ANNUAL REPORT LETTER FOR APRIL 1, 2007 TO MARCH 31, 2008

VENTILATION MODELING STUDIES

Project Title: Nye County Ventilation Modeling
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Report Period: April 1, 2007-March 31, 2008
Date of Report: April 24, 2008

Executive Summary
Five work elements have been contracted during the reported period, numbered I through V.

I. <u>Numerical model update and improvements</u>

In 2007, we continued studying the thermal-hydrologic and air flow processes in the engineered barrier system of the proposed nuclear waste repository at Yucca Mountain (YM). In this broad task, we re-examined the baseline design case with a refined model with MULTIFLUX (MF) Version 5.0, the code version which has been subject to qualification and verification in a separate research project supported by DOE. The model refinement involved three major modifications:

(1) The inclusion of two long, 80-m unheated sections at either end of the emplacement drift, to make the geometry consistent in all model studies, shown in Figure 1.
(2) The explicit evaluation of the air flow velocity distribution in the emplacement drift during post-closure; and the incorporation of this time- and spatial-dependent velocity field in the heat and moisture transport model elements, causing heat and moisture convections. An example of an explicit flow field in the emplacement drift is shown in Figures 2 through 5 for only year 1000, for brevity. Figures 2 and 3 depict the axial velocity component variation along the drift length at four locations above and four locations below the drip shield air spaces, respectively. Figures 4 and 5 show velocities in the vertical cross sections along the drift length, evaluated at four locations above and four locations below the drip shield air spaces, respectively. Figures 6 and 7 show the location of lumped air nodes above and below the drip shield air spaces, respectively. Figure 8 shows the back-calculated axial moisture dispersion coefficient from the flow field results, which shows the spatial and temporal variation. Figures 9 and 10 show the spatial variation of temperature, relative humidity, and condensation along the drift length at years 1000 and 5000. respectively.
(3) The use of the TOUGH2 rock mass model element in the MF model for the baseline analysis in order to make the results comparable with those studies conducted at the Lawrence Berkeley National Laboratory (LBNL) for the same emplacement drift arrangement.

II. <u>New model studies and their conclusions</u>
We found the new model results somewhat different from those of previous model studies due to the refinements in the model conditions and assumptions. For this reason alone, we re-visited

the previous, most important tasks (in addition to the baseline design case), and re-calculated them with the new model. The following studies were repeated with the new model:

(1) Analysis of the baseline case with an equivalent, effective dispersion coefficient, and corresponding diffusive/dispersive heat and moisture transport. We found the results to be in good agreement with those published in DOE reports regarding the temperature distribution along the hot emplacement drift section. Differences in the results concerning humidity distribution along the drift length are discussed in an upcoming publication in the Journal of Nuclear Technology. The results were used in the Journal of Nuclear Technology paper in terms of temperature and relative humidity variations in time and space in three dimensional figures, shown in Figure 11.
(2) Analysis of the baseline case with an explicit velocity field and corresponding convective heat and moisture transport. We obtained new results for the in-drift axial transport from the new, convective model configuration, showing a significantly larger, axial moisture transport component relative to those in current DOE studies.
(3) Barometric pressure pumping study. We repeated a previous study with a refined set of model conditions, and found the effect of barometric pressure pumping on heat and moisture still significant, but less dramatic. The effect on condensation and relative humidity for three drift wall segments are shown in Figures 12 through 14.
(4) Studies of the drift vapor attraction mechanism. We repeated a previous study with the new model and re-calculated the spatial and temporal humidity distributions.

III. <u>Revision of research reports and manuscript</u>

Using the re-calculated model results, we revised the previous draft of Five-Year ISIP report regarding the thermal-hydrologic and ventilation tasks. It was necessary to revise existing documents in draft form with new results. The following documents were changed and/or re-submitted:

(1) Five-Year ISIP summary report regarding the chapter dealing with ventilation.
(2) Annual Letter Report for FY06 regarding the following model updates:
    a. Detailed in-drift model configuration with under and above drip shield regions.
    b. Unheated 80-m drift sections at both ends.
    c. 600-m heated section vs. 714-m heated drift in the 2005 study report.
    d. Recent addition of an air flow CFD solver.
    e. Inclusion of latent heat of condensation at the unheated drift sections.
(3) The Journal of Nuclear Technology manuscript with new figures based on the new results. The paper will be published in July 2008.

IV. A clearer picture is evolving based on the model studies regarding the processes and their significance in the evolution of the expected thermal-hydrologic environment in the emplacement drift at YM. This picture is generally in good agreement with that of DOE regarding temperatures along the hot drift section for the baseline study. Significant differences are found in moisture flows and humidity, and liquid water flow due to the appearance of condensation at early time periods. Most notable is the emergence of liquid water under the drip shield due to condensation.

Preparation of draft contentions

Recognition of the significance of convective transport processes is expressed in the draft contentions that we have been preparing to assist Nye County efforts in license application review. Several draft contentions were developed, and are under consideration by the NWRPO.

V. Attendance of workshops and meetings

We have attended several presentations with Nye County project management and participating contractors, most notably those as follows:

(1) Attended Nye technical meeting and the Devil's Hole Workshop on May 4, 2007 and presented a summary of FY06 results.
(2) Project review meeting, Feb 12, 2008, Nye County Nuclear Waste Repository Project Office (NWRPO).
(3) Workshop on contentions, March 3-4, 2008, Nye County NWRPO.

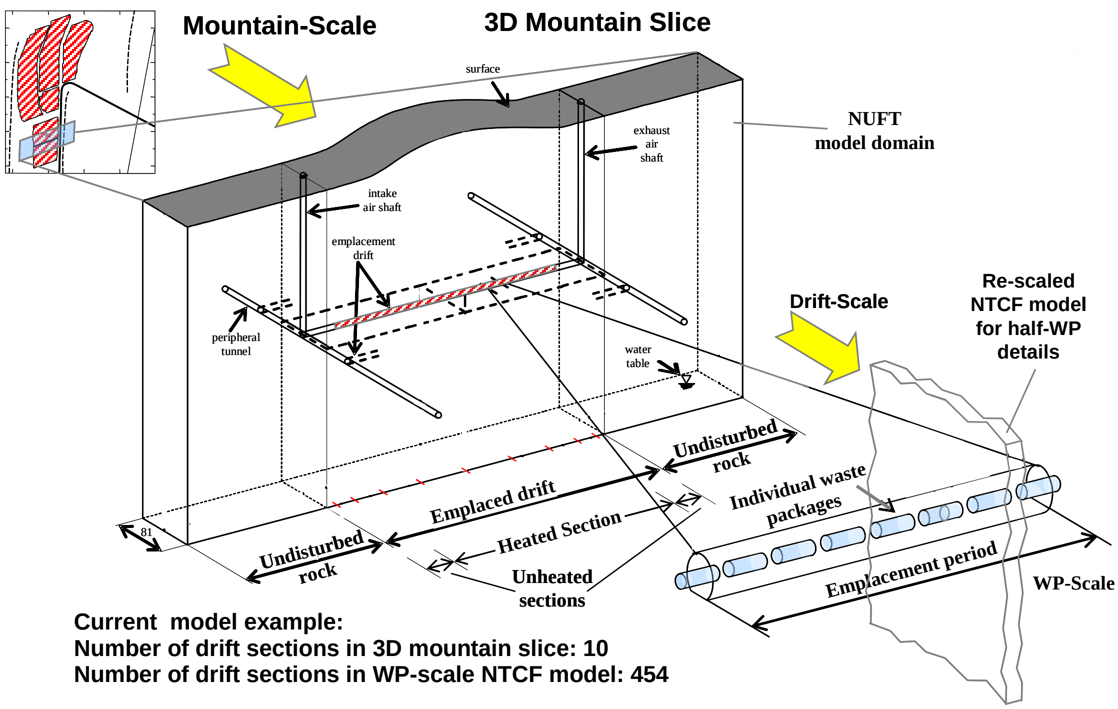

Figure 1. The mountain-scale and in-drift model domains.

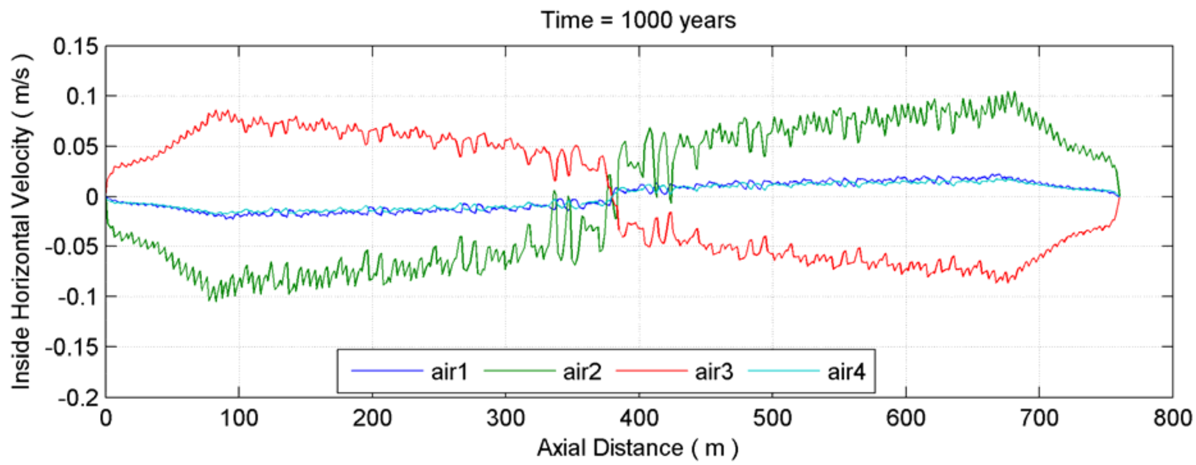

Figure 2. Horizontal air flow velocity variation along the emplacement drift at four locations below the drip shield air space at year 1000.

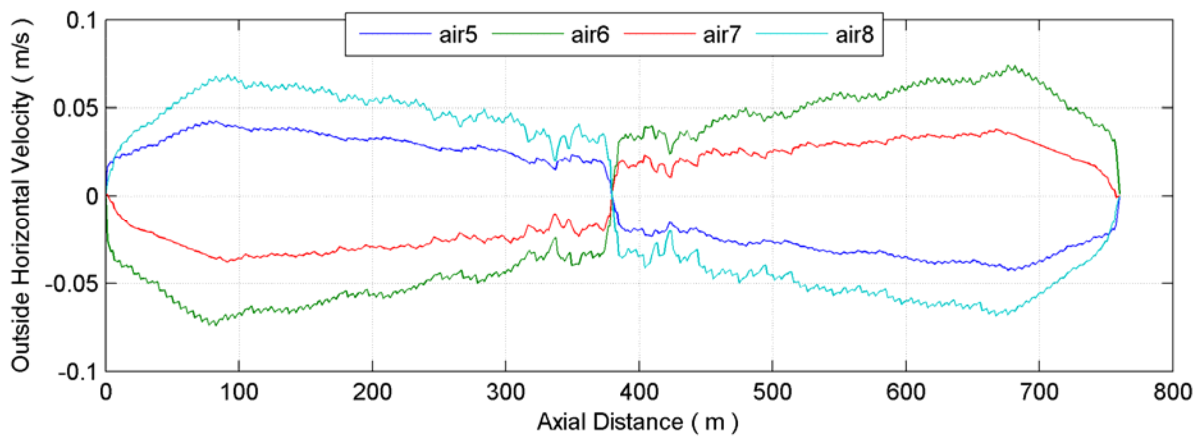

Figure 3. Horizontal air flow velocity variation along the emplacement drift at four locations above the drip shield air space at year 1000.

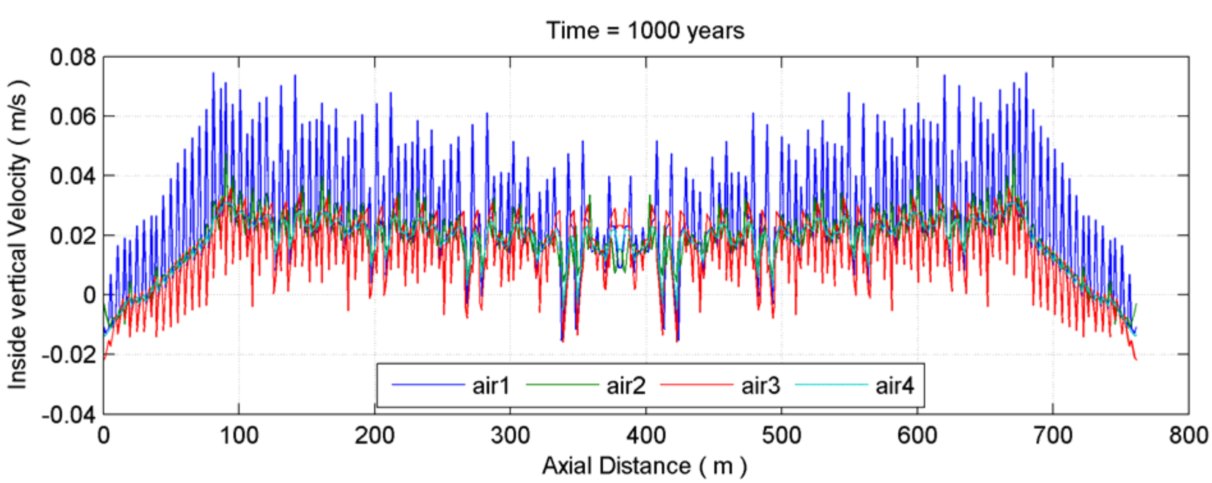

Figure 4. Velocities in vertical cross sections along the drift length at four locations below the drip shield air space at year 1000.

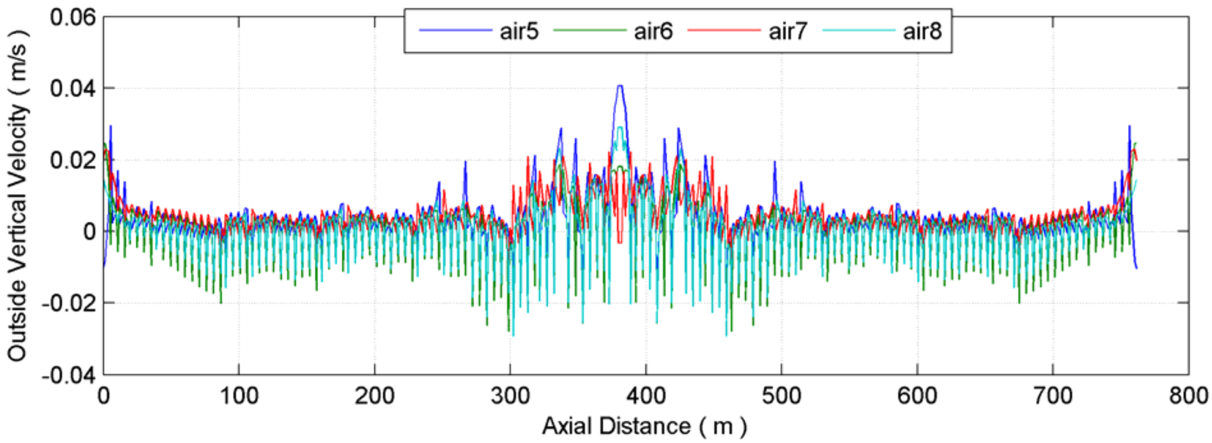

Figure 5. Velocities in vertical cross sections along the drift length at four locations below the drip shield air space at year 1000.

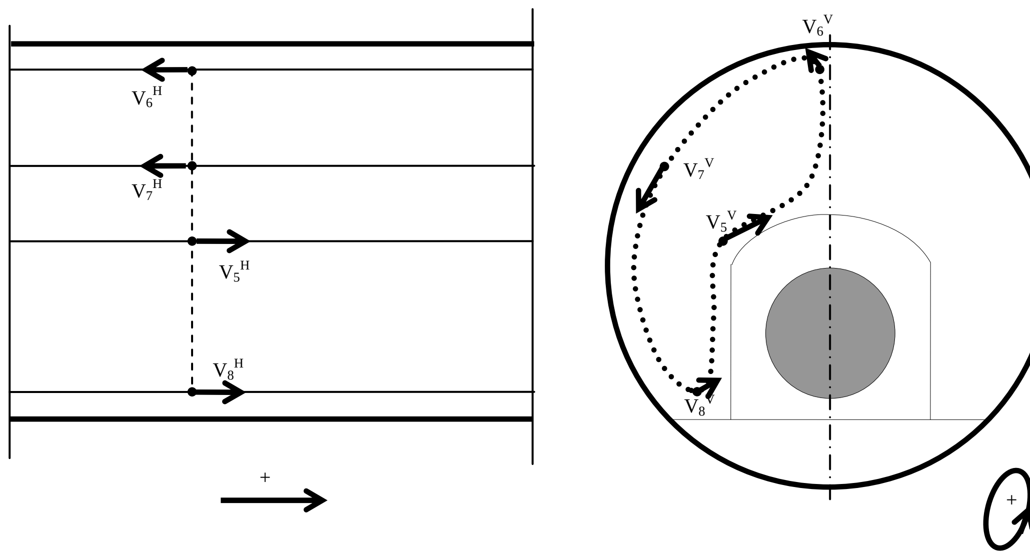

Figure 6. Definition of horizontal and vertical velocity components at a given cross section above the drip shields.

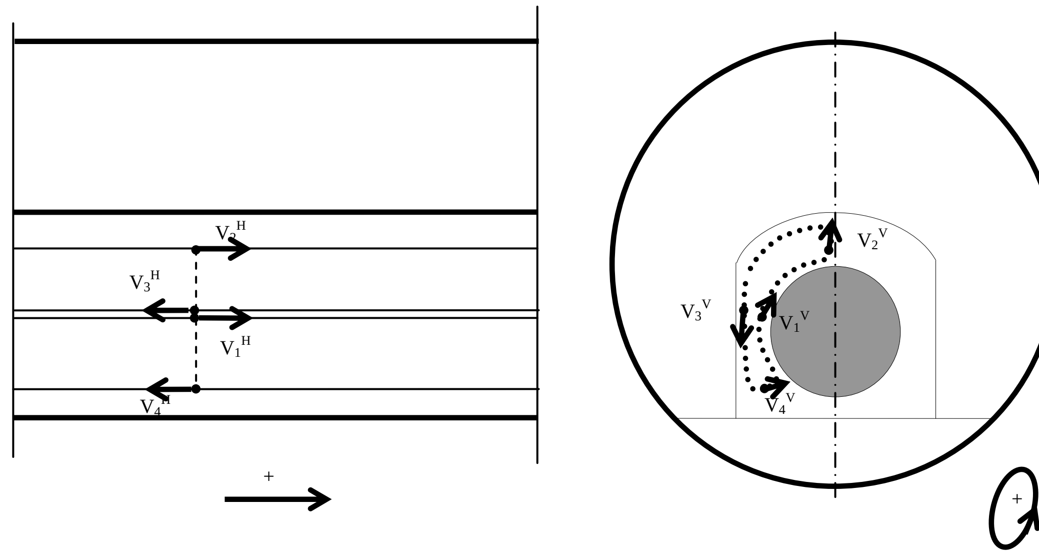

Figure 7. Definition of horizontal and vertical velocity components at a given cross section below the drip shield

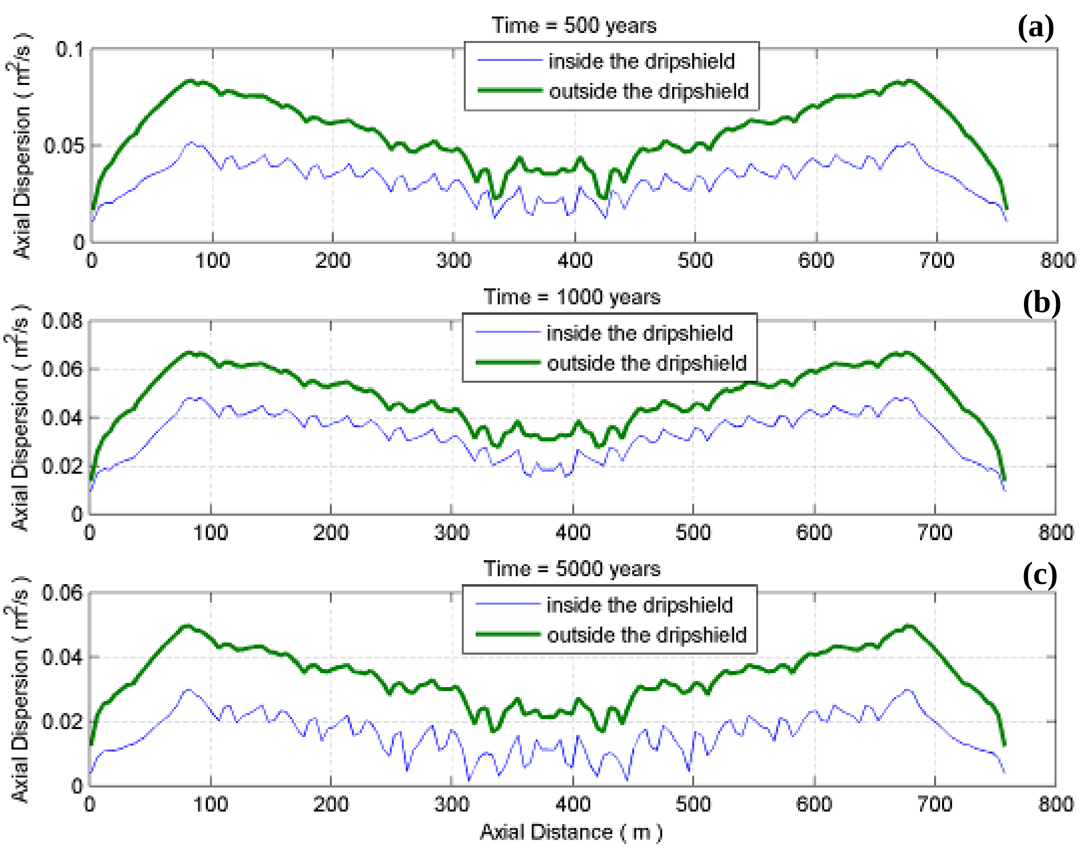

Figure 8. Axial distribution of the equivalent dispersion coefficient in the air space inside (thin line) and outside (thick line) of the drip shields at years 500 (a), 1000 (b), and 5000 (c).

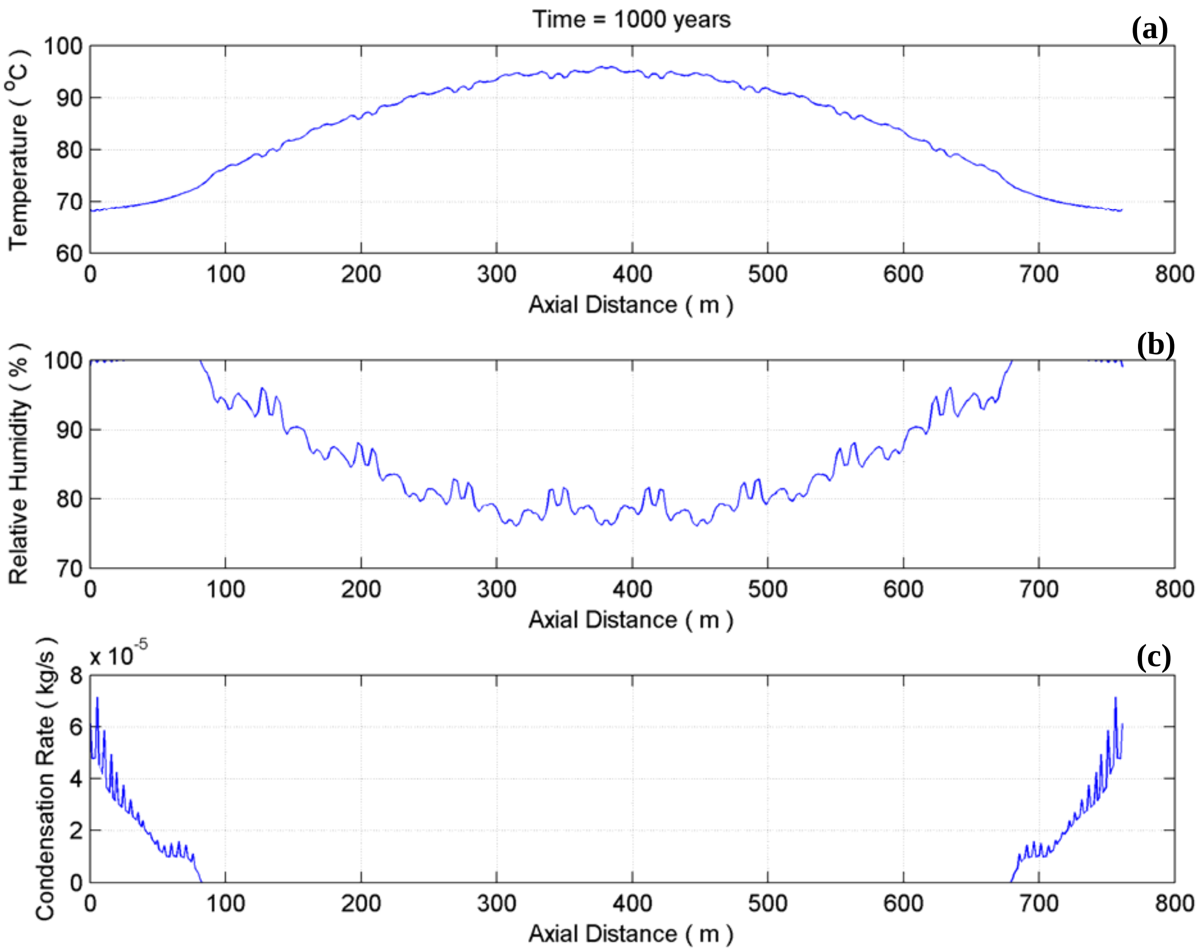

Figure 9. Axial distribution of (a) temperature, (b) relative humidity, and (c) rate of condensation distributions along the drift length for year 1000.

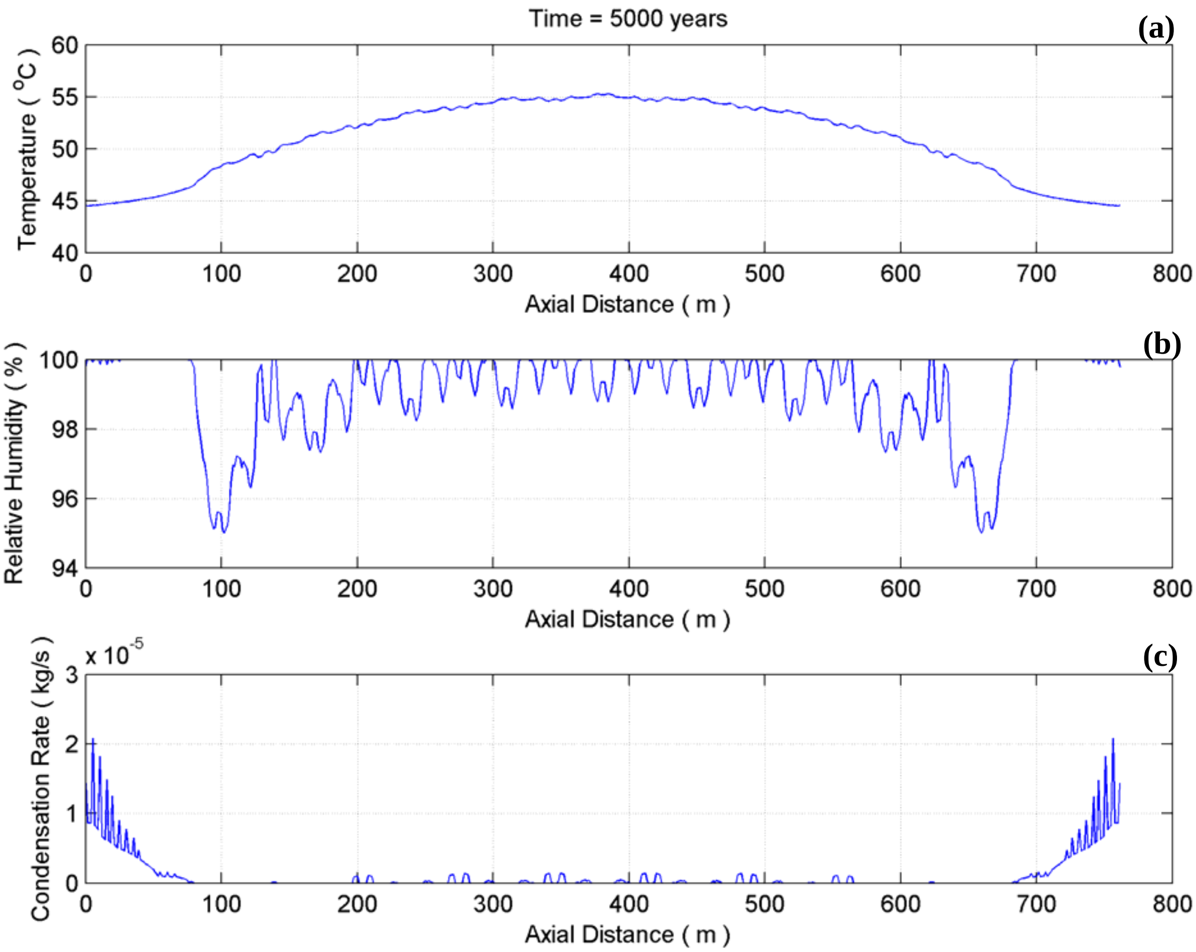

Figure 10. Axial distribution of (a) temperature, (b) relative humidity, and (c) rate of condensation distributions along the drift length for year 5000.

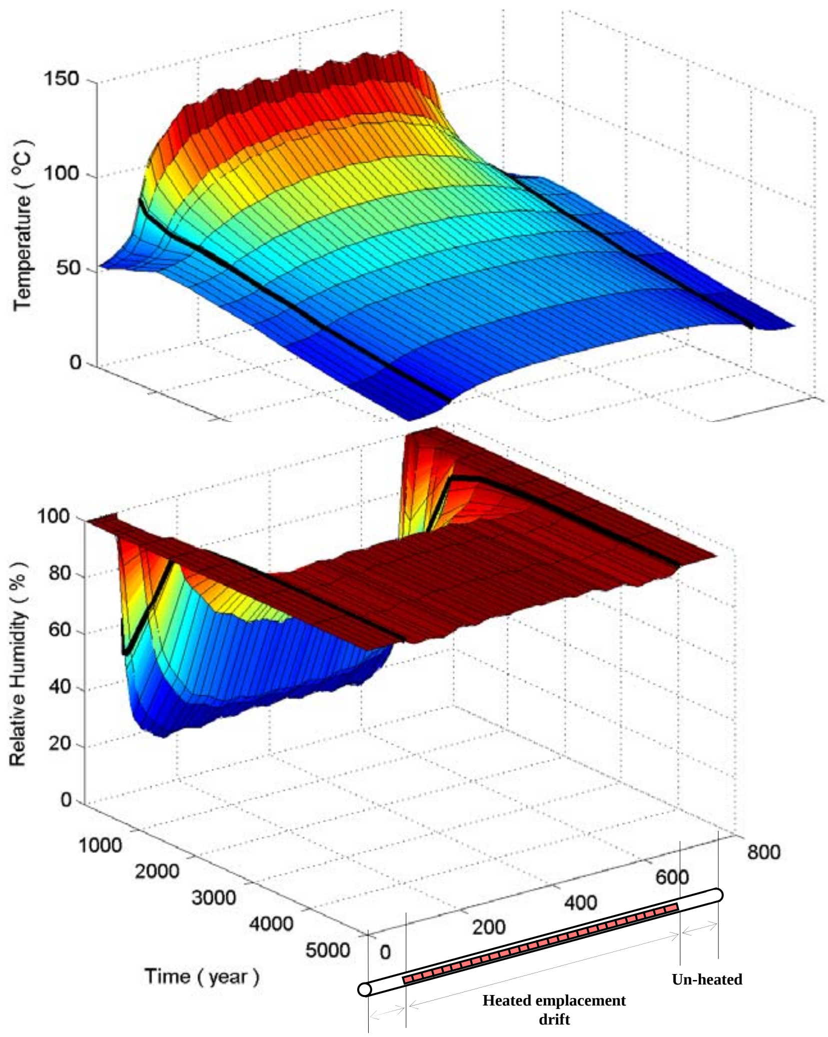

Figure 11. Spatial and temporal variations of the drift wall temperature (a); and relative humidity (b); in a hot emplacement drift for DOE's baseline design, according to a new, coupled thermal-hydrologic model.

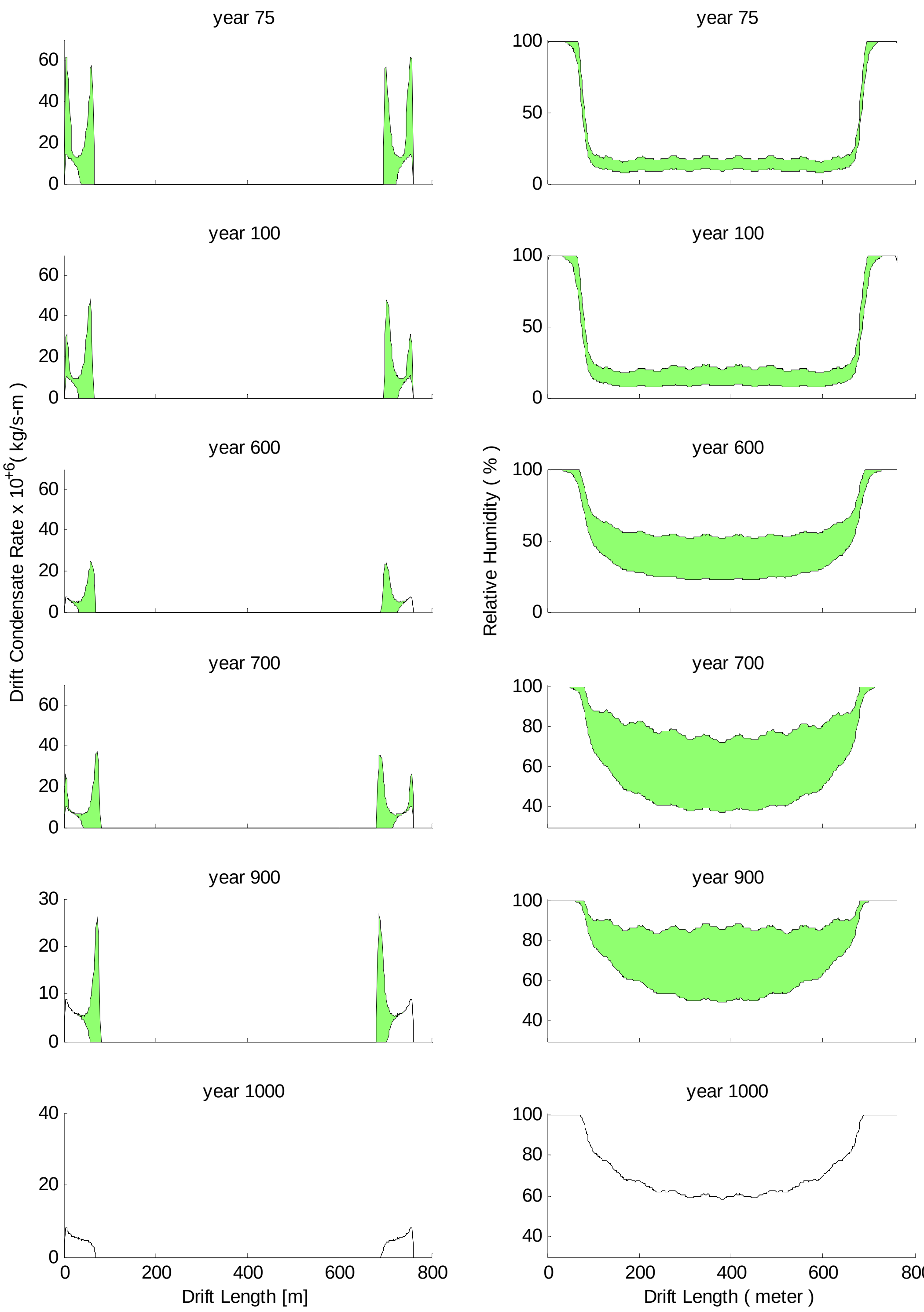

Figure 12. Barometric pressure fluctuation effects on relative humidity and condensation rate, at the roof segment of the drift wall.

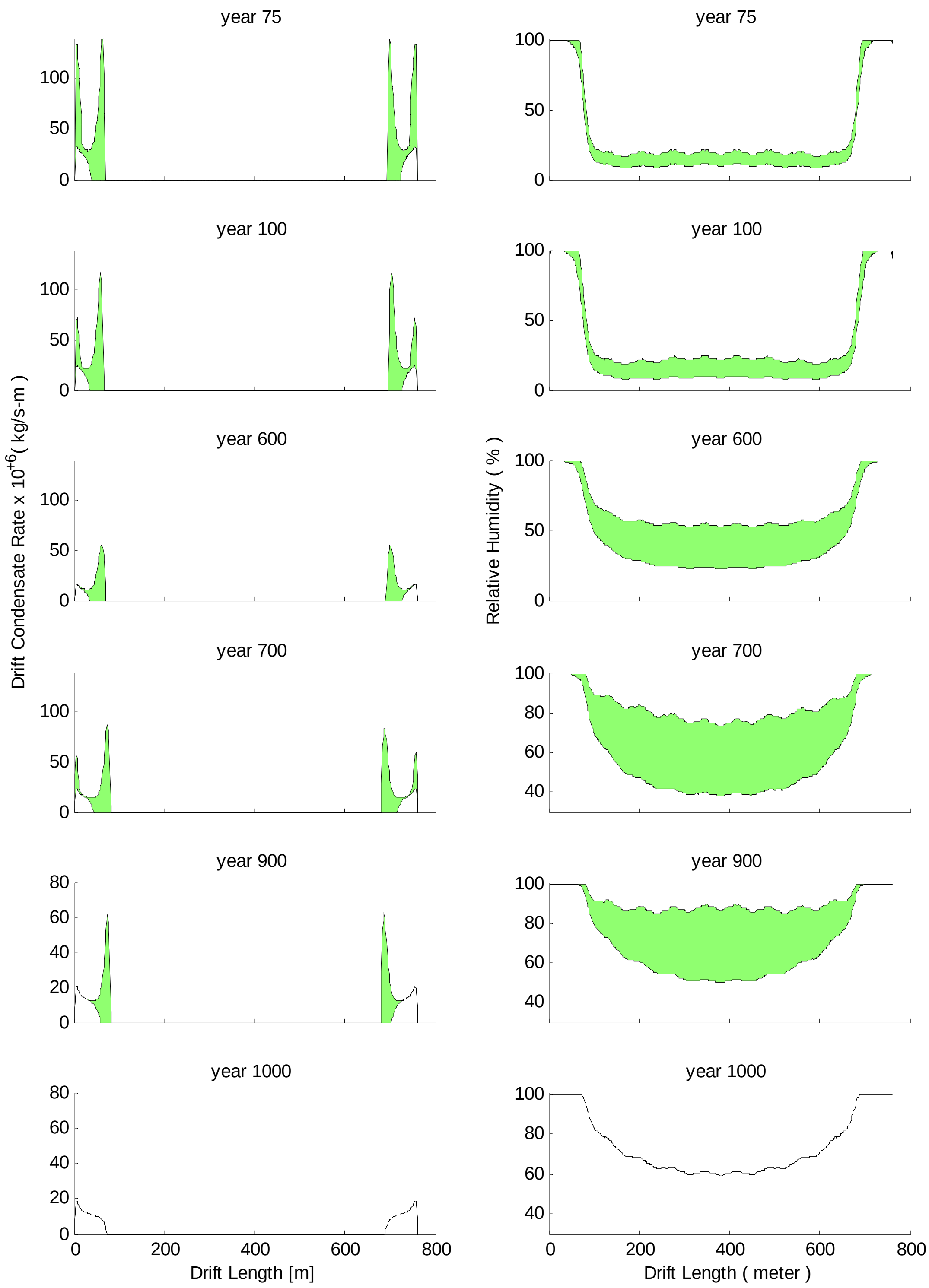

Figure 13. Barometric pressure fluctuation effects on relative humidity and condensation rate, at the sidewalls segment of the drift wall.

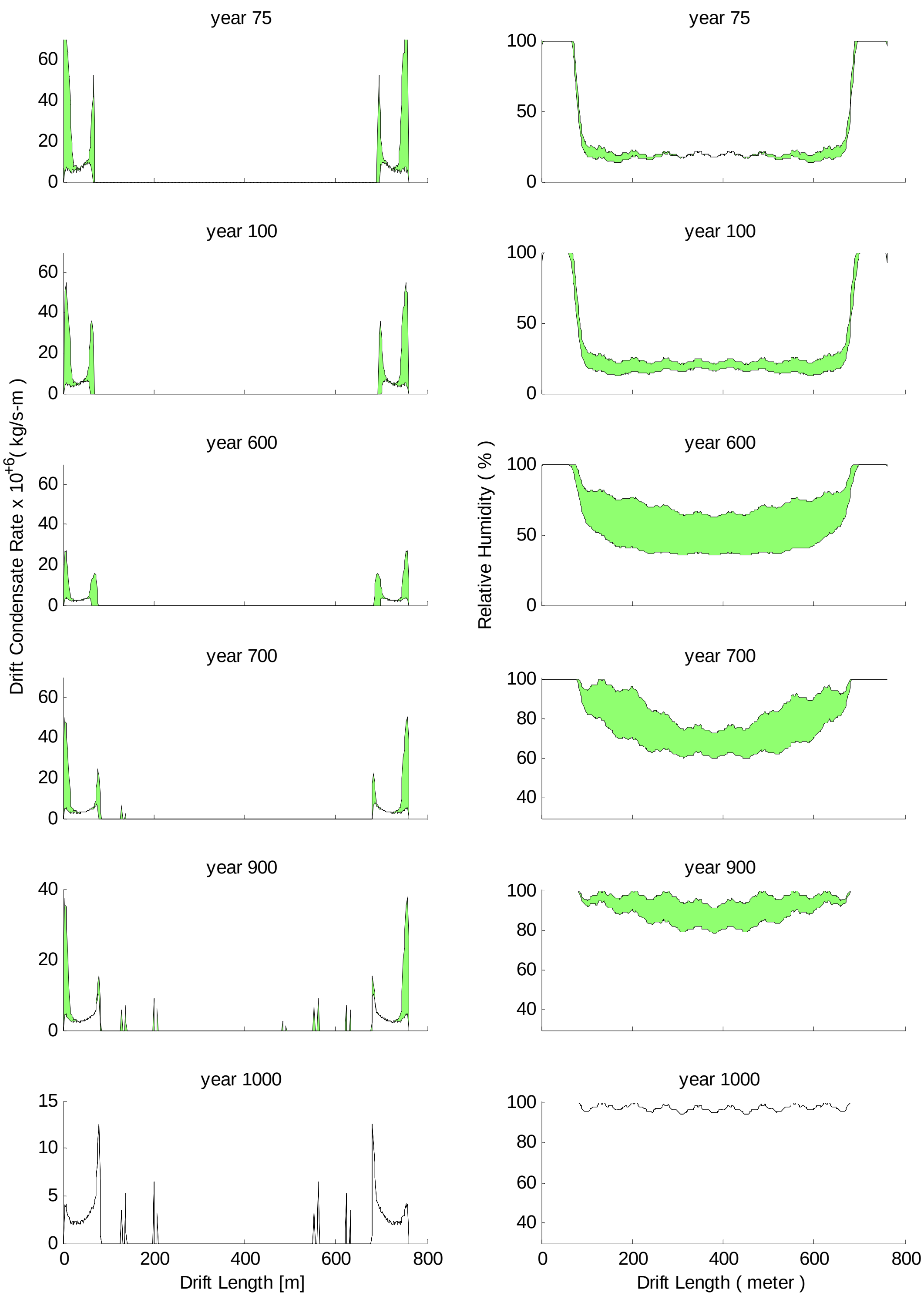

Figure 14. Barometric pressure fluctuation effects on relative humidity and condensation rate, at the floor segment of the drift wall, over the invert.