Model code

To facilitate the use of PERM more widely the PERM code from Excel VBA is given below as a function. The PERM model parameters and their maximum and minimum values passed to this function are:

Parameter	Description	Range
Smax	Soil moisture storage capacity (mm)	[50 - 2000]
ETrate	Rate of evapotranspiration (mm / ^{o}C / month)	[0 - 200]
K	Baseflow linear recession constant	[0 - 1]
Melt	Proportion of snowmelt volume to runoff	[0 – 1]
Imax	Interception storage capacity (mm)	[0 - 300]

The input data for this function is a two-dimensional array of monthly data of N (the number of months) rows x 6 columns. The data in each column are: (1) year; (2) month; (3) observed runoff (mm); (4) observed precipitation (mm); (5) observed temperature (^{o}C); and (6) modelled runoff (mm) [filled by the function].

The function repeats the first 12 months twice, first to warm up the model stores and second to model the runoff.

```
----------Start of Excel VBA code ---------------------------------------
'
' This is the PERM code for predicting monthly runoff from monthly precipitation and temperature data
'
' Written by Murray Peel and Tom McMahon from 2001 - 2007
'
Function PERM(MonData() As Double, N As Integer, Smax As Double, ETrate As Double, K As Double, Melt As Double, Imax As Double) As Double

    Dim Sprev As Double, S As Double, ACCUM As Double, Base As Double, F As Double, MeltVol As Double, ASoET As Double
    Dim R As Double, P As Double, T As Double, ET As Double, Qsnow As Double, Qsoil As Double, Qparea As Double
    Dim ICprev As Double, ICt As Double, IC As Double, RGap As Double, ETSnow As Double
    Dim Warmup As Integer, WarmCount As Integer, TSnow As Integer, ETallSnow As Integer
'
' Run the data through the model
'
    Sprev = 0.5 * Smax
    ICprev = 0.5 * Imax
    ACCUM = 0
```

```
ETallSnow = 0
TSnow = 0
ETSnow = 0
ASoET = 0
Warmup = 0
WarmCount = 0
For xx = 1 To N
   P = MonData(xx, 4)
   T = MonData(xx, 5)
   ' Check for Snow
   If T <= TSnow Then
      ACCUM = P + ACCUM
      R = 0
      ET = 0
      S = Sprev + R - ET
      Base = K * (Sprev + S) / 2
      F = Base
      ICt = 0
   Else
      ' Deal with any snow melt (no interception when there is snowpack)
      If ACCUM > 0 Then
         If T * ETrate <= ACCUM Then
            MeltVol = T * ETrate
            ETallSnow = 1
         Else
            MeltVol = ACCUM
            ETallSnow = 0
         End If
         ETSnow = MeltVol
         ACCUM = ACCUM – MeltVol
         ' Split the precip with the MeltVol to streamflow or soil infiltration
         R = (1 - Melt) * (MeltVol + P)
         Qsnow = Melt * (MeltVol + P)
         ICt = 0
      Else
         ' Take out the interception from the precipitation
         If P > Imax - ICprev Then
            R = P - (Imax - ICprev)
            IC = Imax
```

```
    Else
        R = 0
        IC = ICprev + P
    End If
    ' Calculate ET from the interception store and see if any PET is left for the soil
    If IC <= ETrate * T Then
        ICt = IC
        IC = 0
    Else
        ICt = ETrate * T
        IC = IC - ICt
    End If
    ETSnow = 0
End If
' A quasi partial area infiltration component as a proportion of soil moisture status
Qparea = R * Sprev / Smax
R = R - Qparea
' Update the Soil store
If ETallSnow = 0 Then ' there is still some energy left after removing the snow pack
    ' Temporary estimate of S for averaging
    S = Sprev + R
    ' Check for water limited or energy limited case
    If 300 * ((S + Sprev) / 2) / Smax >= ETrate * T - ICt - ETSnow Then
        ' Energy limited
        ASoET = ETrate * T - ICt - ETSnow
    Else
        ' Water limited
        ASoET = 300 * ((S + Sprev) / 2) / Smax
    End If
    ' Calculate new soil moisture store based on real ASoET
    S = Sprev + R - ASoET
    ' Check that soil moisture store is not < 0
    If S < 0 Then
        ' There is more actual soil ET than soil water
        RGap = -S
        ' Reduce the actual soil ET
        ASoET = ASoET + S
        S = 0
    End If
```

```
        ' Calculate the total ET
        ET = ICt + ASoET
    Else
        S = Sprev + R
        ET = 0
    End If
    ' Check for Quick flow
    If S > Smax Then
        Qsoil = S - Smax
        S = Smax
    End If
    ' Calculate Base flow
    If S > 0 Then
        Base = K * (S + Sprev) / 2
        If Base > S Then
            Base = S
        End If
    Else
        Base = 0
    End If
    ' Calculate total flow
    F = Qsnow + Qparea + Qsoil + Base
End If
MonData(xx, 6) = F
If Warmup = 0 Then
    If WarmCount = 12 Then
        Warmup = 1
        xx = 0
    Else
        WarmCount = WarmCount + 1
    End If
End If
' Set up for the next time step
Sprev = S - Base
If Sprev < 0 Then
    Sprev = 0
End If
ICprev = IC
RGap = 0
```

```
        ETallSnow = 0
        Qsnow = 0
        Qparea = 0
        Qsoil = 0
        Base = 0
        MeltVol = 0
        ICt = 0
        ETSnow = 0
        ASoET = 0
    Next
End Function

----------End of Excel VBA code ----------
```