



Determination of Mars clouds' altitude on amateur images and implication on new types of clouds

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- Clouds on illuminated surface well known and monitored by probes
- Transient clouds on the night side or above the limb have special interest
- Key element to study them is their altitude, which can be determined from amateur astronomers' monitoring

➤ What can be measured for a cloud feature:

- Pos_{proj} the **projected position** (e.g. latitude and longitude) when it is visible on the surface of the planet *below the limb*
- H_{limbproj} the **projected limb altitude** *when it is above the limb*
- H_{termproj} the **projected terminator altitude** above the terminator when it is on the night side whether below or above the limb

**Apparent
limb altitude**

**Apparent
terminator altitude**

WinJUPOS provides:

Date, Mars' geometric information

1. Julian Day
2. Longitude of Central Meridian (=CM)
3. Declination of **Earth** (=CLat)
4. Longitude of **subsolar** point (=IS)
5. Latitude of **subsolar** point (=bS)

Cloud feature measurements

6. **Projected position** on Mars disk
(in Mars' radius) POS_{proj} (=X, Y)
7. Projected longitude Pos_{proj} (=L1)
8. Projected latitude Pos_{proj} (=B)
9. **Projected altitude** above **limb** $H_{limbproj}$ (km)
10. **Projected altitude** above **terminator** $H_{termproj}$ (km)

*NB: 1, 9 and 10 are only provided
(with the other values) in clipboard*

WinJUPOS 12.0.9 - Database for Object Positions on Mars - [Measurements of Mars images 2020-11-17-2016.6-EBa-R]

Program Recording Analysis Lists Administration Tools Window Help

Imag. Adj. Pos. Misc. Opt. CM 163,8° CLat -23,9° tS -4,3h lS 136,7° X -0,576 NR Close

L 201,6° B +19,8° nS 16° bS -17,1° Y +0,611 Help

Cross-wires

X	-0,904
Y	-0,384
L1	253,1°
tS	-7,8h
aS	-15°
B	-25,2°

Type: Small with outline

Size (F6): 10

Draw cross-wires (Space)

Measurements file: EBa.meas

Save object position

Measured object positions

- Display (Ctrl+Space)
- No later measurements
- Object descriptions

Size: 1

In time interval ± 1 minute(s)

2020/11/17 20:16,6 G:\OneDrive\work\2021-Lilsten-Mars aurores\2020-11-17 EBa\rawim2020-11-17_20-16-33_R_EBa. 0 180,2 pixels 0,0940° / pixel RotA 357,29°

First ex: **cloud above limb**^a

Sanchez-Lavega et al., Nature 2015

Measures ($H_{limbproj}$, Pos_{proj}) from different observations over time (colored circles)

Assumption that cloud position is the one for which the apparent terminator altitude is the highest

Confirmation by matching observations with simulations (dashed colored lines) from equations (profile of projected altitude for different real altitudes)

$$H_{limbproj\,simu} = f(H_{actual}, Pos_{proj}, geometry)$$

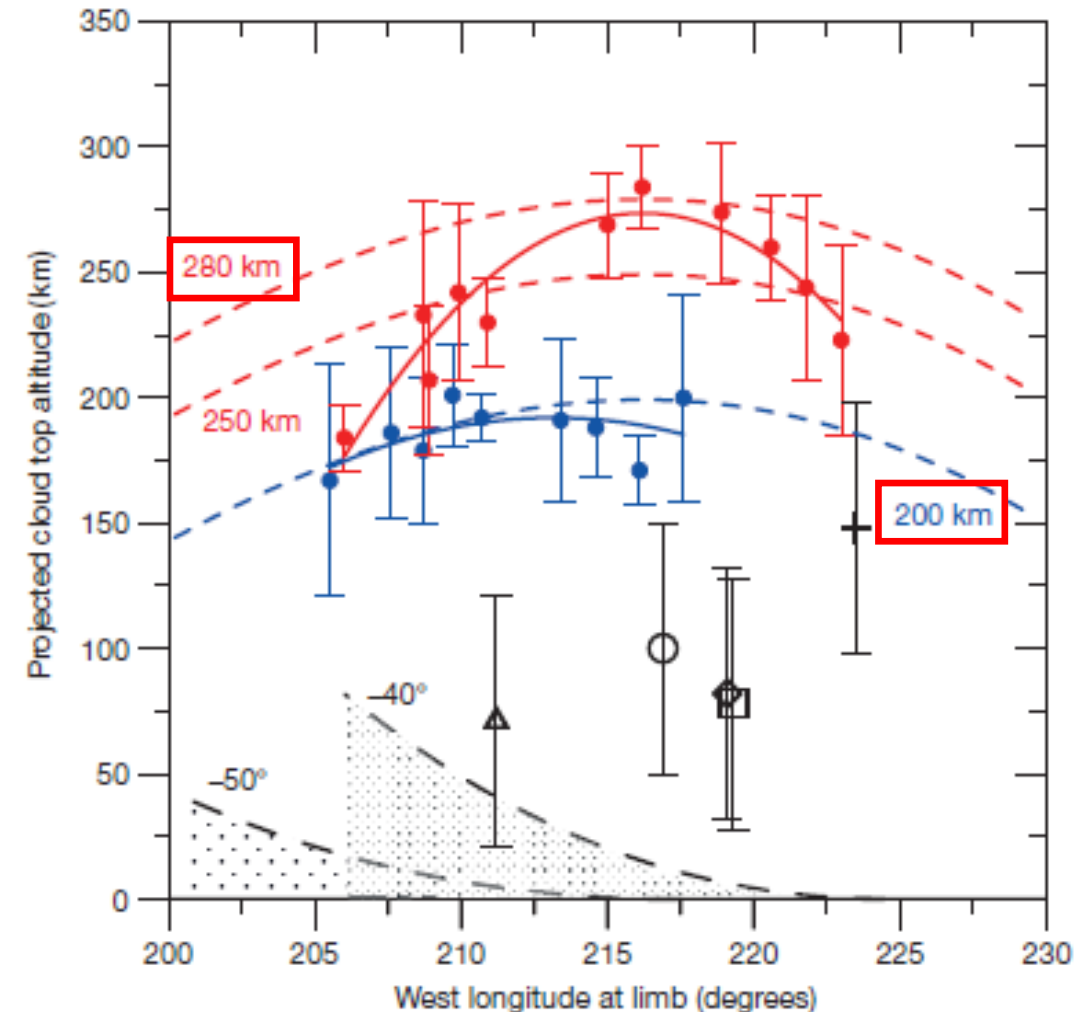
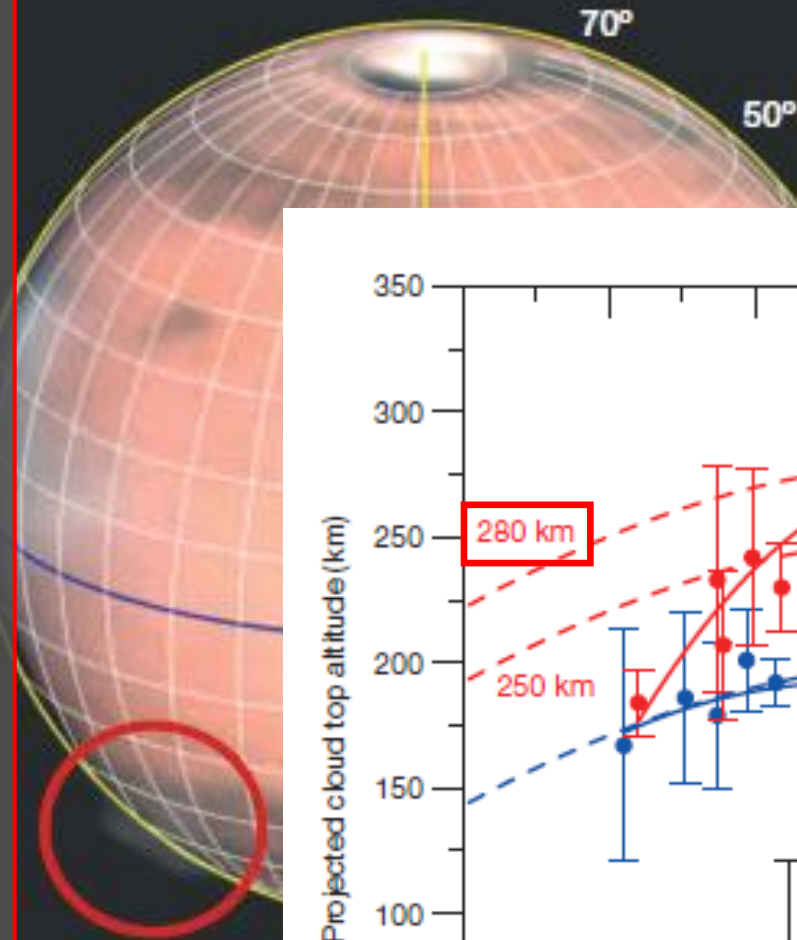


Figure 2 | Plume top altitude and its rapid changes. Filled circles show the

m2020-11-17_20-16-33_R_EBa

m2020-11-17_20-40-01_R_EBa

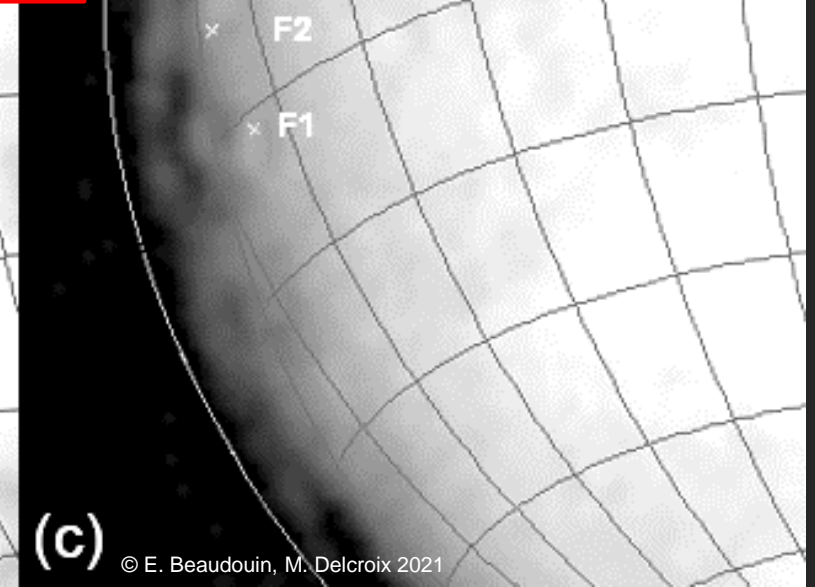
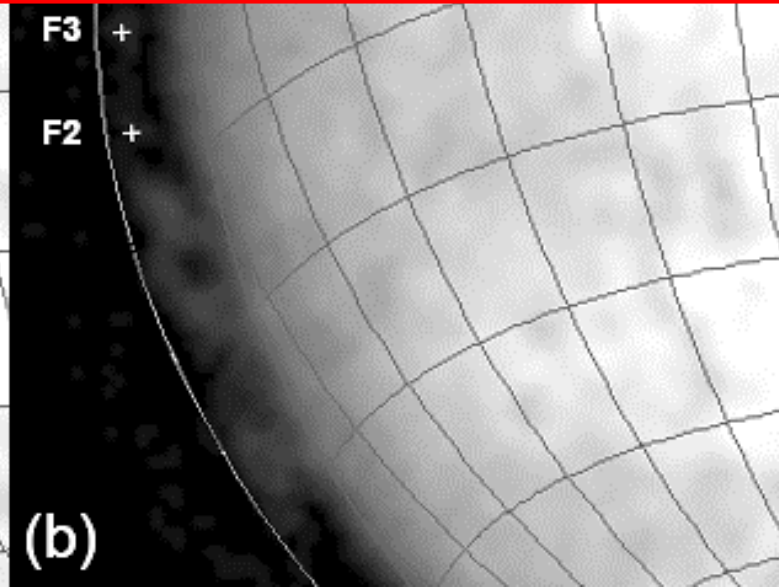
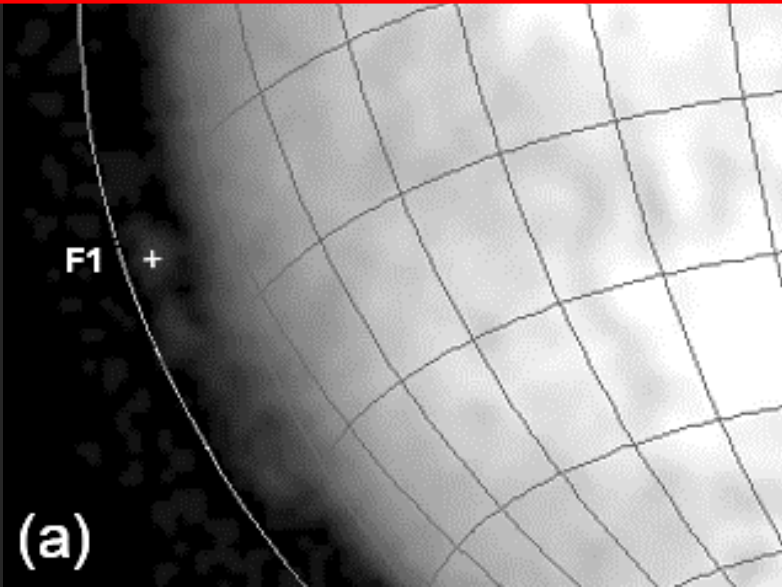
m2020-11-17_21-46-30_G_EBa

Second ex: clouds emerging from shadow (below limb) Lilensten et al., submitted 2021

Assumption of emergence (because of sudden appearance, feature looking like rotating into view)

Confirmation by matching cloud features' eastern front Pos_{proj} (lat., long.) over time vs their assumed at emergence

Altitude $H_{actual} = H_{shadow} = f(H_{limbproj}, Pos_{proj}, geometry) = \sim 90km$



- ❑ Amateur observations useful for studying limb/night side Mars' clouds and their altitudes
- ❑ WinJUPOS performs the relevant measurements
- ❑ Altitude determination with different approaches:
simulations vs observations
emergence from planet's shadow
- ❑ Scientific proven value for studying specific clouds and their composition