

# Dynamics of the extremely elongated cloud on Mars Arsia Mons volcano

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We report a previously unnoticed annually repeating phenomenon consisting of the daily formation of an extremely elongated cloud extending as far as 1800 km westward from Arsia Mons. It takes place in the Solar Longitude (Ls) range of  $\sim 220^\circ$ - $320^\circ$ , around the Southern solstice.

This cloud exhibits a very rapid daily cycle: its growth starts before sunrise on the western slope of the volcano, followed by a westward expansion that lasts 2.5 hours with a velocity of around 160 m/s in the mesosphere ( $\sim 45$  km over the areoid). It evaporates before the afternoon, when most sun-synchronous orbiters observe.

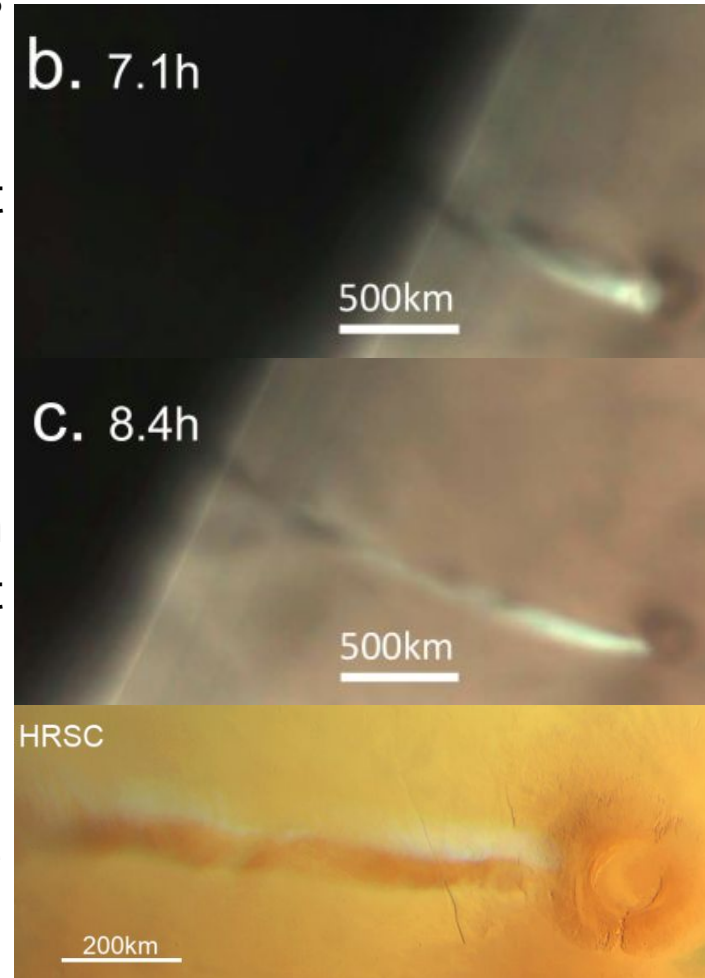
Hernández-Bernal et al. (2020) *An Extremely Elongated Cloud over Arsia Mons Volcano on Mars: Life Cycle*. Submitted to JGR.

# Context

Mars clouds and dust masses have been widely studied across the years as part of the efforts to understand the climate of Mars. The first half of the Martian Year is known to be the cloudy season, and the second half is known to be the dusty season. Clouds of orographic origin are very common around Mars giant volcanoes, mostly in the Tharsis Region, in fact, the topographically forced circulation around these volcanoes plays a significant role in the vertical transport of materials and the global circulation.

In the last few decades of Mars exploration most orbiters have been placed in sun-synchronous orbits around the afternoon, this is great for some studies, but it means that few observations at diverse local times have been acquired.

Here we report a very particular cloud of orographic origin, rising from the Arsia Mons volcano in Tharsis, it forms for a long season in the second half of the Martian Year (Ls 220°-320°), and it is only visible in the early morning, thus it has been imaged sparsely.



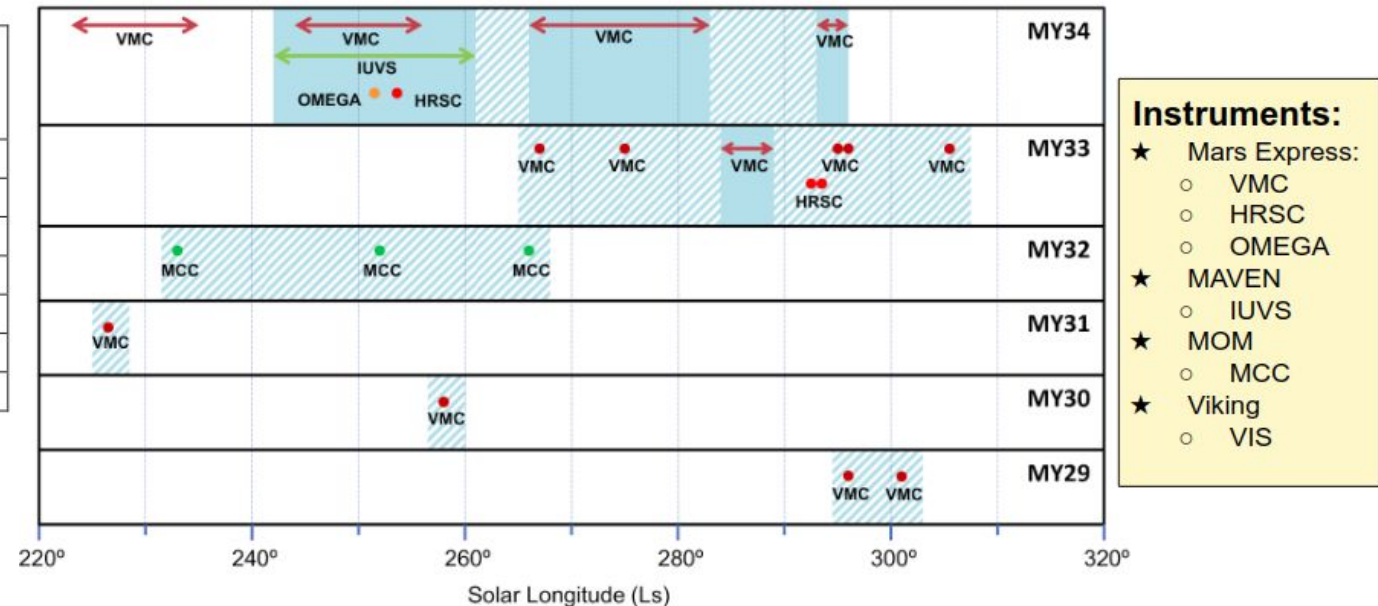
# Dataset and methodology

We first noticed the Arsia Mons Elongated Cloud (AMEC) in september 2018 in images from VMC onboard Mars Express, then we found that it was also there in some VMC images from previous Martian Years in the same season.

We have used data from VMC, HRSC and OMEGA onboard Mars Express, IUVS on MAVEN, MCC on ISRO's MOM orbiter, and visible cameras on Viking Orbiters. We have also used MRO/MARCI images as support, however MARCI observes only in the afternoon and thus it did not capture the phenomenon.

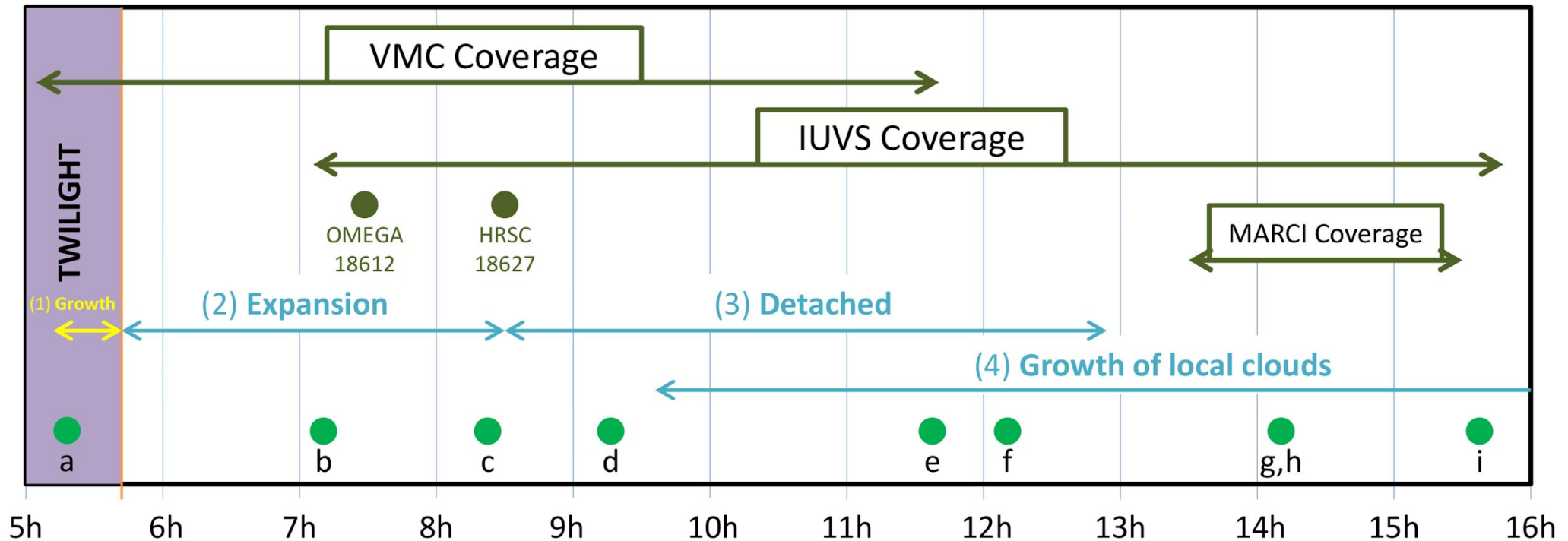
Observations of the AMEC along the years

Instrument	Spacecraft	Number of observations	Spatial resolution (km px <sup>-1</sup> )	MY
VMC	Mars Express	63	12	29,30,31,33,34
HRSC	Mars Express	3	1	33,34
OMEGA	Mars Express	1	5	34
IUVS	MAVEN	29	10	34
MCC	MOM	3	1	32
VIS	Viking 2	2	1	12
MARCI	MRO	*	1	28 – 34



# Results - Daily Cycle

We study the AMEC Daily Cycle in detail in Martian Year (MY) 34 in terms of Local True Solar Time (LTST) and find that it exhibits a very rapid daily cycle: the cloud growth starts before sunrise on the western slope of the volcano, followed by a westward expansion that lasts 2.5 hours. The cloud formation then ceases, it detaches from its formation point, and continues moving westward until it evaporates before the afternoon, when most sun-synchronous orbiters observe.



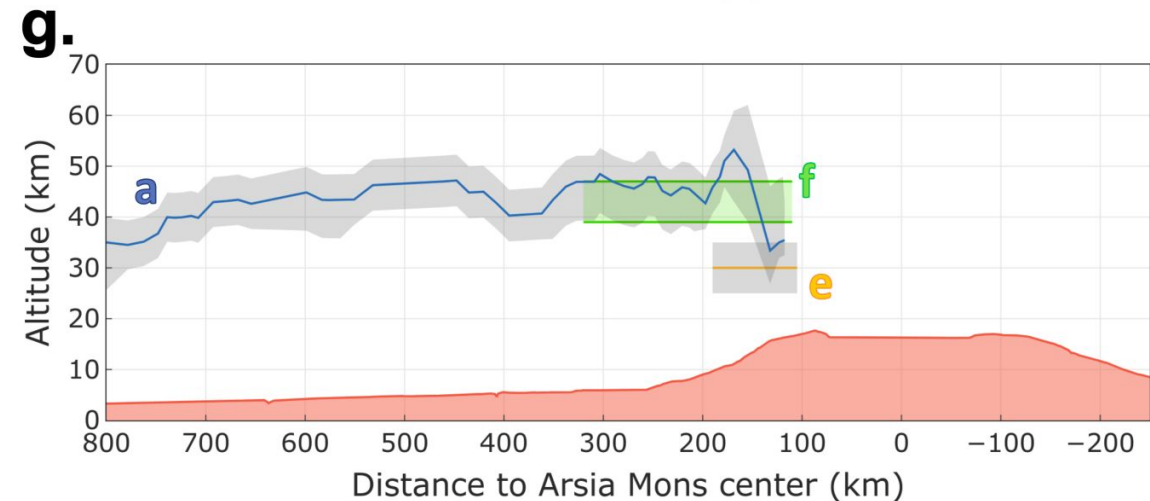
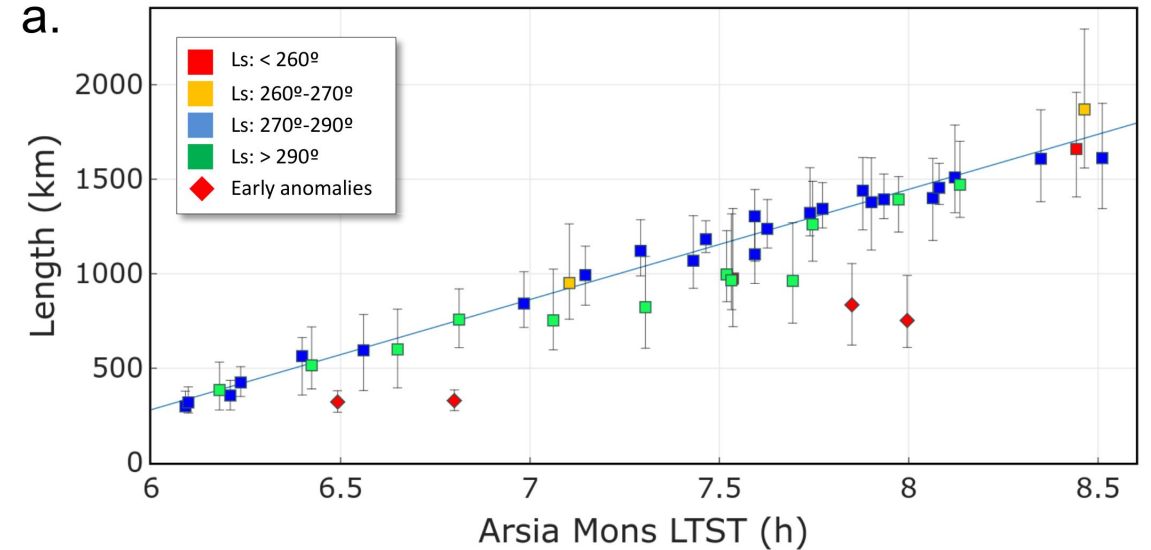
# Results - Velocity and altitude

## Velocity

We measure the length of the AMEC on images from different sols, we find that except in the early season, the expansion of the cloud is very regular. We measure by linear fit an expansion velocity of  $\sim 160\text{m/s}$

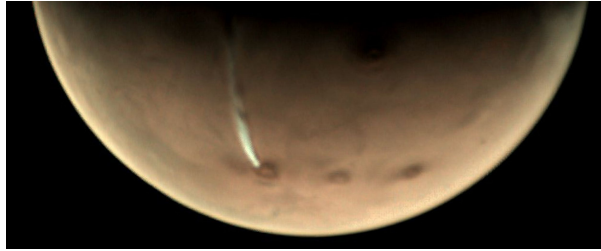
## Altitude

From shadows, limb observations, and twilight observations, we infer an altitude of  $\sim 45\text{km}$  (mesosphere) over the areoid, and probably an ascent during twilight.



# Impact and Prospects for the Future

We found a previously observed but unnoticed annually repeating phenomenon consisting in an elongated cloud extending very fast in the mesosphere from Arsia Mons volcano. We find that some previously reported elongated clouds show a number of similarities and might be result of the same subjacent physics, we refer to the Valles Marineris Cloud Trails and the elongated clouds from Ascræus Mons reported in the Viking era.



Arsia Mons Elongated Cloud  
*AMEC*, This work



Ascræus Mons Elongated Cloud  
*AsMEC*



Valles Marineris Cloud Trails  
*VMCT*, Clancy et al. (2009)

We are now keeping an eye on Arsia Mons, as we expect a new *AMEC* on Martian Year 35. All these elongated clouds are annually repeating phenomena and we plan to include them in a bigger study about the interannual variations of the martian climate based on annually repeating meteorological events used as proxies for the general state of the atmosphere.

We also find that much of our knowledge about the martian climate is based on afternoon observations by sun-synchronous orbiters, and that might be a bias, as the martian meteorology evolves very fast with local time.