Corrections to CFL3D V5.0 User's Manual (Edition 2)

(Some of these may already be corrected in your hardcopy, depending on when you got it. They are listed in chronological order of their discovery, from oldest to most recent. All these changes have already been made in the files currently downloadable from the WEBsite.)

1. p. 100 eqn. 6-36 should have 2π in paren ... $\sin(2\pi k_r t)$

2. p. 301 extra $\frac{1}{\rho}$ in last term of eqn. H-192

3. p. 20 at end of sref description, add: (You must also account for the grid-distance between 2-D planes when i2d=1.)

4. p. 66 at end, add: For 2-D grids (i2d=1), idim must be 2 (i.e., the grid must be described by 2 repeated planes). We recommend making the grid-distance between the planes = 1, although any distance is okay provided that it is accounted for in the sref term in the input file.

5. p. 281 - eqn. H-52: delete f_{v3}

   - eqn. H-53: no longer used

   - eqn. H-54: change to: $f_{v2} = 1 - \frac{\chi}{1 + \chi f_{v1}}$

   - change next paragraph to: CFL3D currently uses Spalart's Version Ia[34]. The f_{v3} term was employed as a smooth fix to prevent $\hat{S}$ from going negative prior to 12/97, but was removed after an error was discovered ($\hat{S}$ and f_{v2} were also different).

   - eqn. H-55: change to $c_{w1} = \frac{c_{b1}}{\kappa^2} + \frac{(1 + c_{b2})}{\sigma}$ (note typo in ref. 34)

6. p. 151 Before section 9.1, add: Note: you may see slight differences in your results, due to errors in CFL3D that have been corrected since the plots in this chapter were generated.

7. p. 270 — eqn G-25: First equation $(\vec{F}_l)_x$ should be $(\vec{F}_l)_z$

8. p. 293 — eqns H-152 and H-153: L_0^1 should be L_1^0 (3 occurrences)

9. p. 48 — Before section 3.40, add: See caution in section 3.35. It applies here as well.

10. p. 296 — After "d is the distance to the nearest wall", add: "scaled by Re/5.e6"

11. p. 296 — eqn H-169: change $v3d = \dfrac{100K_{IC}}{t_{max}}$ to $v3d = max\left[\dfrac{100K_{IC}}{t_{max}}, 0.009\right]$

12. p. 93 — Definitions of $c_q < 0$ and $c_q > 0$ are incorrect. It should read:

    $c_q < 0$ results in suction (mass flow OUT of the zone)

    $c_q > 0$ results in blowing (mass flow INTO the zone)

13. p. 284 — Γ_1 should have ω in denominator, not Ω (H-82)

14. p. 186 — Change $\tilde{a}*$ to $\tilde{u}*$ in eqn (9-7) (to be strictly correct, but because the reference point is the sonic point, it just so happens in this case that $\tilde{u}* = \tilde{a}*$).

15. p. 40 — In description of "movie" parameter, add: Meant for use with time-accurate runs only (dt > 0 and number of total time steps dictated by ntstep).

16. p. 54 — Change sentence at top of page to read (for better clarity): Note that meters could be substituted for feet, kg for slugs, etc., in the above definitions, as long as it is done consistently.

17. p. 75 ff — In the example for "Control Surface 1" the mass flow nondimensionalization should read: Mass flow / (rhoinf*vinf*(L_R)**2).

At the bottom of page 75, then continuing to the top of the following page, add:

***NOTE: the following definitions are used in the output (∞ represents the reference values - see note on p. 3):

mass flow rate through specified area: $\dot{m} = \dfrac{\tilde{\dot{m}}}{\tilde{\rho}_\infty |\tilde{\mathbf{V}}|_\infty \tilde{L}_R^2}$ ($\tilde{\dot{m}}$ in slug/s or kg/s, etc.)

distance to 1st gridpoint above wall: $yplus = \tilde{n}\sqrt{\tilde{\tau}_w/\tilde{\rho}}(\tilde{\rho}/\tilde{\mu})$ ref. White[45], sect 6-4.2

pressure coefficient: $c_p = \dfrac{2(\tilde{p}_w - \tilde{p}_\infty)}{\tilde{\rho}_\infty |\tilde{\mathbf{V}}|_\infty^2}$ ref. White, eq. 1-3

skin friction coefficient: $c_f = \dfrac{2\tilde{\tau}_w}{\tilde{\rho}_\infty |\tilde{\mathbf{V}}|_\infty^2} = \dfrac{2\tilde{\mu}_w(\partial|\tilde{\mathbf{V}}|/\partial\tilde{n})_w}{\tilde{\rho}_\infty |\tilde{\mathbf{V}}|_\infty^2}$ ref. White, eq. 3-181

heat transfer coefficient: $c_h = \dfrac{\tilde{k}(\partial\tilde{T}/\partial\tilde{n})_w}{\tilde{\rho}_\infty |\tilde{\mathbf{V}}|_\infty \tilde{C}_p(\tilde{T}_w - \tilde{T}_{t,\infty})}$ ref. White, eq. 7-138

c_h + indicates heat flux *toward* wall

Currently, c_f is given as positive when u (the x-component of velocity) at the first cell center above the wall is positive; c_f is negative when u is negative. In the definition of c_h, the Prandtl number $Pr \equiv \tilde{\mu}\tilde{C}_p/\tilde{k}$ is taken to be constant = 0.72. (Also note that in the definition of c_h a reference total temperature $\tilde{T}_{t,\infty}$ is used in CFL3D rather than a local wall total temperature $\tilde{T}_{t,w}$ as defined in White[45].)

18. p. 249 In eqn C-43, the minus signs (-) in the 2nd, 3rd, and 4th terms of the 5-term vector should each be plus (+).

19. p. 303 In the last bullet item on the page (concerning limiter of 100,000), change “In all models” to “In all two-equation models”.

20. p. 302 After: Each sweep requires the solution of a scalar tridiagonal matrix.

Add: (Note: for time-accurate computations, 1st order t-TS subits are used on the turb eqns, so an additional RHS term $k^n - k^m$ is added to the first sweep - see Appendix B for a description of the t-TS method.)

21. p. 37, 38, 39, 41, 42, 43, 46, 49 After each of the titles 3.24, 3.27, 3.28, 3.30, 3.31, 3.33, 3.37, 3.41, add the parenthetical phrase: (extra comment line needed prior).

22. p. 284 Change (in (H-82)): $F_2 = \tanh\Pi$ to: $F_2 = \tanh(\Pi^2)$

23. p. 288 Add $0.2 \times 10^{-8}(\eta^6 + \zeta^6)$ to numerator in (H-116), so that it reads:

$$C_\mu' = \frac{3(1+\eta^2) + 0.2 \times 10^{-8}(\eta^6 + \zeta^6)}{3 + \eta^2 + 6\zeta^2\eta^2 + 6\zeta^2 + \eta^6 + \zeta^6}\alpha_1$$

24. p. 26 At the end of Note (1) of Section 3.7, add: "Note that if an overlapped (Chimera) grid is used and there is grid overlap ON solid surfaces, then forces are double-counted at the overlap. If possible, use segment < 0 (see note (2)) to remedy this."

25. p. 116 After the last paragraph, add: "Note that if an overlapped (Chimera) grid is used and there is grid overlap ON solid surfaces, then forces are double-counted at the overlap. If possible, make appropriate use of segment < 0 (see note (2) of Section 3.7) to remedy this."

26. p. 26-27 For ivisc=8, change "eddy-viscosity formulation" to "linear formulation"

For ivisc=9, change "eddy-viscosity formulation" to "linear formulation"

(Special note to users: Some of the turbulence models are different between V5 and V6 - see V6 web page for details. <- This note does NOT appear in the V5 manual!)

27. p. 76 (12/20/01): Change to earlier change #17: change:

$yplus = \tilde{n}\sqrt{\tilde{\tau}_w/\tilde{\rho}}(\tilde{\rho}/\tilde{\mu})$ ref. White[45], sect 6-4.2 to:

$y^+ = \tilde{n}\sqrt{\tilde{\tau}_w/\tilde{\rho}_w}(\tilde{\rho}_w/\tilde{\mu}_w)$ ref. White[45], eq. 7-123

28. p. 301-302 (7/29/02) (many changes):

In equations (H-194), change both n 's to m 's.

Change eq (H-195) and its preamble to:

Then, t-TS subiterations are used (see Appendix B). (If no subiterations, then $m = n$.)

$$\frac{(1+\phi)(k^{(m+1)}-k^{(n)})-\phi(k^{(n)}-k^{(n-1)})}{\Delta t} = \mathrm{RHS_k}$$

Delete reference to eq (H-196) (there is nothing there).

Prior to new eq (H-196) (old eq (H-197)), change preamble to read:

$\phi = 0$ for 1st order in time (also used for non-time-accurate runs), $\phi = 1/2$ for 2nd order in time. Linearize the right-hand-side terms that are taken at time level $(m+1)$:

In new eqs (H-196) - (H-198) (old eqs (H-197) - (H-199)), change all superscript n's to m's.

Change new eq (H-199) (old eq (H-200)) to 2 new equations, labeled (H-199) and (H-200), respectively:

$$\frac{1}{(1+\phi)^2}\left[(1+\phi)\mathrm{I}+\Delta t U\delta_\xi{}^{upwind}+\Delta t\left(\frac{Re}{M_\infty}\right)\beta'\omega-\Delta t\left(\frac{M_\infty}{Re}\right)\frac{1}{\rho}\frac{\partial}{\partial\xi}(\chi_\xi\delta_\xi)\right]$$
$$\left[(1+\phi)\mathrm{I}+\Delta t V\delta_\eta{}^{upwind}-\Delta t\left(\frac{M_\infty}{Re}\right)\frac{1}{\rho}\frac{\partial}{\partial\eta}(\chi_\eta\delta_\eta)\right]$$
$$\left[(1+\phi)\mathrm{I}+\Delta t W\delta_\zeta{}^{upwind}-\Delta t\left(\frac{M_\infty}{Re}\right)\frac{1}{\rho}\frac{\partial}{\partial\zeta}(\chi_\zeta\delta_\zeta)\right]\Delta\mathrm{k} = R$$

$$R = \Delta t\mathrm{RHS_k}+\phi\Delta k^{(n-1)}-(1+\phi)(k^{(m)}-k^{(n)})$$

Change eq (H-201) to:

$$\left[(1+\phi)\mathrm{I}+\Delta t U\delta_\xi{}^{upwind}+\Delta t\left(\frac{Re}{M_\infty}\right)\beta'\omega-\Delta t\left(\frac{M_\infty}{Re}\right)\frac{1}{\rho}\frac{\partial}{\partial\xi}(\chi_\xi\delta_\xi)\right]\Delta\mathrm{k}^* = R$$
$$\left[(1+\phi)\mathrm{I}+\Delta t V\delta_\eta{}^{upwind}-\Delta t\left(\frac{M_\infty}{Re}\right)\frac{1}{\rho}\frac{\partial}{\partial\eta}(\chi_\eta\delta_\eta)\right]\Delta\mathrm{k}^{**} = (1+\phi)\Delta\mathrm{k}^*$$
$$\left[(1+\phi)\mathrm{I}+\Delta t W\delta_\zeta{}^{upwind}-\Delta t\left(\frac{M_\infty}{Re}\right)\frac{1}{\rho}\frac{\partial}{\partial\zeta}(\chi_\zeta\delta_\zeta)\right]\Delta\mathrm{k} = (1+\phi)\Delta\mathrm{k}^{**}$$
$$\mathrm{k}^{(m+1)} = \mathrm{k}^{(m)}+\Delta\mathrm{k}$$

Change the paragraph prior to section H.9 to:

Each sweep requires the solution of a scalar tridiagonal matrix. In versions of CFL3D prior to March 2002, $\phi = 0$ always for the turbulence equations, regardless of the temporal order of accuracy of the mean flow equations.

29. p. 68-70 (7/29/02):

In the code segment, change all "write(3)"s to "read(3)"s

After:

```
       read(3) ((((q(j,k,i,l,nb),j=1,jdim-1),k=1,kdim-1),
     .                i=1,idim-1),l=1,5)
```

Add:

```
       if (irghost .ne. 0)
     .    read(3)  ((((qi0(j,k,l,m),j=1,jdim-1),k=1,kdim-1),l=1,5),m=1,4),
     .             ((((qj0(k,i,l,m),k=1,kdim-1),i=1,idim-1),l=1,5),m=1,4),
     .            ((((qk0(j,i,l,m),j=1,jdim-1),i=1,idim-1),l=1,5),m=1,4)
```

After:

```
              read(3) ((((qc0(j,k,i,l,nb),j=1,jdim-1),k=1,kdim-1),
     .                     i=1,idim-1),l=1,5)
```

Add:

```
              if (itime2read .ne. 0) then
                read(3) dt
                read(3) ((((tursav2(j,k,i,l),j=1,jdim-1),k=1,kdim-1),
     .                    i=1,idim-1),l=1,2)
              end if
```

Replace:

The binary restart file has the following format. (Note that this Version 5.0 format is different from the formats in Version 4.1 and earlier versions.)

General case information, the `q` array, and the turbulence quantities are written as follows (`nblk` is the total number of blocks)

With:

(In the following, `nblk` is the number of blocks. Also, note that in versions of CFL3D prior to 2001-2002, `irghost` and `itime2read` both always = 0, but in later versions the defaults are 1)

In table, change: **Q** values to: **q** values

Add to table:

qi0, qj0, qk0	boundary condition values
dt	time step
tursav2	turbulence quantities at previous time step

30. p. 297 (7/29/02) Just before Section H.7.2, add:

Also note that for two-equation models in the code, ε (or ω) is represented by the 1st turbulence variable (e.g., **tur10**), and k by the 2nd (e.g., **tur20**).

Then, on p. 352 (in the index), add **tur10** and **tur20** references to p. 297.

31. p. 234 (10/18/02):

Three references to Equation (B-4) on this page should be (B-5).

32. p. 135 (7/30/03):

Line type 22 in the example at the middle of the page (2nd line only) should read NCYC=200 and MGLEVG=3, rather than NCYC=200 and MGLEVG=2. Using MGLEVG=2 would also work, but this number is inconsistent with the 1st and 3rd steps of the example.

33. p. 272 (10/7/03):

After eqn (H-14), add the following clarifying statement:

Note that $\widetilde{\overline{u_i u_j}} = -\tilde{\tau}_{ij}^{T}/\tilde{\rho}$, or $-2\frac{\tilde{\mu}_T}{\tilde{\rho}}\left(\tilde{S}_{ij} - \frac{1}{3}\frac{\partial \tilde{u}_k}{\partial \tilde{x}_k}\delta_{ij}\right)$ in this case.