ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ
ΤΜΗΜΑ ΠΟΛΙΤΙΚΩΝ ΜΗΧΑΝΙΚΩΝ
ΤΟΜΕΑΣ ΥΔΡΑΥΛΙΚΗΣ ΚΑΙ ΠΕΡΙΒΑΛΛΟΝΤΙΚΗΣ ΤΕΧΝΙΚΗΣ

Ειδική διάλεξη 2: Εισαγωγή στον κώδικα της εργασίας

Χειμερινό εξάμηνο 2008

Αρχίζοντας....

A THREE-DIMENSIONAL NUMERICAL MODEL FOR SIMULATION OF SEDIMENT MOVEMENTS IN WATER INTAKES WITH MULTIBLOCK OPTION

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Αρχίζοντας....

http://folk.ntnu.no/nilsol/ssiim/

Download the SSIIM User's Manual (5. November 2007, 1.2 MB PDF file)
Download SSIIM 1 for Windows, non-parallel version (8. October 2007, 1.1 MB) The version is compiled for 32 bits Windows. It uses the DLL files that can be downloaded from the links below. The version does not contain algorithms for running on parallell systems or exploit multi-core processors.
Download SSIIM 1 for Windows (10. December 2007, 3.4 MB) The version uses the DLL files and is compiled for 32 bits Windows.
Download SSIIM 1 for 64 bits Windows (23. November 2007, 2.4 MB) The version does not use the DLL files and is compiled for 64 bits Windows.
Download SSIIM 1 for 32 bits Linux (7. November 2007, 1.1 MB) The version does not use DLL files. It is compiled on SUSE Linux, but should also work on other Linux versions.
Download SSIIM 1 for IBM p575+ (26. October 2007, 1.9 MB) The version does not use DLL files. It is compiled on a 64 bits AIX operating system.
Download SSIIM 2 for Windows, non-parallel version (29. September 2007, 1.1 MB) The version is compiled for 32 bits Windows. It uses the DLL files that can be downloaded from the links below. The version does not contain algorithms for running on parallell systems or exploit multi-core processors.
Download SSIIM 2 for Windows (12. December 2007, 2.5 MB) The version is compiled for 32 bits Windows. It uses the DLL files that can be downloaded from the links below.
Download document discussing the performance of the parallel SSIIM versions (17. October 2007, 130 kB)
Download the SSIIM 3D OpenGL viewer for SSIIM 1 (13. February 2007, 160 kB) This is a home-made 3D post-processor. We recommend to use the freeware ParaView instead.
Download OS/2 version of SSIIM with example files (20. November 1996, 1 MB zip file)

Αρχίζοντας….

Download DLL files for SSIIM 1 (11. July 2007, 503 kB) These files are needed to run the latest version of SSIIM 1 for Windows.
If you have downloaded the DLLs for SSIIM 1 before, there might have been fewer DLLs in the zip'ed file. Some DLL files can be downloaded separately in a zip'ed format here:
Download walldll.zip. (1/11-03)
Download tsc1dll.zip. (update 18/2-05)
Download beddll.zip. (update 27/10-06)
Download roughm1.zip.
Download turbdll.zip. (update 2/6-05)
Download slide1dll.zip. (update 16/4-07)

Download DLL files for SSIIM 2 (26. October 2007, 455 kB)
Download separate DLL files for SSIIM 2:
Download beddll.dll (31. October 2006).
Download vegdll.dll (16. April 2001).
Download tsc2dll.dll (1. January 2002).
Download sfdifdll.dll (15. October 2004).
Download walldll.dll (21. October 2003).
Download turbdll.dll (27. May 2005).
Download nestdll.dll (27. September 2006).
Download slide2dll.dll (13. March 2007).
Download source2dll.dll (29. September 2007).

Περιορισμοί και προβλήματα ....

- * The program neglects non-orthogonal diffusive terms.
- * The grid lines in the vertical direction have to be exactly vertical.
- * Kinematic viscosity of the fluid is equivalent to water at 20 degrees Centergrade. This is hard-coded and can not be changed.
- * The program is not made for the marine environment, so all effects of density gradients due to salinity differences are not taken into account.

In computer science, a very well tested program still contains about one bug pr. 2000 lines of source code. The SSIIM programs contains over 100 000 lines of source code, and several modules have not been much tested. Also, combinations of modules may not have been tested at all. It is therefore likely that there are a number of bugs in the program. The user is advised to take this into consideration when evaluating the results of the program.

Βασικές εξισώσεις

$$\frac{\partial U_i}{\partial t} + U_j \frac{\partial U_i}{\partial x_j} = \frac{1}{\rho} \frac{\partial}{\partial x_j} \left(-P \delta_{ij} - \rho \overline{u_i u_j} \right)$$

The equations are discretized with a control-volume approach. An implicit solver is used, also for the multi-block option. The SIMPLE method is the default method used for pressure- correction. The SIMPLEC method is invoked by the *K 9* data set in the control file. The power-law scheme or the second-order upwind scheme is used in the discretization of the convective terms. This is determined by the values on the *K 6* data set in the control file. The numerical methods are further described by Patankar (1980), Melaaen (1992) and Olsen (1991).

Προσέγγιση Boussinesq και μοντέλα τύρβης

Όρος Reynolds stress: $$-\overline{u_i u_j} = \nu_T\left(\frac{\partial U_j}{\partial x_i} + \frac{\partial U_i}{\partial x_j}\right) + \frac{2}{3}k\delta_{ij}$$

Μοντέλο k-ε

Υπόθεση eddy-viscosity $$\nu_T = c_\mu \frac{k}{\varepsilon^{2}} \qquad k \equiv \frac{1}{2}\overline{u_i u_i}$$

Κινητική ενέργεια: $$\frac{\partial k}{\partial t} + U_j \frac{\partial k}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\frac{\nu_T}{\sigma_k}\frac{\partial k}{\partial x_j}\right) + P_k - \varepsilon$$

Παραγωγή: $$P_k = \nu_T \frac{\partial U_j}{\partial x_i}\left(\frac{\partial U_j}{\partial x_i} + \frac{\partial U_i}{\partial x_j}\right)$$

Σκέδαση: $$\frac{\partial \varepsilon}{\partial t} + U_j \frac{\partial \varepsilon}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\frac{\nu_T}{\sigma_k}\frac{\partial \varepsilon}{\partial x_j}\right) + C_{\varepsilon 1}\frac{\varepsilon}{k}P_k + C_{\varepsilon 2}\frac{\varepsilon^{2}}{k}$$

Μοντέλο k-ω

$$\nu_T = \frac{k}{\omega}$$

Wilcox (2000)

$$\frac{\partial k}{\partial t} + U_j \frac{\partial k}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\sigma \nu_T \frac{\partial k}{\partial x_j}\right) + P_k - \beta^* k \omega$$

$$\frac{\partial \omega}{\partial t} + U_j \frac{\partial \omega}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\sigma \nu_T \frac{\partial \omega}{\partial x_j}\right) + \alpha \frac{\omega}{k} P_k - \beta \omega^2$$

$$\alpha = \frac{13}{25} \qquad \sigma = \frac{1}{2} \qquad \beta = \beta_0 f_\beta$$

$$f_\beta = \frac{1 + 70\chi_\omega^2}{1 + 80\chi_\omega^2} \qquad \chi_\omega = \left|\frac{\Omega_{ij}\Omega_{jk}S_{ki}}{(\beta\omega)^3}\right|$$

$$\beta^* = \beta_0^* f_{\beta^*} \qquad \beta_0 = \frac{9}{125} \qquad \beta_0^* = \frac{9}{100}$$

$$f_{\beta^*} = \begin{cases} 1, & \chi_k < 0 \\ \dfrac{1 + 680\chi_k^2}{1 + 400\chi_k^2}, & \chi_k > 0 \end{cases} \qquad \chi_k = \frac{1}{\omega^3}\frac{\partial k}{\partial x_j}\frac{\partial \omega}{\partial x_j}$$

$$\Omega_{ij} = \frac{1}{2}\left(\frac{\partial U_i}{\partial x_j} - \frac{\partial U_j}{\partial x_i}\right) \qquad S_{ij} = \frac{1}{2}\left(\frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i}\right)$$

The *k*-ω model often gives less turbulent diffusion than the *k*-ε model. This means it may overpredict the size of recirculation zones, whereas the *k*-ε model often underpredicts the recirculation zone length.

Επίδραση της βαρύτητας και μοντέλα τοίχου

The effect of the density variations on the water flow field is taken into account by introducing a modified eddy viscosity. The eddy viscosity from the k-ε model is multiplied with a factor taking into account the velocity and concentration gradients (Rodi, 1980):

$$\nu_T = \nu_{T,0}\left[1 + \beta\left(-\frac{g}{\rho}\frac{\frac{\partial \rho}{\partial z}}{\left\langle\frac{\partial U}{\partial z}\right\rangle^2}\right)\right]^{\alpha}$$

The default wall law in SSIIM is given below. It is an empirical formula for rough walls (Schlichting, 1979):

$$\frac{U}{u_x} = \frac{1}{\kappa}\ln\left(\frac{30y}{k_s}\right)$$

The shear velocity is denoted u_x and κ is a constant equal to 0.4. The distance to the wall is y and the roughness, k_s

In SSIIM 1, it is also possible to use wall laws for smooth boundaries. This is done by giving an F 15 5 data set in the control file. The following function is then used:

$$\frac{U}{u_x} = \frac{1}{\kappa}\ln\left(\frac{Eyu_x}{n}\right)$$

E is an empirical parameter equal to 9.0.

Επίδραση της συγκέντρωσης άμμου στη ροή

1. The sediments close to the bed move by jumping up into the flow and settling again.

Einstein and Ning Chen (1955)

$$\kappa = \kappa_0 \frac{1}{(1 + 2.5c)}$$

2. The other process is the sediment concentration increasing the density of the fluid

$$\rho_s g \frac{\partial c}{\partial z}$$

Υπολογισμοί της ποιότητας του νερού

$$\frac{\partial c}{\partial t} + U_j \frac{\partial c}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\Gamma_T \frac{\partial c}{\partial x_j}\right)$$

Q 0 0 temperature
Q 0 1 oxygen
Q 0 2 nitrogen

Initial values

Adsorption

Resuspension

Pathogens and toxics

$$\frac{\partial c}{\partial t} = a(\tau - \tau_0)^b$$

Gas reaeration at the water surface

$$\text{Reaeration} = \frac{r v_T (c_{air} - c_o)}{\Delta H}$$

Inflow of water quality constituents

Time-dependent variation in input parameters

timei file:

	time	timestep	windspeed	winddir_x	winddir_y	inflow0	inflow1	inflow2	irradiance
M	0.0	0.0	1.0	1.0	0.0	0.001	0.0003	0.002	0.0
M	1000.0	0.0	1.0	1.0	0.0	0.001	0.0003	0.002	10.0

Ροή άμμου

$$\frac{\partial c}{\partial t} + U_j \frac{\partial c}{\partial x_j} + w \frac{\partial c}{\partial z} = \frac{\partial}{\partial x_j}\left(\Gamma_T \frac{\partial c}{\partial x_j}\right)$$

The fall velocity of the sediment particles is denoted *w*.

$$\Gamma = \frac{\nu_T}{Sc}$$

Sc is the Schmidt number, set to 1.0

effective roughness is computed as (van Rijn, 1987):

$$k_s = 3D_{90} + 1.1\Delta\left(1 - e^{\frac{25\Delta}{\lambda}}\right)$$

The bed form height, Δ, is calculated by van Rijn's equation (1987):

$$\frac{\Delta}{d} = 0.11\left(\frac{D_{50}}{d}\right)^{0.3}\left(1 - e^{\left[\frac{\tau-\tau_c}{2\tau_c}\right]}\right)\left(25 - \left[\frac{\tau-\tau_c}{\tau_c}\right]\right)$$

Υπολογισμοί θερμοκρασίας

$$\frac{\partial T}{\partial t} + U_j \frac{\partial T}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\Gamma_T \frac{\partial T}{\partial x_j}\right)$$

Heat flux across the water surface

The heat flux across the water surface is calculated according to the following processes:

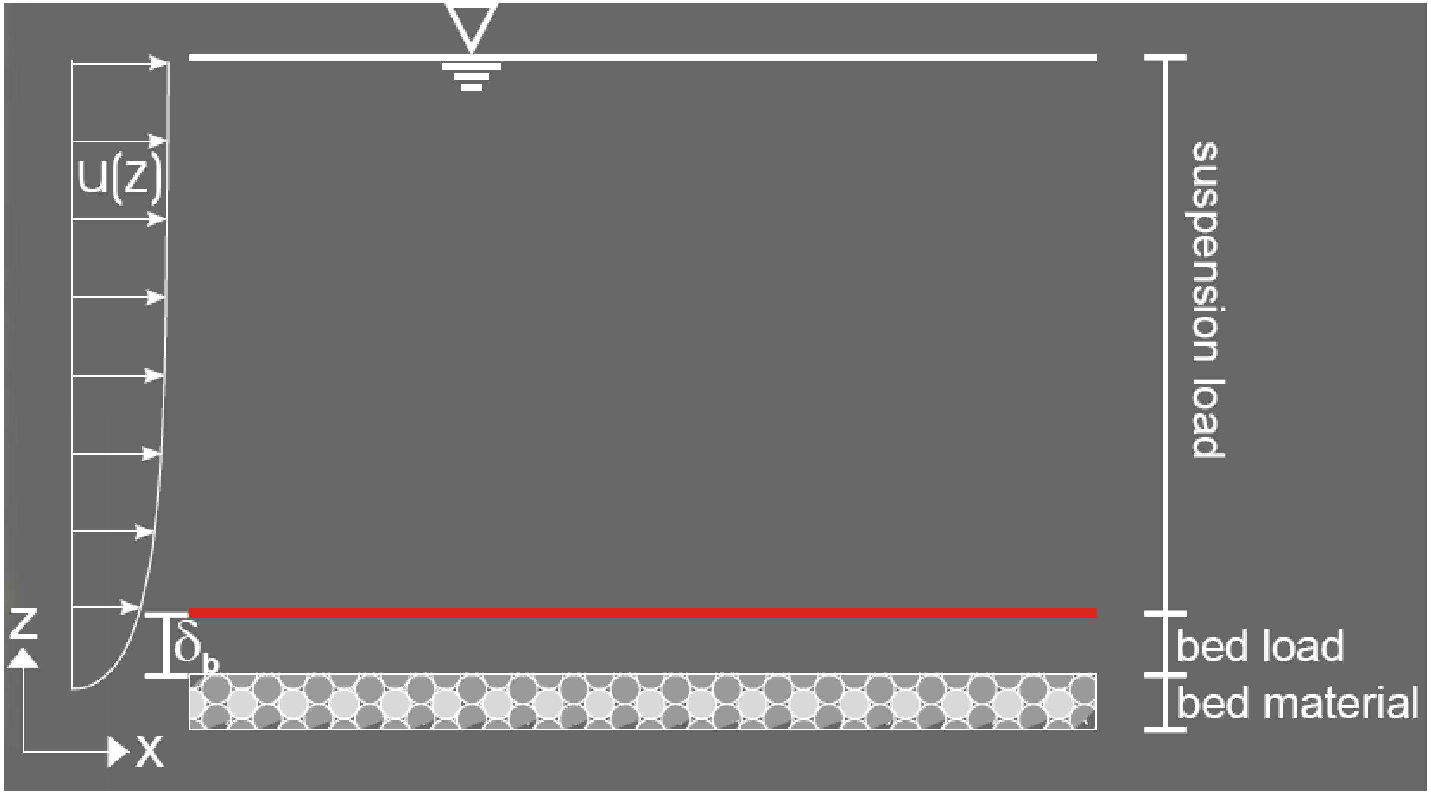
- solar short-wave radiation
- atmospheric longwave radiation
- longwave back radiation from the water
- conduction
- evaporation

The formula for the surface flux, I, can be written according to Chapra (1997):

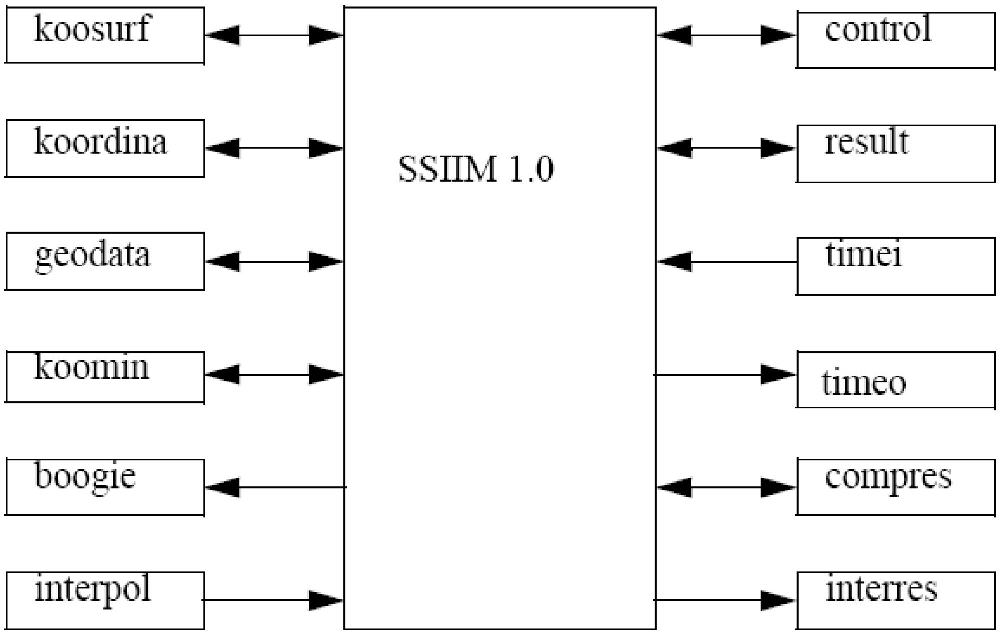
$$I = IrB + \sigma(T_{air} + 273)^4 (A + 0.031\sqrt{e_{air}})(1 - R_L) - \varepsilon\sigma(T_s + 273)^4 - c_1 fU_w(T_s - T_{air}) - fU_w(e_s - e_{air}) \qquad (2.4.2)$$

In the formula, *Ir* is the irradiance, *T* is the temperature, *s* is the Stefan-Bolzman's constant, *f(Uw)* is a function of the wind speed, given by Chapra (1997) and e_s is the saturation vapour pressure at the water surface. The other parameters are given below in the description of the corresponding data set.

Παράδειγμα υπολογιστικού πεδίου



Βασικά στοιχεία του προγράμματος



Αρχείο boogie

This is a file that shows a print-out of intermediate results from the calculations. It also shows parameters as average water velocity, shear stress and water depth in the initialisation. Trap efficiency and sediment grain size distribution is also written here. If errors occur, an explanation is also often written to this file before the program stops. The file contains the data that is normally written to the screen in a DOS program.

The option *D* on the *F 1* data set will give additional print-out to the file.

Initially in the file it is written how much memory that is occupied by the arrays that are dynamically allocated. To estimate the total recommended memory requirement for SSIIM, add the size of the SSIIM executable to this value.

A table then follows, which shows the cross-sectional area, hydraulic radius, average velocity and water level at the cross-sections that have been used for initializing the water surface. If the option *D* on the *F 1* data set is used, this information is written for all the cross-sections additionally. Then a table of waterlevels for all cross-sections follows. An example is given below:

Loop1,iter,area,radius,velocity,waterlevel: 12 1.002389e+00 1.002389e+00 9.976163e-01 1.002390e+00
Loop1,iter,area,radius,velocity,waterlevel: 11 1.001588e+00 1.001588e+00 9.984146e-01 1.001589e+00
Waterlevel = 1.000398 meters for cross-section i = 10
Waterlevel = 1.000797 meters for cross-section i = 9

Αρχείο boogie (συνέχεια)

Waterlevel = 1.001195 meters for cross-section i = 8

If the MB-flow module is used, the residual norms are written. Then follows a sequence of two lines for each iteration of MB-flow. An example with four iterations is shown below:

Iter: 5, Resid: 1.69e-05 4.10e-06 2.73e-05 1.17e-04 1.38e-02 1.13e-02
Cont: 9.23e-08, DefMax: 1.65e-03, U,V,W(96,7,20): 6.40e-01 -5.14e-03 5.76e-02
Iter: 6, Resid: 1.62e-05 3.85e-06 2.62e-05 1.10e-04 1.31e-02 1.08e-02
Cont: 9.23e-08, DefMax: 1.56e-03, U,V,W(96,7,20): 6.40e-01 -5.14e-03 5.76e-02
Iter: 7, Resid: 1.57e-05 3.65e-06 2.50e-05 1.04e-04 1.25e-02 1.03e-02
Cont: 9.23e-08, DefMax: 1.48e-03, U,V,W(96,7,20): 6.40e-01 -5.14e-03 5.76e-02
Iter: 8, Resid: 1.51e-05 3.46e-06 2.38e-05 9.86e-05 1.18e-02 9.77e-03
Cont: 9.23e-08, DefMax: 1.41e-03, U,V,W(96,7,20): 6.40e-01 -5.14e-03 5.76e-02

The first line has the word "*Iter*" at first. Then an integer follows, which shows the number of the iteration. In the example above this runs from iteration number 5 to 9. Then the residuals for the six equations are shown. The x,y and z velocity equations are first, then the pressure equation and the k and e equation follow. All these must be under 10-3 before the solution has

The second line starts with the word "*Cont:*". Then a floating point value is shown. This is the sum of all the water inflow and outflow in the geometry. This should be a very low value, typically under 10-7. If a larger value is given, check the boundary conditions. Then the word "DefMax" is written. The residual for the cell with largest water continuity defect is then written. The indexes for this cell are then written, with the velocities in the three directions for this cell. In iteration 9 for the example above, the maximum water continuity defect was 1.41e-3 kg/s for cell i=96, j=7, k=20. The velocity in the x-direction for this cell was 0.64 m/s, the velocity in the y direction was -5.14 mm/s and the velocity in the vertical direction was 5.76 cm/s.

Αρχείο control

The control file gives most of the parameters the model needs. The main parameters are the size of the arrays used for the program. To generate the water surface it is necessary to know a downstream water level, together with the water discharge and the Manning-Strickler's friction factor. These parameters are given on the *G 1* and the *W 1* data set in the control file. If the control file does not exist, the user is prompted for these parameters in a dialog box. The user can then later choose Write control in the File option of the main menu, and get a control file written to the disk (as control.new). This can then be edited according to the user's needs. Note that only the most used parameters are written to the control.new file.

During the water flow calculations there are several parameters that can be varied. These parameters affect the accuracy and the convergence of the solution. Some of the parameters can be modified while the water flow field is being calculated. A dialog box with the parameters is invoked by choosing Waterflow parameters from the Input Editor choice in the main menu.

The *control* file contains most of the other data necessary for the program. SSIIM reads each character of the file one by one, and stops if a capital letter is encountered. Then a data set is read, depending on the letter. A data set is here defined as one or more numbers or letters that the program uses. This can for example be the water discharge, or the Manning-Strickler's friction coefficient. It is possible to use lower-case letters between the data sets, and it is possible to have more than one data set on each line. Not all data sets are required, but some are. Default values are given when a non-required data set is missing. SSIIM checks the data sets in the *control* file to a certain degree, and if an error is found, a message is written to the *boogie* file and the program is terminated. Note that if more than one numbers are needed on a data set, these are separated by a space, and not by any other character.

Αρχείο control (συνέχεια)

Important note: The F and G data sets should be given before any other data sets. These data sets should also be ordered according to their number. This is because the data may be checked against the size of the grid.

In the following the data sets for the *control* file is described:

F 1 Debugging option. If the character that follows is a D, one will get a more extensive printout to the boogie file. If the character is a C, the coefficients in the discretized equations will be printed to the boogie file. For SSIIM 1, if the character is Q, then the program will allow a grid with negative areas. Otherwise, the program will stop when negative areas occur. This can be useful when making a complex grid.

Αρχείο control (συνέχεια)

F 2 Automatic execution possibility. Some parts of the program will be executed directly after the initialisation if a character is placed in this field. The sub- programs will be executed in the order they are given. The possibilities are:

R	Read the result file
I	Initialize sediment concentration computation
S	Calculate sediment concentration
W	Start the water flow computation
U	Read the unstruc file (only SSIIM 2)
X	Read the XCYC file (only SSIIM 1)
Q	Compute water quality (SSIIM 1)
C	Compute water quality (SSIIM 2)
E	Write the results from the water quality computation (SSIIM 2 only)
O	Read the results from the water quality computation (SSIIM 2 only)
A	End the program and exit (SSIIM 1)
X	End the program and exit (SSIIM 2)
M	Write the result file

Example 1 : F 2 WISA

The program will first compute the water flow, then compute the sediment flow and then exit. This is for SSIIM 1.

Αρχείο control (συνέχεια)

Example 2: F 2 URIS

The program will first read the *unstruc* file, and then read an initial water flow field from the *results* file. Then the sediment transport is computed. This combination is often use for time-dependent morphological computations. The *unstruc* file is only read in SSIIM 2. For SSIIM 1, the *U* is omitted.

F 4 Relaxation factor for second order interpolation of bed concentration, maximum iterations for concentration calculations and convergence criteria for suspended sediment calculation. The convergence criteria is given as allowable flux deficit as part of inflowing sediments.

Note that this data set has changed from SSIIM version 1.1

Defaults: relaxation: 0.5, iterations: 500, convergence criteria: 0.01.

F 6 Coefficients for formula for bed concentration. Default is van Rijn's coefficients: 0.015, 1.5 and 0.3. If one uses this option, the sediment transport formula given in dataset *F 10* must be *R*, which means that van Rijn's formula is used.

Αρχείο control (συνέχεια)

F 7 Run options. read 10 characters. If the following capital letters are included this will mean:

D: Double the number of grid cells in streamwise direction in comparison to what is given in the **koordina** file. Each cell is divided in two equal parts. When this option is used for the whole geometry, the number of grid lines in the stream-wise direction (on the *G 1* data set) must be multiplied with 2 and 1 must be subtracted. **SSIIM 1 only.**

J: Double the number of grid cells in the cross-streamwise direction. The same procedure for the lines in the cross-streamwise direction (*G 1* data set) is required.**SSIIM 1 only.**

I: Inflowing velocities in the y-direction are set to zero. **SSIIM 1 only.**

A: Diffusion for sediment calculations in non-vertical direction is set to zero. **SSIIM 1 only.**

B: Correction for sloping bed is used when calculating bed sediment concentration.

G: Cell walls at outblocked area is not changed when there are changes in the cells outside the block. **SSIIM 1 only.**

V: 90 degree turning of the plot seen from above (map). **Only SSIIM 1 for OS/2.**

Z: Vertical distribution of inflowing sediment is uniform. **SSIIM 1 only.**

E: Activate a routine that changes the flux on the wall if ap=0.

P: Use porosity calculation and the **porosity** file. **SSIIM 1 only.**

Αρχείο control (συνέχεια)

F 9 **SSIIM 1 only.** Factor that is used to change the turbulent viscosity of the inflowing water. The factor is proportional to the turbulent viscosity. Default: 1.0.

F 10 Which sediment transport formula is used to calculate the concentration at the bed. The following options are given:

R	van Rijn's formula
E	Engelund/Hansen's formula
A	Ackers/White's formula
Y	Yang's streampower formula
S	Shen/Hung's formula
I	Einstein's bed load formula

Default: R.

Note that only the option R is tested.

F 11 Density of sediments and Shield's coefficient of critical bed shear for movement of a sediment particle.

Default: F 11 2.65 0.047 (SSIIM 1) and *F 11 2.65 -0.047* (SSIIM2).

If a negative Shield's coefficient is given, the program will calculate it according to a parameterization of the original curve.

Αρχείο control (συνέχεια)

F 12 Schmidt's coefficient, which is a correction factor for deviation between the turbulent diffusivity and the eddy-viscosity. The factor will affect both the water velocity and the sediment concentration computations. Default: 1.0

If multiple sediment sizes are to be modelled, it is possible to give multiple Schmidt numbers. Example for three sizes:

Example: F 12 1.0 1.2 1.3

F 15 **SSIIM 1 only.** An integer giving a choice between several algorithms for wall laws. If the value is 1 and there are two walls in a cell, only the closest (usually the bed) will be used. If the integer is 1, both walls will be used. Note that the 1 option will only work with the k-epsilon model.

Default: F 15 0.

SSIIM 1 only: If the integer 3 is specified, wall shear will be used in the source terms of the Navier-Stokes equations, and zero gradients used for k and epsilon on the side walls. If the integer is 4, an algorithm similar to option 3 is used, but only if the cell is below a level equal to the roughness height. Above this height, normal wall functions will be used for all variables. If the integer is 5, smooth wall laws will be used. If the integer is 11, a rough wall law formulation by Rodi (1980) will be used for k.

Αρχείο control (συνέχεια)

F 16 Roughness coefficient which is used on the side walls and the bed. If not set, the coefficient is calculated from the Manning-Strickler's friction coefficient (van Rijn, 1982). Values in the *bedrough* file overrides this value for the bed cells.

F 18 Density current source. A float is read, and if it is above 10-6, the sediment density term in the Navier-Stokes equation is added. The float is multiplied with the density term, so a value of 1.0 is recommended when this term is needed. Default 0.0 (the term is not used). Note that this option has not yet been tested.

F 20 **SSIIM 1 only.** Repeated calculation option. An integer is read, and the calculation sequence on the F 2 data set will be repeated this many times. Note that the graphical view of the bed level changes (only OS/2 version) will only appear on the last iteration when sediment calculations are done. Also note that if a result file is read in the F2 data set, it is only read during the first iteration.

F 21 Relaxation coefficient for the Rhie and Chow interpolation. Normally a value between 0.0 and 1.0 is used. When 0.0 is used the Rhie and Chow interpolation will have no effect. When 1.0 is used the Rhie and Chow interpolation will be used normally. Default 1.0.

F 24 Turbulence model. An integer is read, which corresponds to the following models:

0: standard k-ε model (default)
1: k-ε model with some RNG extensions
3: local k-ε model based on water velocity
4: constant isotropic eddy-viscosity model, value given on F 72 data set
5: local k-ε model based on wind shear
6: constant non-istotropic eddy-viscosity model, vertical and horizontal values given on the *F 77* data set
7: eddy viscosity = 0.11 * depth * shear velocity (Keefer, 1971)
10: zero-equation used in shallow areas only, k-epsilon elsewhere. Only SSIIM 2
14: Spalart-Almaras model, only for SSIIM1, not fully implemented
15: K-omega model with Wilcox's wall laws, only for SSIIM 1, not tested
16: K-omega model with k-epsilon wall laws, only for SSIIM 1.

Note that not all models are implemented in both SSIIM versions.

F 25 Porosity parameters. Four floats and one integer are read. The first float is the minimum porosity. The second float is a relaxation factor for the porosity computation. The second and third parameters are roughness values used in the porosity computation. The last number, the integer, is an index giving which algorithm to use for the computation of the diameter in the equation.

Default: F 25 0.35 2.0 0.5 0.8 5

Αρχείο control (συνέχεια)

F 26 Fraction of compacted sediments in bed deposits. Or 1.0-water content of sediments at bed.

Default: F 26 0.5 (50 % water)

F 33 Transient water flow parameters. A float and an integer is read. The float is the time step. The integer is the number of inner iterations for each iteration. Transient terms will be included in the equations if this data set is present.

F 36 Computation of the vertical elevation of the water surface. An integer is read. If it is 2, the water surface will be updated based on the computed pressure field. The cell given on the *G 6* data set will be kept fixed as a reference level.

For SSIIM 1: If the integer is 1, the gravity will be included in the solution of the Navier-Stokes equations, and the water level will be computed based on the computed water deficit/surplus in the cells close to the water surface. This algorithm is very unstable, and a very short time step needs to be used. The algorithm is only used when computing coefficient of discharge for a spillway, or flood waves with steep fronts.

For SSIIM 2: More algorithms can be used: *F 36 3*: the initial water surface is moved up/down equally in all cells according to downstream changes in water surface specified in the timei file. *F 36 4*: the water surface elevation is computed solving a partial differential equation for the local slope as a function of the pressure gradients to the four neighbour cells. *F 36 8*. Same as F 36 4, but the eight closest neighbour cells are used..

Default: *F 36 0*

Αρχείο control (συνέχεια)

F 37 Transient sediment computation. An integer is read. If this is 1, the transient sediment computation (TSC) algorithms will be used. This option is always used when doing time-dependent computations of sediment transport, and always when computing changes in bed levels. If the integer is 2, then a different algorithm is used for the bed cells, where the sediment concentration formula is converted into an entrainment rate. This can give slightly smaller bed movements where the bed sediment concentration is not in equilibrium.

Default: *F 37 0*

F 38 Residual limit for when warning messages are written to the boogie file. Default: 1.0e+7.

F 40 Turbidity current parameter. If this is unity the extra term in the Navier-Stokes Equation are taken in that takes into account the effect of gravitational forces on water that have higher density because of high sediment concentration. If this is above 0.001, the term is still incorporated but relaxed with the factor on the data set. Default 0.0.

F 41 **SSIIM 2 only.** Sediment thickness in meters. Default value is the maximum size of the sediments given on the S data sets.

F 42 **SSIIM 2 only**. Level of non-erodible material. This data set can be used instead of the koomin file.

F 47 Bed interpolation parameter in meters. One float is read, which is used in the bed interpolation routine that are called from the Grid Editor. If the points given in the geodata file are located a horizontal distance under the interpolation limit, than the interpolation routine will use the exact value of the geodata point instead of interpolating from surrounding points. Default: 0.05 m.

F 48 Parameter for interpolation of results. An integer is read. If 0, then a normal *result* file will be written when this routine is invoked. If higher values are given, the program will **not** write the *result* file. It will search for the *interpol* file and use this file to write an *interres* file. If the value on the F 48 data set is 4, the bed levels will be written to the *interres* file. If 2, the velocities, *k* and epsilon will be written to the file. If 3, then water quality parameters will be written. Default 0. See Chapter 4.12 for more details.

If the integer is 8, a file named *tecplot.dat* will be written. This file contains the coordinates, the velocities, pressure, *k* and epsilon for each cell. The file can be imported into the *Tecplot* program. For SSIIM 1, giving the integer 9 will produce a 2D Tecplot file, in a plan view.

SSIIM 1 only: If the integer is 19, a time will also be read from the *interpol* file. The print-out to the *interres* file will then only happen at this time.

Αρχείο control (συνέχεια)

F 50 Number of water quality constituents. Default *F 50 0*.

F 51 Coriolis parameter.

Example: *F 51 0.0001263* (lakes in South Norway)

F 52 Wind forces on the surface of the lake. Three floats are read. The first float is the magnitude of the wind speed in meters/sec. 10m above the water level. The second and third floats are components of the unity vector in the x and y direction. Note that the vector sum must be unity.

Example: *F 52 4.0 -1.0 0.0*

Note for time-varying wind, the values in the timei file overrides the values on this data set.

F 53 Print iterations. Four integers are read, which gives the interval for when printout to files are done. The first integer applies to the residual printout to the boogie file. The second integer applies to writing the result file. The third integer applies to writing data to the forcelog file. The fourth integer applies to when data is written to the timeo file.

Default: *F 53 100 100 1 1*

This means that for example the result file is written each 100th iteration.

Αρχείο control (συνέχεια)

F 54 A float is read, which is a limit for the residual during the transient calculation. When the maximum residual goes below this value, the inner iterations end, and a new time step starts. This is recommended when doing transient computations. Default 10^{-7}

F 56 Sand slide algorithm. An integer and a float is read. The float is tan(angle of repose). The integer is the number of iterations the algorithm will go through the whole grid.

Default: *F 56 0 1.0* (not used)

Typical values if used: *F 56 10 0.62*

Note that the angle of repose for the sediments is lower for sediments submerged in water than in air. The algorithm does not work properly for more than one sediment size.

Αρχείο control (συνέχεια)

F 58 **SSIIM 1 only.** Parameters for the Transient Free Surface (TFS) algorithm. The TFS algorithm is used when including *F 36 1* in the control file. Four integers and six floats are read:

F 58 i1 i2 i3 i4 f1 f2 f3 f4 f5 f6

Default: *F 58 1 0 0 1 0.02 2.0 2.0 0.0 1.0 0.0*

i1: If this integer is 1, the transient terms are included in the equations. If it is zero, the transient terms are not included

i2: If the integer is 1, the pressure will always be positive

i3: If the integer is 1, the side walls will not move vertically

i4: If the integer is 1, an upwind algorithm is used to transfer the water level movement from the center of the cell to the corners. If the integer is zero, the movement will be equal in all directions.

f1: Parameter in the upwind algorithm for transferring the water level movements from the center of the cell to the corner. If the parameter is zero, all the movement will take place in the downstream direction. A very large parameter will give equal movement in all directions.

Αρχείο control (συνέχεια)

f2: Parameter to dampen the water movement at the walls. If the parameter is 2.0, there will be no damping. A value of 1.0 will dampen the movement to half the non-dampened value. A value of 0.0 will dampen the movement completely, so no movement will take place at the wall.

f3: Parameter to dampen the water movement at obstructions. The numbers are the same as for parameter *f2*.

f4: When the water level moves in a time step, the water surface will get a vertical velocity, *W*. An algorithm is used, where the velocity in the top cell, *w*, is affected by *W*, using the following formula: $w = f4\ W + (1\text{-}f4)\ w$.

f5: Parameter for including the acceleration of the water movement in the vertical component of the Navier-Stokes equation. If it is 1.0, the full acceleration term is included. If the parameter is zero, the acceleration term is not included. A value between 0.0 and 1.0 will take the term into account, multiplied with the parameter.

f6: A factor for smoothing the water levels. If it is zero, no smoothing will be used. A higher, positive value will give more smoothing.

Αρχείο control (συνέχεια)

F 59 Number of iterations in the Gauss-Seidel procedure. This is an integer which will affect the convergence and speed of the program. A lower value will increase the number of iterations pr. time, while slowing the relative convergence pr. iteration. For some cases, a lower value has given decreased computational time. Note that if the TDMA solver (K 10 data set) is used, then the F 59 data set will have no effect. Default: 10.

F 60 Correction of van Rijn's formula for distance from the center of the bed cell to the bed. The data set is used to invoke inclusion of the extrapolation of the Hunter-Rouse sediment distribution when the vertical height of the center of the bed cell is different from what van Rijn subscribed.

Default: *F 60 0 0* (no use of the extrapolation)
Example: *F 60 1 0* (the extrapolation is used)

F 62 Integer to invoke time-dependent calculation of water quality parameters, if 1.

Default: *F 62 0*

F 63 Second-order upwind scheme for water quality constituents if the integer 1 follows.

Default: *F 63 0*

Αρχείο control (συνέχεια)

F 64 **SSIIM 2 only.** Choice of algorithm to generate the grid lines in the longitudinal and lateral direction. An integer is read. If it is 0, completely horizontal grid lines will be generated. This is typically used when modelling lakes, especially with density gradients. For sediment transport computations in rivers, the most tested option is *F 64 11*. This will give a body-fitted grid with priority to hexaheadral cells close to the bed. The option 13 is similar to 11, but has different generation criteria for wetting and drying. The two values on the *F 94* data set is then used.

If the *F 64 13* data set is used, then the cells will be generated initially just like using

previous iteration, unless the cell depths are above 0.0 meters. The value 0.0 meters can be changed by giving it on the *F 162* data set.

Default: *F 64 0*

See also Chapter 3.3.2 for generation of grids.

Αρχείο control (συνέχεια)

F 65 **SSIIM 2 only.** Grid size for the unstructured grid. SSIIM 2 has to allocate the arrays before the grid is read. Because it is possible to expand the grid after it is read, it is necessary to give the grid array sizes in the input file.

Five integers are read. The first integer is the maximum number of grid cells in the grid. The second integer is the maximum number of surfaces in the grid. The third integer is the maximum number of grid corner points. The fourth integer is the maximum number of surfaces in connection between blocks. The sixth integer is the maximum number of connection points, used in the *Grid Editor*.

Default: *F 65 50000 80000 50000 10000 1000*

If the grid has been made, and the grid size will not increase later, it is possible to read the size in the *unstruc* file, and modify the *F 65* data set so that the program does not allocate more memory than necessary.

F 67 **SSIIM 2 only.** Temperature calculation with feedback from water density on the water flow calculation if it the integer 1 follows.

Default: *F 67 0*

Αρχείο control (συνέχεια)

F 68 Parameter for choice of water flow computation. An integer is read.

Default: *F 68 0*

If the parameter is 2, the transient sediment computation will not re-compute the water flow field after an update of the bed. This means a quasi-steady situation is modelled.

For SSIIM 2: If the parameter is 1, the three-dimensional calculation of the water flow will be done using the hydrostatic pressure assumption. This means that the Navier-Stokes solutions will not be solved in the vertical direction, and vertical velocities will be found by the continuity equation. This option causes an extra grid block to be made. The extra block is the last block and is a depth-averaged version of the whole grid. Note that this parameter have to be the same when calculations are done as when the grid was created.

F 70 **SSIIM 2 only.** Wall laws removal option. An integer is read. If 1, the wall laws will be removed from the side surfaces. If 2, the wall laws will be removed from the side and the bed surfaces.

Default: *F 70 0*

Αρχείο control (συνέχεια)

F 71 Turbulence decrease because of density stratification. An integer is read. If 1, the turbulent eddy-viscosity is decrease according to the Richardson number and the procedure given by Rodi (1980).

Default: *F 71 0*

F 72 Minimum turbulent eddy-viscosity. A float is read. The eddy-viscosity for water flow, turbulent kinetic energy and water quality constituent calculations will not be decreased below this value.

Default: *F 72 0.001*

F 73 Choice of wind friction formula. This formula gives the shear stress of the water surface as a function of the wind. The options are:

0: van Dorn (1953), $c_D = 1.0x10^{-3}$ under 5.6 m/s, increases over 5.6 m/s
1: Bengtsson (1973), $c_D = 1.1x10^{-3}$
2: Wu (1969), three non-continous bands of c_D as a function of wind speed

Default: *F 73 0*

Αρχείο control (συνέχεια)

F 76 **SSIIM 2 only.** Turbulence reduction factors. Three floats are read. The two first floats are multiplied with the eddy-viscosity in the horizontal and the vertical direction respectively, thereby reducing and possibly creating a non-isotropic eddy-viscosity. The third float is related to the decreased eddy-viscosity because of density stratification. If it is zero, the eddy-viscosity decrease factor will be applied isotropically. If it is unity, the factor will only be applied to the vertical eddy-viscosity. For values between zero and unity, the factor will partly be applied only vertically and partly isotropically, creating a more or less non-isotropic eddy-viscosity.

Default: *F 76 1.0 1.0 0.0*

F 77 **SSIIM 2 only.** Constant non-isotropic turbulent eddy-viscosity. Two floats are read, the horizontal and the vertical eddy-viscosity. Note that the F 24 data set must have the parameter 6 for this data set to be used.

Default: *F 77 1.0 1.0*

F 78 Bed load vector parameters. An integer and a float is read. The bed load on a transverse sloping bed may not move in the direction of the water velocity close to the bed. If the integer is 1, an algorithm taking this into account is used. Note that this is fairly untested yet, especially for SSIIM 2.

Αρχείο control (συνέχεια)

F 81 Number of time steps in the timei file. An integer is read.

Default: *F 81 200*

F 82 Parameters to decrease the eddy-viscosity as a function of the water density gradients and the Richardson number. In the formula, the alpha and beta are constants. This data set gives the alpha and the beta for the velocity and the temperature/other constituents. Four floats are read.

Default: *F 82 -0.5 10.0 -1.5 3.33*

F 83 Coefficients in van Rijn's formula for bed load sediment transport. Four floats are read.

Default: *F 83 0.053 2.1 0.3 1.5*

F 84 Flag to indicate the sediment transport formula by van Rijn. An integer is read:

0: Suspended load formula
1: Bed load formula
2: Both suspended and bed load formulas are used

Default: *F 84 0*

Αρχείο control (συνέχεια)

F 85 **SSIIM 2 only.** Flag indicating that the computation should not stop if water continuity is not satisfied. This is invoked if 1 is given.

Default: *F 85 0*

F 86 **SSIIM 2 only.** Minimum grid corner height. This is used to prevent very small grid cell heights. If the corner grid cell is lower than this value, it is set to zero. Note that this only works for the F 64 5 option.

Default: *F 86 0.001* (1 mm)

F 87 **SSIIM 2 only**. Parameter for number of grid cells in the vertical direction as a function of water depth.

Default: *F 87 0.6*

F 90 Roughness option. An integer is read, giving several options how the roughness in the wall laws should be calculated:

0: The value on the *W 1* or *F 16* data set is used.
1: The bedrough file is used (SSIIM 1 only)
2: The roughness is calculated from the bed grain size distribution (d_{90})
3: The roughness is calculated from d_{90} and the bed form height
4: Same as 3, but the critical shear stress for sediment movement is reduced so that only the grain roughness effect is taken into account.

Default: *F 90 0*

Αρχείο control (συνέχεια)

F 92 **SSIIM 2 only**. Algorithms to reduce velocity in cells with small depths. An integer is read:

1: Wall laws are used in more than one cell
2: A drag formula is used for velocities where the roughness is higher than the cells

Default: *F 92 0* (Algorithm is not invoked)

F 94 **SSIIM 2 only**. Minimum grid corner height and maximum grid corner height for generation of one cell. Two floats are read. The first float is used to prevent very small grid cell heights. If the corner grid cell is lower than this value, it is set to zero. The second float gives the depth of having only one cell in the vertical direction -> 2D calculation. Note that this only works for the *F 64 11* and *13* options.

Example: *F 94 0.001 0.01* (default)

Grid cells under 1 mm will not be generated, and all cells under 1 cm will be 2D.

Αρχείο control (συνέχεια)

F 99 **SSIIM 2 only**. Integer to determine how often the grid is regenerated for time-dependent sediment flow calculations with moveable bed.

Default: F 99 1

Example: *F 99 10*

The grid will only be regenerated for every 10th time step.

Some times it is necessary to use *F 99 1* to be able to read the *bedres* file together with the other files, when starting from a previous computation.

F 100 **SSIIM 1 only**. Integer to determine if the second term of the Boussinesq equation is included. If the integer is 1, it is included.

Default: *F 100 0*

F 102 **SSIIM 2 only**. Integer to invoke an algorithm to change the shape of the grid cells close to the boundary. If the integer is 1, the algorithm is included. This algorithm is recommended for wetting/drying computations.

Default: *F 102 0*

Αρχείο control (συνέχεια)

F 104 **SSIIM 2 only**. Integer invoking an algorithm to prevent crashes when a single cell is formed. The algorithm is only invoked if the integer is above zero. The algorithm will add a value to the a_p coefficient in the pressure-correction equation of SIMPLE. This will only be used in the cells that have no neighbour cells. The value added is the integer multiplied with the volume of the cell.

Default: *F 104 0*

F 105 **SSIIM 2 only.** An integer is read, giving the number of iterations between each update of the water surface elevation for time-dependent calculations.

Default: *F 105 10*

F 106 A float is read, giving the thickness of the upper active sediment layer. The default value is equal to the maximum sediment grain size diameter on the *S* data sets.

F 107 **SSIIM 1 only.** Upstream water elevation in the TFS algorithm. An integer is read. If it is 1, the TFS algorithm will compute the water level of the most upstream cross-section using a 1D backwater algorithm, from the second most upstream cross-section. This is done automatically if **G 7** data sets are not used, so then this data set is not necessary.

Default: *F 107 0*

Αρχείο control (συνέχεια)

F 108 **SSIIM 1 only.** A minimum water depth used by the TFS algorithm.

Default: *F 108 0.02*

F 109 Parameter in Brook's formula for reduction of the critical sediment particle shear stress when the bed slopes.

Default: *F 109 1.23 0.78 0.2*

The two first floats are tan(θ) for uphill and downhill slopes, where θ is a kind of angle of repose for the sediments. θ is actually an empirical parameter based on flume studies. The third float is a minimum value for the reduction factor. The default values were previously hard-coded.

F 110 **SSIIM 2 only**. Parameters for limiting the effect of the Hunter-Rouse extrapolation for sediment concentration computed in a reference level different from what van Rijn subscribed. The parameter will only have effect when used with the *F 60* data set.

Default: *F 110 2.0 0.01*

F 111 BEDDLL parameter. An integer is read. If it is 1, the sediment transport algorithms in the *beddll.dll* file are used instead of the default algorithms.

Αρχείο control (συνέχεια)

F 112 **SSIIM 2 only**. An integer is read. If it is 1, the program will regenerate the grid automatically right after it has read the *unstruc* file. The regeneration will be made from the water levels given in the *koordina* file. The option is used when computing wetting/drying in a situation where the initial water level is lower than what it will be later. The program needs to know the grid layout of the areas that will be wetted, so the unstruc file needs to cover the whole geometry. If the initial wetted area is smaller, than the water level can be given in the *koordina* file, and the program will start with a grid based on this.

F 113 **SSIIM 2 only**. Algorithms to stabilize the solution in very shallow regions close to the side walls. The algorithms use different interpolation algorithms from the center of the cells to the cell surfaces. Different algorithms have been tested, using integers from 1 to 7.

3,4: Using second-order interpolation instead of third-order interpolations for pressure gradients
5: Setting the Rhie and Chow term to zero for 2D cells in shallow areas. Shallow defined as depths below the values given on the first value of the F 94 data set.
7: Flux-limiter: the extra term from the Rhie and Chow interpolation should not be more than 20 % of the linear interpolation term.

Note that these algorithms are not tested extensively

Default: *F 113 0* (algorithms not used)

Αρχείο control (συνέχεια)

F 114 **SSIIM 2 only**. An integer is read. If it is 9, 10 or 20, special algorithms to compute the pressure gradients are used. This can give a more stable solution where there are very shallow areas inside the main grid. A similar routine is also used on the pressure-correction gradients in the SIMPLE method if the integer is 10.

Default: *F 114 0* (algorithms not used)

F 115 VEGDLL parameter. An integer is read. If it is 1, the algorithms in the *vegdll.dll* file to compute the effect of plants/large stones on the water flow are used instead of the default algorithms.

F 116 **SSIIM 2 only**. TFSDLL parameter. An integer is read. If it is 1 or 2, the free surface algorithms in the *sfdifdll.dll* file are used instead of the default algorithms. If 1, an implicit procedure is used to find the water surface. If the integer is 2, an explicit procedure is used.

F 117 IODLL parameter. An integer is read. If it is above zero, the free output algorithms in the *io1dll.dll* file are used instead of the default algorithms. This DLL is not yet implemented.

Αρχείο control (συνέχεια)

F 128 **SSIIM 2 only.** Setting the pressure field to zero in the TSC algorithm to prevent instabilities. An integer, ***n***, is read. The pressure is set to zero for each ***n***'th time step. The algorithm has not been very successful in testing.

F 130 **SSIIM 2 only**. Four integers giving the indexes defining an area of the first block where a denser grid is to be generated. Not tested yet.

F 131 **SSIIM 2 only**. Cohesive parameters. And integer and a float is read. The integer determines the sediment size. The float is a critical shear stress for erosion of each particle size. Multiple F 131 data sets are given for multiple sediment sizes. Default: 0.0 for all sizes. Note that this number is only used to determine the critical shear stress for erosion of a particle. It is not used in the sediment transport formulas.

F 132 **SSIIM 2 only**. Maximum Froude number for update of water surface. A float is read. This is a stabilizing depth-limiter algorithm for the water surface computation. The water level is limited in size so that high Froude numbers do not emerge. The critical Froude number is given on the float. Default: 0.0, meaning the algorithm is not used. Note that this algorithm may introduce unphysical water levels, with corresponding instabilities.

Αρχείο control (συνέχεια)

F 136 **SSIIM 2 only.** Maximum pressure gradient. A float is read. This algorithm has not been successful.

F 137 **SSIIM 2 only**. *QNgrid* algorithm. The algorithm generates hexaheadral cells with more than six neighbours. The algorithm is not implemented yet.

F 138 **SSIIM 2 only**. Minimum value of the turbulent kinetic energy. A float is read. Default: 10^{-20}.

F 139 **SSIIM 2 only**. Minimum value of $u+$ in the wall laws for the velocity and turbulent kinetic energy (default 1.0).

F 141 **SSIIM 2 only.** A limiter for epsilon. A float is read. This is the maximum value epsilon will get. Default: 100.0. (Minimum value for epsilon is hard-coded to 10^{-16})

F 142 **SSIIM 1 only.** Convergence criteria for update of the water surface. A float is read. *Default: F 142 0.001*.

F 143 **SSIIM 2 only.** Water surface computation algorithm. An integer is read. If it is 2, then the program will use the average pressure over the last iterations for computing the water surface. If it is 1, then the program will do a linear regression analysis over the last iterations to estimate the water surface location. This option is tested and did not give very good results.

Αρχείο control (συνέχεια)

F 144 Bed form smoothing algorithm. An algorithm is invoked to smooth the bed as a function of the bed form characteristics. An integer and a float is read. The smoothing is used if the integer is above 0. The default value is 0.

F 145 **SSIIM 1 only.** Integer to invoke the **roughm1.dll** DLL file. In this file, the bed roughness or the vegetation parameters can be modified by the user. The DLL file is used if the integer is above zero.

F 146 **SSIIM 1 only.** Integer to invoke an algorithm adding a source term to the velocity equations if the flow is supercritical. This is done if the integer is above 0. Default F 146 0. The algorithm was intended to be used to improve results for supercritical flow computations in coarse grids, but it has not been successful yet.

F 147 **SSIIM 2 only.** Parameters for use in extrapolation of initial values to newly wetted cells. *Default: F 147 20 0 1 0.2 1.0 1.0* The first integer gives how many iterations the extrapolation algorithm should be used. This should be larger than the number of cells in one direction in the wetted area. The second integer determines which of two interpolation algorithms are used when transferring variables between two grids. The default algorithm (0) uses a linear interpolation based on the vertical elevation of the cells. An alternative algorithm (1) uses the cell indexes. The third integer invokes the part of the algorithm that extrapolates over multiple cells for each wetting situation. The fourth number, a float, gives a relaxation factor for the velocity values. The fifth and sixth number, both floats, give relaxation factors for *k* and *epsilon*. During initial testing, we have not found any improvements in the results by using values different than the default.

Αρχείο control (συνέχεια)

F 148 **SSIIM 2 only.** Maximum slope of the water surface. A float is read. If the number is above zero, an algorithm is invoked that prevents the water surface to be steeper than the value given. Default -0.1 (algorithm not used).

F 149 Non-isotropic turbulence parameters. Two floats are read. The first float is multiplied with the isotropic diffusion to produce the vertical diffusion used by the program. The second parameter does the same in the horizontal direction.

Default: *F 149 1.0 1.0*.

F 150 **SSIIM 1 only**. Option with modified wall laws. Two integers are read. The first integer modifies the wall laws for high roughness/water depth ratios. Option 1 uses a three-layer model where the middle layer is when the bed form height is higher than the roughness. Option 2 uses a two-layer model where the middle layer is not used. The inner layer is a linear function. Option 0 is the function used previously. The second integer will use a kappa of 0.4 if the integer is 1. If it is zero, it will modify kappa according to the bed concentration, using Einstein's formula.

Default: *F 150 0 0*

This data set is not much tested.

Αρχείο control (συνέχεια)

F 151 **SSIIM 1 only**. Parameters for special algorithms for very shallow flows. An integer and a float is read. The float is the minimum water depth in the grid in meters. The default is 3 % of the average grid cell length. The integer is a choice of combination of different parameters. The algorithms are used if the bed level rises above the minimum water depth. The following options can be used:

A: A sink term in the Navier-Stokes equations are used in the shallow areas
B: The SIMPLE corrections are not used in the shallow areas
C: An algorithm setting a_{nb} to zero in the shallow areas
The options for the integer are:

0: No special algorithms are used (default)
1: *A*
2: *A+B*
3: *B*
4: *B+C*
5: *C*

F 154 Smoothing algorithm for the water surface. An integer and a float is read. Smoothing is done if the integer is 1. The smoothing is done by taking the average of the four neighbour values and multiplying this with the parameter on the data set. Then, 1 - the parameter is multiplied with the old value and added. This gives the new value.

In *SSIIM 1*, the averaging is done on the pressure at the water surface, before the surface changes are done. In *SSIIM 2*, the averaging is done on the water levels directly.

Αρχείο control (συνέχεια)

F 159 **SSIIM 2 only**. Algorithms to improve stability by avoiding grid problems. Five integers are read, for five different algorithms. The algorithms are invoked if the integer is 1, and it is not invoked if the integer is 0. The algorithms are only used when the parameter on the *F 64* data set is equal to 8, 11, 13, 38 or greater than 100.

The first algorithm tries to remove dead-end channels that are only one cell wide. A maximum of 30 cells can be removed.

The second integer invokes different algorithms dealing with the problem of ridges between wet cells. Some algorithms try to give better connection between two neighbour column of cells that are separated by a high ridge. This is done by increasing the water depth. Several algorithms are used with different depths. An integer of 1 sets the depth to 80 % of the first parameter of the F 94 data set. An integer of 2 or 3 sets the water depth to minimum the value of the first parameter on the F 94 data set. An integer of 4 does the same as 1, but uses a value of 200 % of the first F 94 parameter, instead of 80 %. An integer of 3 sets the number of vertical grid lines in the corners between the cells to 1 if one of the corners have a negative depth and the sum of the two corners is smaller than 10 % of the first parameter on the F 94 data set. An integer of 7 does the same thing as 1, but uses 100 % of the second parameter on the F 94 data set instead of 80 % of the first. Other algorithms sets internal walls in the ridges. The integer is then set to 9 or 10.

Αρχείο control (συνέχεια)

The third algorithm will try to remove holes in the grid, where there is only one cell with no connections to side neighbours, only with its neighbours below and above. This is in a wetted area, where in 2D, the neighbours exist.

The fourth algorithm will remove single wet cells with only dry neighbours in 2D.

The fifth integer invokes different algorithms to increase the water depth in partially dry cells, by lowering the bed levels. So far, none of these algorithms have been successful. An integer of 1 lowers the bed level to the first value given on the F 94 data set. This also happens if the integer is 2, but then multiple cells in the vertical direction is allowed, also on side walls. If the integer is 3, then the depth is increased so that the bed slope is not above 20 degrees. If the integer is 5, then neighbours are disconnected if the area between them is smaller than a small number.

Default: *F 159 1 0 0 1 0*

Αρχείο control (συνέχεια)

F 160 **SSIIM 2 only**. Flag to decide which algorithm is used to compute the available sediment at the bed when deciding the limits of sediment concentration. An integer is read. If it is 0, the available sediments will be equal to the bed cell area times the depth of the sediments. If the integer is 1, then also neighbour cells will be included.

Default: *F 160 0.*

F 162 **SSIIM 2 only.** Value to determine whether a cell is generated or not in regions where the bed was dry in the previous time step. Default 0.0 meters. The parameter only works in connection with the *F 64 13* option.

F 163 **SSIIM 2 only.** Flag to decide which algorithms are to be used to limit the movement of the bed. An integer is read. Three options are possible:

0. The bed level will not be allowed to move below the movable bed, but it will be allowed to move above the water surface.

1. The bed level will not be allowed to move above the water surface or below the limit of the movable bed.

2. The bed level may move above the water level or below the limit of the movable bed.

Αρχείο control (συνέχεια)

F 165 **SSIIM 2 only.** Grid numbering direction. When the unstructured grid is made, the indexing of the cells start at the lower left corner, or the first point marked in the Grid Editor. One integer is read on this data set. If the integer is 1, then the cell indexing will start on the corner diagonal opposite in the block. This is mostly useful for debugging purposes.

Default: *F 165 0*

F 166 **SSIIM 2 only.** Regeneration of grid after water surface update. An integer is read. If it is 1, then the grid will be regenerated after each time the water surface is updated, also if time-dependent sediment transport is computed. This is usually not done, as the bed changes are normally recomputed more frequently than the water surface changes, and the grid is always regenerated after each bed change.

Default: *F 166 0*

F 168 SSIIM 2 only. Multi-grid solver for the pressure-correction equation. An integer is read, and this is the number of levels in the grid nesting. If the integers is 0, the algorithm is not used.

Default: *F 168 0*

Αρχείο control (συνέχεια)

F 169 Hiding/exposure parameters. An integer and a float is read. The two parameters are not used by the main SSIIM program, but they are passed on to the *beddll.dll* where they can be used in the sediment transport formulas.

F 173 **SSIIM 1 only**. Bed shear stress gradients at inflow/outflow boundary. An integer is read. If 1, the bed shear stress in the boundary cell will not be larger than the neighbour cell in the direction of the interior domain.

F 174 **SSIIM 1 only**. Cyclic boundary conditions. Two integers are read. The first integer applies to the water flow computation, and the second to the sediment concentration computation. If the integer is positive, say for example 500, then the inflow boundary values will be set equal to the outflow values for each 500th iteration. If a negative number is given, say -8, then the program will run to convergence, then update the inflow boundary condition and restart the computation. This will be repeated 8 times.

Default *F 174 0 0* (no cyclic boundary condition used)

F 182 **SSIIM 2 only**. Reduction of critical bed shear stress due to sloping bed. An integer is read. If it is 1, the same algorithm as F 7 B is used. If the integer is 2, then the algorithm is only used for cells that have a dry neighbour.

Default: *F 182 0*

F 185 **SSIIM 1 only**. Damping of turbulence close to the water surface. An integer and a float is read. If the integer is 1, a formula similar to the wall laws will be used for the epsilon equation. This will give increased values of epsilon at the water surface and turbulence damping. The float is an empirical coefficient in the damping function. Typical values: 0.0046-0.43.

Αρχείο control (συνέχεια)

F 188 SSIIM 2 only. Integer determining which block is to be computed for sediment transport. Options:

0: All blocks (default)
-1: only nested blocks
n: only block no. n.

Example: *F 188 3* : Only compute sediment transport for block no. 3.

F 189 **SSIIM 1 only**. Large roughness algorithms. Special algorithms designed for situations where the bed roughness is larger than the vertical grid cell size close to the bed. An integer and a float is read. The integer determines which algorithm is used, and the float is a parameter in the algorithm.

Several algorithms and approaches have been tested, but not extensively. Currently, the most promising algorithm seems to be an immersed boundary method with a linear velocity profile: F 189 5 0.5, but much more work needs to be done.

F 190 **SSIIM 1 only**: Algorithm to decide if to use cohesive forces or not for the sediments. An integer is read. If it is zero, the cohesive forces from the F 131 data set will only be used if the bed level is below the original level. If the bed level is above the original level, the cohesive forces are not used.

Αρχείο control (συνέχεια)

F 191 **SSIIM 2 only.** When connecting blocks in the GridEditor, the graphics pointer have to be placed within a certain accuracy. The default is 0.01 mm. For large geometries, this value may be raised to get a successful connection.

F 192 **SSIIM 2 only:** Ratio of :

number of cells in the vertical direction for the nested grid

to

number of cells in the coarse grid

Default: 1.0

F 194 **SSIIM 1 only:** Empirical parameter in a formula for adding turbulent eddy-viscosity in areas of vegetation. Default value: 0.0 (no additional turbulence). Values may be in the order of 0.067-0.11.

F 195 **SSIIM 1 only:** Roughness on side walls. Two floats are read. The first float is the roughness on the side wall where j=2. The second float is the roughness on the other side wall.

F 198 Sand slide dll. An integer is read. If it is above zero, the algorithms in the *slide1dll.dll* or *slide2dll.dll* files are used. The two files are made for *SSIIM 1* and *SSIIM 2* respectively.

Αρχείο control (συνέχεια)

F 200 Residual norms for *k* and *epsilon*. An integer and two floats are read. The first float is the residual norm for k and the second is the residual norm for epsilon. The values are used instead of the average inflow values if the integer is above zero.

F 201 **SSIIM 2 only**: Parameters for the *vegdata* file. Three integers are read. The first is the number of variables in the vegdata file. The second is the number of vertical elevations. The third is the number of time steps in the file.

This data set has to be present in the control file if values for multiple times are to be used in the vegdata file.

Default: *F 201 1 4 1*

F 202 **SSIIM 2 only.** Logarithmic inflow velocity profile. An integer and a float are read. If the integer is above zero, then the inflow sections with have a logarithmic profile in the vertical direction. The float is the roughness value that will be used in generating the logarithmic profiles. Note that all inflow profiles will be logarithmic if this data set is used.

Αρχείο control (συνέχεια)

F 206 Maximum number of processors used for the parallel versions of SSIIM. An integer is read, which gives the maximum number of processors. If it is above the number of processors available on the computer, then the maximum available processors are used. The actual number of processors used is written to the *boogie* file.

Default: *F 206 0* (parallellized algorithms not used)

Note this data set will only work on parallel versions of SSIIM.

F 207 **SSIIM 1 only**. Algebraic stress model DLL. Two integers are read. If the first one is above zero, then the algebraic stress model in the *stress1dll.dll* file will be used instead of the other turbulence models in SSIIM 1. The second integer is the size of the array sent to the DLL from the main program.

F 208 SSIIM 1 only. Order of the discretization of the time-term. An integer is read. If this is 1, then a second-order backwards scheme is used for the time term. Default value: 0, meaning a first-order backward Euler method is used. This data set is usually only used if modelling large eddies (URANS).

F 209 **SSIIM 2 only**. Scaling depth for grid generation. The default value is the largest depth in the geometry. The value is used for deciding how many grid cells there will be over the depth for a given location in the geometry.

F 210

F 211 **SSIIM 1 only**. Convergence criteria for the water flow computations.

Default: *F 211 0.001*

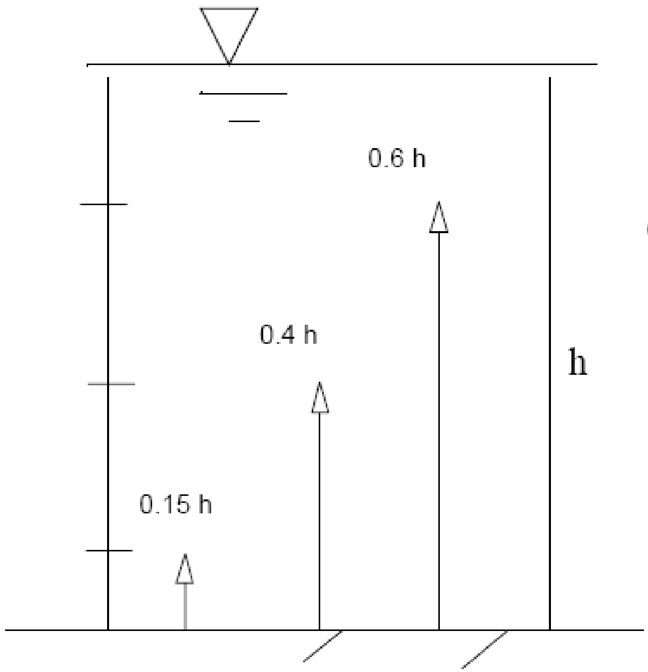
4.3.2 The G data sets

G 1 Four integers are read, called *xnumber*, *ynumber*, *znumber* and *lnumber*.

For SSIIM 1, this gives the number of cross-sections, grid lines in the streamwise direction, and vertical direction, respectively, for a structured grid. The last integer, *lnumber,* is the number of sediment sizes. This data set must be present in the control file. The program will read these values and allocate space for the arrays accordingly.

For SSIIM 2, the unstructured grid will also use structured arrays for connecting the different blocks. The blocks will be put beside each other in the cross-streamwise direction of the grid. The default grid size is 300x300 cells. If the grid size is smaller, it may be an advantage of using smaller numbers on this data set, to reduce the memory requirement. If the length of one block (number of cross-sections) is larger than 300, this data set must be changed accordingly. If the number of blocks times its widths is larger than 300, this data set must also be changed accordingly. The third integer, *znumber*, will be the maximum number of grid lines in the vertical direction. The last integer, *lnumber*, is the number of sediment sizes.

G 3 **For SSIIM 1**: Vertical distribution of grid cells. This is further explained in the figure below, where an example is given. This data set must be present in the file.



G 3 0.0 15.0 40.0 60.0 100.0

The values are given as a percentage of the depth only with the grid options F 64 2 and F 64 5. For F 64 0 and F 64 1, the values are level in meters, and the longitudinal and lateral grid lines are completely horizontal.

For SSIIM 2: The same distribution as described for SSIIM 1 is used if *F 64 2* and *F 64 5* is used in the *control* file. For *F 64 0* (default) and *F 64 1*, the values on the G 3 data set are level in meters, and the longitudinal and lateral grid lines are completely horizontal.

Αρχείο control (συνέχεια)

G 5 **SSIIM 1 only**. Sediment sources. Six integers and lnumber floats are read. The integers indicate a region of the grid. The first two are in the streamwise direction, the following two are in the cross-stream direction and the two last integers indicate the vertical direction. The following floats gives the sediment concentration in volume fractions. Only <u>one</u> **G 5** data set can be used.

Example: Sediment concentration 0.001 flows into the top of the geometry in an area given by the following cells: j=2 to j=4 and i=3 to i=5. It is assumed that there are 11 grid lines in the vertical direction. This gives the following data set:

G 5 3 5 2 4 11 11 0.001

Note that a volume concentration of 0.001 with a specific sediment density of 2.65 is equivalent to a concentration of 0.001 x 2.65 x 1 000 000 = 2650 ppm

Αρχείο control (συνέχεια)

G 6 Data set for calculating water surface elevation with an adaptive grid. Three integers and two floats are read:

iSurf
jSurf
kSurf
RelaxSurface
ConvSurface

The *RelaxSurface* variable is a float relaxing the estimation of the increment to the new recalculated water surface. Recommended values are between 0.5 and 0.95.

The ConvSurface variable is a float setting the limit for when the water surface should be recalculated. The water surface will be updated when the maximum residual of the equations are below this parameter. Recommended value: 0.01 - 1.0

The first three integers are interpreted differently in SSIIM 1 and SSIIM 2.

Αρχείο control (συνέχεια)

SSIIM 1:

Note: The *G 6* data set is not used if *F 36 1* is used in the control file.

The three integers *iSurf, jSurf, kSurf* indicate a cell in the grid. The water surface in this cell is not moved. In the present implementation, *kSurf* have to be equal to *znumber* + 1. This means the cell has to be on the water surface. If not, a warning message is sent to the *boogie* file, and *kSurf* is set to *znumber* + 1. The computations continue afterwards.

Example: G 6 31 7 9 0.1 0.1

Seen from above, the water elevation in cell (31,7) will not move during the computation of the free surface.

Αρχείο control (συνέχεια)

G 7 **SSIIM 1 only**. This data set specifies water inflow on geometry sides, bed or top. Each inflow/outflow location is given on **one** G 7 dataset. It is possible to have up to 19 G 7 datasets.

On each dataset, eight integers and four floats are read. The names of the variables are:

G 7 type side a1 a2 b1 b2 parallel update discharge Xdir Ydir Zdir

Each variable is explained in the following:

type: 1: outflow, 0: inflow.

side: 1: plane i=1, -1: plane i=xnumber,
(cross-streamwise plane)
2: plane j=1, -2: plane j=ynumber,
(streamwise plane)
3: plane k=1, -3: plane k=znumber
(horizontal plane)

a1,a2,b1,b2: four integers that determine the limits of the surface, by the indexes of the cells. This is further described in the figure below.

Αρχείο control (συνέχεια)

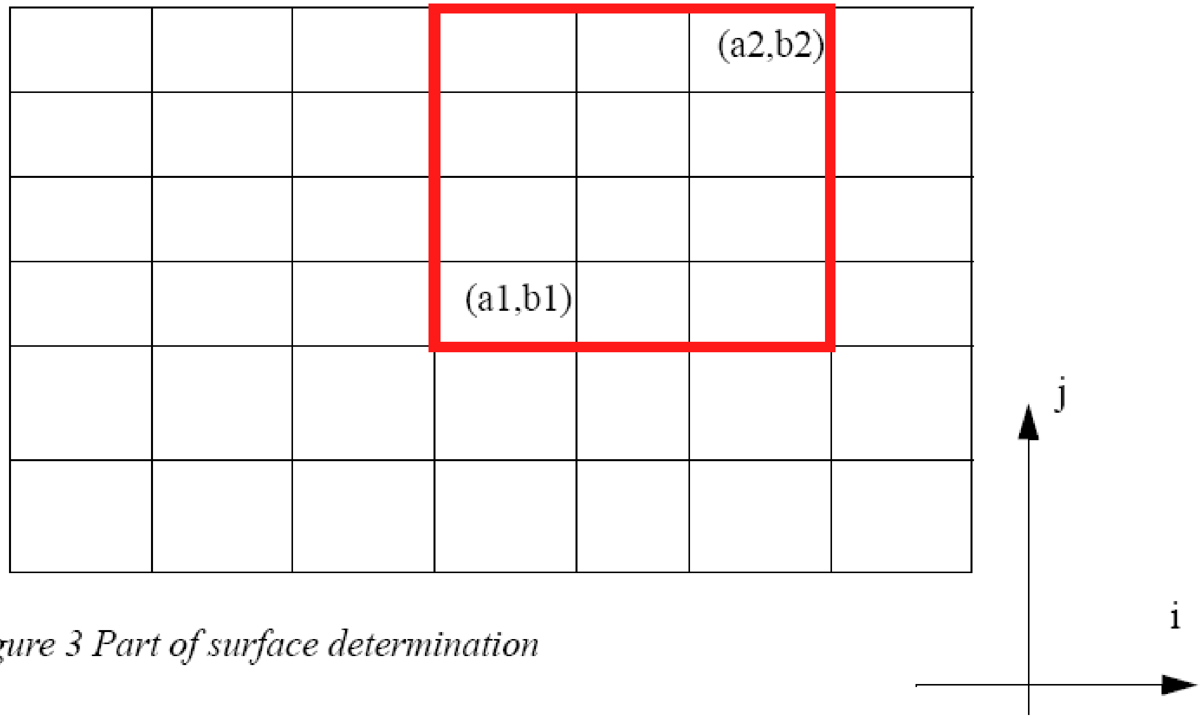


Figure 3 Part of surface determination

parallel: direction of the flow:
- 0: normal to surface
- 1: parallel to grid lines normal to surface
- 2: direction is specified (vector directions)

update: 0 for not update, 1 for update.
(only partly implemented)

Αρχείο control (συνέχεια)

discharge:water discharge in m^3/s. Note that the sign of the discharge must correspond with the direction of the desired flow velocity. Positive discharges indicate velocities in direction of increasing grid line numbers.

Xdir: direction vector in x-direction
Ydir: direction vector in y-direction
Zdir: direction vector in z-direction

Example: *G 7 0 1 2 11 2 11 0 0 32.0 1.0 0.0 0.0*

This example specifies inflow in the most upstream cross-section. The inflow area is from cell no. 2 to cell no. 11 in both cross-streamwise and vertical direction. The flow direction is normal to the cross-section. The discharge is 32 m^3/s

Remember to define the walls of the boundary when this data set is used. The walls with no inflow must be closed with the *W 4* data set. If inflow through a side set as wall is specified with the *G 7* data set, the wall laws must be removed using the *W 4* data set. The default walls are on the sides of the channel. The first and last cross-sections have the inflow and outflow by default.

Also note that it is not possible to have inflow through the free water surface. If such a case is to be simulated, it is necessary to model a closed conduit (K 2 0 0, + addition to koordina file), and then to open a hole in the roof.

For *SSIIM 2*, the data set is not used. Instead, the inflow/outflow is specified in the *Discharge Editor*. The information is stored in the *unstruc* file.

Αρχείο control (συνέχεια)

G 8 **SSIIM 1 only**. Values for initial velocities. Up to 19 *G 8* data sets can be used. Six integers are read first to specify the volume that is being set. Then three floats are read, which gives the velocities in the three directions.

G 8 i1 i2 j1 j2 k1 k2 U V W

G 11 **SSIIM 1 only**. Source terms for the velocity equations. Six integers and two floats.

i1 i2 j1 j2 k1 k2 source relax

The first six integers are indexes for the cells that are influenced by the source term. The source variable is the form factor times a diameter of a cylinder in the cell. The relaxation variable is recommended set between 1.0 and 2.0

Αρχείο control (συνέχεια)

G 13 Outblocking option that is used when a region of the geometry is blocked out by a solid object. An integer is read first, which determines which sides the wall laws will be applied on. The following options are possible:

0: No wall laws are specified
1: Wall laws are used on the sides of the block
2: Wall laws are used on the sides and the top of the block
3: Wall laws are used on the sides, the top and the bottom of the block

Six integers are then read: i1 i2 j1 j2 k1 k2. These integers define the cells of the block. The two first integers are the first and the last cell in the i-direction. The next two integers are the first and the last cell in the j-direction. The last two integers are the first and the last cell in the vertical direction.

When making blocks, note that there must be at least two free cells (not blocked out) between each block or to the wall. It is recommended to use more free cells than two, to resolve the flow pattern between the blocks.

Up to 49 *G 13* data sets can be used.

For **SSIIM 2**, the first and the two last integers are not used, but numbers must be given in anyway. The data set will then only have an effect when given to the control file before the grid is generated.

Αρχείο control (συνέχεια)

G 14 **SSIIM 1 only**. Debug dump option, where a variable in a cell is written to the *boogie* file. Four integers are read. The first integer indicate which equation. Velocities in x,y and z directions are denoted 1,2 and 3, respectively. 5 and 6 are used for k and ε, respectively.

The next three integers are cell indexes i,j and k.

Example: *G 14 1 3 4 6* causes velocity in x-direction for cell i=3, j=4 and k=6 to be written to the *boogie* file for each iteration.

Up to 29 *G 14* data sets can be used.

G 16 **SSIIM 1 only**. Local vertical distribution of grid cells. This data set can be used when a different distribution of grid cells than what is given on the *G 3* data set is wanted in some parts of the geometry. Four integers are read first. These tells which area are affected by the changed distribution. Then *znumber* floats are read, similarly to what is on the *G 3* data set.

Example: *G 16 2 3 1 4 0.0 50.0 75.0 100.0* when *znumber* is 4, gives the new distribution for the eight vertical lines *i*=2 to *i*=3 and *j*=1 to *j*=4.

Up to 20 *G 16* data sets can be used.

Αρχείο control (συνέχεια)

G 18 **SSIIM 1 only**. Boundary inflow specification for water quality calculation. Six integers are read first, specifying the location of the inflow. Then another integer is read, specifying the variable. The integer correspond to the value on the **Q** data set. Then a float is read, which is the value of the variable. The last two numbers are floats, which gives the starting and ending time for the variable to flow into the geometry (in seconds).

Example: *G 18 1 1 2 4 2 5 0 0.01 100.0 200.0*

This gives an inflow at the upstream boundary (*i*=1) in cell *j*=2 to 4 (lateral) and *k*=2 to 5 (vertical). This is variable no. 0, and a value of 0.01 is specified after calculated time 100.0 seconds. The inflow ends after 200.0 seconds

Up to 100 *G 18* data sets can be used.

G 19 **SSIIM 1 only**. OpenGL 3D surfaces parameters. One surface is described on each *G 19* data set. Up to 50 *G 19* data sets can be used.

Each data set consist of eight integers. The first integer specifies the number of the grid line. The second integer is an index showing the main direction of the grid surface. The following options are possible:

1: cross-section
2: longitudinal profile
3: plan view

Αρχείο control (συνέχεια)

The following four integer defines the corners of the surface. The last two integers are presently not used for anything, but they must be given.

Example: *G 19 11 3 2 5 2 6 0 0*

This gives a surface along the grid surface *k*=11, from *i*=2 to 5, and *j*=2 to 6.

If no *G 19* data sets are given, a default data set is used this is:

G 19 1 3 2 xnumber 2 ynumber 0 0

This will give the bed of the geometry. The parameters *xnumber* and *ynumber* are given on the *G 1* data set, and are the number of cross-sections and lines in the stream-wise direction, respectively.

Αρχείο control (συνέχεια)

G 20 **SSIIM 1 only**. Sediment sources. This data set is used for inserting sediment into other areas than what is defined on the I data set.

The data consist of seven integers and a float. The first six integers define a surface, by giving indexes for streamwise, cross-streamwise and vertical direction. The seventh integer is an index for the sediment size. The float is last, and it is the sediment concentration.

Example I: *G 20 2 10 1 1 2 7 1 0.001*

A concentration of 0.001 (by volume) is given for size 1. The concentration is given on the right side wall of the volume (j=1 to 1, repeated indexes). The surface area is within the indexes i=2 to 10 and k=2 to 7.

Example II: *G 20 2 10 2 4 12 12 3 0.002*

A concentration of 0.001 (by volume) is given for size 3. The concentration is given on the water surface, as there are 11 cells in the vertical direction. The surface area is within the indexes i=2 to 10 and j=2 to 4.

Up to 50 *G 20* data sets can be used.

Αρχείο control (συνέχεια)

G 21 **SSIIM 1 only**. This data set is used for determining fluxes through special parts of the geometry. As a default, the boogie file will only give the fluxes through the four sides of the geometry. Additional surfaces can be specified on this dataset.
Six integers are read. The first integer specifies if the surface is a cross-section (1), a longitudinal section (2) or a horizontal section (3). The second number specifies the section number. The following four integers specifies the surface area.

Example:

G 21 1 83 2 9 2 21
G 21 1 83 2 9 2 6

The two data sets specifies two cross-sectional surfaces, located at node i=83. Both surfaces covers j=2 to j=9, but the first surface is from k=2 to k=21, while the second surface is from k=2 to k=6.

The effect of the data sets is that an extra line is written to the *boogie* file for each data set. The example above gives the following print-out in the *boogie* file. The bold text is specific for the *G 21* data sets.

Αρχείο control (συνέχεια)

Trap efficiency after 49 iter: all values in kg/s
l=1: Trapped: 0.0510563, Fluxes (I1,I2,J1,J2): 1, 0.948, 0, 0 Resid: 0.0008
Flux 1 = 0.948952
Flux 2 = 0.881389

The numbering of the surfaces follows the grid lines, which is different from the numbering of the cells. If the water is flowing in a direction of decreasing grid cell numbers, then the sediment flux will be equal to the concentration in a cell multiplied with the water flux in the cell side with the cell number minus one. To take this into account, the user can specify a negative sign for the integer indicating the direction. For example -1 instead of 1 for a cross-section where the water is flowing into the geometry at the last cross-section, or out of the geometry at the first cross-section.

Up to 20 *G 21* data sets can be used.

Αρχείο control (συνέχεια)

G 23 **SSIIM 1 only**. Data set to model scour around submerged structures. If this data set is not used, the position of the grid intersection will move vertically as the grid changes. This data set fixes one grid surface. Five integers are read. The first two are indexes for the first and last cross-section of the surface. The next two are the first and last index of the grid line numbers in the lateral direction. The last and fifth integer is an index for the vertical level.

Example: *G 23 31 45 1 18 6*

Surface number 6 from the bed is fixed in the region between cross-sections no. 31 and 45 and between the right bank and grid line j=18.

Up to 9 *G 23* data sets can be used, if there are multiple submerged structures.

The data set is mostly used in combination with blocking out a region of the flow. This is done by using the *G 13* data set.

G 24 Data set to determine which variables are written to the *Tecplot* files. First, an integer is read giving the number of variables on the data set. Then, for each variable, a char-
integer gives the sediment size. For some variables, this information is not relevant. Integers still have to be given, but they are then not used.

Example: *G 24 3 u 1 0 p 2 0 c 1 2*

Αρχείο control (συνέχεια)

G 40 Initial vertical distribution of temperature. An integer, *n*, is read, which gives the number of points in the profile. Then *n* pairs of floats are read, the first float being a vertical level in meters, and the second float is the corresponding temperature in degrees Centergrade.

Example: *G 40 2 101.0 20.0 88.0 17.0*

At the start of the calculation, the temperature is 20 degrees Centergrade at level 101.0 meters and 17 degrees at level 88.0. There is linear variation between the given levels.

The highest levels must be first in the data set

G 41 Initial vertical distribution of a water quality parameter. Two integers are first read, where the first integer is the number of the water quality parameter. This corresponds to the Q data sets. The second integer is the number of data points, *n*, in the vertical direction. Then *n* pairs of floats are read, the first float being a vertical level in meters, and the second float is the corresponding temperature in degrees Centergrade.

Example: *G 41 4 2 101.0 20.0 88.0 17.0*

At the start of the calculation, the water quality parameter no. 4 is 20 at level 101 meters and 17 level 88.0. There is linear variation between the given levels.

The highest levels must be first in the data set.

G 42 **SSIIM 2 only**. Multiple vertical surfaces for the OpenGL graphics. A surface is give on each *G 42* data set, and up t 20 *G 42* data sets can be given. For each data set, two integers are read. The first integer is a grid node number. This indicates the starting point of the surface. The second integer is a flag indicating the direction of the surface. A zero is in one direction, and 1 is the other. It is necessary with a trial and error run to get the second parameter right.

4.3.3 The I data set

SSIIM 1 only. Inflow of sediments at the upstream cross-section. An integer is read first, giving the number of the size fraction. Then the sediment inflow in kg/s is given.

Example: *I 1 3.2*
I 2 4.8

There is 3.2 kg/s sediment inflow of size 1 and 4.8 kg/s of size 2.
Note that this data set only applies for the upstream cross-section. If sediments flow into another surface, the *G 20* data set can be used.

4.3.4 The K data sets

K 1 Number of iterations for flow procedure and number that determines the minimum iterations between updates of water surface. Two integers.

Default: *K 1 40000 50000*

K 2 Two integers that indicate if laws of the wall are being used for the water flow computation. If 0, wall laws are used, and if 1, zero-gradients are used. The first integer applies to the side walls. The second integer applies for the surface. Wall laws are always used for the bed, if not changed by the *W 4* data set. Default: *K 2 0 1*.

K 3 Relaxation factors. Six floats. For the three velocity equations, the pressure correction equation and the k and e equation. For further description of the relaxation factors, see Chapter 5.4.

Default: *K 3 0.8 0.8 0.8 0.2 0.5 0.5*

K 4 Number of iteration for each equation. Six integers. Default: *K 4 1 1 1 5 1 1*

Αρχείο control (συνέχεια)

K 5 Block-correction. Six integers are read, one for each of the six water flow equations. If the integer is 1, block-correction is used. For the TSC algorithm in SSIIM 2 for Windows, the integer 2 indicates that the block-correction is only used in the first of the inner iterations in each time step. For SSIIM 2, the integer 10 used in connection with F 168 will invoke a multi-grid algorithm.

Default: *K 5 0 0 0 0 0 0*

K 6 Six integers are read which determines whether the SOU or POW scheme is used. If 0 POW is used, if 1, SOU is used.

Note that this only applies to the velocity and turbulence equations. The pressure-correction equation will use a different approach. This means that a 0 should always be used for the fourth integer.

Default: *K 6 0 0 0 0 0 0*

K 10 Solver: Usually, a TDMA solver is used. However, if the *K 10 Y* is given in the control file, a Gauss-Seidel solver is used instead.

Αρχείο control (συνέχεια)

4.3.5 The L data set

L Specification of isoline values for ContourMap plot. First, an integer is read, which gives the number of isolines. Then, this number of floats are read. The floats specify the isolines. Example:

L 6 55.0 56.0 57.0 58.0 59.0 60.0

If the geometry has bed levels between 55 and 60 meters, and the user chooses bed levels from the graphics options, a contour map of the bed levels will be displayed. There will be contour lines for each meter, from 55 to 60 meters.

Default: The program finds the maximum and minimum value of the variable in the field, and uses 7 lines located between the values.

If more than 7 lines are displayed, all lines will be black. Otherwise each line will have different colour.

Note that sometimes there may be errors in the contouring, if the contour line and the value are identical. This can often be the case for plotting bed levels. To avoid this problem, add a very small value to the values on the L data set. For example, if the above data set is used and there is a problem for the 57.0 contour line because the bed level at one of the grid intersections are 57.0, change the data set to:

L 6 55.0 56.0 57.0001 58.0 59.9 60.0

Note that the values can be changed by the user from the Values option in the Scale menu of the Contour map plot.

4.3.6 The M data set (SSIIM 2 only)

The *M* data set specifies inflow of a water quality constituent or sediments. A maximum of 9 groups of *M* data sets can be used. Each group corresponds to an inflow section, specified in the *DischargeEditor*. Two integers are read first. The first integer is an index for the group. The first group has index zero. The second integer is an index for the water quality constituent/sediment size. Zero is the smallest number possible. After the two integers, a float is read. This is the value of the inflow concentration of this parameter.

Example: *M 0 2 0.001*

If sediments are computed: In inflow section 0, the concentration of size 2 is 0.001.

For example, if there are three inflow sections, and five water quality constituents, it will make sense to have 15 *M* data sets. If no *M* data set is given for a particular inflow section and water quality parameter, the inflow is zero. *M* data sets given for sections with water outflow has no effect on the computation, and should not be used.

The values of the *M* data set does not change over time, unless altered by using *M* data sets in the *timei* file. This is the recommended procedure to model time-varying inflow of water quality components.

It is recommended to model time-varying inflow of sediment concentration by specifying the concentrations in the *timei* file, without using *M* data sets in the control file.

Αρχείο control (συνέχεια)

4.3.7 The *N* data set (SSIIM 1 only)

The *N* data set composes the size fractions of different groups of sediments. Two integers and one float is read. The first integer is an index for the group. The second integer is an index for the sediment size, similar to the first index on the *S* and *I* data sets. The float is the fraction of the size in the group.

Normally, multiple N data sets are used for making a group. For example if there are three groups and five sediment sizes, there should be 15 *N* data sets.

The different sediment groups are distributed in the geometry by using the *B* data sets.

Αρχείο control (συνέχεια)

4.3.8 The *B* data set (SSIIM 1 only)

The B data set distributes different sediment groups to different locations of the geometry. The groups are made using the N data set.

Five integers are read. The first integer is an index for the group number, similar to the first integer on the N data set. The second and third integer are indexes for the cell numbers in the streamwise direction. The fourth and fifth integer are indexes for the cell numbers in the lateral direction.

Example: *B 0 2 6 2 9*

Sediment group no. 0 is placed in the cells from i=2 to i=6 and j=2 to j=9, where i is an integer for the streamwise cell number and j is an integer for the cell numbering in the lateral direction.

If only one group is used, it is possible to give *B 0 0 0 0 0*, which indicates that this group is distributed in all the cells.

4.3.9 The P data sets

P 2 Five floating points that give scaling for the graphical presentation. The first three gives scales in streamwise, cross-streamwise and vertical direction. The fourth and fifth give movements in left-right and vertical direction. Defaults: 1.0 for the scales, and 0.0 for the movements.

P 3 Four integers that give initial location of the graphical plots in streamwise, cross-streamwise and vertical direction, and sediment fraction number.

P 4 A character that indicates initial type of plot. "g" gives the grid, "v" gives velocity lines, "V" gives velocity vectors, "c" gives concentration.

P 6 Minimum and maximum values for blue and red colours in the OpenGL graphics. Two floats are read.

P 10 Integer for the number of global iterations between printing results for time-dependent computations. In SSIIM 2, the *result* and *bedres* files are printed, with an increasing number extension. These files can be renamed to have no extension, and read by *Tec-plot* to show the results at a specific time.

Αρχείο control (συνέχεια)

P 11 **SSIIM 2 only**. Extra print-out to the *boogie* file for each time step. An integer is read. Depending on the integer, different information is printed.

1: Total amount of water quality constituent 1 for the whole grid
2: Average value of water quality constituent 1 in the surface cells
4: Total number of grid cells, surfaces and points.

Default *P 11 0* (no extra print-out)

P 14 A float is read, which gives a time interval for when a graphic file is automatically saved in the profile and contour plot. The graphic window have to be open and the timer has to be running. This only works for time-dependent calculations. The time interval is given in seconds.

4.3.10 The Q data sets

There are two types of Q data sets. One is the Q 0 data set, which gives the name of the variable. The other type specifies the variables and constants in the source terms in the convection-diffusion equations.

Q 0 An integer is first read, corresponding to the equation number. Then a text string of up to 15 character is given. The text is the name of the variable in the equation.

Αρχείο control (συνέχεια)

Q (1-..) All other Q data sets have the following in common:

The first integer specifies which source term is used. If the integer is below 1000 or above 3000, the source term is applied for all the cells. If the integer is above 1000, but below 2000, the source term is only applied to the cells closest to the water surface. These terms can typically be used for specification of fluxes across the water surface. If the integer is above 2000 but under 3000, the source term only applies to the cells closest to the bed.

The second integer after the Q is an index equal to the number of the equation the source term is applied to.

In the following, note that this is not repeated, and the two fist integers are not described further.

Q 1 The second number is a float, giving the value of a constant source.

Αρχείο control (συνέχεια)

Q 3 The second number is an integer. This is an index for the first variable in the source term. The third number is an integer, giving the second variable in the source term. The fourth number is a float, which is multiplied with both variables.

Example: *Q 3 1 2 1 0.04*

This means that a source term for equation 1 is used, and the source term is 0.04 multiplied with the value of variable 2, multiplied with the value of variable 1 (the same variable as calculated for this source term).

Q 11 Fall velocity data set. This is a special data set to include the effect of the fall velocity of a water quality constituent, for example sediments or algae. A constant fall velocity is given. Note that calculating algae with variable fall velocity as a function of light irradiance, for example the Q 151 / Q 221 data sets can be used instead.

The second parameter is a float, which is the fall velocity in meters/second. A positive number denotes a rise velocity, while a negative number denotes a fall velocity in downwards direction.

Example: *Q 11 2 -0.0001*

Variable no. 2 has a fall velocity of 0.1 mm/second.

Αρχείο control (συνέχεια)

Q 42 **SSIIM 2 only.** Special data set to calculate algae growth where there is only one species of algae, and this is only growth-limited by light. Four floats are read. The first two floats are constants in the regression formula for the vertical attenuation coefficient as a function of the algae concentration. The last two floats are the coefficients c0 and c1 in the formula for algae growth.

Q 51 **SSIIM 2 only.** Special data set for fall velocity for dinoflagellates as a function of irradiance. Five floats are read after the control integer. The two first are coefficients in the formula for the light attenuation coefficients. The third is the optimum irradiance. The fourth is the maximum fall/rise velocity in m/s. The fifth is the difference between optimum and actual irradiance when the fall/rise velocity is maximum.

Example: *Q 51 1 0.45 4.8 100.0 0.01 100.0*

The algae concentration is in variable number 1.

Q 113 **SSIIM 2 only.** Special data set to calculate light history, if more than one algae species or sediment variable contribute to the light shading:

integer 1: pointer to irradiance variable
float 1: averaging time period in seconds

Αρχείο control (συνέχεια)

Q 121 **SSIIM 2 only.** Special data set to calculate predatation. This data set must be used for both the phytoplankton and the zooplankton.If phytoplankton is calculated, the grazing rate is negative. If zooplankton is calculated, the grazing rate is positive.Note that if zooplankton is calculated, the coefficient also includes the grazing efficiency and possible conversion between phytoplankton and zooplankton units.

Example: *Q 121 2 4 -0.01 1.067*

Algae is calculated as variable no. 2, zooplankton as variable no. 4. The grazing rate is 0.01 and the temperature coefficient is 1.067.

Q 122 **SSIIM 2 only.** Special data set for reduction of patogens from light. One integer and two floats are read. The second integer is a pointer to the irradiance variable. The first float is the proportionality constant for decrease of patogens. The second float is a temperature constant.

Example: *Q 122 1 3 -0.001 1.067*

Pathogens are calculated as variable no. 1 and irradiance as variable no. 3. The proportionality constant is -0.001 and the temperature coefficient is 1.067.

Αρχείο control (συνέχεια)

Q 123 **SSIIM 2 only.** Special data set for sorption, containing one integer and two floats. The integer is an index to the sediment variable. The first float is the absorption coefficient. The second float is the fall velocity of the sediment.

Example: *Q 123 2 4 0.1 0.005*

Variable no. 2 is adsorped to variable no. 4, with the adsorption coefficient 0.1. The fall velocity of variable 4 is 5 mm/second.

Q 131 **SSIIM 2 only.** Special data set for calculation of algae fall velocity from density variable

integer1: pointer to algae density
float 1: algae diameter in meters, from Q 221
float 2: form resistance (around 1.0-1.15), from Q 221
float 3: temperature in degree Centergrade

Αρχείο control (συνέχεια)

Q 132 SSIIM 2 only. Special data set for calculation of light history from one species of algae. The light history is calculated by a formula and fixed.

integer 1: pointer to algae concentration
float 1: a - regression constant in formula for specific vertical attenuation coefficient, as Q 42
float 2: b - regression constant in formula for specific vertical attenuation coefficient, as Q 42
float 3: averaging period in seconds, for example: 86400.0 for 24 hours

Q 133 SSIIM 2 only. Special data set for calculation of light history from one species of algae. The light history is calculated as a passive contaminant.

integer 1: pointer to algae concentration
float 1: a - regression constant in formula for specific vertical attenuation coefficient, as Q 42
float 2: b - regression constant in formula for specific vertical attenuation coefficient, as Q 42
float 3: averaging period in seconds, for example: 86400.0 for 24 hours

Q 151 **SSIIM 2 only.** This is a special data set to calculate the density of algae in a lake. The second number is an integer, which is an index for the variable number which is the algae concentration. The algae concentration is used when calculating the light transmission. After the second integer, five floats are read. The first float is the light transmissivity. The second, third and fourth float are coefficients c1,c2 and c3 in the formula for algae density. The fifth float is the half-saturation irradiance for maximum rate of density increase. This is also used in the density formula.

Note that the convection-diffusion equation is not solved for the algae density, but from a user point of view, this variable is similar to other variables.

Example: *Q 151 1 2 1.0 2.0 3.0 4.0 5.0*

Algal density is in variable no. 1, and algae concentration is in variable no. 2. The light transmissivity is 1.0, and the coefficients in the density equations are: $c1$ = 2.0, $c2$ = 3.0, $c3$ = 4.0. The half-saturation irradiance coefficient is 5.0. Note that these numbers are arbitrarily chosen, and may be unphysical.

Also note that if a Q 151 data set is present in the control file, and the timei file is read for time-dependent calculations, an extra float is read as the last number of each line. The float is the irradiance.

Q 161 **SSIIM 2 only.** Special data set to calculate algal density for cyanobacteria. The second number is an integer, which is an index for the variable number which is the algae concentration. The algae concentration is used when calculating the light transmission. After the second integer, five floats are read. The first float is the light transmissivity. The second, third and fourth float are coefficients c1,c2 and c3 in the formula for algae density. The fifth float is the half-saturation irradiance for maximum rate of density increase. This is also used in the density formula.

Note that the convection-diffusion equation is not solved for the algae density, but from a user point of view, this variable is similar to other variables.

Example: *Q 161 1 2 0.67 0.087 2.0 3.0 4.0 5.0*

Algal density is in variable no. 1, and algae concentration is in variable no. 2. The coefficients in the equation for light transmissivity are 0.67 and 0.087, and the coefficients in the density equations are: $c1 = 2.0$, $c2 = 3.0$, $c3 = 4.0$. The half-saturation irradiance coefficient is 5.0. Note that these numbers are arbitrarily chosen, and may be unphysical.

Also note that if a *Q 161* data set is present in the control file, and the *timei* file is read for time-dependent calculations, an extra float is read as the last number of each line. The float is the irradiance.

Αρχείο control (συνέχεια)

Q 221 SSIIM 2 only. This a special data set that calculates the fall velocity of algae in a lake. The second and third number are integers. The second number points to the variable number of the algae density. The third integer points to the variable number of the temperature. Then two floats follow. The first float is the algae diameter in metres. The second float is a form resistance coefficient, usually around 1.0.

Example: Q 221 2 1 0 0.00001 1.0

The algae concentration is variable no. 2, the algae density is variable no. 1, and the temperature is variable no. 0. The algae diameter is 0.00001 meters and the form resistance coefficient is 1.0.

Q 252 SSIIM 2 only. Special data set to calculate algae growth in case of only one nutrient + irradiance limiting the growth:

integer 1: pointer to light irradiance variable
integer 2: pointer to nutrient variable
float 1: c0 - formula for growth rate, k, irradiance.
float 2: c1 - formula for growth rate, k, irradiance.
float 3: kmax - maximum growth rate
float 4: Ks constant for nutrient
float 5: temperature coefficient

Αρχείο control (συνέχεια)

Q 261 SSIIM 2 only. Special data set for nutrient depletion from algae growth, for multiple algae species limiting the light, and one nutrient. Three integers and seven floats are read:

integer 1: integer pointing to light variable
integer 2: integer pointing to algae variable
float 1: c0 - formula for growth rate, k, irradiance.
float 2: c1 - formula for growth rate, k, irradiance.
float 3: kmax - maximum growth rate
float 4: Ks constant for the nutrient being calculated
float 5: temperature coefficient
float 6: fraction of nutrient in algae growth

Q 281 SSIIM 2 only. Special data set for algae growth, with phosphorus, nitrogen and light as the limiting variables:

integer 1: integer pointing to phosphorous variable
integer 2: integer pointing to nitrogen variable
float 1: a - regression constant in formula for specific vertical attenuation coefficient
float 2: b - regression constant in formula for specific vertical attenuation coefficient
float 3: c0 - formula for growth rate, k, irradiance.
float 4: c1 - formula for growth rate, k, irradiance.
float 5: kmax - maximum growth rate
float 6: Ks constant for phosphorous
float 7: Ks constant for nitrogen
float 8: temperature coefficient, Kt

Αρχείο control (συνέχεια)

Q 282 **SSIIM 2 only.** Special data set for calculation of algae density from one species of algae:

integer 1: pointer to algae concentration
integer 2: pointer to light history
float 1: a - regression constant in formula for specific vertical attenuation coefficient, as Q 42
float 2: b - regression constant in formula for specific vertical attenuation coefficient, as Q 42
float 3: c1 - formula 5, SCUM, as Q 151
float 4: c2 - formula 5, SCUM, as Q 151
float 5: c3 - formula 5, SCUM, as Q 151
float 6: Ki - half-saturation irradiance, formula 5, SCUM, as Q 151
float 7: minimum algae density
float 8: maximum algae density

Αρχείο control (συνέχεια)

Q 291 **SSIIM 2 only.** Special data set for nutrient depletion from algae growth, for two nutrients and one algae shading the light. Two integers and nine floats are read:

integer 1: integer pointing to algae variable
integer 2: integer pointing to the other nutrient variable

float 1: a - regression constant in formula for specific vertical attenuation coefficient
float 2: b - regression constant in formula for specific vertical attenuation coefficient
float 3: c0 - formula for growth rate, k, irradiance.
float 4: c1 - formula for growth rate, k, irradiance.
float 5: kmax - maximum growth rate
float 6: Ks constant for the nutrient being calculated
float 7: Ks constant for the other nutrient
float 8: temperature coefficient
float 9: fraction of nutrient in algae growth

The data set is used for both nitrogen and phosphorous. It is similar to Q 281, but the last float is the fraction of the algae growth.

Αρχείο control (συνέχεια)

Q 361 **SSIIM 2 only.** Special data set to calculate algae growth in case of two nutrients+light limiting the growth:

integer 1: pointer to light irradiance variable
integer 2: pointer to phosphorous variable
integer 3: pointer to nitrogen variable
float 1: c0 - formula for growth rate, k, irradiance.
float 2: c1 - formula for growth rate, k, irradiance.
float 3: kmax - maximum growth rate
float 4: Ks constant for phosphorous
float 5: Ks constant for nitrogen
float 6: temperature coefficient

Αρχείο control (συνέχεια)

Q 371 **SSIIM 2 only.** Special data set for nutrient depletion from algae growth, for multiple algae species limiting the light, and two nutrients. Three integers and seven floats are read:

integer 1: integer pointing to light variable
integer 2: integer pointing to algae variable
integer 3: integer pointing to the other nutrient variable
float 1: c0 - formula for growth rate, k, irradiance.
float 2: c1 - formula for growth rate, k, irradiance.
float 3: kmax - maximum growth rate
float 4: Ks constant for the nutrient being calculated
float 5: Ks constant for the other nutrient
float 6: temperature coefficient
float 7: fraction of nutrient in algae growth
The data set is similar to Q 291, except for the extra integer pointing to the light irradiance, and the omission of the attenuation coefficients.

Q 1001 The second number is a float, giving the value of a constant source.

Αρχείο control (συνέχεια)

Q 1002 The second and third numbers are floats. The source term is:

*Source = float1 * (float2 - variable)*

Example: *Q 2 1 0.0005 20.0*

Source1 = 0.0005 * (20.0 - *variable1*)

This term can be used for calculation of temperature fluxes across the water surface, where the first float is the heat exchange coefficient for the water surface and the second float is the air temperature.

Αρχείο control (συνέχεια)

Q 1003 The second number is an integer. This is an index for the first variable in the source term. The third number is an integer, giving the second variable in the source term. The fourth number is a float, which is multiplied with both variables.

Example: *Q 3100 1 2 1 0.04*

This means that a source term for equation 1 is used, and the source term is 0.04 multiplied with the value of variable 2, multiplied with the value of variable 1 (the same variable as calculated for this source term)

Q 1012 The second number is an integer. This is an index for the variable in the source term. The third number is a float, giving a coefficient which is multiplied with the variable.

Example: *Q 1012 1 2 0.05*

This means that a source term for equation 1 is used, and the source term is 0.05 multiplied with the value of variable 2.

Αρχείο control (συνέχεια)

Q 1060 Special data set to calculate temperature flux at the water surface. Six floats are read:

float 1: multiplication factor, *B*, for irradiance from the timei file (1.0)
float 2: a coefficient, *A*, for light attenuation (0.5-0.7)
float 3: air vapour pressure, e_{air} (mmHg)
float 4: reflection coefficient, *RL* (0.03)
float 5: water emissivity, *e* (0.97)
float 6: Bowen's coefficient, *c1* (0.47 mmHg/C)

Q 1102 Special data set to calculate gas transfer at the water surface. The data set has two floats as parameters: c_{air} and a coefficient, *r*, which is multiplied with the eddy-viscosity to give the effective diffusion. The data set is only applied to the cells bordering the water surface.

Q 2001 The second number is a float, giving the value of a constant source.

Αρχείο control (συνέχεια)

Q 2002 The second number is an integer. This is an index for the variable in the source term. The third number is a float, giving a coefficient which is multiplied with the variable.

Q 2003 The second number is an integer. This is an index for the first variable in the source term. The third number is an integer, giving the second variable in the source term. The fourth number is a float, which is multiplied with both variables.

Q 2030 Special data set to calculate resuspension, where three floats are read. The first float is the critical shear stress for initiation of resuspension. The second integer is the coefficient a in the resuspension equation, being proportional to the shear stress surplus raised to the third coefficient. The critical shear stress is given in Pascal.

Example: *Q 2030 3 0.3 0.1 1.5*

The resuspension is calculated for variable no. 3, and the critical shear stress is 0.3 Pa.

Αρχείο control (συνέχεια)

Q 6100 **SSIIM 2 only.** Special data set for calculating irradiance when there are more than one algae species or sediment concentration. The data set reads six integers and ten floats. The first integer is the number of algae species. The following integers are indexes for the variable numbers of the algae. Then ten floats are read, which are pairs of coefficients for the light attenuation curve.

Example: *Q 6100 9 2 5 6 0 0 0 0.07 0.2 0.06 0.23 0.0 0.0 0.0 0.0 0.0 0.0*

Here, variable no. 9 is the light irradiance. Two species of algae is used: variable no. 5 and no. 6. The light transmissivity coefficients are 0.07 and 0.2 for the first algae species and 0.06 and 0.23 for the second algae species.

Note that the component reducing the light does not have to be an algae. It is also possible to specify for example an inorganic sediment.

Αρχείο control (συνέχεια)

4.3.11 The S data set

The S data sets gives the size and fall velocity of the sediments. An integer is first read, indicating the size group. Then the diameter in meters are given and then the fall velocity in m/s.

Example: *S 1 0.001 0.06*

Sediment size 1 has a diameter of 1 mm, and a fall velocity of 6 cm/s.

4.3.12 The T data set

T   Title field. The following 30 characters are used in the graphics.

4.3.13 The W data sets

W 1 Stricklers number, discharge and downstream water level. This data set must be present in the file. The parameters given here are used to generate the water level for the calculations using a standard backwater calculation.

Default values for SSIIM 2: *W 1 50.0 1.0 1.0*

Note that the Strickler value M is $1.0/n$, where n is the Manning's number.

W 2 Integers identifying which cross-sections are used in the initial backwater water surface computation. First, an integer is read, giving the number of cross-sections. Then, the number of each cross-section is given.

For example, if the grid has 20 cross-sections, and three sections are used: the first (number 1), the last (number 20) and one in the middle (number 10), the following data set is given:

W 2 3 1 10 20

The water elevation for the other cross-sections in between will be linearly interpolated.

W 4 **SSIIM 1 only.** Specification of extra walls for the multi-block water flow module. Seven integers have to be given for each wall. There can be up to 29 walls, and each wall is described on **one** *W 4* data set.

The variable names are:

W 4 dir posneg node a1 a2 b1 b2

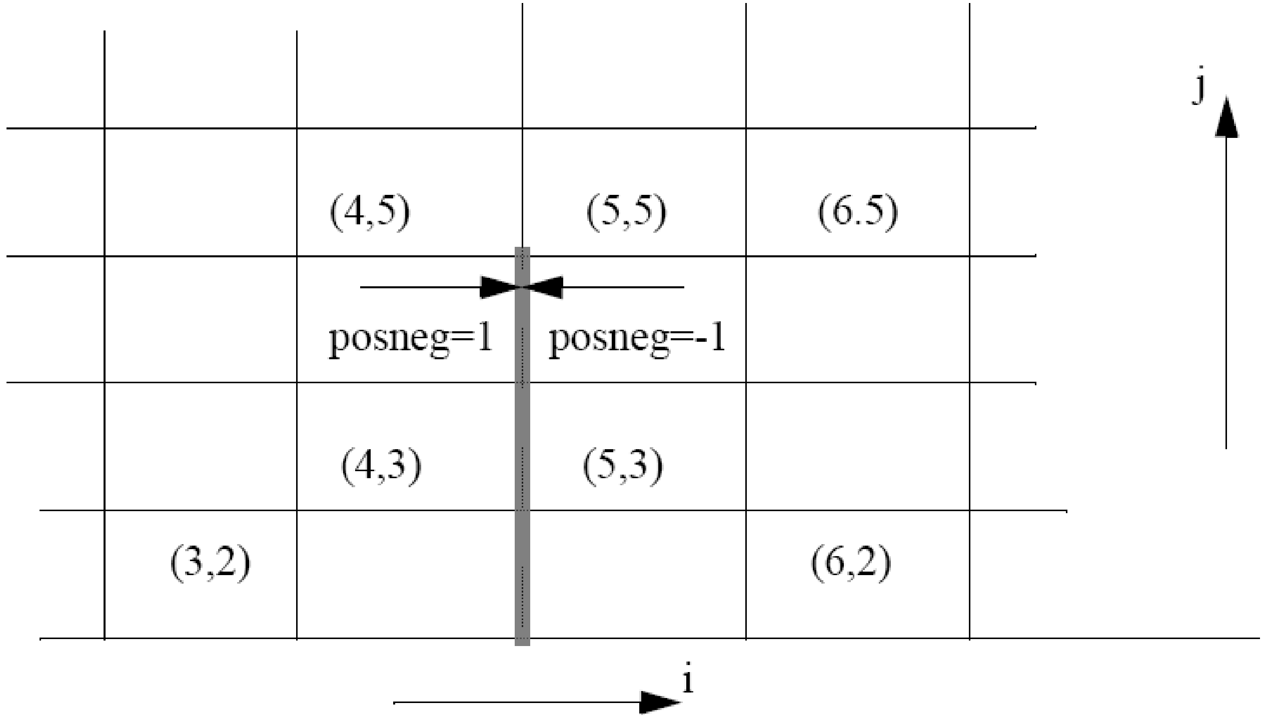
The first integer, *dir,* indicates the plane. 1 is the *j-k* plane (cross-section), 2 is the *i-k* plane (longitudinal section) and 3 is the *i-j* plane (seen from above).

The second integer, *posneg*, indicates which of the sides of the cell is calculated as a wall. Three possible options exist: 1, -1 or 0. If 0 is given, a previously set wall is deleted. If the index is 1, the wall is calculated on the wall in the direction of declining cell indexes. If -1 is given, the wall is calculated in the direction of increasing cell indexes. This is further explained in Fig. 4.

The third integer is the number of the node plane.

Αρχείο control (συνέχεια)

An example is given in Fig. 4 below. The figure shows the *i-j* plane (the grid seen from above). The wall is to be given in cells where *i*=4 (between cross-section no. 3 and 4). If the second integer, *posneg*, is 1, then wall laws are applied on cross-section no. 3, between cell 3 and cell 4, in the negative *i*-direction. If posneg = -1, then the wall laws are applied on cross-section no.4, between cell no. 4 and 5, in the positive i-direction.



Αρχείο control (συνέχεια)

The following integers are indexes a1 a2 b1 b2, which gives the two-dimensional coordinates for the corner points of the part of the plane that is described. The four variables are similar to the variables with the same name on the *G 7* data set.

Note that if an internal wall is used, where water is flowing on both sides of the grid line, then wall laws must be declared on both sides of the wall, and two *W 4* data sets must be used.

Example: If the groyne given in Fig. 4 is to block the water from the bed to the water surface and there are four cells in the vertical direction (cell no. 2 to 5), the following data sets have to be given:

W 4 1 1 4 2 4 2 5
W 4 1 -1 5 2 4 2 5

Two W 4 data sets have to be given, one for each side of the groyne. The first is for the left side (Fig. 4), and the second is for the right side.

Αρχείο control (συνέχεια)

W 5 **SSIIM 1 only.** Different Strickler's values than the default value for cross-sections. An integer is first read, which tells how many cross-sections are read. Then an integer and a float is read for each cross-section. The integer tells which cross- section is changed, and the float tells the Strickler's value. Several *W 5* data sets can be used.

Note that the Strickler's value in the most upstream cross-section will be used on a reach between two cross-sections. The Strickler's values are the inverse of the Mannings n values: $M=1/n$.

W 6 NoMovePoint - a point which is used in the Grid Editor. Two integers are read, which is the numbers of the i and j grid lines. The intersection of these lines are not moved by the elliptic grid generator. One *W 6* data set is required for each NoMovePoint. Maximum 1999 points can be used. The *W 6* data set is usually generated by the *Grid Editor.*

Αρχείο control (συνέχεια)

W 7 Attraction point used in the *Grid Editor*. Each *W 7* data set represents attraction to one grid line or point. Maximum 1999 attraction points can be used. An integer is read first which tells the type of attraction. The following options are given:

0: Point attraction in i-direction
1: Point attraction in j-direction
2: Line attraction in i-direction
3: Line attraction in j-direction

Then two integers are read, that tell which grid line intersection the attraction is towards. For the line attraction, only one of the integers are used. Then the two attraction parameters are read, which are floats.

The *W 7* data set is normally generated by the *Grid Editor*.

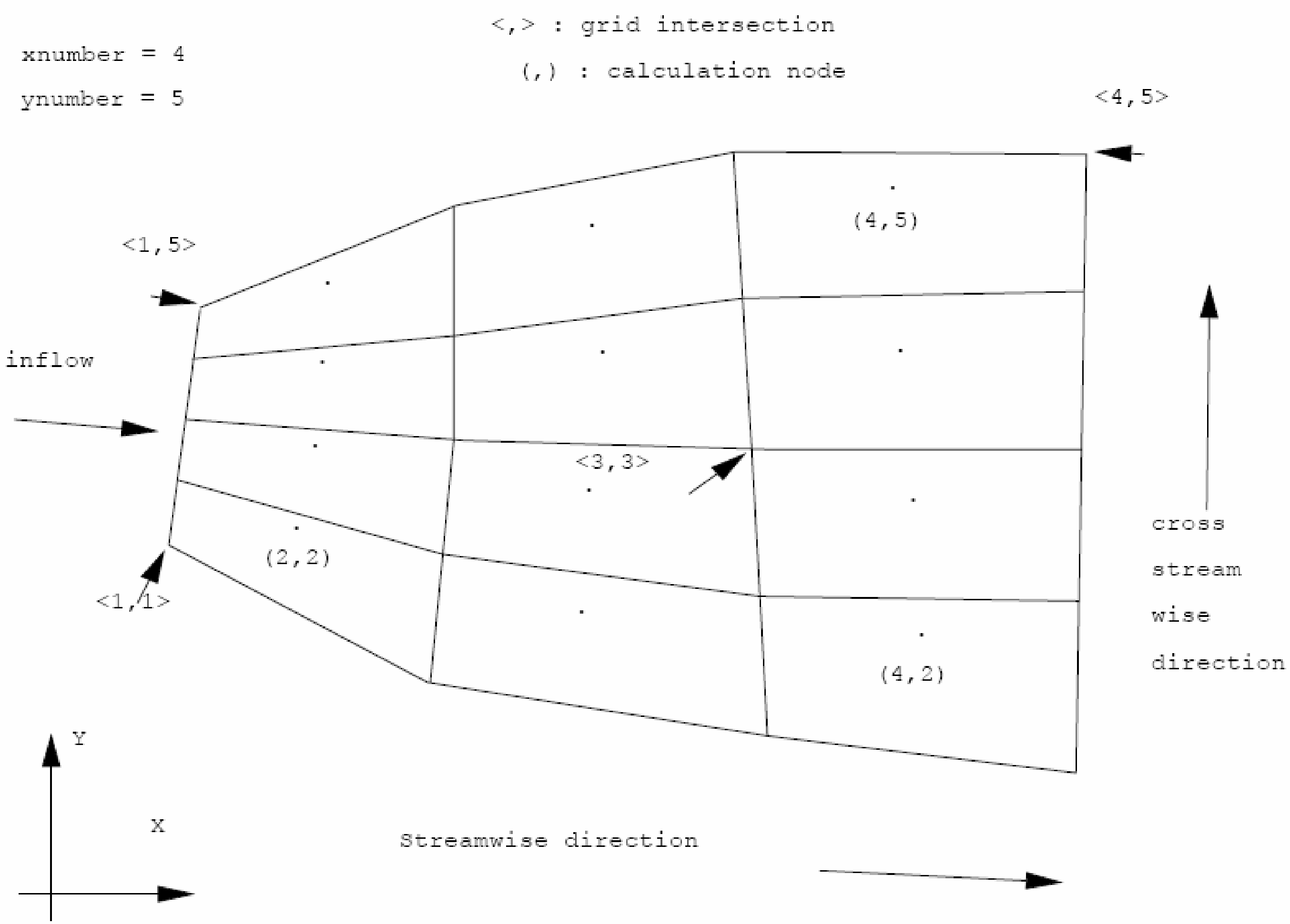
Αρχείο control (συνέχεια)

this is the control file for the simulation of a fish tank with
8 sides. the inflow is on the side, and it is 10 liters/second. the
outlet is in the bottom of the tank. with the following parameters,
the program converged after 691 iterations.

```
T Oppdrettskar            title field
F 2 W                                                run-choise
F 7 V            lkjh
F 16 0.0001
G 1 29 29 13 1    number of nodes in x,y and z direction+sed.size
G 3 0 3 7 12 20 30 40 50 60 70 80 90 100                        distribution of vertical grids
g 3 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100  distribution of vertical grids
g 4 1 6 6 10.0           point source
G 7 0 1 15 15 2 13 2 0 0.05 0.707 0.707 0.0 inflow in side
G 7 1 3 15 16 15 16 0 0 0.05 0.0 0.0 1.0 outflow in bottom
G 8 2 29 2 29 2 13 0.01 0.0 0.0
P 2 1.0 1.0 1.0 0.2  0.25    graphics scaling parameters
P 3 15 15 6 1                         graphics nodes, cross-sections and part size no.
P 4 g
I 1 0.0            inflowing sediments in kg/s
S 1 0.07  3.5                         sediment fraction nr, size, fallvelo,
N 0 1 1.0                           sediment sample
B 0 0 0 0 0                                         bed koordinates, composed of sediment
                                                     fraction, part of bed covered with this
W 1 80 0.001 1.5                      mannings M, discharge and downst. w. lev.
W 2 13 1 2 3 4 5 7 9 11 13 15 17 19 21              initialization cross-section numbers
W 4 1 1 2 2 14 2 13
W 4 1 1 2 16 29 2 13
W 4 1 -1 29 2 29 2 13
W 4 3 0 2 15 16 15 16
K 1 1000 2000                                                  number of iterations for flow procedure
k 3 0.05 0.05 0.05 0.01 0.02 0.02                  relaxation coefficients
K 5 1 1 1 1 1 1
k 10 N
```

Αρχείο koordina

The koordina file describes the bed of the geometry with a structured grid (SSIIM 1). An example is show in the figure below. The grid can be made using a map, a spreadsheet or the *GridEditor*.



Αρχείο koordina (συνέχεια)

The necessary input data is the x,y and z coordinates of the points where the grid lines meet. The format of the data is given below.

i j x y z

An example:

1 1 0.34 0.54 0.11
1 2 0.35 0.66 0.12
...

The first two numbers are integers, while the following three are floats. The numbers are read in a free format, which means that the distance between them does not matter. The sequence of the points are not important, as long as all points are included. This is not controlled by the model, so the user must do this by looking at the grid in the graphic modules of the program.

If a tunnel is simulated, or the user wants to specify the water surface, an additional floating point number is read for each line. This gives the top level for each grid intersection. An example:

Αρχείο koordina (συνέχεια)

1 1 0.34 0.54 0.11 1.21
1 2 0.35 0.66 0.12 1.33
...
To make SSIIM read the last float, the *K 2* data set in the *control* file must be: *K 2 0 0* (SSIIM 1)

Some words about indexing and numbering of grid lines and cells. The variable names for the number of grid lines in the three directions are:

xnumber : number of cross-sections
ynumber : number of longitudinal lines
znumber : number of horizontal planes

The numbering of the grid lines goes from 1 to xnumber in the streamwise direction, and similarly for the other two directions.

However, the grid lines define cells between the grid lines. The variables are calculated in the center of each cell. This means that a numbering system for the cells is also required. The word node is often used for the center of a cell.

Αρχείο koordina (συνέχεια)

From a geometrical view of the grid, it is observed that the number of lines always exceeds the number of cells by one in each direction. When the arrays are defined, it is therefore a choice for the programmer to start the numbering of the cells on one or two. The choice that is made in this program is that the numbering starts on two. This means that the cell that is defined by grid lines i=1 and i=2 and j=1 and j=2 has the number (2,2). Cell number (1,1) does not exist. The numbering of the cells is also shown in Fig. 1. The numbering of the grid lines is shown with the <,> sign, while the numbering of the calculation nodes is shown with the (,) sign. The grid is non-staggered.

The data on the *koordina* file defines a surface. It is possible to make a file with exactly the same format and call it *koomin*. This surface is then used as a minimum elevation surface for bed changes. The bed will not be lowered under this surface.

If SSIIM terminates right after startup and the *boogie* file contains the following message: *Error, negative areas for cell i=13, j=2*, or some other combinations of i and j, then there is an error in the *koordina* file. The indexes denote the cell number, so for i=13, j=2, the x and y coordinates for the following grid line intersections should be checked: (13,2); (13,1); (12,2) and (12,1).

4.10 The result file

This file contains the results from the water flow calculations. The file is written when the prescribed number of iterations have been calculated or when the solution has converged. The results are velocities in three dimensions, k, ε, pressure, and the fluxes on all the walls of the cells. The data from this file is used as input for the sediment flow calculations. This file can also be read when the user wants to start the water flow calculations from where the result file was last written (hot start).

Αρχείο result (συνέχεια)

An example of a *result* file:

Results from SSIIM - flow, iter = 12910
Residuals: 0.000732 0.000588 0.000002 0.000003 0.001000 0.000000
Roughness : 0.050000
C 54 9 11
i j k u v w k e f1 f2 f3 p
D 1 1 1 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
0.00000000e+00 0.00000000e+00 0.00000000e+00
D 1 1 2 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
0.00000000e+00 0.00000000e+00 0.00000000e+00
D 1 1 3 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
0.00000000e+00 0.00000000e+00 0.00000000e+00
.....

D 2 4 7 6.31143968e-01 2.02894592e-01 -6.80367016e-05 6.47305125e-03 3.85539263e-04 3.47858729e+03
-5.19507052e+02 1.39776552e+03 1.91355310e+02
D 2 4 8 6.38189711e-01 2.05198514e-01 -2.09522025e-04 6.40727451e-03 3.13804122e-04 3.54203761e+03
-5.25291012e+02 1.09548199e+03 1.91350056e+02
D 2 4 9 6.42687814e-01 2.06670571e-01 -3.70305526e-04 6.37079494e-03 2.71714390e-04 3.58421958e+03
-5.28978103e+02 7.51732364e+02 1.91343817e+02

The first lines give the residuals, the roughness and the grid size. Then each line gives the nine values for one cell. The letter *D* starts the line, then the three indexes for the cell. Then the three velocities, the k and ε values. Then the fluxes in the three directions and finally the pressure. All the parameters are placed on one line in the file, although this is not shown above because the line was too long.