THE IDENTIFICATION OF ACETYLENE ON TITAN’S SURFACE. S. Singh1,2, T. B. McCord3, J. P. Combe2, S. Rodriguez4, T. Cornet1, V. F. Chevrier1, L. Maltagliati1, 1Arkansas Center for Space and Planetary Science, University of Arkansas, Fayetteville, AR, 72701 (sxs099@uark.edu), 2Bear Fight Institute, Winthrop, WA, 3Université Paris Diderot, France, 4European Space Astronomy Center, Madrid, Spain.

Introduction: Saturn’s moon Titan possesses a thick atmosphere mainly composed of N2 (95%), CH4 (4.9%) and less than 1% of minor species, mostly hydrocarbons [1][2][3]. According to photochemical models, the dissociation of N2 and CH4 forms acetylene (C2H2) along with other hydrocarbons and nitriles in the atmosphere. These may settle and exist under their solid form at the surface [1]. Over the geological time scale, a C2H2 solid layer, a few hundreds of meters thick would have formed on the surface of Titan [1][3]. The detection of some of the heavier hydrocarbons has been reported in VIMS data by [4]. Although predicted to be among the most produced hydrocarbons in the atmosphere, and therefore probably one of the most abundant at the surface, so far C2H2 has not been detected using VIMS data on Titan’s surface.

In this study we have attempted to find C2H2 on the surface of Titan using 1.6 μm VIMS atmospheric window. We focused on 1.6 μm methane window because one of the deepest C2H2 absorption band (1.55 μm) lies within this window. It is important to note that at longer wavelengths (2-5 μm) C2H2 do not have any major absorption feature within the VIMS atmospheric windows, except a weak absorption at 4.94 μm [4].

Methods: In attempt of finding C2H2 on the surface of Titan we needed high signal to noise spectra of the surface for compositional analysis. To satisfy all the requirements and to select spectral data obtained in favorable geometries (incidence and emergence angles generally lower that 50°), we focused on the equatorial regions of Titan. We selected regions of Shangri la, Tui Regio, Hotei Arcus, and Yalaing Terra and divided each of these regions of interest in two areas depending on the terrain types (bright and dark).

The identification of C2H2 involves two techniques. First, we compute, the band depth at 1.55 μm of the region of interest (ROI’s) i.e. dark and bright terrain by using average spectra of the ROI’s. We also monitor the variations of the 1.55-μm absorption band across Titan (Fig. 1 a,b,c). The variations would be consistent with surface heterogeneity, and therefore it would support the interpretation of the presence of C2H2 in specific areas. On the other hand, the absence of variations would be ambiguous, as it could be associated to a systematic absorption, possibly from the atmosphere, or to an instrument artifact.

In order to check, if the absorption feature at 1.55 μm is coming from the surface and not an atmosphere artifact, we used a Radiative Transfer (RT) model [5][6]. We extracted the mean viewing conditions in the regions of interests (incidence, emergence/emission and phase angles) for the VIMS cubes and performed an inversion using RT model with a uniform surface albedo of 0 and 1 in order to test 1) the influence of the average brightness of the surface and 2) the influence of the atmospheric absorption on the C2H2 absorption feature detectibility (Fig. 1e). This test allows to ensure that the absorption and its possible deepening cannot be caused by the methane gas only but is coming from a real surface feature.

The second technique involves the way to improve the detection criteria for C2H2 in the VIMS data and to avoid any false detection. The criterion uses the ratios of the slope of 1.54 to 1.55 μm and slope between 1.54 and 1.59 μm. It writes as: [1-(slope b/w 1.54 and 1.55/5 μm)] (slope b/w 1.54 and 1.59 μm).

Using calculations from RT model for surface albedo ranging from 0 to 1 with 0.1 increments, figure 2 shows that C2H2 shows up quite readily with respect to any other constant surface albedo. Making this assumption of a flat surface albedo in such short wavelength range (1.54-1.59 μm) as a “no detection” reference is fully reasonable, indicating if there is a local absorption around 1.55 μm.

Results/Discussion: According to the band depth calculation (technique #1) the band depth seems to increase where the surface albedo is higher. This is the general trend we observe from dark to bright terrains. There is undeniably a positive correlation between surface albedo and band depth at 1.55 μm. Variations are small (~2-5%) but they define surface units that are spatially coherent (Fig. 1d). A bright surface component such as C2H2 with an absorption band at 1.55 μm could explain the observation.

Using RT model we performed 3 simulations, two are for a constant surface albedo of 0 and 1 and the last one is for a surface covered with C2H2 (Fig. 1E). The 1.55 μm "shoulder" in the wing of the 1.6 window is well simulated and we can see that its "slope" is quite sensitive to surface albedo and of course to the presence of C2H2 (Fig. 1E).

For each mean viewing conditions (incidence, emergence and φ) of each ROI, a pure C2H2 spectra is simulated with the respective atmospheric influence. Spectra using the same conditions are also generated for uniform albedos of 0 and 1 at all wavelengths (so we have the cases of perfectly bright and dark surfaces in addition to the C2H2 one).
We saw in the simulated spectra of C$_2$H$_2$ (in red in fig. 1E) the negative slope at 1.55 µm due to the absorption of C$_2$H$_2$ under all viewing conditions. This slope is theoretically not present if the area is rather uniformly bright with wavelength (there is a neutral to positive slope), which can be explained with the overall shape of the spectrum of brighter terrain. The slope seems to shift with higher reflectance. The negative slope is almost not perceptible if the area is uniformly dark with wavelength (very slightly negative to neutral, on the figure with the albedos of 0.1 and 0.3) (Fig. 2 black line). In summary, the view of the absorption at 1.55 micron seems quite independent of the viewing geometry if the angles of incidence/emergence are lower than 60 degrees and even with the presence of the atmosphere we can see the absorption feature.

For the “second” criterion we considered a mixture of [C$_2$H$_2$/constant alb. of 0, 0.5 and 1.] ranging from 100% (pure C$_2$H$_2$) to 10% C$_2$H$_2$ (Fig. 2). C$_2$H$_2$ largely dominated the criterion down to 40-50% mixture. Below 40% of C$_2$H$_2$ a surface of constant albedo begins having some influence on the spectral behavior. At the same time, C$_2$H$_2$ begins being almost indiscernible from a surface of constant albedo, thus almost undetectable.

**Conclusions:** We have successfully identified solid C$_2$H$_2$ on the surface of Titan using 1.6 micron VIMS atmospheric window. The C$_2$H$_2$ abundance differs from dark to bright terrains. The band depths of C$_2$H$_2$ at 1.55 µm appear significantly larger in bright terrain than dark terrains suggesting higher quantity of C$_2$H$_2$. However, the negative slope at 1.55 µm in dark terrains also suggests some amount of C$_2$H$_2$. Further work is ongoing in order to better emphasize the C$_2$H$_2$ detection based on couples criteria and compute detection maps.