2016 Trace Gas Orbiter
Mars Atmospheric Global Imaging Experiment
(MAGIE)

Bruce Cantor

PITEAM Masters Forum-3

(Discovery Mission & Mars 2016 TGO US Instruments)

Annapolis, MD

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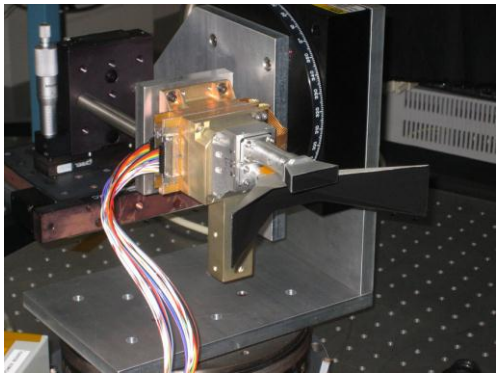
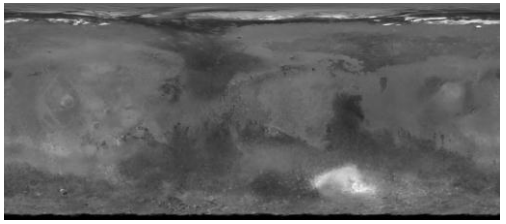
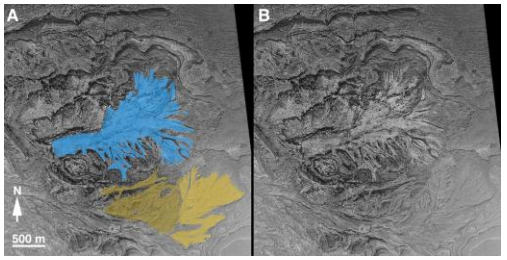
Malin Space Science Systems

- Who we are
  - Small company headquartered in San Diego
  - 20 years of hardware history
- What we do
  - Imaging system development
  - Mission operations
  - Science data analysis
- Track record
  - Cumulative 34+ instrument years of deep space operations
  - Currently seven different MSSS cameras in operation on spacecraft orbiting three different planetary bodies.
  - Two more launches this year (Juno, MSL)



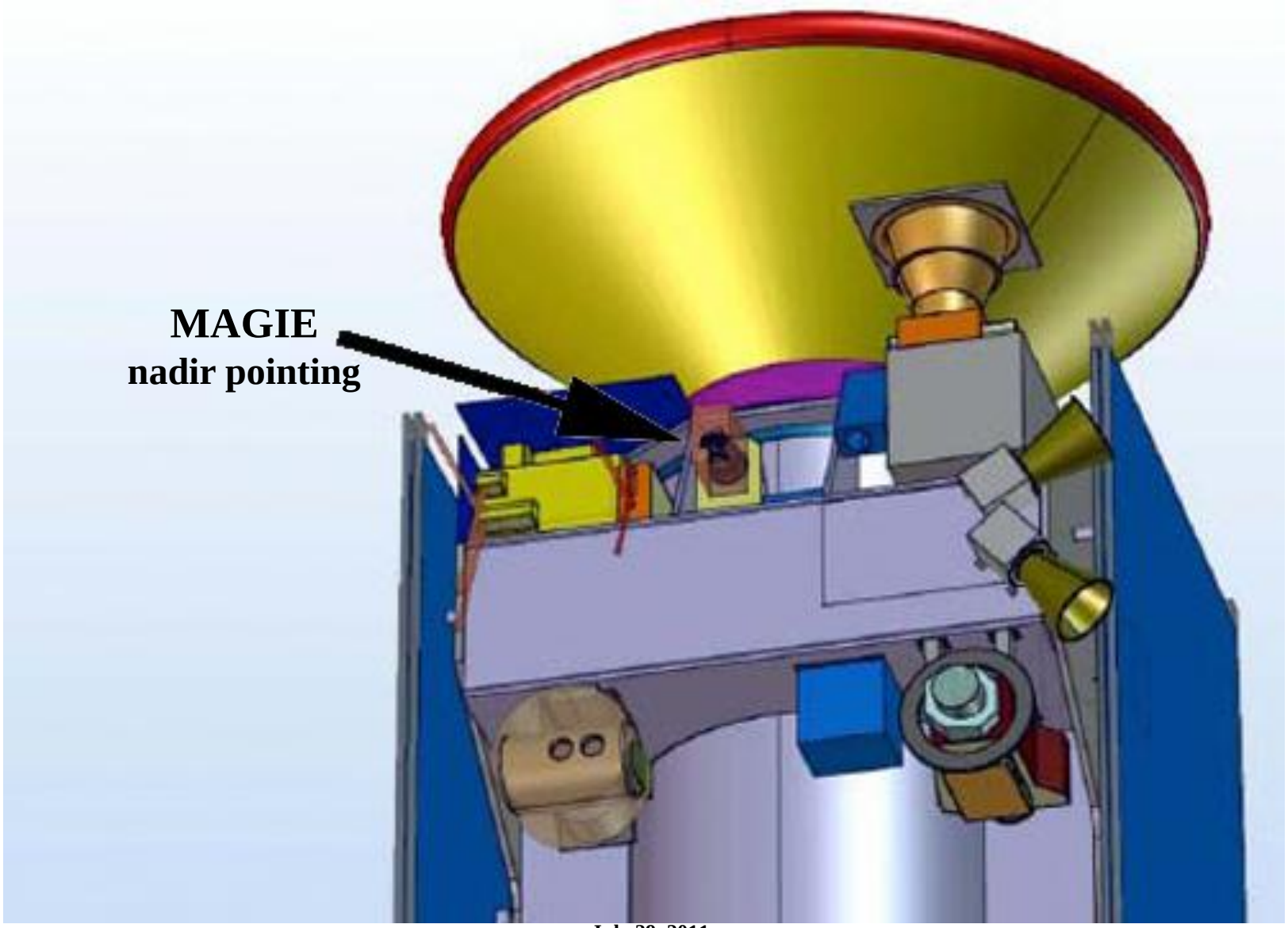




MSSS Flight Experience

- 20 flight instruments
- 12 missions (Mars, Jupiter, Earth, and Earth's Moon)
- 700,000+ images commanded & downlinked
- 300,000+ operational hours

MAGIE — *2016 Trace Gas Orbiter*

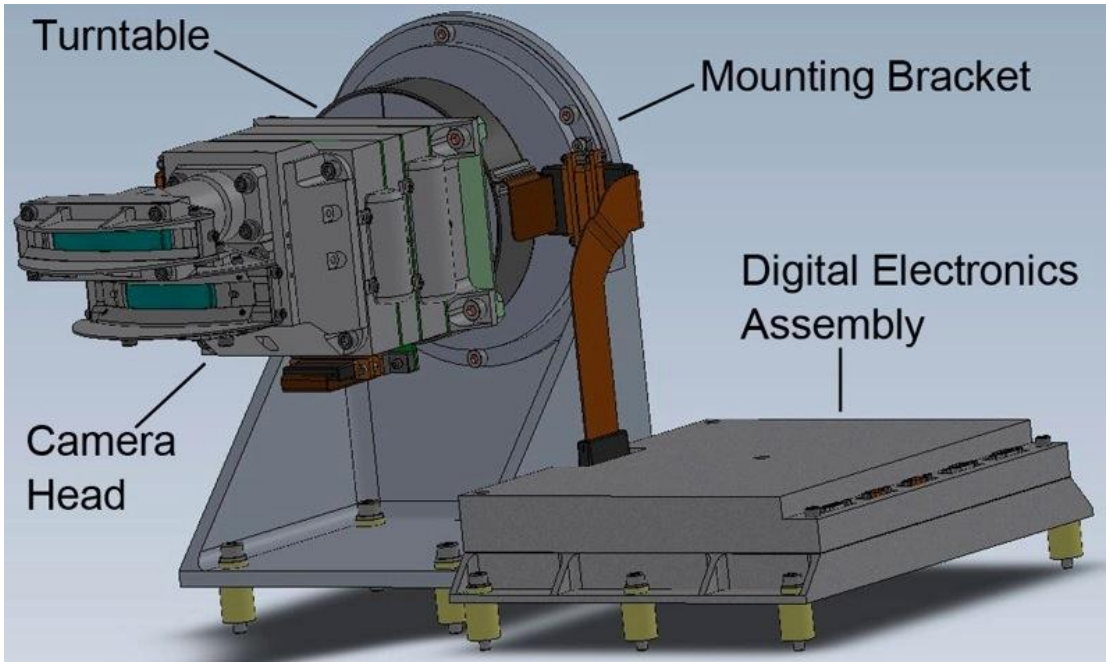


International Science Team

Investigators	Country	Institution
Bruce Cantor, (PI)	U.S.A.	MSSS
James Bell, (Co-I)	U.S.A.	Cornell Univ.
Mark Lemmon, (Co-I)	U.S.A.	Texas A&M Univ.
Huiqun Wang, (Co-I)	U.S.A.	SAO
Michael Wolff, (Co-I)	U.S.A.	SSI
Anna Fedorova, (Co-I)	Russia	IKI
Frank Daerden, (Co-I)	Belgium	BIRA-IASB
Francios Forget, (Co-I)	France	LMD
Yves Langevin, (Co-I)	France	IAS
Franck Montmessin, (Co-I)	France	CNRS/LATMOS

Instrument:

MAGIE consists of a single camera head with dual optics and a digital electronics assembly.



Instrument Contributions:

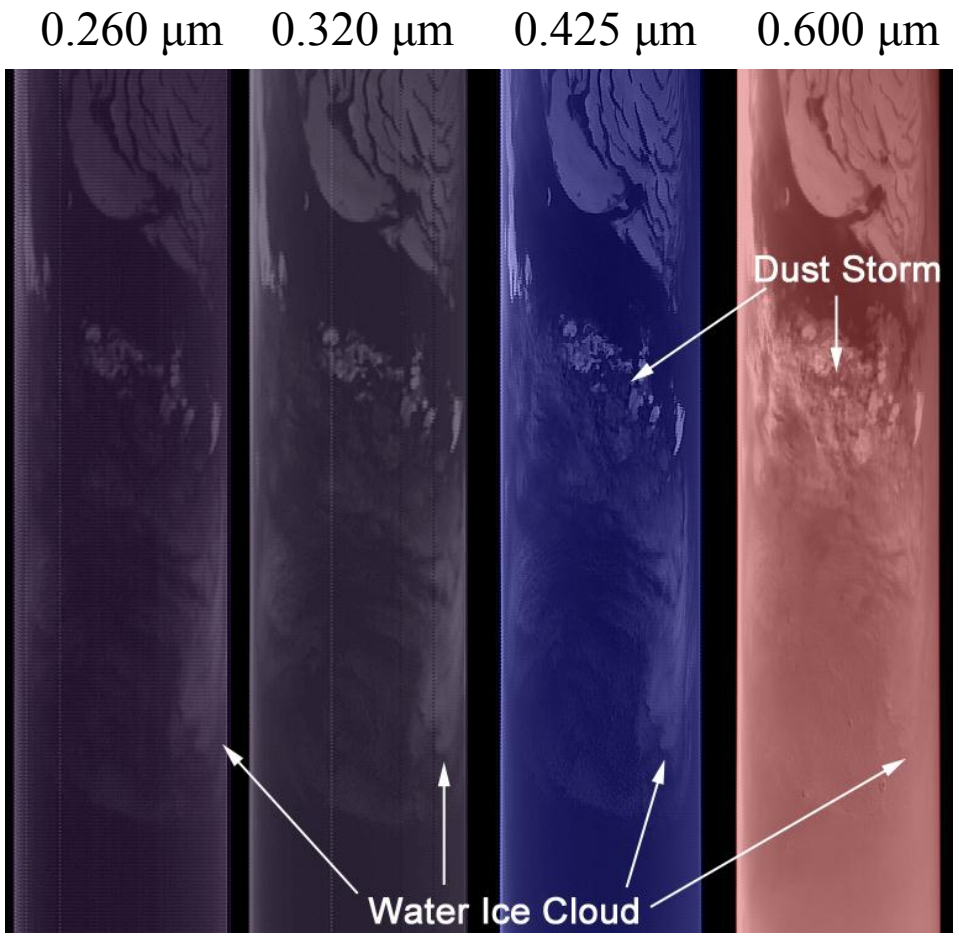
Implementation: Malin Space Science Systems (MSSS) Overall instrument management, all hardware and software, design and build.

Heritage

- Optics: MRO MARCI (modified FOV and format)
- Camera Head Electronics: MSL Mastcam, MAHLI and MARDI and Junocam
- Turntable: MSL Mastcam filter wheel
- Digital Electronic Assembly: MSL Mastcam, MAHLI and MARDI

Instrument Investigation:

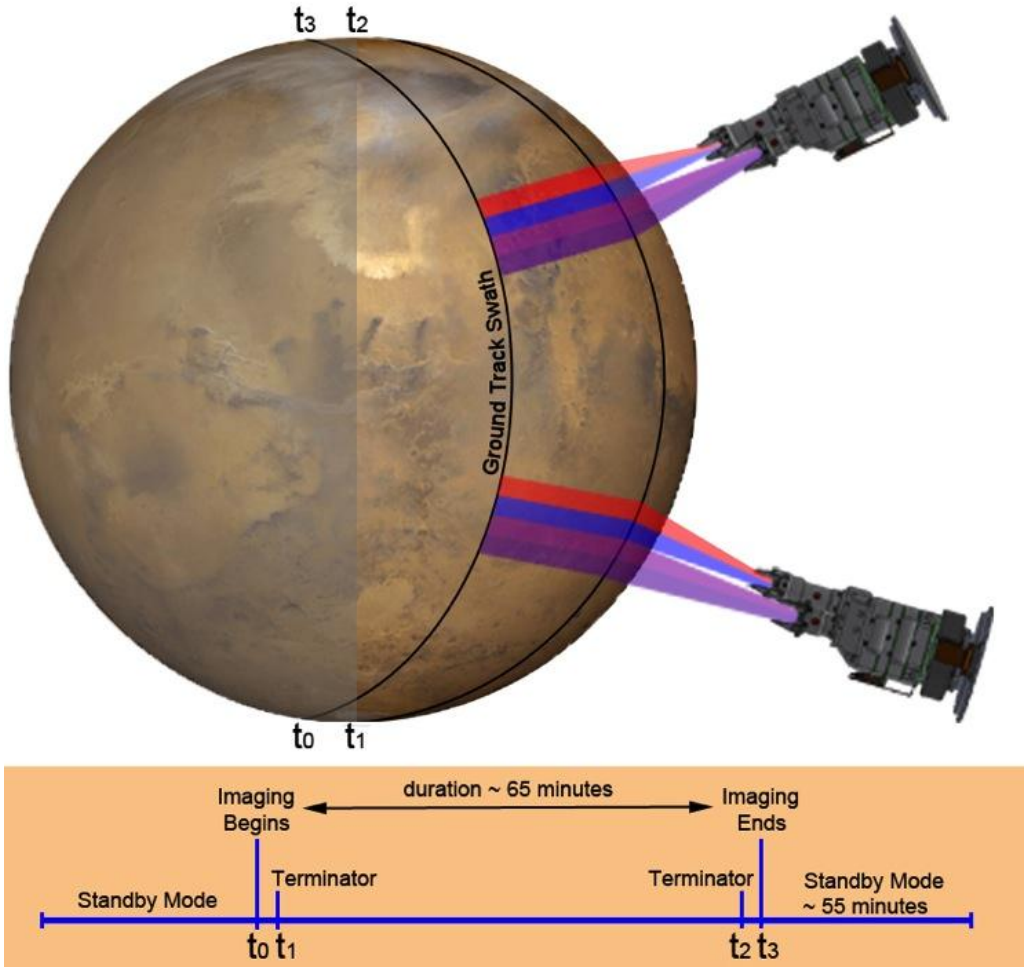
Wide-field push-frame camera with two visible bands (140^0 FOV) and two UV (125^0 FOV) bands. Provides a daily record of synoptic meteorological events occurring on the full sun-lit side of Mars, and measures the planet-wide variation of atmospheric physical state [ice condensates (H_2O, CO_2) and dust] and the variation of trace gas (O_3).



Ground Sampling Resolution: < 500 m (nadir) / ~ 2500 m (limb), at 400 km altitude.

Operation:

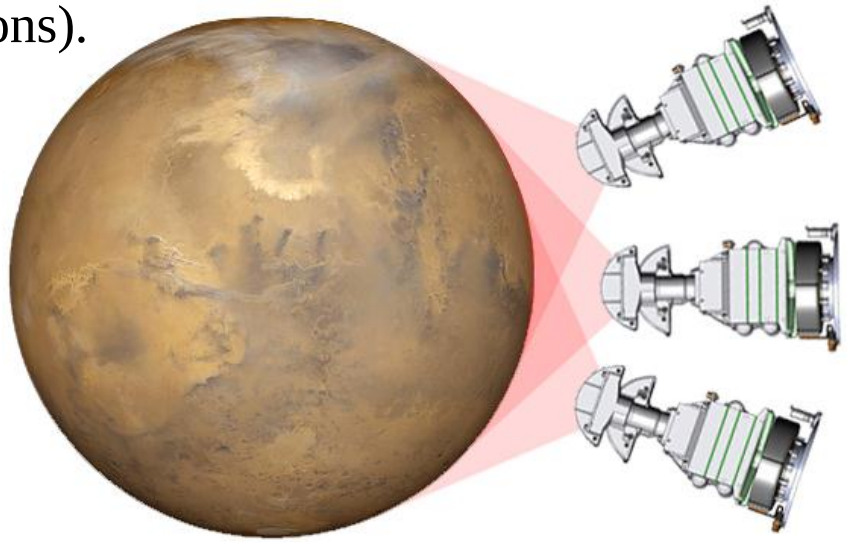
MAGIE will image on the entire dayside of each orbit, from terminator-to terminator and limb-to-limb. Imaging shall begin approximately 2.5 minutes before dayside terminator crossing and end approximately 2.5 minutes after night side terminator crossing.



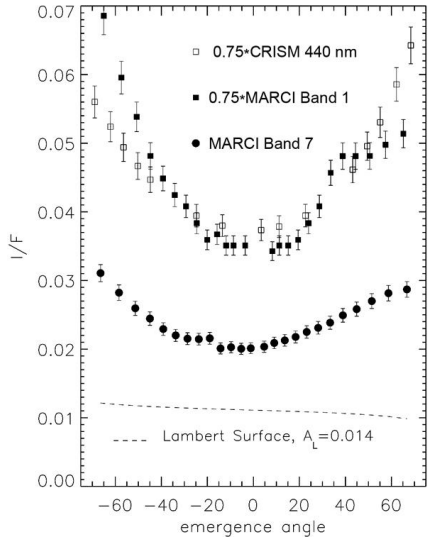
Expanded Capability: Emission Phase Function Observations

The MAGIE turntable, used for yaw compensation, also provides the capability for EPF (Emission Phase Function) observations. But at the expense of daily global mapping coverage on the dayside but possibly crossing the terminator. This is done by aligning the long-track (cross-track) direction of the detector with the spacecraft velocity vector. Several thousand EPFs can be taken on a single orbit.

Provides additional context of meteorological conditions, specifically atmospheric aerosols (visible optical depths, particle sizes, and single scattering phase functions).



July 29, 2011



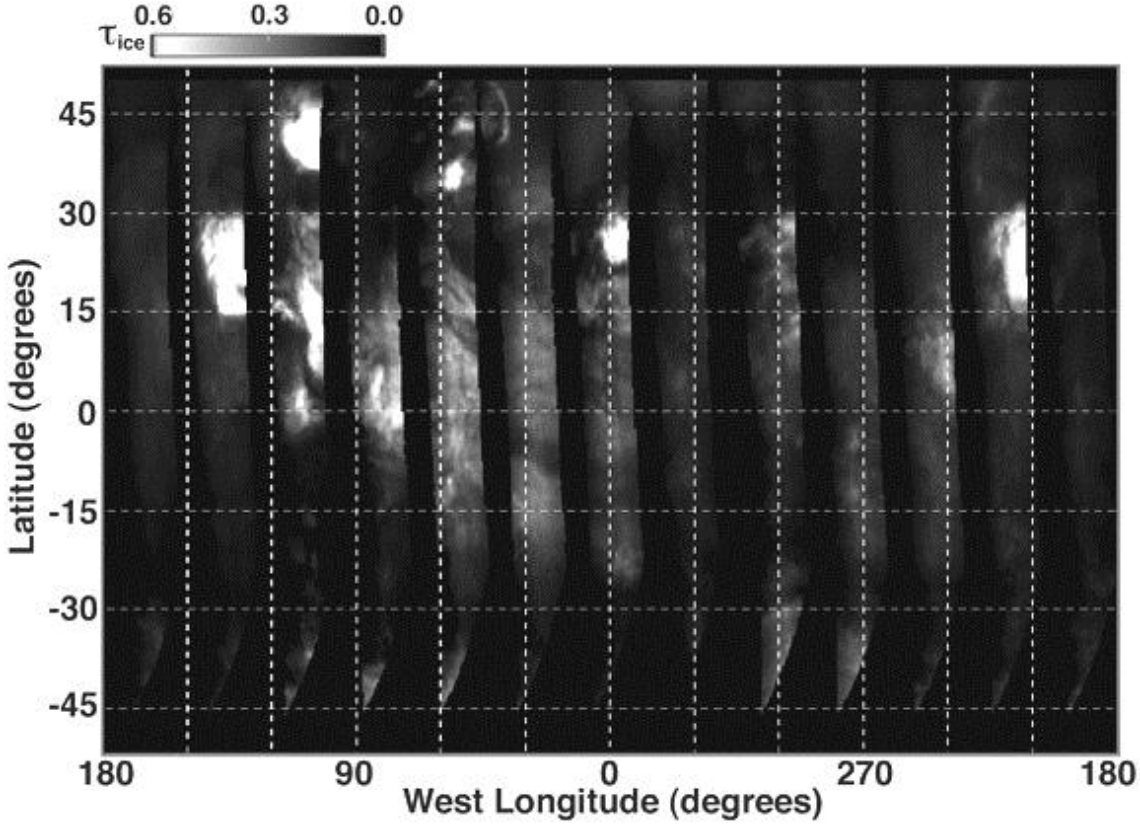
MARCI pseudo-EPF & CRISM EPF during 2007 dust event, near MER-A (courtesy, M. J.

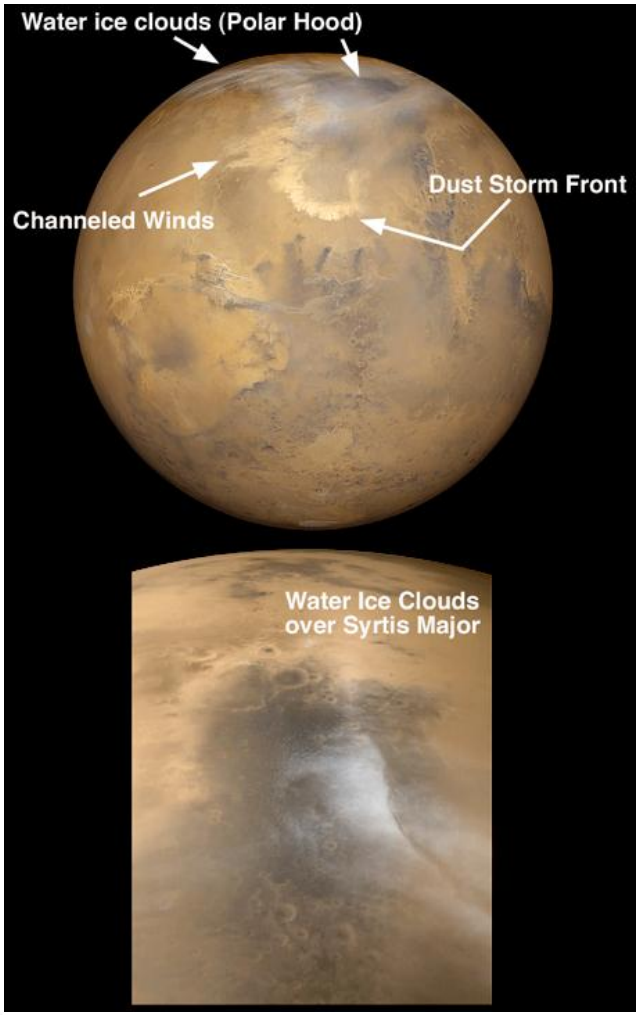
Science Objectives

MAGIE Science Objectives		EMTGO Science Objectives	
1	Provide meteorological context for Trace Gas Observations.	B	Trace gas spatial and temporal variability.
		C	Localize trace gas sources and sinks, and relation to aerosols and atmospheric state.
2	Map the occurrence of atmospheric ozone.	A	Detect trace gases.
3	Provide Geologic/Surface Context for Trace Gas Observations.	D	Geologic context of trace gas sources and sinks.
4	Extend the daily global meteorological record.	C	Localize trace gas sources and sinks, and relation to aerosols and atmospheric state.
		E	Support EDL demonstrator and 2018 rover mission.
5	Provide meteorological support for the 2018 and 2020s Mars Missions.	E	Support EDL demonstrator and 2018 rover mission.

1. Meteorological Context for Trace Gas Observations

The distribution of atmospheric trace gases are controlled by meteorological conditions.
MAGIE will provide daily images that document the weather conditions (condensate clouds and dust storms, seasonal behavior of polar caps) on the day-lit portion of each orbit, when other trace gas





2. Map the Occurrence of Atmospheric Ozone

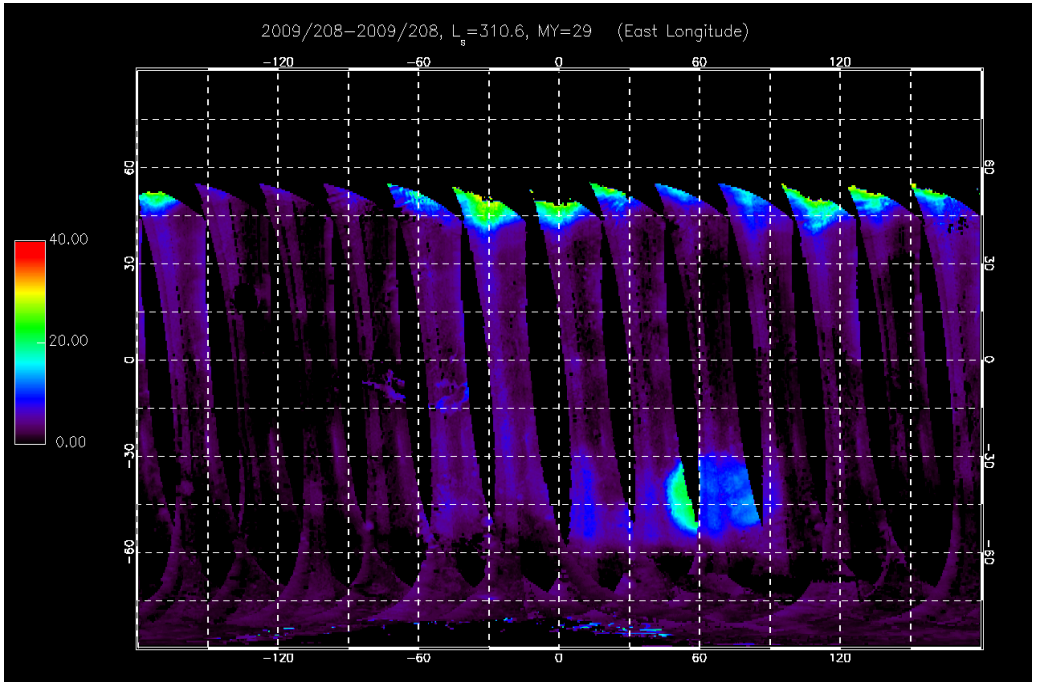
Ozone is an important reactive constituent of Martian atmosphere which controls the UV flux that reaches the surface.

It's a tracer of photochemistry and highly relevant to overall trace gas research.

Ozone is created in the atmosphere as a byproduct of photolysis of CO_2.
The oxygen trace products of CO_2 photolytic dissociation, O_2 and O, combine through 3-body reaction,

$$O_2 + O + M \rightarrow M + O_3$$

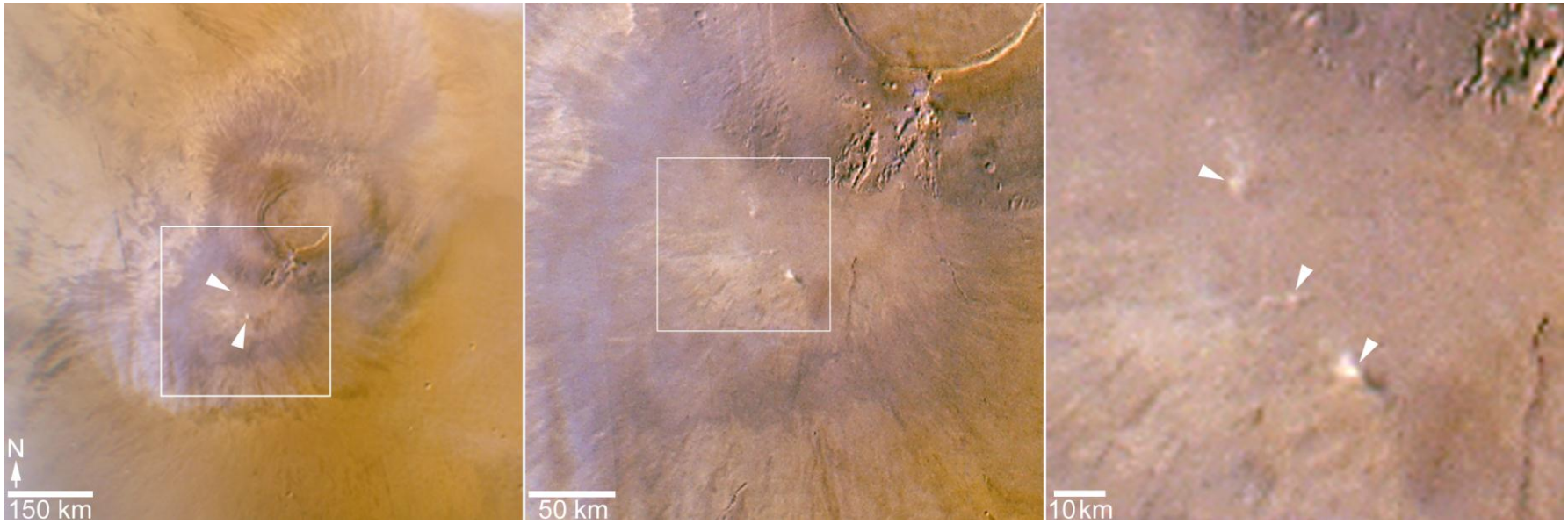
Trace products of water vapor photolysis, notably OH and HO_2, Catalytically mediate the recombination of CO and O_2 to form CO_2. These HO_x trace radicals effect catalytic destruction of O_3, such that Water vapor and Ozone Abundances show strong anti-correlations spatially and temporally.



3. Geologic/Surface Context for Trace Gas Observations

The notion that Mars today has active volcanism or hydromagmatic processes (geysers) can be considered a long shot, but one that is very enticing to consider because of the implications for trace gas emission, the potential for linkage between such "warm havens" and astrobiologic interests.

Some candidates were observed by Viking on the southern slopes of Arsia Mons, but follow-up MRO-MARCI imaging indicated these were dust devils and/or dust plumes.

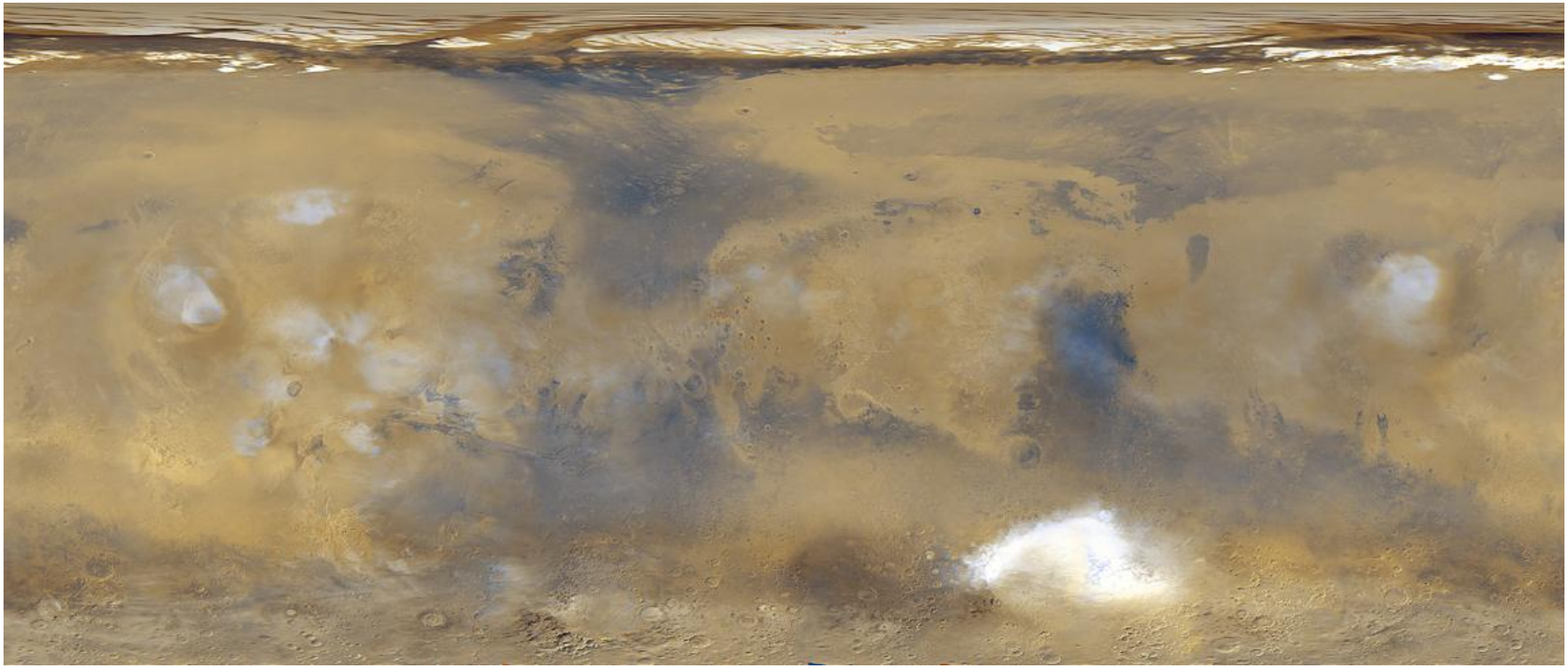


MAGIE will search for:

1. Eruptive plumes of tephra and steam associated with volcanic vents.
2. Albedo changes in the vicinity of vents caused by new large tephra falls or new lava flows.

4. Extend Daily Global Meteorological Record

MAGIE data are vital for the long-term prediction and understanding of Martian meteorology and GCM validation. MAGIE will continue and extend the record of daily global images documenting the dynamic state of the atmosphere (condensate clouds, dust storms) and surface (seasonal frost and albedo changes) begun by MGS MOC in 1997 and continued in 2006 by MRO MARCI.



5. Meteorological Support for 2018 and 2020s Mars Missions

- Daily global imaging has been used in all Mars missions since the Pathfinder in 1997.
- MAGIE will continue this effort by provide weather updates and forecasts in support of EDL and surface/orbital operations for the 2018 rover mission and missions to follow in the 2020s.

6-7 November 2008, L_s = 153-154