Atmospheric Boundary Conditions

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Atmospheric Boundary (1 of 5)

- No atmospheric boundary element needed for Richards equation (EOS9)
- Dirichlet boundary element (large volume or inactive; special rock type, e.g. ATMOS)
- A single atmospheric element can be connected to all elements at the ground surface (use, e.g., AddBound.exe)
- Use small nodal distance (e.g., boundary layer thickness) from atmospheric element to interface with first row of soil elements

Atmospheric Boundary (2 of 5)

- Initial condition in atmospheric element:
  - Atmospheric pressure and temeperature
  - For 100% relative humidity, use two-phase point with liquid saturation smaller than residual liquid saturation (so relative permeability is zero, preventing liquid flow into soil)
  - For less than 100% relative humidity, use single-phase gas point with appropriate air mass fraction (1.0 for dry air; minimum value depends on, vapor pressure, i.e., temperature; intermediate values determine relative humidity)

Atmospheric Boundary (3 of 5)

- Material Properties
  - Select relative permeability and capillary pressure functions so that (for the saturation given in the atmospheric boundary element):
    - Liquid relative permeability is *zero*
    - Gas relative permeability is *one*
    - Capillary pressure is *zero*
    - Ensure *upstream weighting* of mobilities (see `MOP(11)`)
- Infiltration
  - Specify infiltration rates in row of elements *below* the atmospheric boundary element using the `GENER` block
- Evaporation
  - Simulate as *binary diffusion* process (atmosphere at <100% r.h.)
  - Specify ET rate in row of elements *below* the atmospheric boundary element using the `GENER` block
  - Assign capillary pressure according to *Kelvin's equation* in atmospheric element (see Ghezzehei et al., *Vadose Zone J.*, 3: 806–818, 2004)

Atmospheric Boundary (4 of 5)

Dirichlet atmospheric b.c.:

Two-phase for 100% r. h.

$S_{l,initial} = 0.01 < S_{lr}$

Single-phase gas for < 100% r.h.

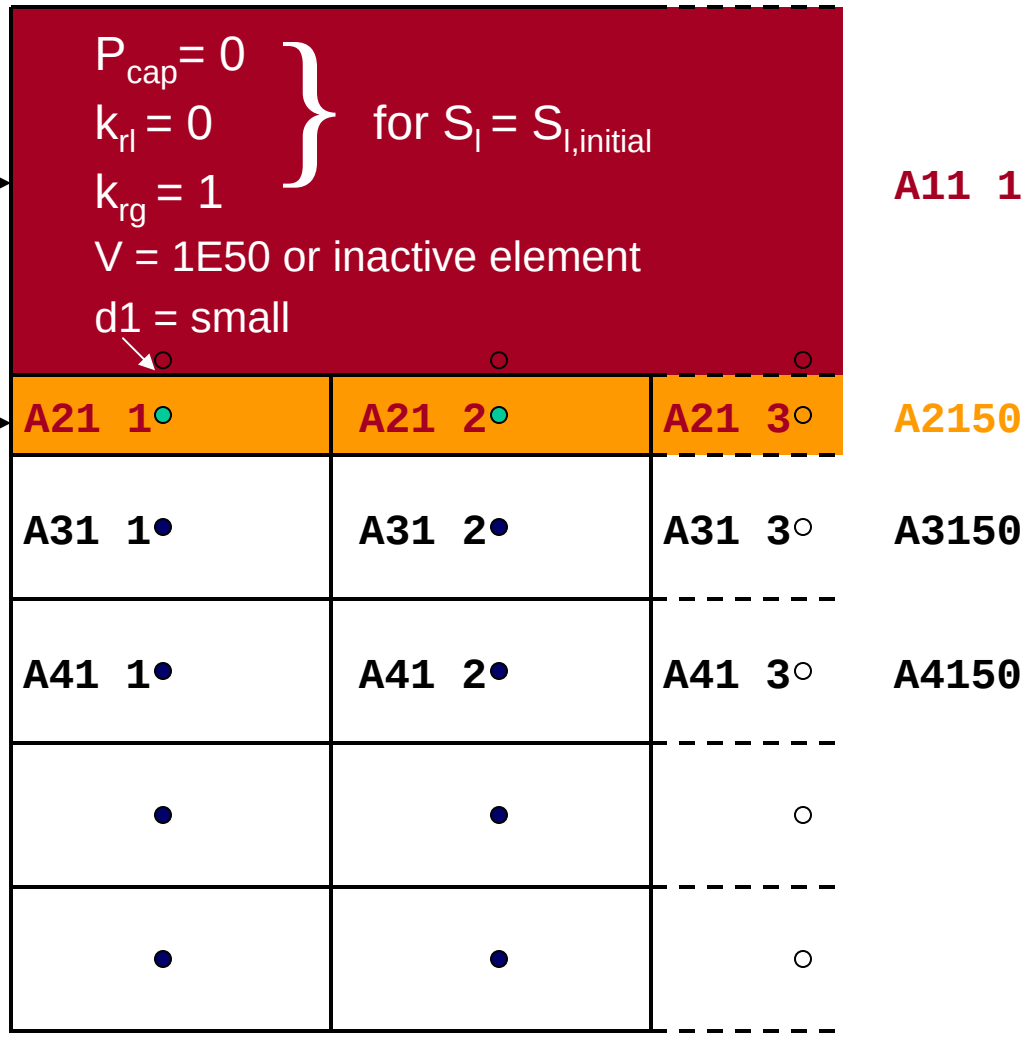
$X^a_{g,min}(T) < X^a_g \leq 1.0$

Neumann b.c.:

GENER, with rates

positive for infiltration and

negative for ET



Atmospheric Boundary (5 of 5)

```
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
ATMOS    2     2650.     .9999                    1.000E-12      2.51   100000.
                                  1.0
    1            0.1       0.0       1.0       0.1
    1            0.0       0.0       1.0
SOIL     0     2650.     .3000 1.000E-12 1.000E-12 1.000E-12      2.51      920.

ELEME
A11 1          ATMOS0.1000E+510.1000E+01                                    0.0
A21 1          SOIL 0.5000E-010.0000E+00          0.5000E+000.5000E+00-.2500E-01
A31 1          SOIL 0.5000E-010.0000E+00          0.5000E+000.5000E+00-.7500E-01
.....              ......................          ..............................
A2150          SOIL 0.5000E-010.0000E+00          0.1000E+010.5000E+00-.2500E-01
A3150          SOIL 0.5000E-010.0000E+00          0.1500E+010.5000E+00-.7500E-01
..........                 ........................................

CONNE
A11 1A21 1                 30.5000E-020.2500E-010.1000E+010.1000E+01
A11 1A21 2                 30.5000E-020.2500E-010.1000E+010.1000E+01
..........                 ........................................
A11 1A2150                 30.5000E-020.2500E-010.1000E+010.1000E+01
..........                 ........................................
A2250A3150                 30.2500E-010.2500E-010.1000E+010.1000E+01
..........                 ........................................

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A11 1
            1.013E5               10.99               20.0

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A21 1INF 1   49    1    1          WATE     1.0E-4
```