Un programme de science participative découvre un nuage atypique de 3000km sur Mars

Jean Lilensten, Jean-Luc Dauvergne, Christophe Pellier, Marc Delcroix, Emmanuel Beaudoin, Mathieu Vincendon

IPAG - CNRS

OSUG

Sérendipité ?

- La réponse est 4. Quelle est la question ?
(*Le guide du routard intergalactique, Douglas Adams, 1978*)

- « Derrière chaque nombre se trouve une question »
(*Hubert Reeves, Poussière d'étoile, 1976*)

- « J'ai remarqué que pour réussir dans la vie, il faut beaucoup de chance. Mais j'ai aussi remarqué que plus je travaille, et plus j'en ai » (*Abraham Lincoln*)

- La sérendipité, c'est donc beaucoup travailler pour essayer d'avoir la chance de trouver la question à laquelle répond correctement une observation qu'on fait dans un autre but…

- « Si vous avez compris ce que je viens de dire, c'est que je me suis mal exprimé » (*Alan Greenspan, Banque centrale américaine*)

Le prix Gemini ?

A&A 661, A127 (2022)
https://doi.org/10.1051/0004-6361/202141735

Astronomy & Astrophysics

Observation from Earth of an atypical cloud system in the upper Martian atmosphere*

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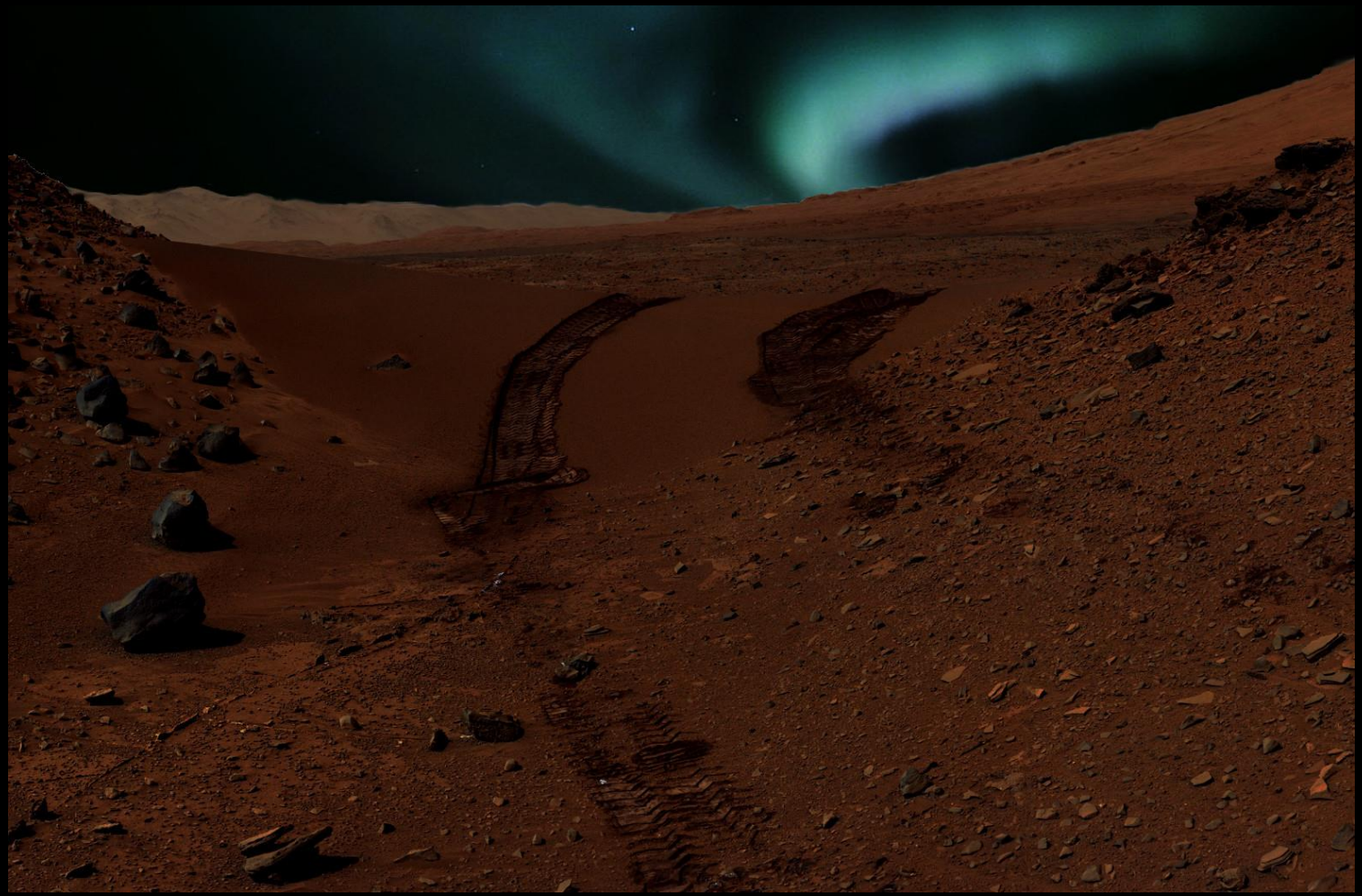
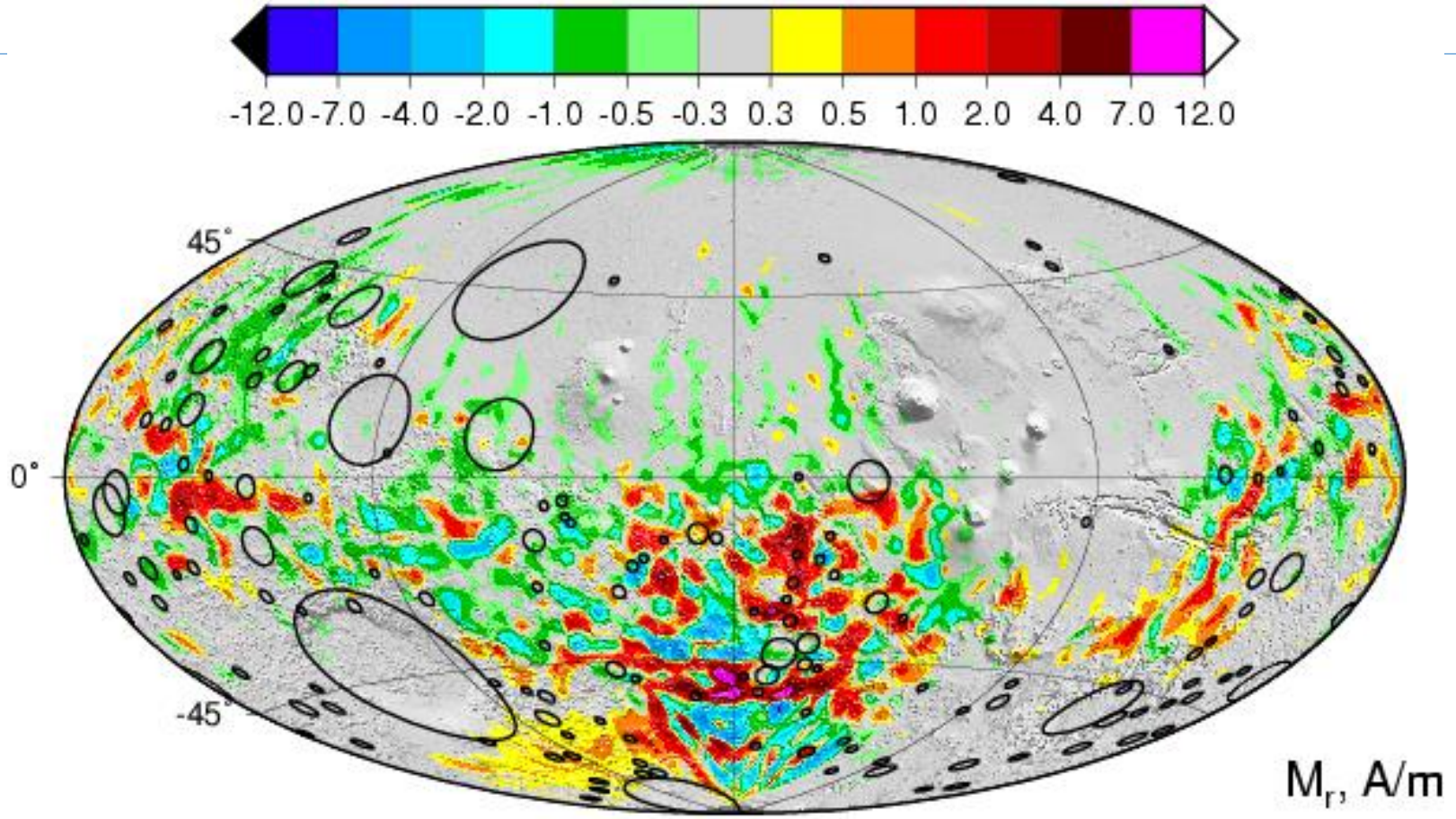
Received 7 July 2021 / Accepted 14 February 2022

ABSTRACT

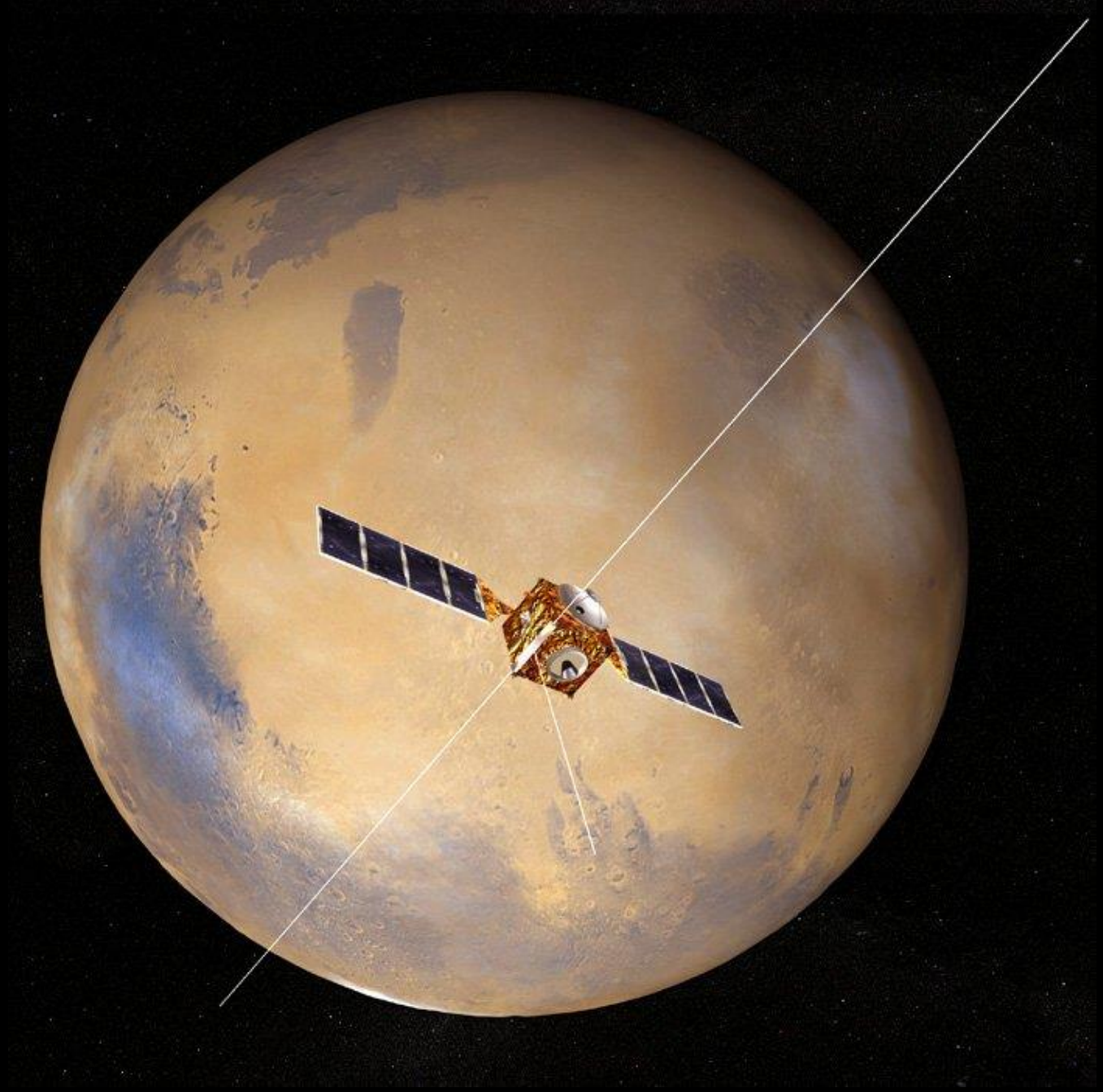
Context. The atmosphere of Mars is characterised by a complex seasonal cycle of cloud formation related to the condensation of CO_2 and H_2O, and to the lifting of surface dust. Several decades of spacecraft observations have provided an impressive amount of data to

Cette fois, tout est parti de la recherche d'aurores sur la planète Mars …





2001: découverte d'un champ magnétique crustal (MAG-ER sur Mars Global Surveyor), essentiellement dans l'hémisphère sud.



2005 : découverte des aurores martiennes, mais seulement dans l'UV par l'instrument SPICAM sur MEX (ESA) au dessus des anomalies magnétiques (Bertaux et al., Nature)

nature Vol 435|9 June 2005|doi:10.1038/nature03603

LETTERS

Discovery of an aurora on Mars

Jean-Loup Bertaux[1], François Leblanc[1], Olivier Witasse[2], Eric Quemerais[1], Jean Lilensten[3], S. A. Stern[4], B. Sandel[5] & Oleg Korablev[6]

In the high-latitude regions of Earth, aurorae are the often-spectacular visual manifestation of the interaction between electrically charged particles (electrons, protons or ions) with the neutral upper atmosphere, as they precipitate along magnetic field lines. More generally, auroral emissions in planetary atmospheres "are those that result from the impact of particles other than photoelectrons" (ref. 1). Auroral activity has been found on all four giant planets possessing a magnetic field (Jupiter[2], Saturn[3], Uranus[4] and Neptune[5]), as well as on Venus, which has no magnetic field[6]. On the nightside of Venus, atomic O emissions at 130.4 nm and 135.6 nm appear in bright patches of varying sizes and intensities[6], which are believed to be produced by electrons with energy <300 eV (ref. 7). Here we report the discovery of an aurora in the martian atmosphere, using the ultraviolet spec-

identified recently[16] as the γ and δ bands of the nitric oxide (NO) molecule, emitted when O and N atoms recombine, after having been produced by solar extreme UV photo-dissociation of CO_2, O_2 and N_2 on the dayside and transported to the nightside.

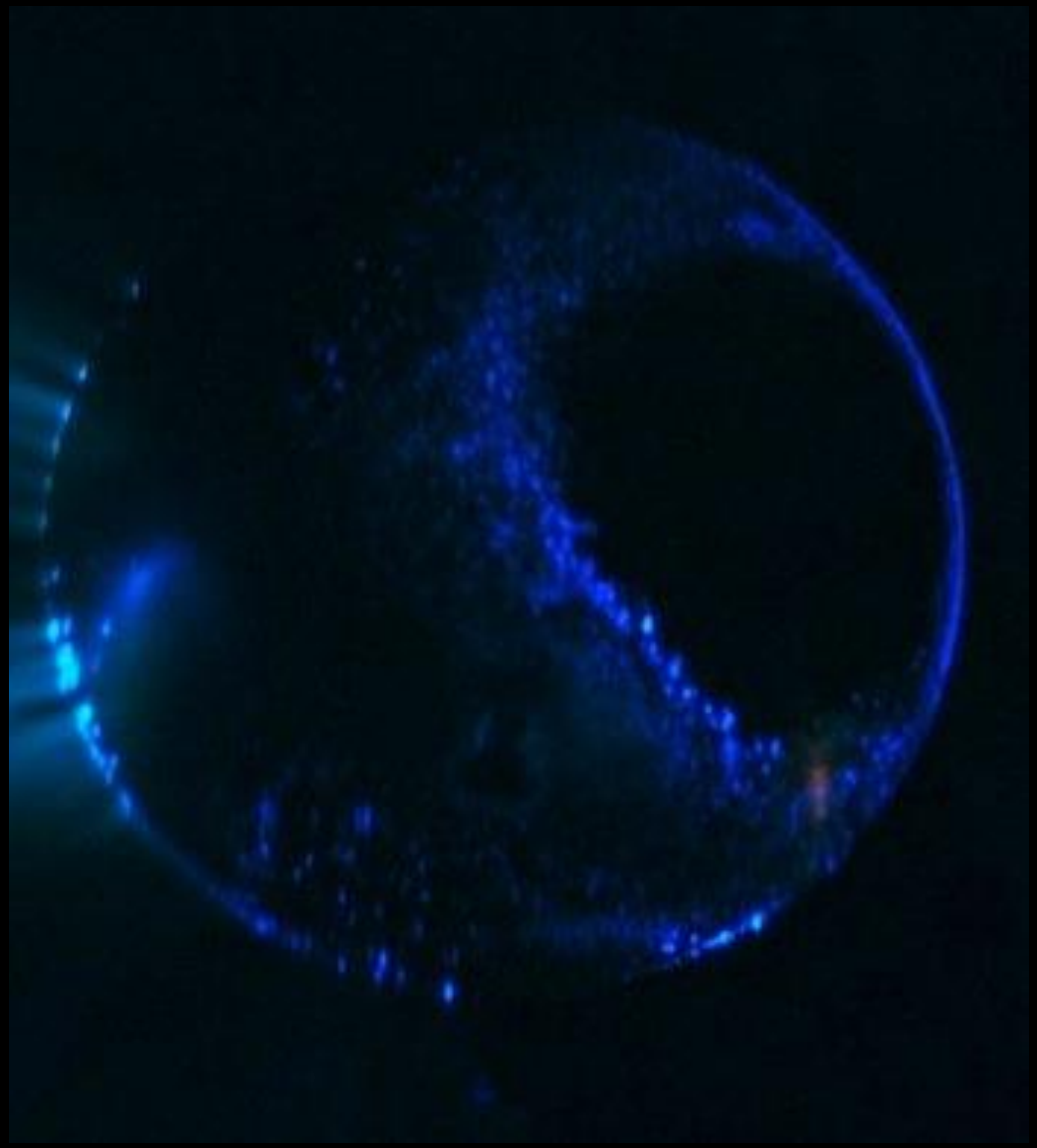
In Fig. 1b the nightglow signal integrated over the wavelength range of the NO bands (181–298 nm) is displayed as a function of time for the five spatial bins. The signal is more intense for spatial bins 3, 4 and 5 than for spatial bins 1 and 2 because the FOV is wider and the source is extended. All curves show the same behaviour, almost identical to the variation of the NO emission observed six days later at orbit 734[16]; this behaviour is explained by the variation of the altitude and the latitude of the Mars nearest point (MNP) when the LOS scans across the NO emitting layer—this layer is confined in the altitude range 60–80 km, and is more intense at large

Les Américains n'étaient pas contents… Ils ont appelé ça des « phénomènes de type auroral »

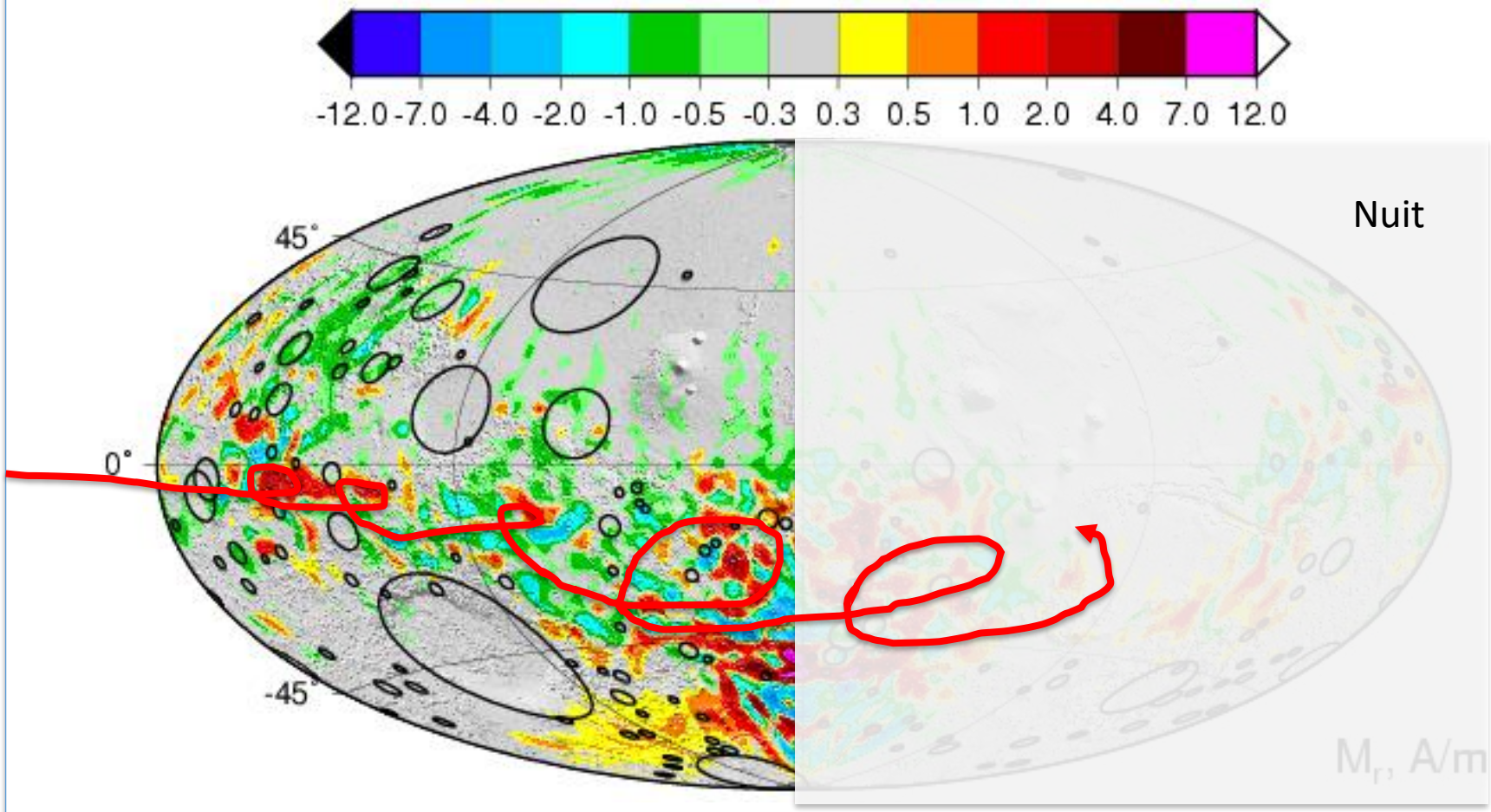
Il y a eu une polémique sur l'énergie du vent solaire que j'avais calculée. Et ça, ça me troublait…

2007 : Je mets au point un simulateur auroral, la Planeterrella.

En 2012, on peut y injecter d’autres gaz que l’air.



Des aurores d’un bleu intense !



Par la modélisation et la comparaison avec des données sur Vénus, nous avons pu montrer que cela se produit quelques fois par cycle solaire, juste avant le lever du soleil ou juste après.

- Bleues (N2+) et vertes (O) à 140 km
- Rouges (O) à 160 km

Contents lists available at ScienceDirect

Planetary and Space Science

journal homepage: www.elsevier.com/locate/pss

Prediction of blue, red and green aurorae at Mars☆

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ARTICLE INFO

Article history:
Received 17 June 2014
Received in revised form
17 April 2015
Accepted 22 April 2015

Keywords:
Mars
Aurora

ABSTRACT

The upper atmosphere of Mars is a laboratory for better understanding the planetary atmosphere evolution, and is an example of the interaction of the solar wind with an unmagnetized planet that has only patches of crustal magnetic field. In that context, several space missions were launched to study the Martian environment and its aurorae, notably ESA's Mars Express discovered the first aurora-like structures, and more recently NASA's MAVEN, which is dedicated to understand the atmospheric escape. However, none of the existing missions have spectrometers in the visible spectral range for the observation of the upper atmosphere and the aurorae, but there are UV spectrometer which can be used to infer visible aurora emission.

The UV aurorae on Mars have a counterpart in the visible spectral range which should be detectable under the right conditions. We discuss what are the most favorable conditions to observe these aurorae discernible with the naked eye. In this paper, we simulate the Martian aurora in the visible spectral range both with an experimental setup (the Planeterrella, which we use to measure intensity with respect to the naked eye) and with a numerical ionosphere simulation model (Trans*/Aeroplanets). We show that the electron impact on CO_2 produces strong emissions at 412 nm and 434 nm, i.e., in the blue part of the visible spectrum which are due to the CO_2^+(A) Fox–Duffendack–Barker bands. The modeling of the electron transport at Mars shows that these blue emissions as well as the emissions of the 630 nm (red) and 557.7 nm (green) lines of atomic oxygen may be observable several times during a solar cycle during strong solar events.

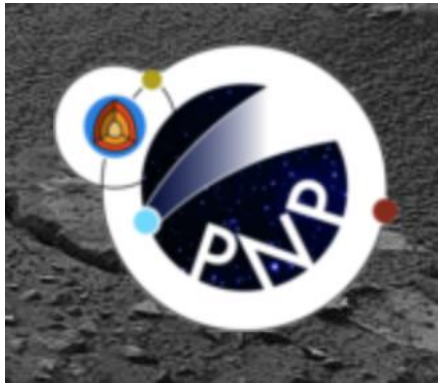
The absence of visible spectrometers dedicated to these observations onboard existing space missions and the location of the different Martian rovers, far from the vertically aligned crustal magnetic field lines of Mars, have prevented so far the observations of such an aurora. In the foreseeable future, two missions may help observing these aurorae: the exo-Mars/Trace Gas Orbiter mission will carry a visible spectrometer which could be used to detect these events in the visible spectral range. NOMAD (Nadir and Occultation for Mars Discovery) will carry a UV-visible spectrometer in the 200–650 nm range.

1. Introduction

The aurora at Mars was discovered in 2005 by Mars Express (MEX). The detection (Bertaux et al., 2005a) was made by the UV channel of the SPICAM instrument. These aurorae are located close

references therein). However, these aurorae have only been studied in the UV, mainly due to lack of instrumentation able to observe the counterpart in the visible spectral range (Section 2.2). At Venus, continuous and highly variable emissions at 130.4 nm have been observed on the nightside by the Pioneer Venus Orbiter ultraviolet

Sur une idée (fantastique) de Jean-Luc Dauvergne (AFA / Ciel et Espace), nous contactons 10 astrophotographes amateurs. Sur un financement du Programme National de Planétologie (merci!), je leur paye des filtres bleus.



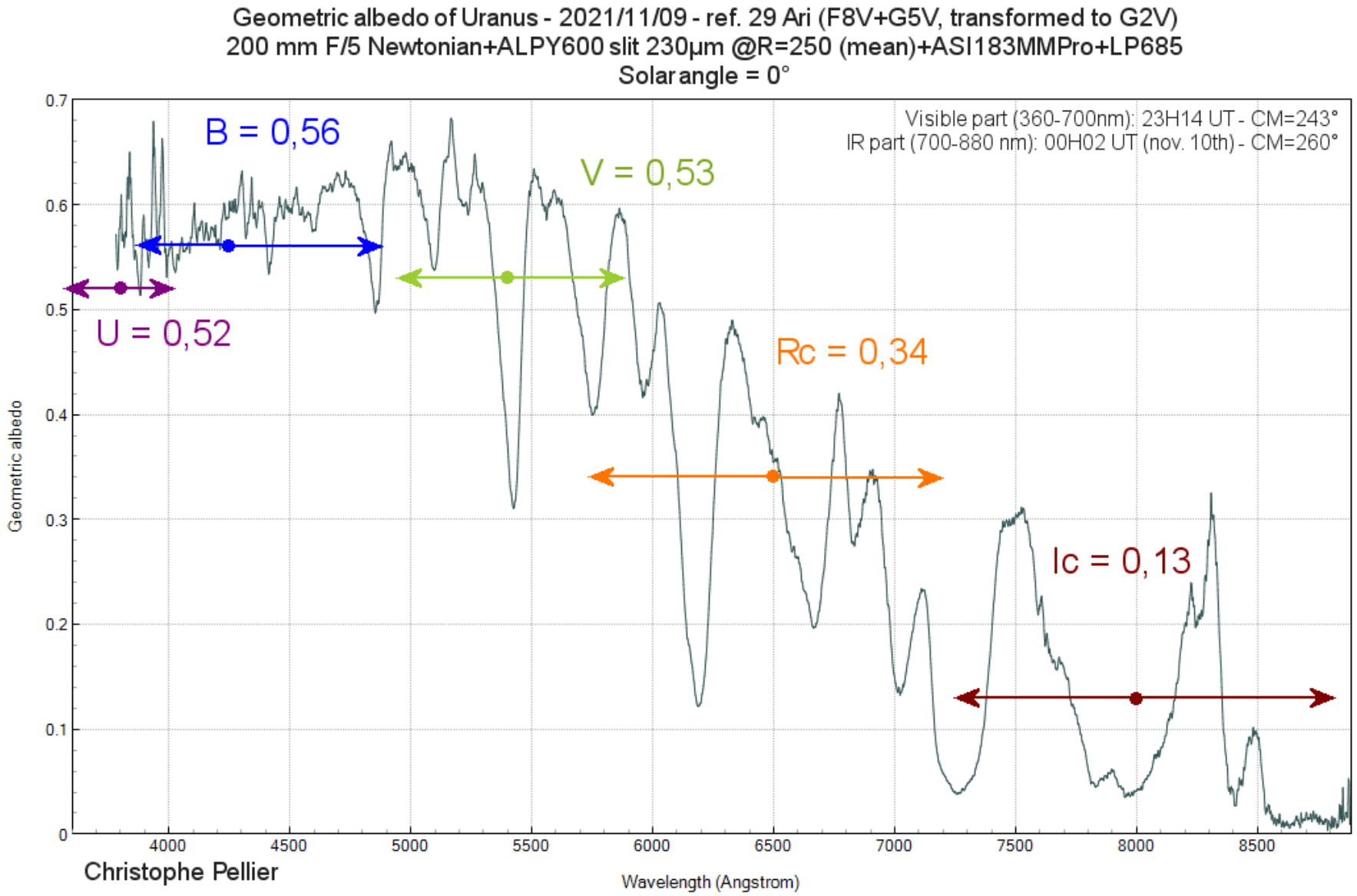
Jean-Luc Dauvergne, Christophe Pellier, Marc Delcroix, Emmanuel Beaudoin, Emil Kraaikamp, Guillaume Bertrand, Clyde Foster, Christopher Go, Emmanuel Kardasis, Alexei Pace, Damian Peach, Anthony Wesley

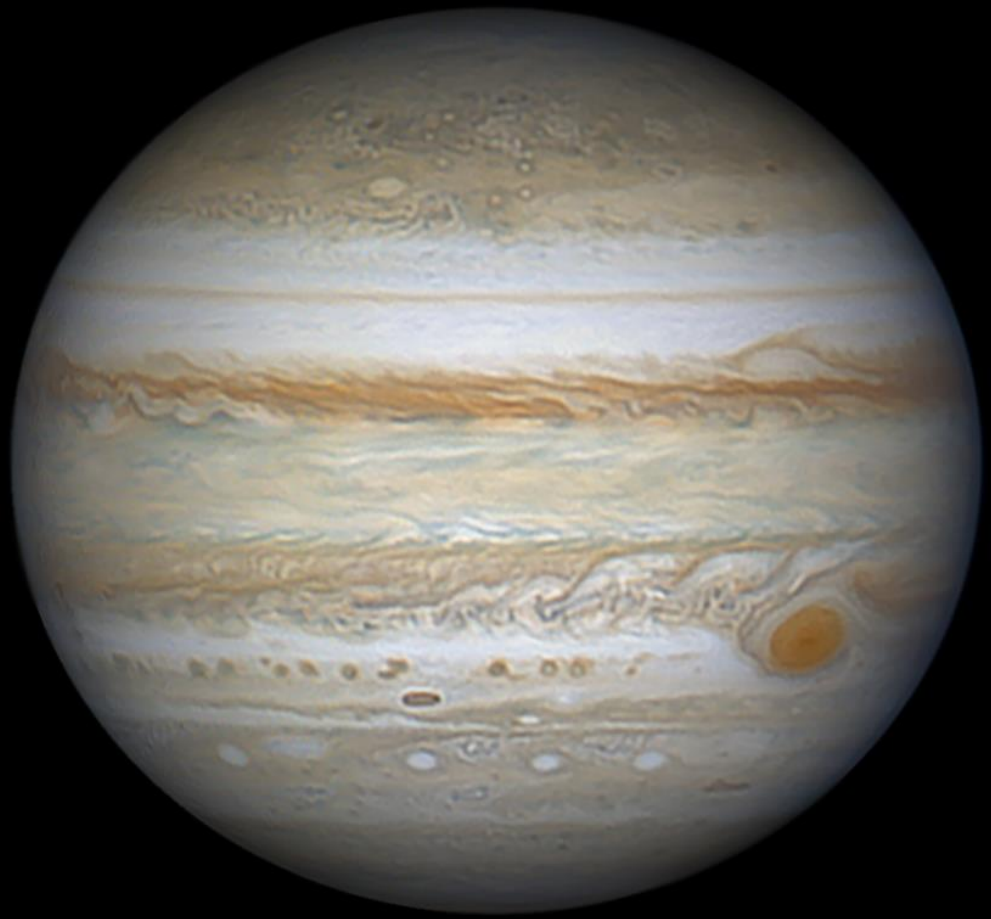
Emmanuel Beaudoin

Suivi de Venus !

200mm et un filtre UV.
CM = méridien central,
Il pour celui de l'atmosphère, qui ne tourne pas au même rythme que le sol

Christophe Pellier





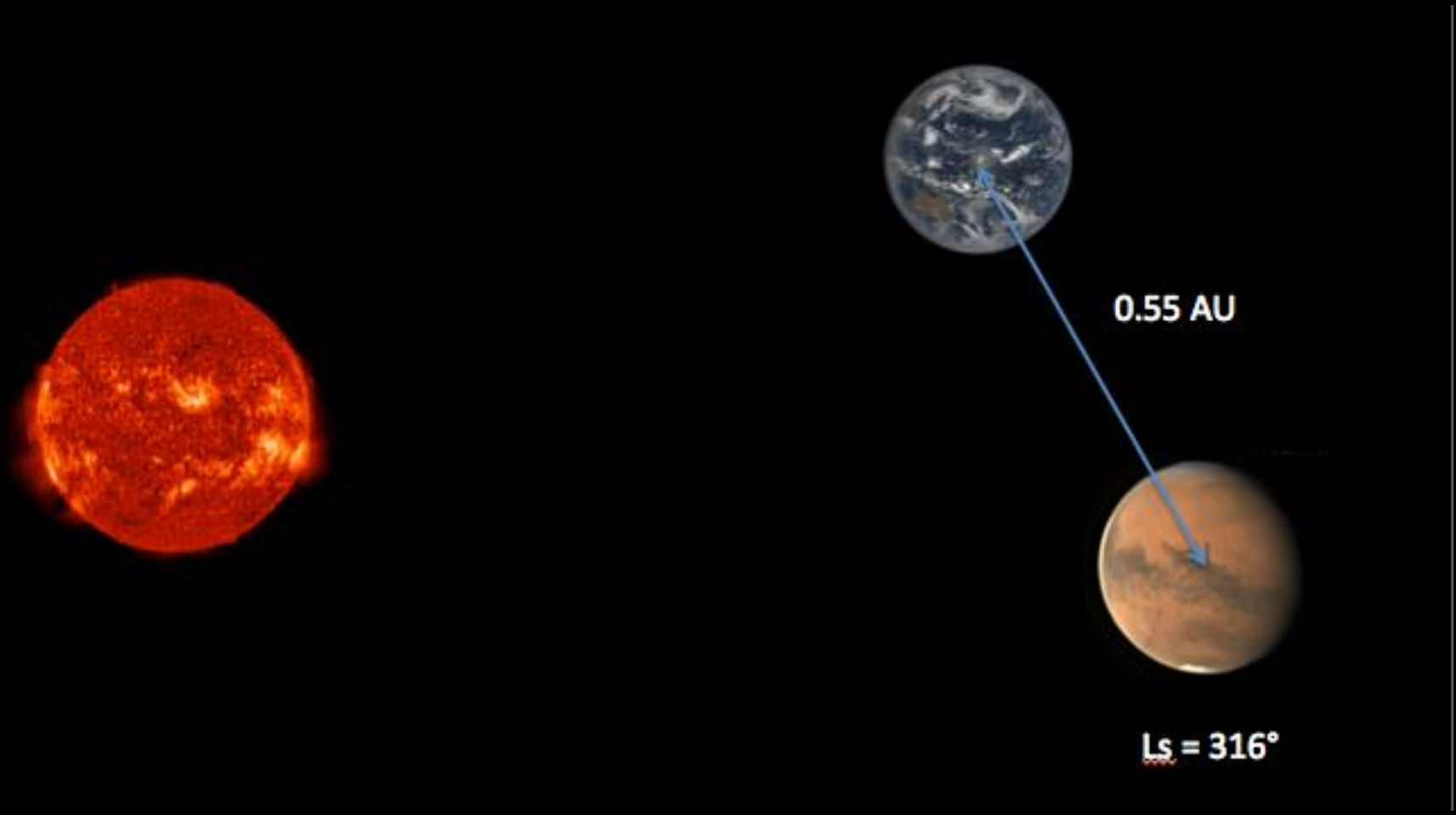
Jupiter
2022-09-22 (yyyy-mm-dd), 22:44.4 UT CM I 65,0° CM II 69,0° CM III 358,5°
Mewlon 300 / IMX290
Paris / France
JL Dauvergne

Jean-Luc Dauvergne

Marc Delcroix

Tempête sur Saturne avec, de gauche à droite Titan, Dioné, Téthys, Rhéa, Encelade.

Novembre 2020: Une bonne configuration pour observer Mars depuis la Terre.

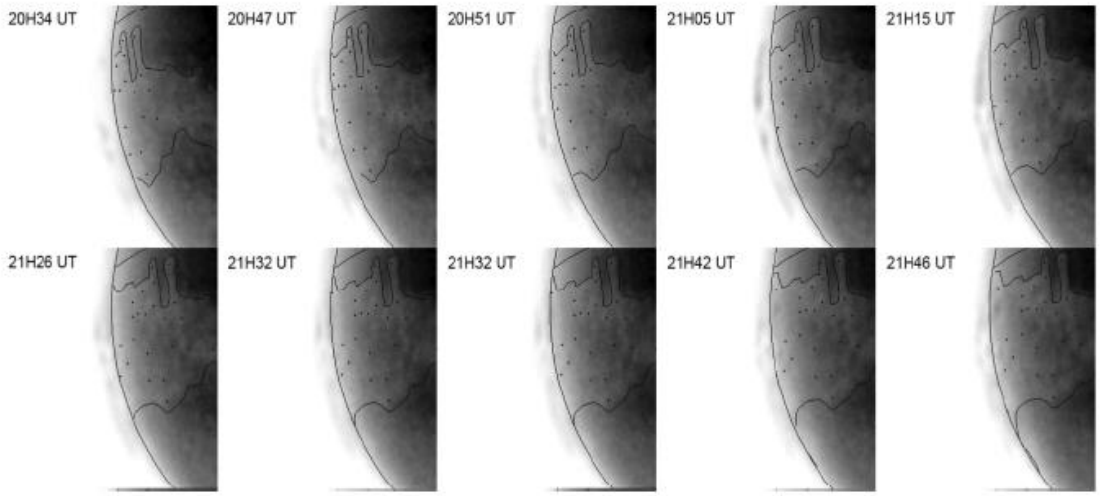


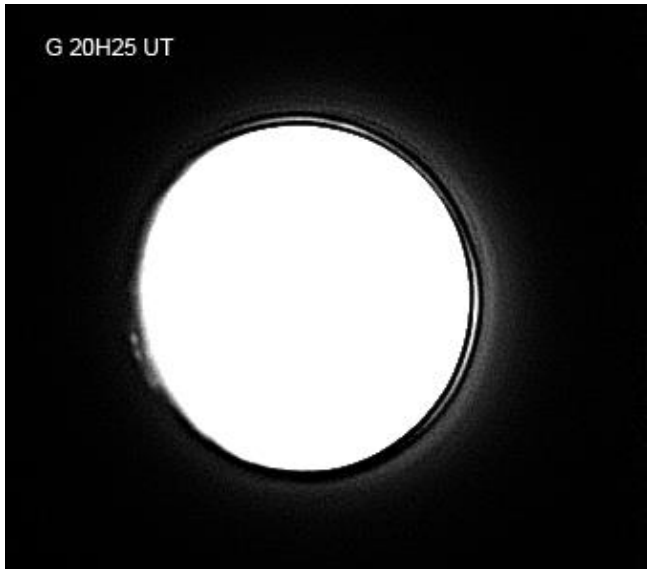
Detection

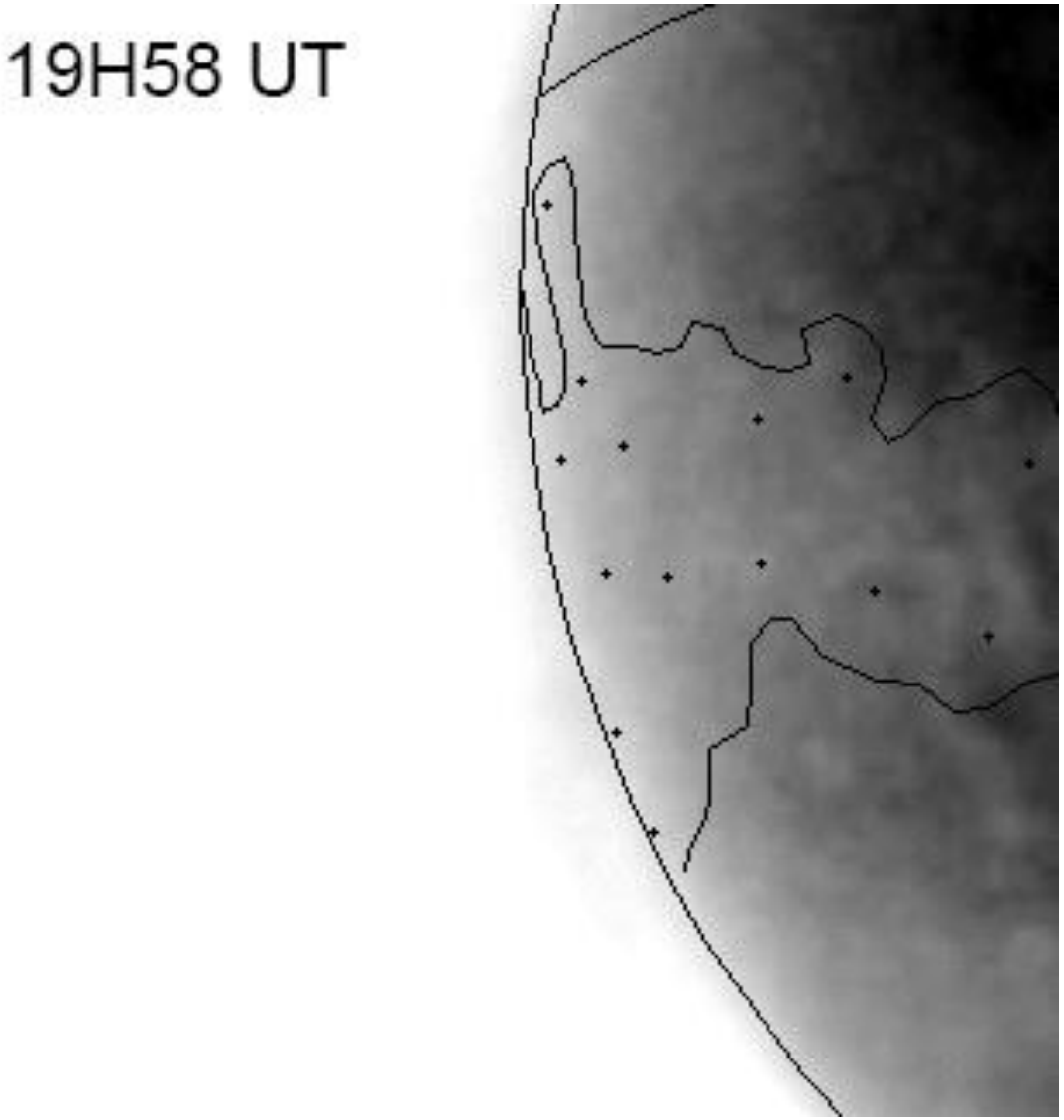
- Christophe Pellier
  - Nantes (France, +47°12 N, 1°33 W)
  - 305mm (12") f/5 Newtonian telescope
  - Various filters, 5ms timeframe (color camera) to 100ms (UV filter)

- Emmanuel Beaudoin
  - Palaiseau (France, +48.7°N, 2.23°E)
  - 356mm (Celestron 14) Schmidt-Cassegrain on a AP900 mount
  - 2.5ms (red filter), 3.5ms (Green) 5.5ms (Blue)

Une structure à très haute altitude émergeant de l'ombre





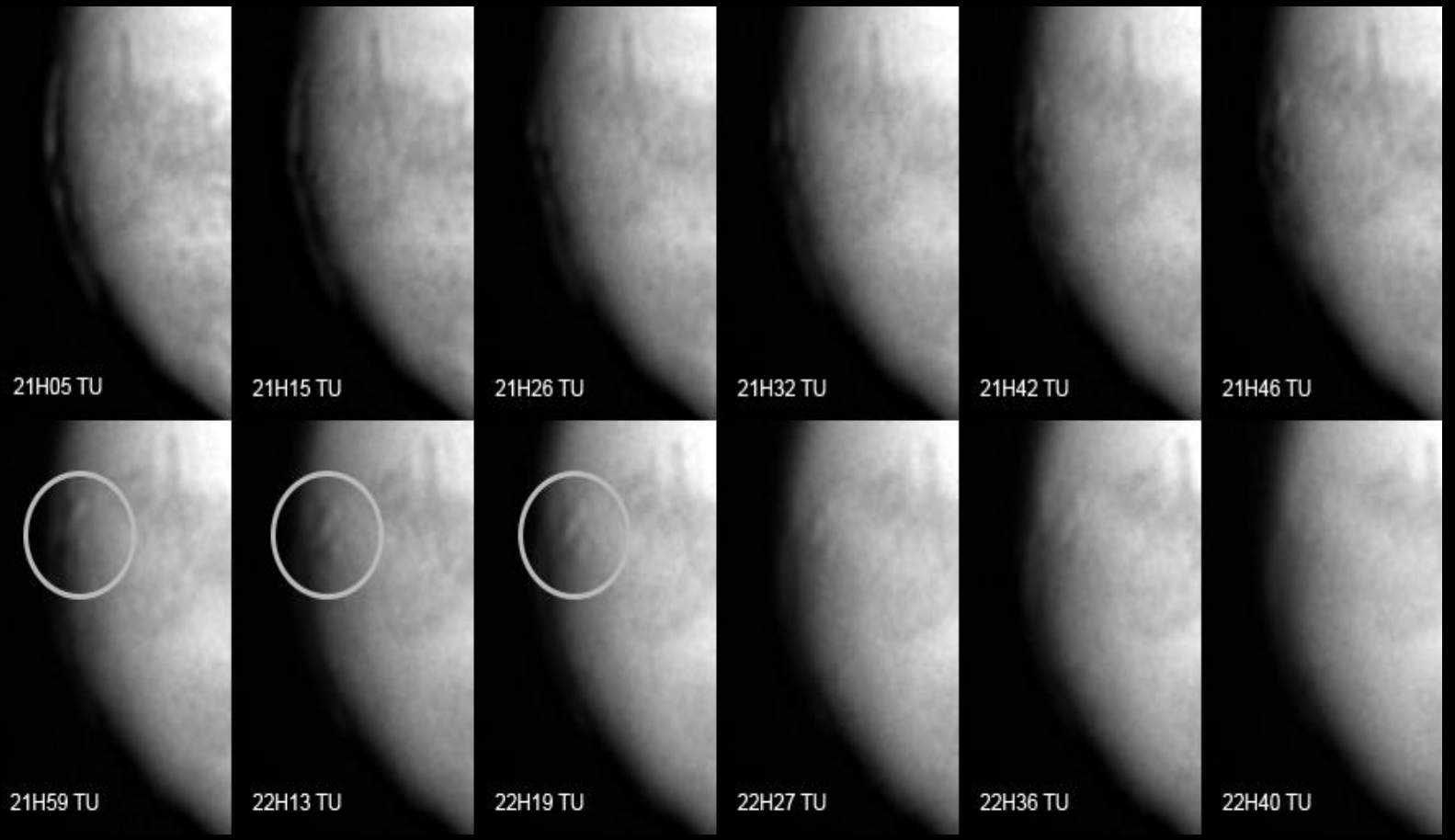


17 novembre 2020

Pour la première fois, on observe une structure atmosphérique martienne de très grande ampleur depuis la Terre.

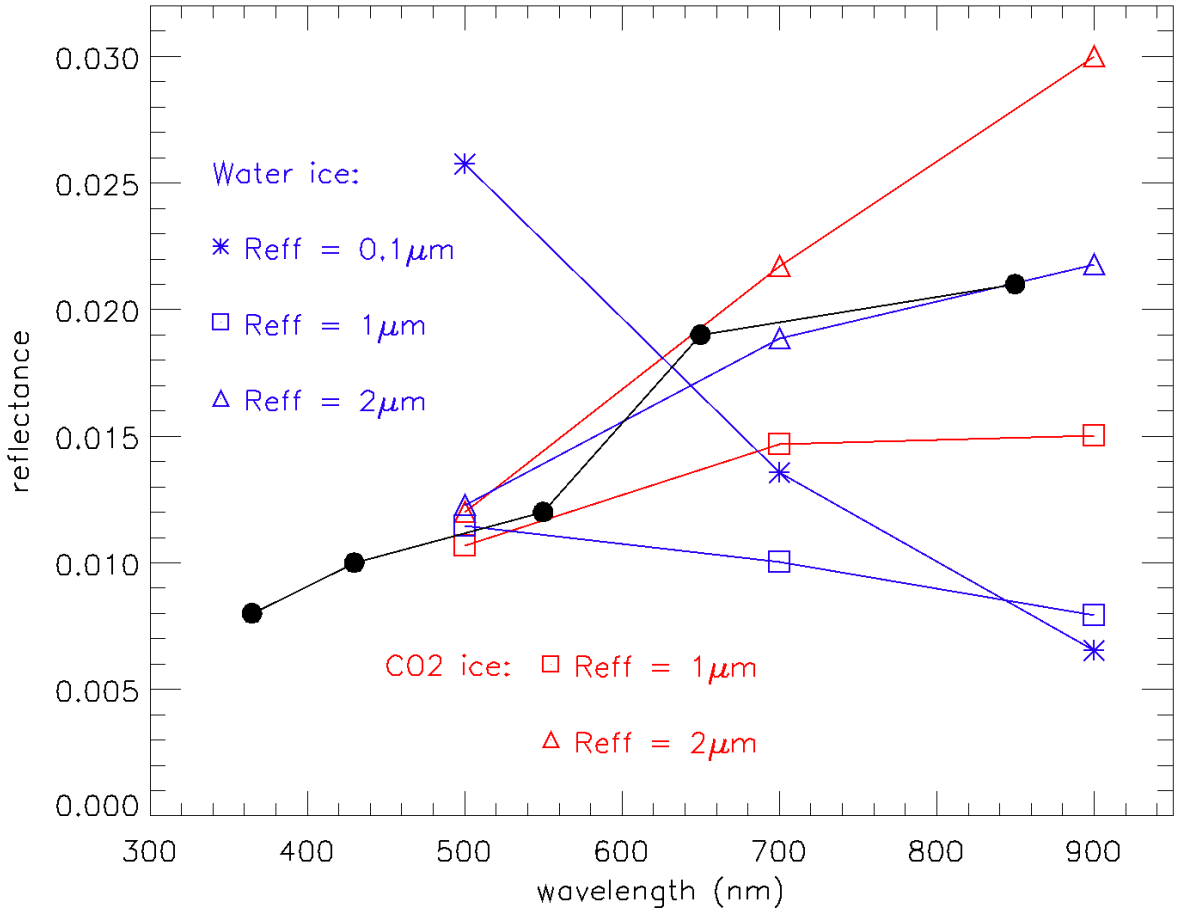
90km d'altitude (un peu « trop » bas) et 3000km de large (!!!)

AAAhhhhhrrrrgggghhhh ! Il y a une ombre !
Ce n’est pas une aurore !



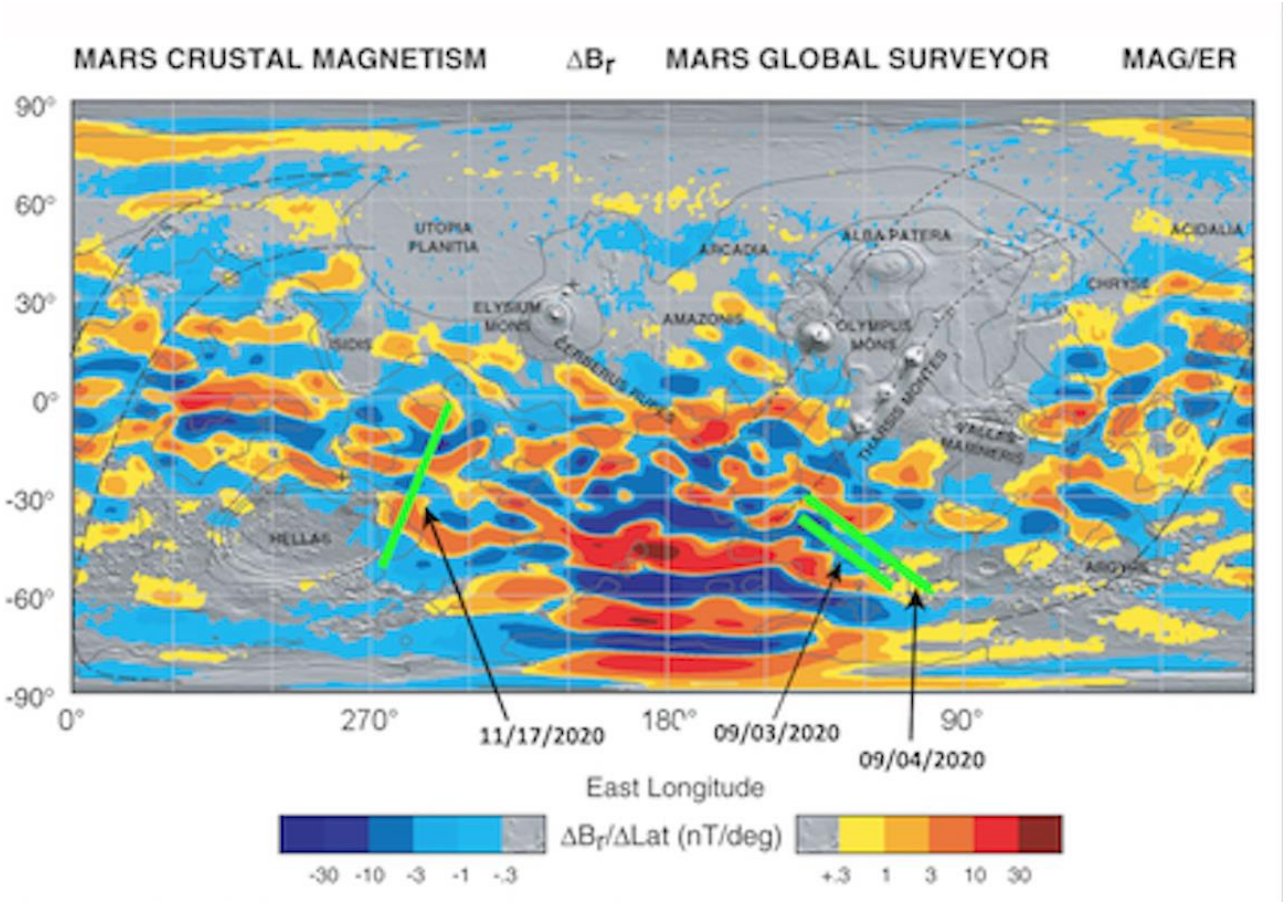
Emmanuel Beaudoin / Marc Delcroix

Mais c’est super !!!
On a découvert des nuages martiens à 90 km! Depuis la Terre !
Magie de la serempidité



En comparant leur spectre observé et la simulation par transfert radiatif (Mathieu Vincendon), on déduit que ce sont probablement des structures de glace de CO2. D'où peuvent-elles venir ?

Probablement du vent des autres étoiles, le “rayonnement cosmique”. Et hop, revoilà la météo de l’espace !



Beauté de la sérendipité !!!

Et c’est sûr, un jour, on les verra ces aurores !!! (prochaine occurrence : fin 2024)

Remarque finale :

Le prix est doté d’une récompense de 1000 €. Le groupe de récipiendaires a collectivement décidé de remettre l’intégralité de cette somme à l'association "Station de Planétologie des Pyrénées" (S2P) qui œuvre au soutien de l'astronomie amateure au Pic du Midi.

Vive la collaboration Pro-Am! Et merci la SAF !