Introduction: The Spring evolution of the Martian seasonal caps has first been characterized in the visible and thermal infrared spectral ranges allowing the identification of processes involving CO$_2$ ice and mineral dust [e.g. 1,2]. More recently, global time-resolved observations in the near-infrared spectral range obtained by the OMEGA instrument permitted a clear distinction between H$_2$O and CO$_2$ ices as well as a more precise determination of the dust/H$_2$O ice/CO$_2$ ice associations (stratigraphy, mixture…) [3,4].

Three instruments on board the MRO spacecraft, the HiRISE and CTX cameras and the CRISM near-infrared imaging spectrometer, now provide invaluable complementary information on these processes by repeatedly observing selected areas of the Northern and Southern polar areas during spring and summer seasons. Contrary to previous datasets, they only offer a very partial coverage but an extremely high spatial resolution (50 cm / pixel for HiRISE, 20 m / pixel for CRISM).

We present time series of visible and spectral images in both Northern and Southern hemispheres that we analyze in the context of global observations. We use the high spatial and temporal resolution observations to test and refine the general scenarios that were derived from global lower resolution datasets.

Methods: We have studied the evolution with time of 12 different regions of interest around the Martian south pole [5] and of 9 regions around the Martian North Pole. These regions were chosen for the availability of repeated observations with good temporal resolution. In the South, we mostly use data from the first year of MRO operations while we use data from both first and second year of operation in the North to maximize the temporal coverage.

From both HiRISE and CRISM data, we extract and follow the temporal evolution of albedo of selected terrains. In addition, we calculate from CRISM data, the strength of CO$_2$ and H$_2$O spectral signatures that we follow in time as integrated time curves and/or time series of spectral maps. Time series of color images are produced from repeated HiRISE observations in a similar way.

The local evolutions of terrains are analyzed and compared to large-scale evolutions previously obtained by other instruments. Scenarios are then proposed to account for the temporal evolutions of terrains appearance and composition.

Southern Hemisphere: Figure 1 shows a typical example of the temporal evolution of south polar terrains during early spring. It displays many of the features, dark fans, elongated bright features, blue haloes…, described in more details by [5].

![Figure 1: Temporal evolution of a fixed scene in the region of Ithaca (178°E, 85°S) from HiRISE color observations.](image-url)
During later spring ($L_s = 200 – 250^\circ$), we observe from both HiRISE and CRISM a brightening of the volatiles layer accompanied by an increase of CO$_2$ ice spectral signature and a decrease of H$_2$O ice signature. The sublimation of the ice layer from its surface is responsible for these evolutions. Blue haloes around dark fans around $L_s = 200^\circ$ (figure 1c) are caused by the large mineral grains sinking below an optically thin layer of ice at the time of the transition between bottom and top sublimation.

Figure 2: Illustration of the jet activity during early spring, triggered by meter-scale topography. The self-cleaning of the ice layer occurs where local slopes allow to collect the solar light more efficiently at high incidence angle.

After $L_s=250^\circ$, both albedo and CO$_2$ spectral signatures decrease as the progressive sublimation of the volatiles layer results in a patchwork of frosted and defrosted areas until complete defrosting in summer.

Northern Hemisphere: The spring evolution of the northern seasonal cap differs in many ways from the southern cap. The general scenario recently proposed by [4] involves complex and dynamic evolutions of the stratigraphy between the CO$_2$ and H$_2$O ices. As for the southern seasonal cap, high spatial resolution is crucial to confirm and detail the processes suggested by global scale observations. Dynamic evolutions of ice on the northern dune fields have recently been documented using HiRISE images [6].

Figure 3 shows an example of snapshot from a time series of CRISM visible images and near-IR compositional maps obtained for one of the nine studied regions. These images perfectly illustrates the complexity of the temporal evolutions of the studied spectral parameters. In addition to the general evolution of H$_2$O and CO$_2$ band strengths described by [4], we observe spatial heterogeneity at small spatial scales in most of the studied areas. The spatial variability is essentially due to the presence of dune fields or to the topography of the polar layered deposits. In addition, the comparison between the two Martian Springs observed by MRO seems to indicate some significant interannual variability.

As we previously did for the southern seasonal cap, we merge the high resolution color observations of HiRISE into the CRISM spectral maps to get more insights into the dynamic processes occurring at small scale and interpret in terms of ice composition the color variations seen by HiRISE. This allows us to refine the scenarios of the volatile layer sublimation in the northern hemisphere. The comparison of this scenario with the one established for the southern hemisphere is particularly interesting, pointing to major differences, essentially related to the role of water.