forward_model_explicit

October 14, 2013

1 Forward eco-physiological modelling of ΔO_{18} in tree rings

forward version

1.0.1 TODO

create a dictionnary with key : value = cell reference : parameter

```
In [149]: d_ex = {}
          d_ex['E3']='gs'
```

```
In [150]: def C2K(T):
              """
              conversion celsius to Kelvin
              """
              return T + 273.16
```

1.0.2 Inputs

```
In [151]: airtemp = 14.2666666667
          windspeed = 5.4
          rh = 84.4
          pressure = 1015.3333333333
          gs = 0.25
          leaf_width = 0.015
          PAR = 925
```

1.0.3 Energy balance calculations

```
In [152]: rs = 1. / gs
```

```
In [153]: r_times_b = 3.8 * (leaf_width**0.25)*(windspeed**(-0.5))
```

```
In [154]: rb = 0.89 * r_times_b
```

```
In [155]: gr = (4*0.98*(0.000000056703)*(C2K(airtemp)**3))/(29.2)
```

```
In [156]: rBH = 1./((1./r_times_b)+gr)
```

```
In [157]: Qtot = (PAR/4.6)*2
```

```
In [158]: Qabs = 0.5 * Qtot
```

1.0.4 Calculating ϵ

```
In [159]: lesstemp = airtemp - 1
```

```
In [160]: estemp = (6.13753 * exp(lesstemp * ((18.564 - (lesstemp/254.4)))/(lesstemp +255.57)))*100.
```

```
In [161]: s = (((6.13753 * exp(airtemp * ((18.564 - (airtemp/254.4)))/(airtemp +255.57))))-estemp)/(C2K
```

```
In [162]: smbar = 6.13753*(((airtemp+255.7)*(18.564 - (2*airtemp/254.4)) - airtemp*(18.564 - \
                             (airtemp/254.4)))/((airtemp+255.57)**2))*(exp(airtemp*(18.564 - (airtemp/2
```

```
In [163]: epsilon = (smbar*44012)/(29.2*(pressure))
```

```
In [164]: epsilon
```

```
Out[164]: 1.5705189529981114
```

1.0.5 Calculating $\frac{EA}{EI}$

```
In [165]: ea = (rh / 100) * (6.13753 * exp(airtemp * ((18.564 - (airtemp/254.4)))/(airtemp +255.57)))
```

```
In [166]: es = (6.13753 * exp(airtemp * ((18.564 - (airtemp/254.4)))/(airtemp +255.57)))
```

```
In [167]: temp_diff = (rBH*((Qabs*(rs+rb))-(44012*D)))/(29.2*(rs+rb+(epsilon*rBH)))
```

```
In [168]: temp_diff
```

```
Out[168]: 2.6567603450679336
```

```
In [169]: leaf_temp = airtemp + temp_diff
```

```
In [170]: leaf_temp
```

```
Out[170]: 16.923427011767934
```

```
In [171]: leaf_temp = airtemp + (rBH * ((Qabs * (rs + rb)) - (44012. * D))) / (29.2 * (rs + rb + (epsil
```

```
In [172]: ei = (6.13753 * exp(leaf_temp * ((18.564 - (leaf_temp/254.4)))/(leaf_temp +255.57)))
```

```
In [173]: D = (((6.13753 * exp(airtemp * ((18.564 - (airtemp/254.4)))/(airtemp +255.57))))-ea)/pressure
```

```
In [174]: leaf_temp_K = C2K(leaf_temp)
```

```
In [175]: ea_ei = ea / ei
```

1.0.6 Calculating transpiration

```
In [176]: transpiration = (epsilon * rBH * Qabs / 44012. + D) / (rs + rb + epsilon * rBH)
```

```
In [177]: transpiration
```

```
Out[177]: 0.0011702780786241177
```

1.0.7 Craig / Gordon parameters

```
In [178]: d_source_H2O = -5.17

In [179]: d_water_vapour = d_source_H2O + -1*(2.644-3.206*(1000/C2K(airtemp))+1.534*(1000000/(C2K(airte

In [180]: fract_through_stomata = 32

In [181]: fract_through_boundary_layer = 28

In [182]: ek = ((fract_through_stomata*1/gs)+(fract_through_boundary_layer*rb))/((1/gs)+rb)

In [183]: ek

Out[183]: 31.54819869722034

In [184]: e_star = 2.644-3.206*((10**3)/leaf_temp_K)+1.534*((10**6)/(leaf_temp_K**2))

In [185]: e_star

Out[185]: 9.8217071407997025

In [186]: dv = ((d_water_vapour/1000.)*(1+(d_source_H2O/1000))+(d_source_H2O/1000.))*1000.

In [187]: dv = -20.3

In [188]: de = ek+e_star+((d_water_vapour-ek)*ea_ei)
```

1.0.8 Estimating the Peclet effect

```
In [194]: eff_length = 0.0077

In [195]: C = 55.5*1000 ## ?????

In [197]: D_Peclet = 0.000000119*(exp(-(637/(leaf_temp_K-137))))

In [198]: D_Peclet

Out[198]: 1.8552023220405627e-09

In [199]: p_Peclet = (transpiration*eff_length)/(C*D_Peclet)

In [200]: p_Peclet

Out[200]: 0.087517626877115701

In [201]: DL = (de*(1-exp(-1*p_Peclet)))/p_Peclet

In [202]: DL

Out[202]: 7.7282241517103367

In [203]: dL = ((DL/1000)*(1+(d_source_H2O/1000))+(d_source_H2O/1000))*1000

In [204]: dL

Out[204]: 2.5182692328459941
```

1.0.9 Calculating Δ cellulose and Δ leaf

```
In [206]: C_O_fract = 27
```

```
In [207]: Dcel_Dom = 9
```

```
In [208]: prop_exc = 0.45
```

```
In [209]: prop_Xylem = 0.56
```

```
In [210]: D_sucrose = DL + C_O_fract
```

```
In [212]: D_cellulose = (DL*(1-(prop_exc*prop_Xylem)))+C_O_fract
```

```
In [214]: D_leaf = D_cellulose - Dcel_Dom
```

```
In [216]: d_sucrose = ((D_sucrose/1000)*(1+(d_source_H2O/1000))+(d_source_H2O/1000))*1000
```

```
In [218]: d_leaf = ((D_leaf/1000)*(1+(d_source_H2O/1000))+(d_source_H2O/1000))*1000
```

1.0.10 OUTPUT = ΔO_{18} in tree-rings cellulose

```
In [220]: OUTPUT = ((D_cellulose/1000)*(1+(d_source_H2O/1000))+(d_source_H2O/1000))*1000
```