodes that it connects" ;
Mesh2D_edge_nodes:start_index = 1 ;
double Mesh2D_face_nodes(nMesh2D_face, max_nMesh2D_face_nodes) ;
Mesh2D_face_nodes:_FillValue = 0. ;
Mesh2D_face_nodes:cf_role = "face_node_connectivity" ;
Mesh2D_face_nodes:long_name = "Maps every face to the nodes that it defines" ;
Mesh2D_face_nodes:start_index = 1 ;
uint composite_mesh ;
composite_mesh:cf_role = "mesh_topology_parent" ;
composite_mesh:meshes = "mesh1D mesh2D" ;
composite_mesh:mesh_contact = "link1d2d" ;
uint link1d2d(nlinks_1d2d, Two) ;
link1d2d:cf_role = "mesh_topology_contact" ;
link1d2d:contact = "mesh1D:node mesh2D:face" ;
link1d2d:start_index = 1 ;
double time(time) ;
time:standard_name = "time" ;
time:long_name = "Time" ;
time:units = "seconds since 2017-01-01 00:00:00" ;
time:calender = "gregorian" ;
double s1_1d(time, nMesh1DNodes) ;
s1_1d:location = "node" ;
s1_1d:long_name = "Water level" ;
s1_1d:mesh = "mesh1D" ;
s1_1d:standard_name = "sea_surface_height_above_geoid" ;
s1_1d:units = "m" ;
double u_1d(time, nMesh1DEdges) ;
u_1d:location = "edge" ;
```

```
u_1d:long_name = "velocity along branch" ;
u_1d:mesh = "mesh1D" ;
u_1d:standard_name = "sea_water_speed" ;
u_1d:units = "m s-1" ;
double s1_2d(time, nMesh2D_face) ;
s1_2d:coordinates = "Mesh2D_face_x Mesh2D_face_y" ;
s1_2d:location = "face" ;
s1_2d:long_name = "water level" ;
s1_2d:mesh = "Mesh2D" ;
s1_2d:standard_name = "sea_surface_height_above_geoid" ;
s1_2d:units = "m" ;
double u_2d(time, nMesh2D_edge) ;
u_2d:coordinates = "Mesh2D_edge_x Mesh2D_edge_y" ;
u_2d:location = "edge" ;
u_2d:long_name = "Normal velocity at edge" ;
u_2d:mesh = "Mesh2D" ;
u_2d:standard_name = "sea_water_speed" ;
u_2d:units = "m s-1" ;

// global attributes:
:Conventions = "CF-1.7 UGRID-1.0 Deltares-0.9" ;
:history = "Created on 2018-09-12 14:09:25.360958 D-Flow 1D, D-Flow FM. lD2D coupling" ;
:institution = "Deltares" ;
:reference = "http://www.deltares.nl" ;
:source = "Python program to test layout of a D-Flow 1D, D-Flow FM" ;
data:

 network1D = _ ;

 network1D_nodes_x = -187.96667, 2195.7333, 4071.4928, 3445.4246 ;

 network1D_nodes_y = 720.81667, 708.71667, 690.94861, 1540.1838 ;

 network1D_geometry = 2500, 2100, 1600 ;

 network1D_edge_nodes =
  1, 2,
  2, 3,
  2, 4 ;

 network1D_part_node_count = 22, 13, 11 ;

 network1D_geom_x = -187.96667, -127.96887, -53.84786, 56.174104, 187.13333,
    352.5, 529.96667, 683.23333, 828.43333, 892.96667, 993.8, 1082.5333,
    1219.6667, 1405.2, 1492.2591, 1598.5306, 1712.2164, 1818.4835, 1912.3747,
    2007.9644, 2094.9, 2195.7333, 2195.7333, 2269.2456, 2381.5612, 2460.2412,
    2577.8276, 2774.8643, 2911.5187, 3029.1051, 3235.6759, 3438.7319,
    3582.0791, 3817.2519, 4071.4928, 2195.7333, 2275.9165, 2377.6129,
    2539.6914, 2739.9061, 2901.9847, 3041.8172, 3140.3355, 3226.4949,
    3321.8353, 3445.4246 ;

 network1D_geom_y = 720.81667, 802.67261, 879.96131, 968.25292, 1039.45,
    1079.7833, 1063.65, 995.08333, 861.98333, 773.25, 652.25, 539.31667,
    406.21667, 293.28333, 265.90693, 260.14026, 273.32123, 301.64228,
    343.82527, 427.37378, 547.38333, 708.71667, 708.71667, 705.99709,
    676.04627, 633.74441, 567.00618, 519.33601, 506.62397, 522.51403,
    576.54021, 655.98306, 684.59259, 690.94861, 690.94861, 708.71667,
    802.179, 862.56121, 900.69734, 938.83347, 1005.5717, 1116.8021,
    1237.5665, 1367.1587, 1480.1547, 1540.1838 ;

 mesh1D = _ ;

 mesh1D_nodes_branch_id = 1, 1, 1, 1, 1, 1, 3, 3, 3, 2, 2, 2, 2 ;

 mesh1D_nodes_branch_offset = 0, 500, 1000, 1500, 2000, 2500, 700, 1400,
    2100, 400, 800, 1200, 1600 ;
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```
Mesh2D = _ ;

Mesh2D_node_x = -150, 133.043016423945, 581.589811881954, 976.640200542219,
    1581.56110817825, 2104.17985151006, 2330.51080334667, 2820.20868095679,
    3326.36699142775, 3836.64041011393, 4091.3328, 4091.0588, 4087.6891,
    3547.526, 3104.2863, 2530.6819, 2009.2233, 1428.1695, 835.9416,
    321.93246, -150, -150, 2441.32387428041, 326.036595922787,
    3368.4335297957, 2852.91575366228, 564.605213864027, 1077.48494483683 ;

Mesh2D_node_y = 625.39432, 908.781962364921, 921.127287010554,
    464.350275122123, 155.717158981291, 443.774734046067, 600.148846224089,
    414.968976539589, 530.1920065655, 600.148846224089, 565.79906,
    99.9999999999999, -350, -350, -350, -350, -350, -350, -350, -350,
    99.9999999999999, 125.838619350021, 513.501770748115, 134.310966738994,
    -5.00908866931604, 62.2847173147688, -3.38148493072237 ;

Mesh2D_edge_x = 3963.98660505697, 3963.84960505697, 4091.1958,
    2217.34532742836, 2272.75186289524, 2385.91733881354, 2630.7662776186,
    2575.35974215173, 2056.70157575503, -8.4784917880275, 88.0182979613934,
    229.539806173366, 3325.90615, 3457.97976489785, 3236.35991489785,
    2836.56221730954, 4089.37395, 3819.2924, 3817.60755, 357.316414152949,
    453.81320390237, -150, 85.96623, 85.96623, 2978.60102683114,
    2691.79882683114, 2817.4841, 2486.00288714021, 3347.40026061173,
    3073.28783619227, 3094.32110537625, 578.93703, 700.273406932013,
    443.268836932014, 2269.9526, -150, 88.0182979613934, 207.302606932014,
    956.713272418414, 651.338398232503, 779.115006212086, 1718.6964,
    1795.39220408913, 1504.86530408912, 1132.05555, 1252.82722241841,
    1329.52302650754, 1027.06257268952, 770.622707203123, 1279.10065436023,
    1842.87047984415, 3602.53696995482, 3581.50370077084 ;

Mesh2D_edge_y = 582.973953112045, 350.074423112044, 332.89953,
    521.961790135078, 284.806676698044, 362.993732787055, 270.403797944805,
    507.558911381839, 46.8873670230335, 767.088141182461, 569.448045374058,
    711.141866556518, -350, -107.844516630503, -107.844516630503,
    204.979943935137, -125, -125, -350, 914.954624687738, 717.314528879334,
    -125, -350, -125, -177.504544334658, -177.504544334658, -350,
    -112.080690324989, 332.251486652247, 472.580491552545, 274.639971639292,
    -350, -143.857641342616, -143.857641342616, -350, 362.69716,
    306.750885374057, 81.1423586573843, -176.690742465361, 488.926022935119,
    692.738781066338, -350, -97.1414205093546, -97.1414205093546, -350,
    -176.690742465361, 76.1678370252842, 230.4843950957, 263.317496218446,
    310.033717051707, 299.745946513679, 367.229906481542, 565.170426394795 ;

Mesh2D_edge_nodes =
 11, 10,
 10, 12,
 12, 11,
 7, 6,
 6, 23,
 23, 7,
 23, 8,
 8, 7,
 6, 17,
 2, 1,
 1, 24,
 24, 2,
 15, 14,
 14, 25,
 25, 15,
 26, 8,
 13, 12,
 12, 14,
 14, 13,
 3, 2,
 24, 3,
 22, 21,
 21, 20,
```

```
    20, 22,
    26, 15,
    26, 16,
    16, 15,
    23, 16,
    25, 9,
    9, 8,
    8, 25,
    20, 19,
    19, 27,
    27, 20,
    17, 16,
    1, 22,
    22, 24,
    27, 22,
    19, 28,
    24, 4,
    4, 3,
    18, 17,
    17, 5,
    5, 18,
    19, 18,
    18, 28,
    5, 28,
    28, 4,
    4, 27,
    5, 4,
    6, 5,
    25, 10,
    10, 9 ;

Mesh2D_face_nodes =
    1, 22, 24, _,
    1, 24, 2, _,
    2, 24, 3, _,
    3, 24, 4, _,
    4, 28, 5, _,
    5, 17, 6, _,
    5, 28, 18, _,
    5, 18, 17, _,
    6, 23, 7, _,
    7, 23, 8, _,
    8, 25, 9, _,
    9, 25, 10, _,
    10, 12, 11, _,
    12, 14, 13, _,
    14, 25, 15, _,
    15, 26, 16, _,
    18, 28, 19, _,
    19, 27, 20, _,
    20, 27, 22, _,
    20, 22, 21, _,
    4, 24, 22, 27,
    4, 27, 19, 28,
    6, 17, 16, 23,
    8, 23, 16, 26,
    8, 26, 15, 25,
    10, 25, 14, 12 ;

composite_mesh = _ ;

link1d2d =
    1, 2,
    2, 3,
    3, 4,
    4, 5,
    5, 6,
```

```
  6, 9,
 10, 10,
 11, 11,
 12, 12,
 13, 13 ;

time = 60, 120 ;

s1_1d =
 1, 1.33333333333333, 1.66666666666667, 2, 2.33333333333333,
    2.66666666666667, 3, 3.33333333333333, 3.66666666666667, 4,
    4.33333333333333, 4.66666666666667, 5,
 3, 3.33333333333333, 3.66666666666667, 4, 4.33333333333333,
    4.66666666666667, 5, 5.33333333333333, 5.66666666666667, 6,
    6.33333333333333, 6.66666666666667, 7 ;

u_1d =
 1, 1.36363636363636, 1.72727272727273, 2.09090909090909, 2.45454545454545,
    2.81818181818182, 3.18181818181818, 3.54545454545455, 3.90909090909091,
    4.27272727272727, 4.63636363636364, 5,
 3, 3.36363636363636, 3.72727272727273, 4.09090909090909, 4.45454545454546,
    4.81818181818182, 5.18181818181818, 5.54545454545454, 5.90909090909091,
    6.27272727272727, 6.63636363636364, 7 ;

s1_2d =
 2, 2.16, 2.32, 2.48, 2.64, 2.8, 2.96, 3.12, 3.28, 3.44, 3.6, 3.76, 3.92,
    4.08, 4.24, 4.4, 4.56, 4.72, 4.88, 5.04, 5.2, 5.36, 5.52, 5.68, 5.84, 6,
 4, 4.16, 4.32, 4.48, 4.64, 4.8, 4.96, 5.12, 5.28, 5.44, 5.6, 5.76, 5.92,
    6.08, 6.24, 6.4, 6.56, 6.72, 6.88, 7.04, 7.2, 7.36, 7.52, 7.68, 7.84, 8 ;

u_2d =
 2, 2.07692307692308, 2.15384615384615, 2.23076923076923, 2.30769230769231,
    2.38461538461538, 2.46153846153846, 2.53846153846154, 2.61538461538462,
    2.69230769230769, 2.76923076923077, 2.84615384615385, 2.92307692307692,
    3, 3.07692307692308, 3.15384615384615, 3.23076923076923,
    3.30769230769231, 3.38461538461538, 3.46153846153846, 3.53846153846154,
    3.61538461538462, 3.69230769230769, 3.76923076923077, 3.84615384615385,
    3.92307692307692, 4, 4.07692307692308, 4.15384615384615,
    4.23076923076923, 4.30769230769231, 4.38461538461539, 4.46153846153846,
    4.53846153846154, 4.61538461538461, 4.69230769230769, 4.76923076923077,
    4.84615384615385, 4.92307692307692, 5, 5.07692307692308,
    5.15384615384615, 5.23076923076923, 5.30769230769231, 5.38461538461539,
    5.46153846153846, 5.53846153846154, 5.61538461538461, 5.69230769230769,
    5.76923076923077, 5.84615384615385, 5.92307692307692, 6,
 4, 4.07692307692308, 4.15384615384615, 4.23076923076923, 4.30769230769231,
    4.38461538461539, 4.46153846153846, 4.53846153846154, 4.61538461538461,
    4.69230769230769, 4.76923076923077, 4.84615384615385, 4.92307692307692,
    5, 5.07692307692308, 5.15384615384615, 5.23076923076923,
    5.30769230769231, 5.38461538461539, 5.46153846153846, 5.53846153846154,
    5.61538461538461, 5.69230769230769, 5.76923076923077, 5.84615384615385,
    5.92307692307692, 6, 6.07692307692308, 6.15384615384615,
    6.23076923076923, 6.30769230769231, 6.38461538461539, 6.46153846153846,
    6.53846153846154, 6.61538461538461, 6.69230769230769, 6.76923076923077,
    6.84615384615385, 6.92307692307692, 7, 7.07692307692308,
    7.15384615384615, 7.23076923076923, 7.30769230769231, 7.38461538461539,
    7.46153846153846, 7.53846153846154, 7.61538461538461, 7.69230769230769,
    7.76923076923077, 7.84615384615385, 7.92307692307692, 8 ;
}
```

End ncdump output