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INTRODUCTION TO A SPECIAL SECTION

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Special Section:
Major Results From the MAVEN Mission to Mars

Key Point:
- The MAVEN spacecraft is observing the Mars upper atmosphere, its interactions with the Sun and the solar wind, and escape of atmospheric gases to space

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MAVEN observations of the Mars upper atmosphere, ionosphere, and solar wind interactions

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Abstract The Mars Atmosphere and Volatile Evolution (MAVEN) mission to Mars has been operating in orbit for more than a full Martian year. Observations are dramatically changing our view of the Mars upper atmosphere system, which includes the upper atmosphere, ionosphere, coupling to the lower atmosphere, magnetosphere, and interactions with the Sun and the solar wind. The data are allowing us to understand the processes controlling the present-day structure of the upper atmosphere and the rates of escape of gas to space. These will tell us the role that escape to space has played in the evolution of the Mars atmosphere and climate.

The *Mars Atmosphere and Volatile Evolution (MAVEN)* spacecraft has been in orbit at Mars since September 2014. It has completed its one-Earth-year primary mission and has also completed one full Mars year (just under two Earth years) of science observations. The goals of the mission are to understand the composition, structure, and variability of the upper atmosphere system, the energetic drivers of the system and how they affect the controlling processes, how they lead to loss of atmospheric gas to space, and the integrated amount of gas that has been lost to space through time. (We use "Mars upper atmosphere" as shorthand to indicate the neutral upper atmosphere, the ionosphere, the magnetosphere, interactions with the Sun and solar wind, and the resulting energization of atoms, molecules, and ions that can lead to loss to space. Of necessity, this includes some components that stretch to the lower atmosphere or even down to the surface.)

In order to understand the loss to space, we have to start with the very detailed behavior of individual processes and how they can affect sometimes-subtle aspects of the upper atmosphere system. We report many of the key observations from that first year of science observations, including presentation of the full data sets from some of the instruments, detailed analysis pertaining to specific processes in each component of the upper atmosphere system, and implications for loss to space at the present epoch. This collection follows on two previous "first results" sets of papers in November 2015, in *Geophysical Research Letters* and in *Science*, as well as numerous papers published separately.

These results by no means represent the total breadth and depth of ongoing *MAVEN* analyses, nor do they represent the final word on any of the components of the Mars upper atmosphere system. They are, however, a solid beginning of the analysis of a very rich and robust data set, providing a benchmark of where we are in our understanding today.

Analysis of the existing data is continuing, and results continue to be presented and written up for publication. At this writing, the *MAVEN* spacecraft and science instruments continue to perform nominally, with operations being carried out nearly flawlessly by an outstanding team. Now in its second extended mission, *MAVEN* continues to collect data and is producing a longer timeline of observations under different planetary and solar boundary conditions. In addition, new observations have been implemented that will provide additional insights into the Mars system.

However, no single spacecraft can capture all of the important aspects of the Mars environment or all of the complex interconnections between the different components, even just within the upper atmosphere. *MAVEN* observations are now being analyzed in combination with observations from other spacecraft both in orbit and on the surface at Mars. The combination of results from, at present, five different orbiters and two rovers is providing a remarkable set of data that is fundamentally changing our view of the planet. With additional Mars spacecraft getting ready to collect science data or to be launched in the next several years, the interdisciplinary and integrated analyses will become increasingly important for Mars science.

In this set of papers, the topics addressed range from very specific, detailed analysis of individual processes observed at Mars for the first time, up to the integrated rates of loss to space at the present epoch by individual processes and their extrapolation to loss through time. Through these analyses, we are seeing the connections between the upper atmosphere and other components of the Mars environmental system and we are starting to see how the upper atmosphere affects the lower atmosphere and, through it, the surface and geological history. These results are providing a broad perspective on the behavior of the upper atmosphere that can be combined with results from the other spacecraft to provide a compelling new picture of the planet as a whole.