up to 80%, with the greatest effect for the lowest albedos.[7] Arvidson *et al.* [2] also found that for these aerosol optical depths, for "brighter" surfaces of Lambert albedo greater than the transition Lambert albedo of $A_{L,\mathrm{trans},1} \sim 0.15$, the modeled I/F is lower than the Lambert albedo by up to 20%, with the greatest effect for the highest albedos. These changes in the I/F from the expected values without an atmosphere are caused by the aerosols. These general statements apply for wavelengths between 0.6 and 2.6 μm, exempting the CO_2 gas bands between 1.9 and 2.2 μm. For shorter wavelengths between 0.4 and 0.6 μm, a similar behavior applies but with different amplitudes and a transition Lambert albedo of $A_{L,\mathrm{trans},0} = 0.08$ instead of the longer wavelength transition Lambert albedo of $A_{L,\mathrm{trans},1} = 0.15$. For wavelengths in the CO_2 gas bands between 1.9 and 2.2 μm, Arvidson *et al.* [2] modeled that the absorption can be rather deep, with a 50% relative absorption by CO_2 for surfaces of Lambert albedo equal to 0.35 and with a 30% relative absorption by CO_2 for surfaces of Lambert albedo equal to 0.05.

All in all, this variance of behaviors of relatively darker I/F for bright surfaces and relatively brighter I/F for dark surfaces (in the presence of aerosols) is a primary reason for the detailed radiative transfer correction of the CRISM data that we present here. Aerosols reduce contrast; the radiative transfer correction of CRISM data restores much of this contrast. Furthermore, the amplitude of darkening over "brighter" surfaces and the brightening over "darker" surfaces depends on the aerosol content in the martian atmosphere as well as the photometric viewing angles [2], [59]. Wolff *et al.* [59] applied a one-band version of the technique, which we describe here, for MGS-TES broadband albedos over the nonpolar regions of Mars (60° S–60° N), and found that the bright areas of Mars have solarband MGS-TES Lambert albedos that are typically 5% brighter than without atmospheric correction (see [59, Fig. A1]). Wolff *et al.* [59] also found that dark areas of Mars have solarband MGS-TES Lambert albedos that are up to 30% darker than without atmospheric correction. Without radiative transfer correction of aerosol effects over surfaces of variable brightness, the quantitative accuracy of CRISM multispectral products would be significantly diminished.

The structure of this paper is as follows. First, we give a general overview of the pipeline processing used for CRISM multispectral mapping to correct for surface pressure, aerosols, thermal emission, and photometric angles. Second, we discuss the DISORT-based radiative transfer retrieval of Lambert albedos. Third, we describe the climatology of pressure, temperature, and aerosols, where "climatology" is defined as the historical record of these quantities at different places on Mars as a function of Mars year, solar longitude (day of year), and time of day. Fourth, we describe some results from the application of the correction system to several different CRISM multispectral image cubes or map tiles, including a particular example of correcting a CRISM map tile for an area near the landing site for the Phoenix Lander 2007. Finally, we summarize our results and discuss future work.

[7]The term "transition Lambert albedo" means the value of the Lambert albedo (for particular levels of the ice and dust aerosols) that divides the brightened "darker" surfaces from the darkened "brighter" surfaces. $A_{L,\mathrm{trans},1}$ is defined as the value of this transition Lambert albedo for most wavelengths between 0.6 and 2.2 μm. $A_{L,\mathrm{trans},0}$ is defined as the value of this transition Lambert albedo for wavelengths between 0.4 and 0.6 μm.

II. General Overview of Pipeline Processing Used to Correct for Surface Pressure, Aerosols, Thermal Emission, and Photometric Angles

In Fig. 1, we show the processing flowchart for the photometric, atmospheric, and thermal correction system described in this paper. The multispectral data cube in raw EDR format[8] is calibrated to I/F format (preliminary TRDR),[9] which is then converted to a Lambert albedo (A_L) TRDR by correcting the following:

1) photometric effects of different viewing and incidence angles;
2) atmospheric effects of scattering and absorption by CO_2 and aerosols;
3) thermal effects caused by emission of photons by surfaces of different temperature.

The intent of this paper is to describe these different correction modules of our system and to give some examples from the initial applications of this system for retrieving Lambert albedos to multispectral CRISM data. In later papers, we will summarize more comprehensive results, system performance, and the utilization of this system for further scientific studies than those presented here. The scientific ends of this system include improvements in mapping the mineralogy of the martian surface and climatological mapping of gas abundances in the martian atmosphere [27].

In addition, in a later paper, we will discuss in more detail the system for temperature estimation that is summarized in Fig. 1. This paper focuses on the blue-colored lines in Fig. 1, which account for the correction for photometric angles, for surface pressure, and for aerosols. Climatological correction for thermal emission is also included as part of the current system, as outlined also by the blue-colored lines.

The purple-, red-, and green-colored lines in Fig. 1 represent how the correction for thermal emission using higher spatial-resolution techniques for temperature estimation will be phased into the CRISM_LambertAlb system. These higher spatial-resolution techniques for temperature estimation are not yet in use, largely since the thermal spectral bands (at wavelengths > 3.0 μm) have just recently been calibrated. Currently, we rely on the simplest choice of temperature, which is to use the ADR-CL[10] lookup table (LUT) to look up the climatological value of MGS-TES surface temperature [47]. This is represented by a portion of the blue lines in Fig. 1.

We do not correct the MGS-TES surface temperatures for the $\sim$1-h difference in time-of-day between Mars Global Surveyor overflight and MRO overflight. These MGS-TES surface temperatures have $3^\circ \times 7.5^\circ$ spatial resolution in latitude and longitude [47]. The use of surface thermometry from MGS-TES is a proxy for more advanced surface thermometry, which will

[8]Experimental data record (EDR).
[9]Targeted reduced data record (TRDR).
[10]Ancillary data record—climatology.