

Habitat Volume Model (HabVol)

Bug Report and Fix #1

Report #1. Bug fix for special case (edge of habitat) calculations

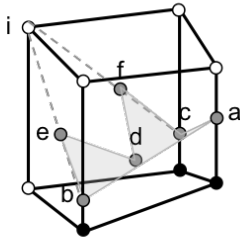
Reported by Katharine Smith (kasmith6@hawaii.edu, March 31, 2018)

Problem: in special case circumstances where suitable habitat does not exist at both the top and bottom node of one or more corners of the grid cell (see Fig. 7 of Smith et al. *in press*, Computers and Geosciences), calculations of habitat volume in that grid cell can be overestimated because the code uses the location of the node where the habitat is not defined to calculate volume (see Illustration below).

Fix: See code below from the Volume_Module.f90 with magenta-colored edits showing which lines should be changed to the text following the "*****=>" indicators.

Illustration of top face of suitable habitat region in an example where an edge has no suitable habitat.

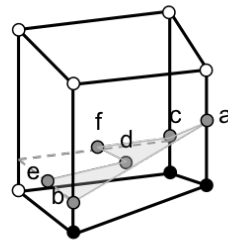
Cell has suitable habitat at three of its bottom nodes (black circles). Other nodes are unsuitable (white circles). Vertical interpolation is used to find habitat vertices a, b, and c. Vertex d is midpoint of a, b, and c.



Original version:

Vertex e is found as the midpoint between b and cell node i.

Vertex f is found as the midpoint between c and cell node i.



Updated version:

Horizontal locations of vertices e and f remain the same.

However, the z height of e is now the same as that of b, and the z height of f is now the same as that of c.

Excerpt of code from Volume_Module.f90 with fixes indicated in magenta:

```
DOUBLE PRECISION FUNCTION vol(x1,y1,z1t,z1b,x2,y2,z2t,z2b,x3,y3,z3t,z3b,      &
                             x4,y4,z4t,z4b,cx,cy,ct,cb,form)
```

```
.....
```

```
CASE(1,2,4,8)
```

```
!If a form other than 1, rotate the element nodes to match form 1
```

```
if(form == 2)then
```

```
  tmpx = xx1
```

```
  tmpy = yy1
```

```
  tmpt = zz1t
```

```
  tmpb = zz1b
```

```
  xx1 = xx2
```

```
  yy1 = yy2
```

```
  zz1t = zz2t
```

```
  zz1b = zz2b
```

```
  xx2 = xx3
```

```
  yy2 = yy3
```

```
  zz2t = zz3t
```

```
  zz2b = zz3b
```

```
  xx3 = xx4
```

```
  yy3 = yy4
```

```
  zz3t = zz4t
```

```
  zz3b = zz4b
```

```
  xx4 = tmpx
```

```
  yy4 = tmpy
```

```
  zz4t = tmpt
```

```
  zz4b = tmpb
```

```
elseif(form == 4)then
```

```
  tmpx = xx1
```

```
  tmpy = yy1
```

```
  tmpt = zz1t
```

```
  tmpb = zz1b
```

```
  xx1 = xx4
```

```
  yy1 = yy4
```

```
  zz1t = zz4t
```

```
  zz1b = zz4b
```

```
  xx4 = xx3
```

```
  yy4 = yy3
```

```
  zz4t = zz3t
```

```
  zz4b = zz3b
```

```
  xx3 = xx2
```

```
  yy3 = yy2
```

```
  zz3t = zz2t
```

```
  zz3b = zz2b
```

```
  xx2 = tmpx
```

```
  yy2 = tmpy
```

```
  zz2t = tmpt
```

```
  zz2b = tmpb
```

```
elseif(form == 8)then
```

```
  tmpx = xx1
```

```
  tmpy = yy1
```

```
  tmpt = zz1t
```

```
  tmpb = zz1b
```

```
  xx1 = xx3
```

```
  yy1 = yy3
```

```

    zz1t = zz3t
    zz1b = zz3b
    xx3 = tmpx
    yy3 = tmpy
    zz3t = tmpz
    zz3b = tmpb
    tmpx = xx2
    tmpy = yy2
    tmpz = zz2t
    tmpb = zz2b
    xx2 = xx4
    yy2 = yy4
    zz2t = zz4t
    zz2b = zz4b
    xx4 = tmpx
    yy4 = tmpy
    zz4t = tmpz
    zz4b = tmpb
endif

!Find the midpoint between nodes 1 and 4 (referred to as 1/4 below)
tx1 = (xx1 + xx4) / DBLE(2)
ty1 = (yy1 + yy4) / DBLE(2)
tz1t = (zz1t + zz4t) / DBLE(2)
tz1b = (zz1b + zz4b) / DBLE(2)
*****==> tz1t = zz1t
*****==> tz1b = zz1b

!Find the midpoint between nodes 3 and 4 (referred to as 3/4 below)
tx2 = (xx3 + xx4) / DBLE(2)
ty2 = (yy3 + yy4) / DBLE(2)
tz2t = (zz3t + zz4t) / DBLE(2)
tz2b = (zz3b + zz4b) / DBLE(2)
*****==> tz2t = zz3t
*****==> tz2b = zz3b

!Find the heights of the triangular prisms
h1 = abs(zz1b+zz2b+cb -zz1t-zz2t-ct)/DBLE(3)
h2 = abs(zz2b+zz3b+cb -zz2t-zz3t-ct)/DBLE(3)
h3 = abs(zz3b+tz2b+cb -zz3t-tz2t-ct)/DBLE(3)
h4 = abs(tz1b+zz1b+cb -tz1t-zz1t-ct)/DBLE(3)

!Find the area of each triangle
t1 = DBLE(0.5)*abs(xx1*(yy2-cy) +xx2*(cy-yy1) +cx*(yy1-yy2)) !1 2 C
t2 = DBLE(0.5)*abs(xx2*(yy3-cy) +xx3*(cy-yy2) +cx*(yy2-yy3)) !2 3 C
t3 = DBLE(0.5)*abs(xx3*(ty2-cy) +tx2*(cy-yy3) +cx*(yy3-ty2)) !3 3/4 C
t4 = DBLE(0.5)*abs(tx1*(yy1-cy) +xx1*(cy-ty1) +cx*(ty1-yy1)) !1 1/4 C
!Triangle:

!Find the volume of each triangular prism
v1 = h1*t1
v2 = h2*t2
v3 = h3*t3
v4 = h4*t4

!Find total volume
vol = v1 + v2 + v3 + v4

CASE(3,5,10,12)

!If a form other than 3, rotate the element nodes to match form 3
if(form == 5)then
    tmpx = xx1
    tmpy = yy1
    tmpz = zz1t
    tmpb = zz1b
    xx1 = xx4
    yy1 = yy4
    zz1t = zz4t
    zz1b = zz4b

```

```

xx4 = xx3
yy4 = yy3
zz4t = zz3t
zz4b = zz3b
xx3 = xx2
yy3 = yy2
zz3t = zz2t
zz3b = zz2b
xx2 = tmpx
yy2 = tmpy
zz2t = tmpx
zz2b = tmpb
elseif(form == 10)then
  tmpx = xx1
  tmpy = yy1
  tmpx = zz1t
  tmpb = zz1b
  xx1 = xx2
  yy1 = yy2
  zz1t = zz2t
  zz1b = zz2b
  xx2 = xx3
  yy2 = yy3
  zz2t = zz3t
  zz2b = zz3b
  xx3 = xx4
  yy3 = yy4
  zz3t = zz4t
  zz3b = zz4b
  xx4 = tmpx
  yy4 = tmpy
  zz4t = tmpx
  zz4b = tmpb
elseif(form == 12)then
  tmpx = xx1
  tmpy = yy1
  tmpx = zz1t
  tmpb = zz1b
  xx1 = xx3
  yy1 = yy3
  zz1t = zz3t
  zz1b = zz3b
  xx3 = tmpx
  yy3 = tmpy
  zz3t = tmpx
  zz3b = tmpb
  tmpx = xx2
  tmpy = yy2
  tmpx = zz2t
  tmpb = zz2b
  xx2 = xx4
  yy2 = yy4
  zz2t = zz4t
  zz2b = zz4b
  xx4 = tmpx
  yy4 = tmpy
  zz4t = tmpx
  zz4b = tmpb
endif

!Find the midpoint between nodes 1 and 2 (referred to as 1/2 below)
tx1 = (xx1 + xx2 ) / DBLE(2)
ty1 = (yy1 + yy2 ) / DBLE(2)
tz1t = (zz1t + zz2t) / DBLE(2)
tz1b = (zz1b + zz2b) / DBLE(2)
*****==> tz1t = zz2t
*****==> tz1b = zz2b

```

```

!Find the midpoint between nodes 3 and 4 (referred to as 3/4 below)
tx2 = (xx3 + xx4 ) / DBLE(2)
ty2 = (yy3 + yy4 ) / DBLE(2)
tz2t = (zz3t + zz4t) / DBLE(2)
tz2b = (zz3b + zz4b) / DBLE(2)

*****==> tz2t = zz3t
*****==> tz2b = zz3b

!Find the heights of the triangular prisms
h1 = abs(tz1b+zz2b+cb -tz1t-zz2t-ct)/DBLE(3)
h2 = abs(zz2b+zz3b+cb -zz2t-zz3t-ct)/DBLE(3)
h3 = abs(zz3b+tz2b+cb -zz3t-tz2t-ct)/DBLE(3)

!Find the area of each triangle
t1 = DBLE(0.5)*abs(tx1*(yy2-cy) +xx2*(cy-ty1) +cx*(ty1-yy2)) !2 1/2 C
t2 = DBLE(0.5)*abs(xx2*(yy3-cy) +xx3*(cy-yy2) +cx*(yy2-yy3)) !2 3 C
t3 = DBLE(0.5)*abs(xx3*(ty2-cy) +tx2*(cy-yy3) +cx*(yy3-ty2)) !3 3/4 C

!Triangle:

!Find the volume of each triangular prism
v1 = h1*t1
v2 = h2*t2
v3 = h3*t3

!Find total volume
vol = v1 + v2 + v3

CASE(7,11,13,14)

!If a form other than 7, rotate the element nodes to match form 7
if(form == 11)then
  tmpx = xx1
  tmpy = yy1
  tmpt = zz1t
  tmpb = zz1b
  xx1 = xx2
  yy1 = yy2
  zz1t = zz2t
  zz1b = zz2b
  xx2 = xx3
  yy2 = yy3
  zz2t = zz3t
  zz2b = zz3b
  xx3 = xx4
  yy3 = yy4
  zz3t = zz4t
  zz3b = zz4b
  xx4 = tmpx
  yy4 = tmpy
  zz4t = tmpt
  zz4b = tmpb
elseif(form == 13)then
  tmpx = xx1
  tmpy = yy1
  tmpt = zz1t
  tmpb = zz1b
  xx1 = xx4
  yy1 = yy4
  zz1t = zz4t
  zz1b = zz4b
  xx4 = xx3
  yy4 = yy3
  zz4t = zz3t
  zz4b = zz3b
  xx3 = xx2
  yy3 = yy2
  zz3t = zz2t

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```

        zz3b = zz2b
        xx2 = tmpx
        yy2 = tmpy
        zz2t = tmpb
        zz2b = tmpb
elseif(form == 14)then
    tmpx = xx1
    tmpy = yy1
    tmpb = zz1t
    tmpb = zz1b
    xx1 = xx3
    yy1 = yy3
    zz1t = zz3t
    zz1b = zz3b
    xx3 = tmpx
    yy3 = tmpy
    zz3t = tmpb
    zz3b = tmpb
    tmpx = xx2
    tmpy = yy2
    tmpb = zz2t
    tmpb = zz2b
    xx2 = xx4
    yy2 = yy4
    zz2t = zz4t
    zz2b = zz4b
    xx4 = tmpx
    yy4 = tmpy
    zz4t = tmpb
    zz4b = tmpb
endif

!Find the midpoint between nodes 1 and 2 (referred to as 1/2 below)
tx1 = (xx1 + xx2 ) / DBLE(2)
ty1 = (yy1 + yy2 ) / DBLE(2)
tz1t = (zz1t + zz2t) / DBLE(2)
tz1b = (zz1b + zz2b) / DBLE(2)
*****=> tz1t = zz2t
*****=> tz1b = zz2b

!Find the midpoint between nodes 2 and 3 (referred to as 2/3 below)
tx2 = (xx2 + xx3 ) / DBLE(2)
ty2 = (yy2 + yy3 ) / DBLE(2)
tz2t = (zz2t + zz3t) / DBLE(2)
tz2b = (zz2b + zz3b) / DBLE(2)
*****=> tz2t = zz2t
*****=> tz2b = zz2b

!Find the heights of the triangular prisms
h1 = abs(tz1b+zz2b+cb -tz1t-zz2t-ct)/DBLE(3)
h2 = abs(zz2b+tz2b+cb -zz2t-tz2t-ct)/DBLE(3)

!Find the area of each triangle
t1 = DBLE(0.5)*abs(tx1*(yy2-cy) +xx2*(cy-ty1) +cx*(ty1-yy2)) !2 1/2 C
t2 = DBLE(0.5)*abs(xx2*(ty2-cy) +tx2*(cy-yy2) +cx*(yy2-ty2)) !2 2/3 C
!Triangle:

!Find the volume of each triangular prism
v1 = h1*t1
v2 = h2*t2

!Find total volume
vol = v1 + v2

!All land or non-ideal water, volume is 0.0
CASE(15)
    vol = 0.0

CASE(16,19)

```

```

!If a form 19, rotate the element nodes to match form 16
if(form == 19)then
  tmpx = xx1
  tmpy = yy1
  tmpt = zz1t
  tmpb = zz1b
  xx1 = xx2
  yy1 = yy2
  zz1t = zz2t
  zz1b = zz2b
  xx2 = xx3
  yy2 = yy3
  zz2t = zz3t
  zz2b = zz3b
  xx3 = xx4
  yy3 = yy4
  zz3t = zz4t
  zz3b = zz4b
  xx4 = tmpx
  yy4 = tmpy
  zz4t = tmpt
  zz4b = tmpb
endif

!Find the midpoint between nodes 1 and 2 (referred to as 1/2 below)
tx1 = (xx1 + xx2) / DBLE(2)
ty1 = (yy1 + yy2) / DBLE(2)
tz1t = (zz1t + zz2t) / DBLE(2)
tz1b = (zz1b + zz2b) / DBLE(2)
*****==> tz1t = zz2t
*****==> tz1b = zz2b

!Find the midpoint between nodes 2 and 3 (referred to as 2/3 below)
tx2 = (xx2 + xx3) / DBLE(2)
ty2 = (yy2 + yy3) / DBLE(2)
tz2t = (zz2t + zz3t) / DBLE(2)
tz2b = (zz2b + zz3b) / DBLE(2)
*****==> tz2t = zz3t
*****==> tz2b = zz3b

!Find the midpoint between nodes 3 and 4 (referred to as 3/4 below)
tx3 = (xx3 + xx4) / DBLE(2)
ty3 = (yy3 + yy4) / DBLE(2)
tz3t = (zz3t + zz4t) / DBLE(2)
tz3b = (zz3b + zz4b) / DBLE(2)
*****==> tz3t = zz4t
*****==> tz3b = zz4b

!Find the midpoint between nodes 1 and 4 (referred to as 1/4 below)
tx4 = (xx1 + xx4) / DBLE(2)
ty4 = (yy1 + yy4) / DBLE(2)
tz4t = (zz1t + zz4t) / DBLE(2)
tz4b = (zz1b + zz4b) / DBLE(2)
*****==> tz4t = zz4t
*****==> tz4b = zz4b

!Find the heights of the triangular prisms
h1 = abs(tz1b+zz2b+cb -tz1t-zz2t-ct)/DBLE(3)
h2 = abs(zz2b+tz2b+cb -zz2t-tz2t-ct)/DBLE(3)
h3 = abs(tz3b+zz4b+cb -tz3t-zz4t-ct)/DBLE(3)
h4 = abs(zz4b+tz4b+cb -zz4t-tz4t-ct)/DBLE(3)
h5 = abs(tz1b+tz4b+cb -tz1t-tz4t-ct)/DBLE(3)
h6 = abs(tz2b+tz3b+cb -tz2t-tz3t-ct)/DBLE(3)

!Find the area of each triangle
t1 = DBLE(0.5)*abs(tx1*(yy2-cy) +xx2*(cy-ty1) +cx*(ty1-yy2)) ! 2 1/2 C
t2 = DBLE(0.5)*abs(xx2*(ty2-cy) +tx2*(cy-yy2) +cx*(yy2-ty2)) ! 2 2/3 C
t3 = DBLE(0.5)*abs(tx3*(yy4-cy) +xx4*(cy-ty3) +cx*(ty3-yy4)) ! 4 3/4 C
t4 = DBLE(0.5)*abs(xx4*(ty4-cy) +tx4*(cy-yy4) +cx*(yy4-ty4)) ! 4 1/4 C
t5 = DBLE(0.5)*abs(tx1*(ty4-cy) +tx4*(cy-ty1) +cx*(ty1-ty4)) !1/2 1/4 C
t6 = DBLE(0.5)*abs(tx2*(ty3-cy) +tx3*(cy-ty2) +cx*(ty2-ty3)) !2/3 3/4 C

!Triangle:
!Find the volume of each triangular prism

```

```

v1 = h1*t1
v2 = h2*t2
v3 = h3*t3
v4 = h4*t4
v5 = h5*t5
v6 = h6*t6

!Find total volume
vol = v1 + v2 + v3 + v4 + v5 + v6

CASE(17,18)

!If a form 18, rotate the element nodes to match form 17
if(form == 18)then
  tmpx = xx1
  tmpy = yy1
  tmpz = zz1t
  tmpb = zz1b
  xx1 = xx2
  yy1 = yy2
  zz1t = zz2t
  zz1b = zz2b
  xx2 = xx3
  yy2 = yy3
  zz2t = zz3t
  zz2b = zz3b
  xx3 = xx4
  yy3 = yy4
  zz3t = zz4t
  zz3b = zz4b
  xx4 = tmpx
  yy4 = tmpy
  zz4t = tmpz
  zz4b = tmpb
endif

!Find the midpoint between nodes 1 and 2 (referred to as 1/2 below)
tx1 = (xx1 + xx2 ) / DBLE(2)
ty1 = (yy1 + yy2 ) / DBLE(2)
tz1t = (zz1t + zz2t) / DBLE(2)
tz1b = (zz1b + zz2b) / DBLE(2)
*****==> tz1t = zz2t
*****==> tz1b = zz2b

!Find the midpoint between nodes 2 and 3 (referred to as 2/3 below)
tx2 = (xx2 + xx3 ) / DBLE(2)
ty2 = (yy2 + yy3 ) / DBLE(2)
tz2t = (zz2t + zz3t) / DBLE(2)
tz2b = (zz2b + zz3b) / DBLE(2)
*****==> tz2t = zz3t
*****==> tz2b = zz3b

!Find the midpoint between nodes 3 and 4 (referred to as 3/4 below)
tx3 = (xx3 + xx4 ) / DBLE(2)
ty3 = (yy3 + yy4 ) / DBLE(2)
tz3t = (zz3t + zz4t) / DBLE(2)
tz3b = (zz3b + zz4b) / DBLE(2)
*****==> tz3t = zz4t
*****==> tz3b = zz4b

!Find the midpoint between nodes 1 and 4 (referred to as 1/4 below)
tx4 = (xx1 + xx4 ) / DBLE(2)
ty4 = (yy1 + yy4 ) / DBLE(2)
tz4t = (zz1t + zz4t) / DBLE(2)
tz4b = (zz1b + zz4b) / DBLE(2)
*****==> tz4t = zz4t
*****==> tz4b = zz4b

!Find the heights of the triangular prisms
h1 = abs(tz1b+tz2b+zz2b -tz1t-tz2t-zz2t)/DBLE(3)
h2 = abs(tz3b+tz4b+zz4b -tz3t-tz4t-zz4t)/DBLE(3)

!Find the area of each triangle
!Triangle:

```



```

t1 =DBLE(0.5)*abs(tx1*(ty2-yy2)+tx2*(yy2-ty1)+xx2*(ty1-ty2)) !1/2 2 2/3
t2 =DBLE(0.5)*abs(tx3*(ty4-yy4)+tx4*(yy4-ty3)+xx4*(ty3-ty4)) !3/4 4 1/4

!Find the volume of each triangular prism
v1 = h1*t1
v2 = h2*t2

!Find total volume
vol = v1 + v2

CASE DEFAULT
  write(*,*) "Error, Impossible Case: ",form
  pause

END SELECT

END FUNCTION vol

```