

CHANGES ON THE SURFACE OF MARS

WHAT DO THEY TELL US ABOUT SURFACE PROCESSES?

IMARS DISSEMINATION EVENT / LONDON, 14 MARCH 2017



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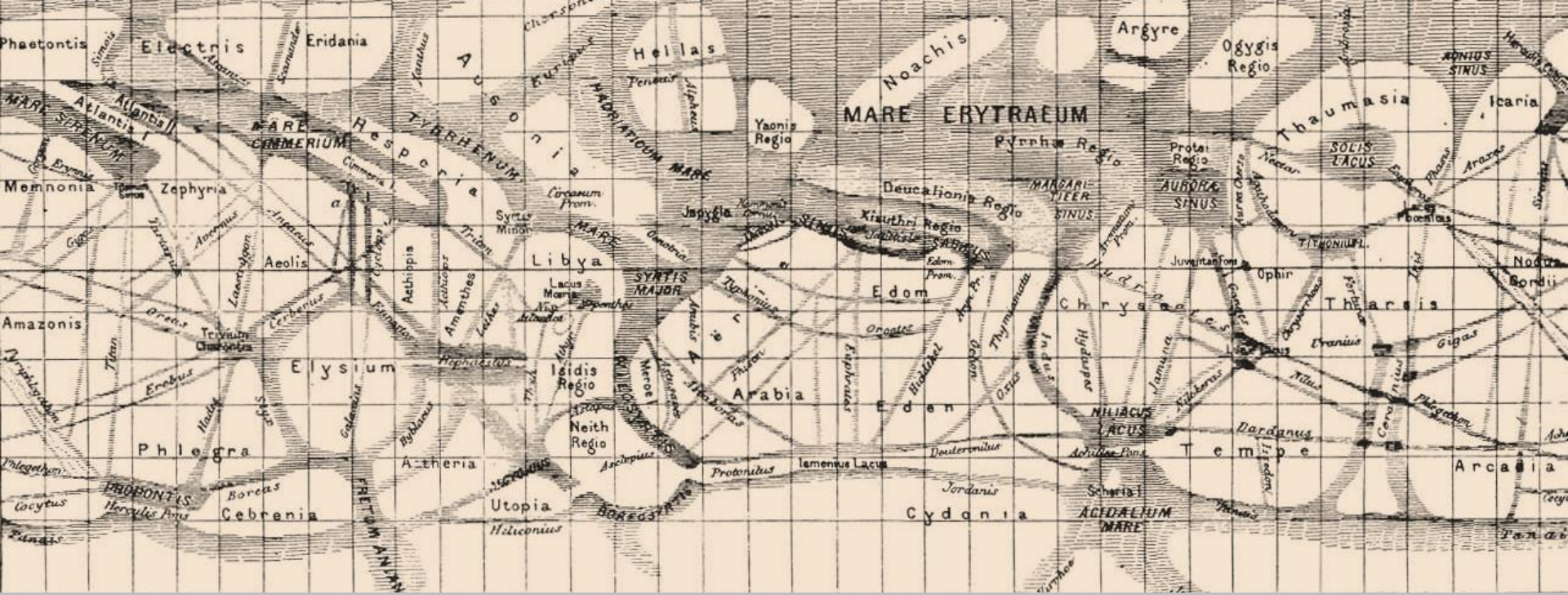
NIGHT-SKY OBSERVATIONS OF MARS

UNTIL 1610, MARS COULD BE OBSERVED ONLY BY THE UNAIDED EYE



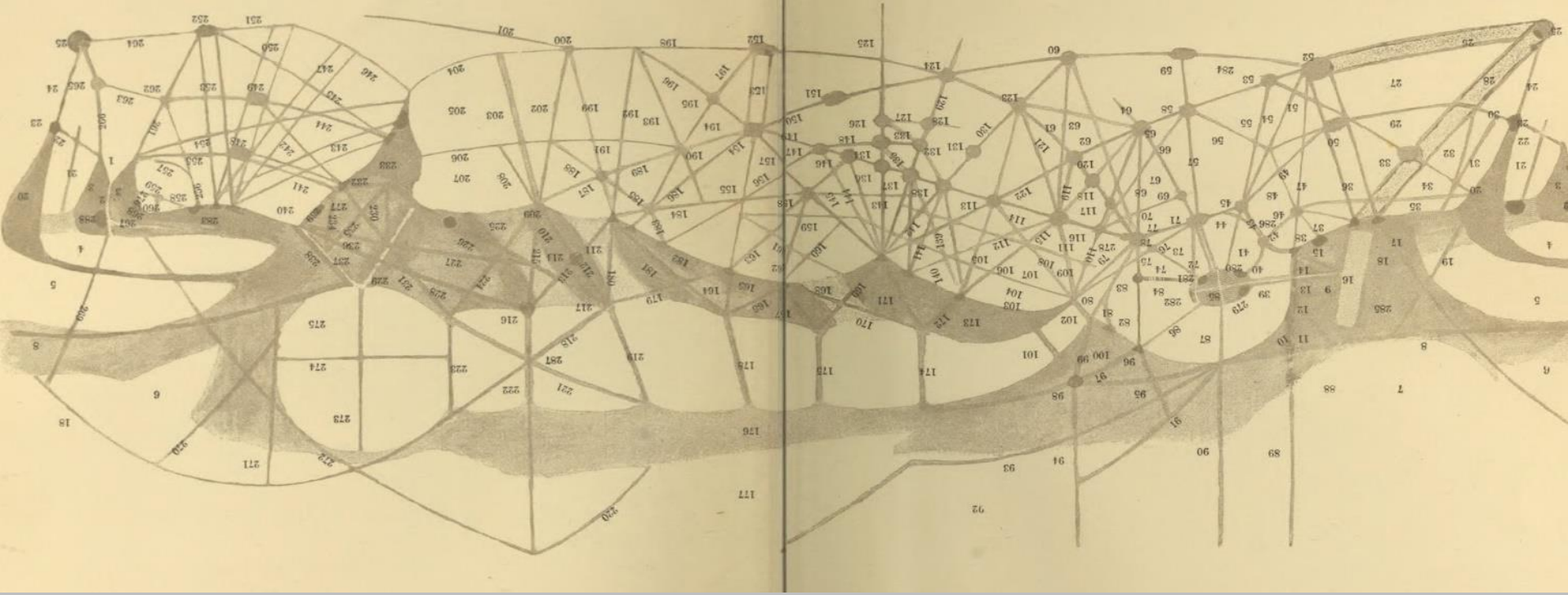
HUYGENS' OBSERVATIONS, 1659

OBSERVED CHANGES WERE DUE TO MARS' MOTION AND ALBEDO CHANGES



SCHIAPARELLI'S MAP, 1877-1886

A COMPLEX PATTERN OF FLUVIAL FEATURES AND ALBEDO VARIATIONS



MAP OF MARS BY PERCIVAL LOWELL, 1894

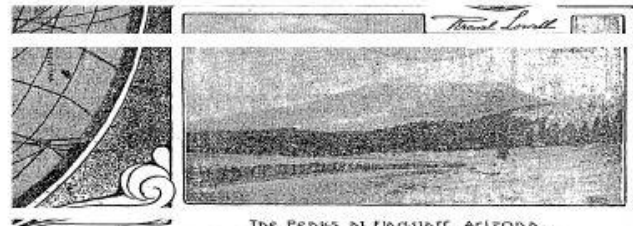
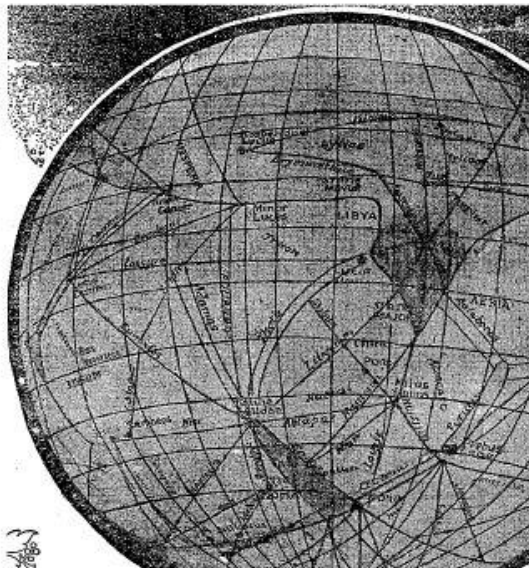
...UNFORTUNATELY MISINTERPRETED AS CANALS AND AGRICULTURE

THERE IS LIFE ON THE PLANET MARS

Prof. Percival Lowell, recognised as the greatest authority on the subject, declares there can be no doubt that living beings inhabit ovr neighbor world.

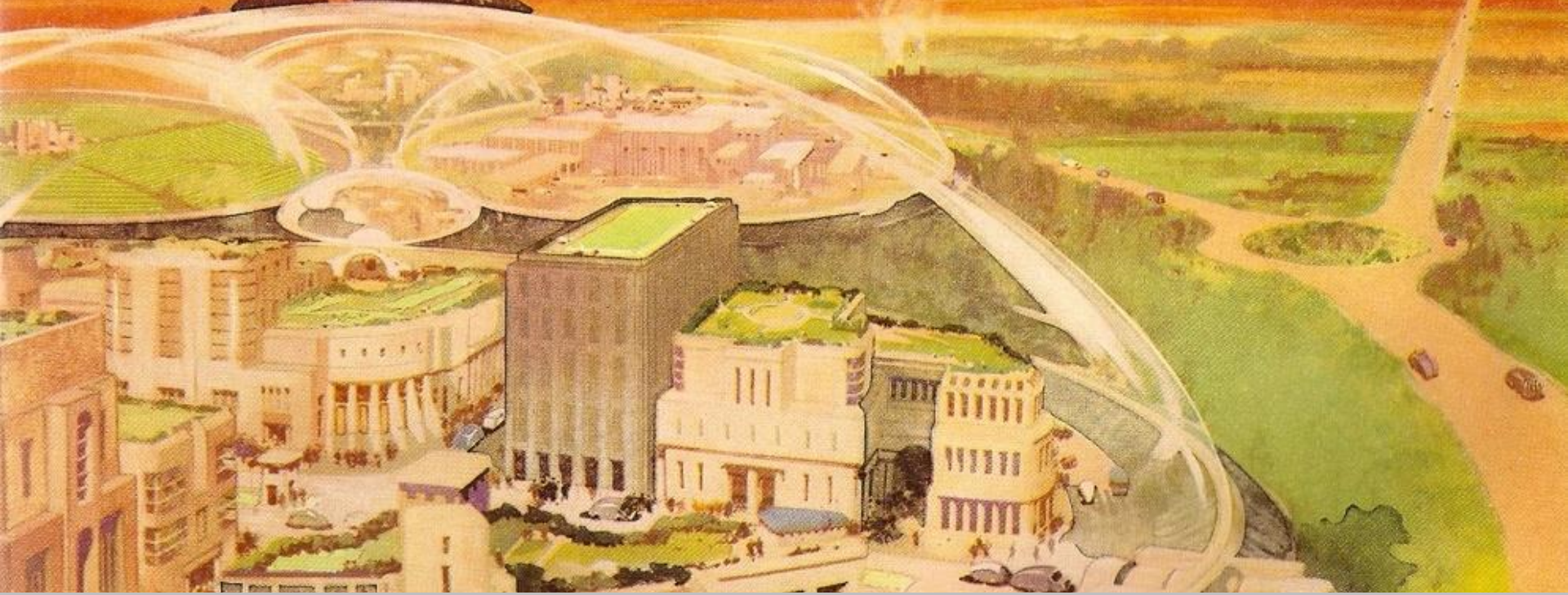
By Lilian Whiting.

THE regions of canals on Mars, forming a colossal and a wisely planned system designed to irrigate the oases of the vast deserts which make up the surface of this



MAP OF MARS BY PERCIVAL LOWELL, 1894

LIFE AS LOGICAL CONSEQUENCE



THE MARTIAN BASE BY LESLIE CARR, 1951

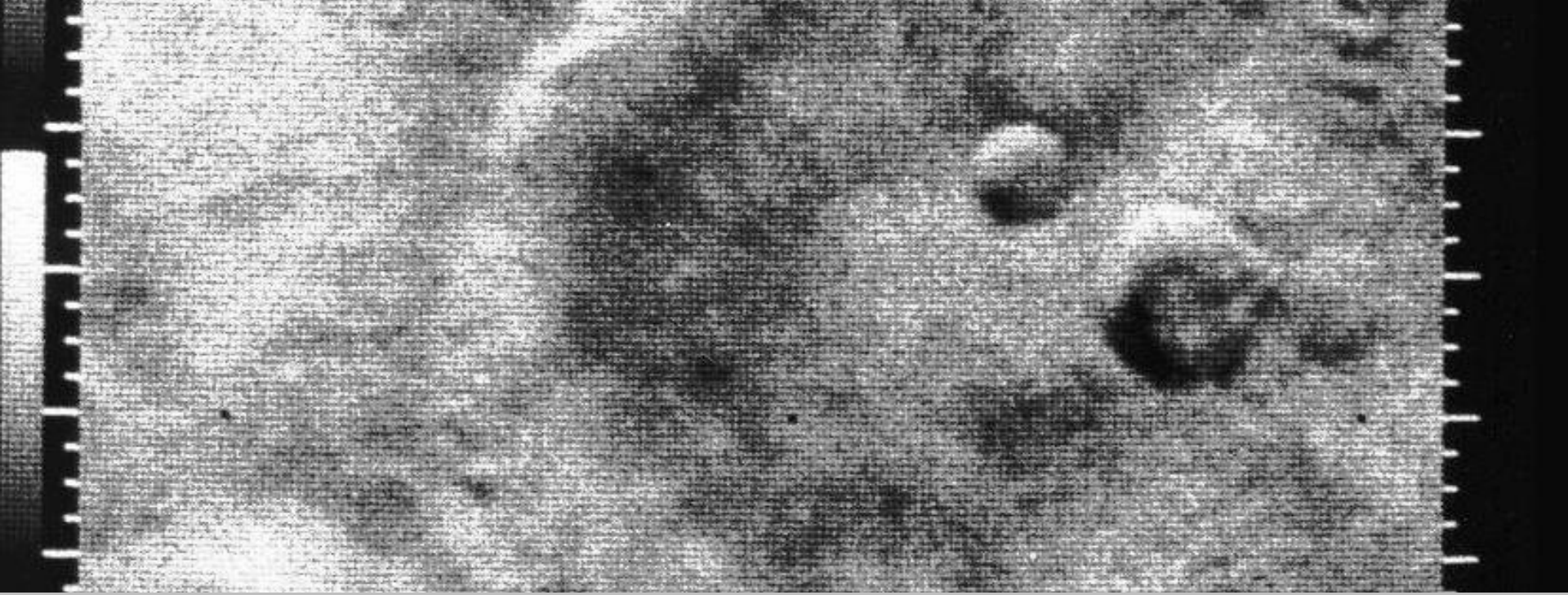
© L. CARR. IN: A. C. CLARKE (1951) THE EXPLORATION OF SPACE



THE MID-50'S PICTURE OF MARS

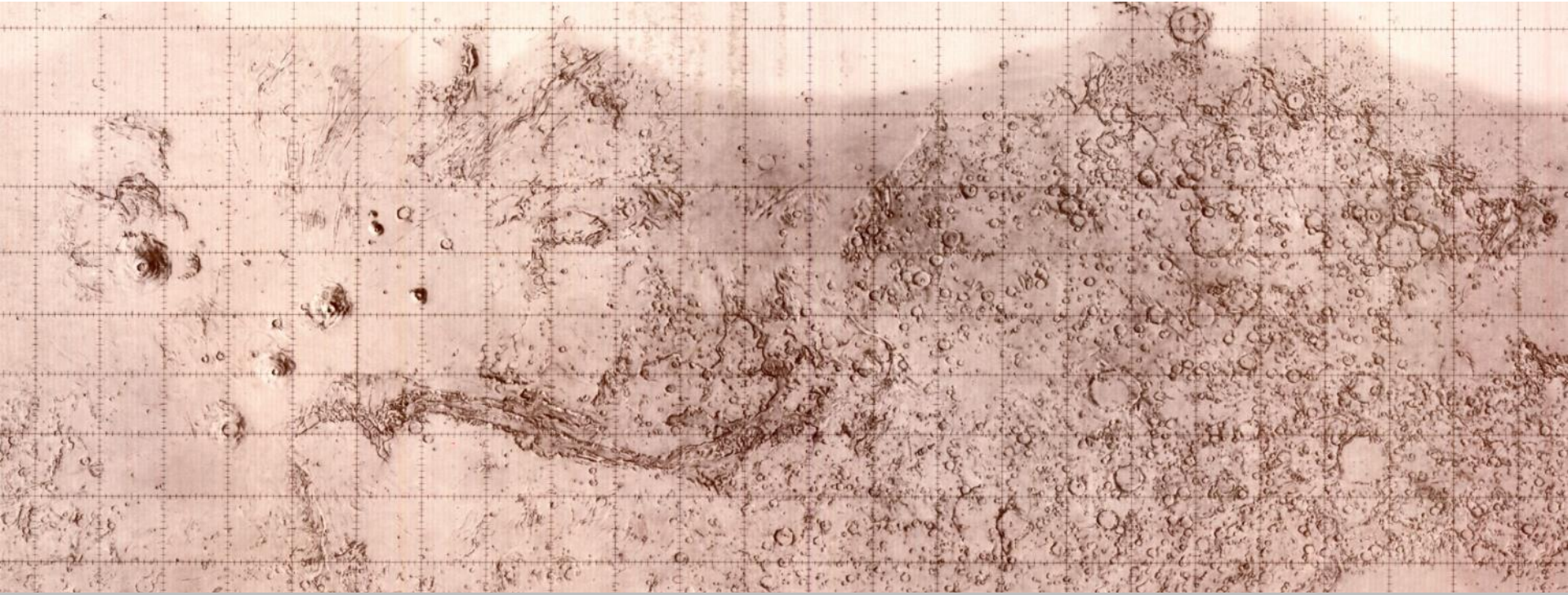
THERE IS LIFE... AND A POTENTIAL THREAT?

© 1953, WAR OF THE WORLDS BY PARAMOUNT PICTURES



MARINER 4'S VIDICON IMAGES MARS, 1964

MARS IS A DEAD PLANET



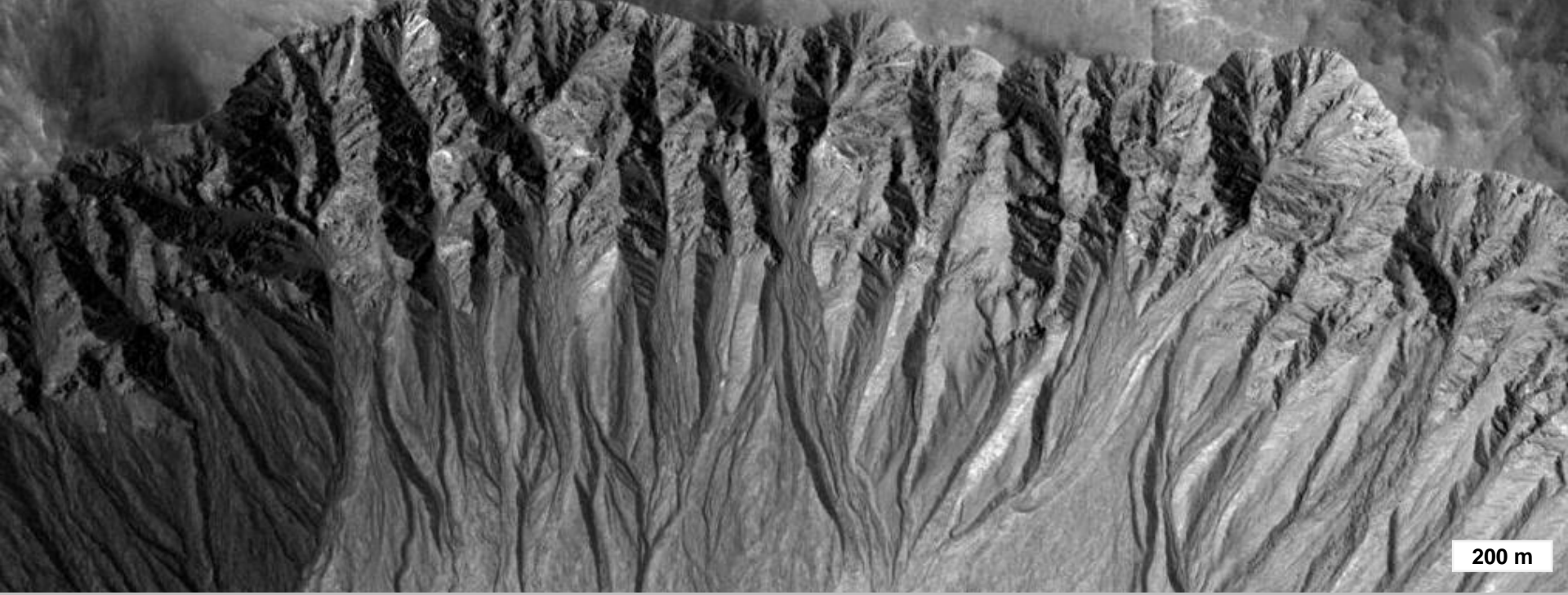
NASA'S MARINER 9 AT MARS, 1972

MARS SHOWS SIGNS OF A WATER-RICH PAST

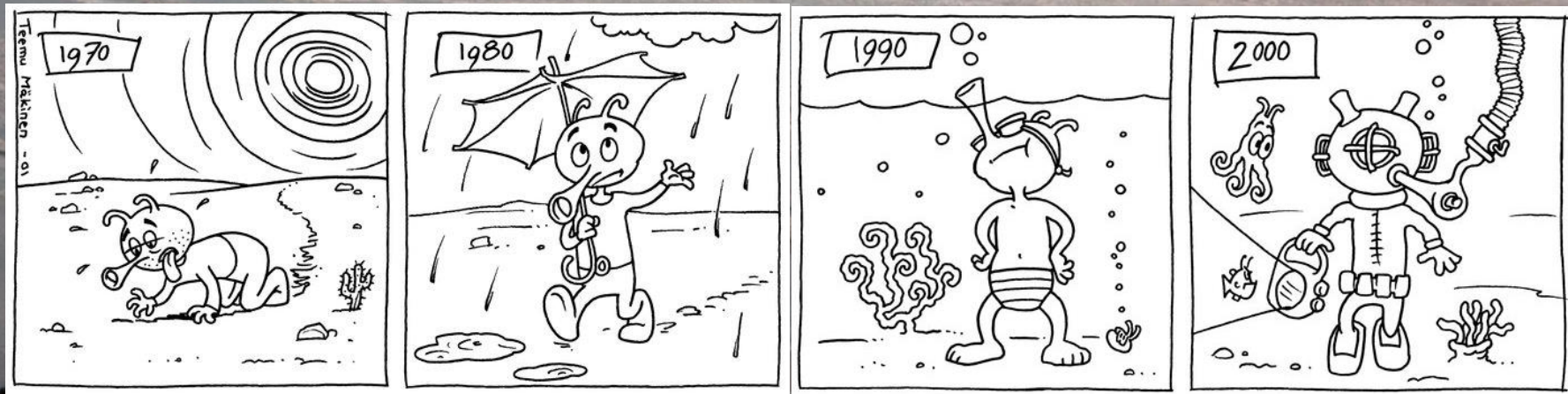


VIKING SHOWS FLUVIAL LANDFORMS, 1980

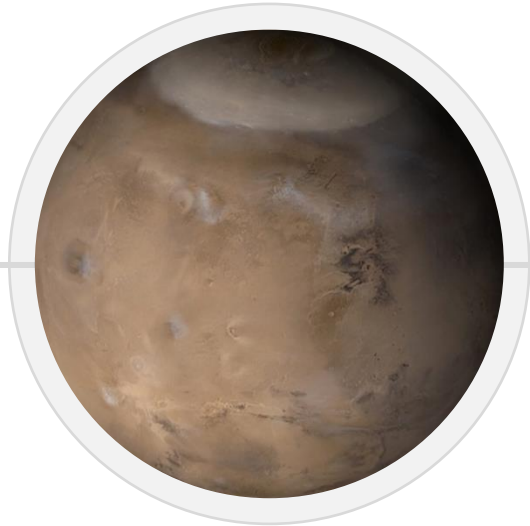
MARS SHOWS *EVEN MORE* SIGNS OF A WATER-RICH PAST



MARS ORBITER CAMERA SEES GULLIES, 1996-2006
AND THESE GULLIES SEEM TO HAVE BEEN FORMED RECENTLY



PERCEPTION HAS CHANGED

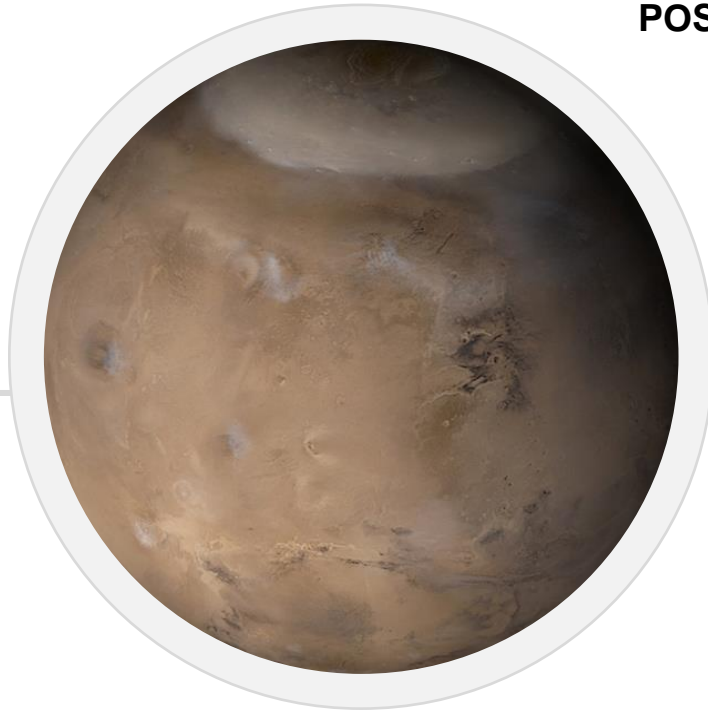


SURFACE CHANGES ON MARS

WHERE CAN WE EXPECT THEM TO HAPPEN?

SURFACE CHANGES ON MARS

WHAT CAN WE EXPECT?



POSITION IN SPACE

INCLINED AXIS

ATMOSPHERE

GRAVITATION

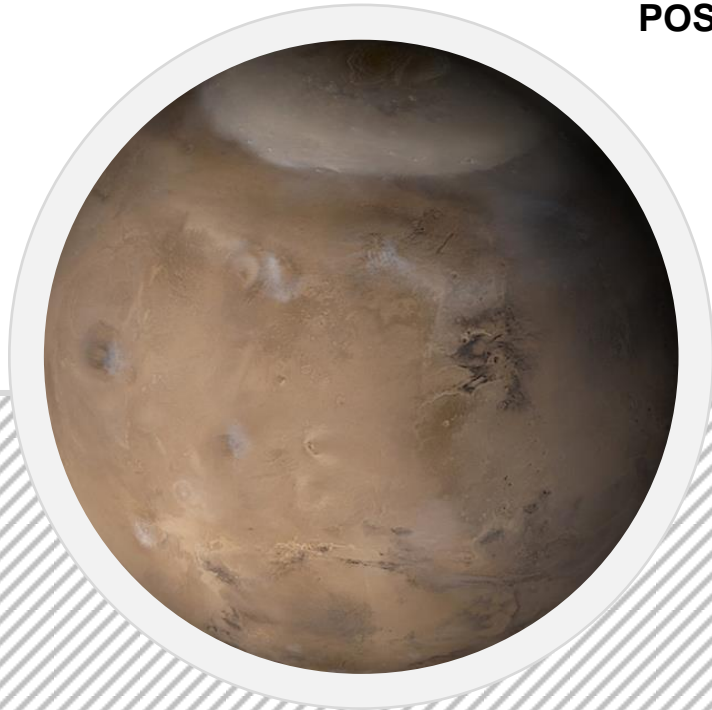
**INTERIOR
DYNAMICS**

**EXOGENIC
DYNAMICS**

**ENDOGENIC
DYNAMICS?**

SURFACE CHANGES ON MARS

WHAT CAN WE EXPECT?



POSITION IN SPACE

INCLINED AXIS

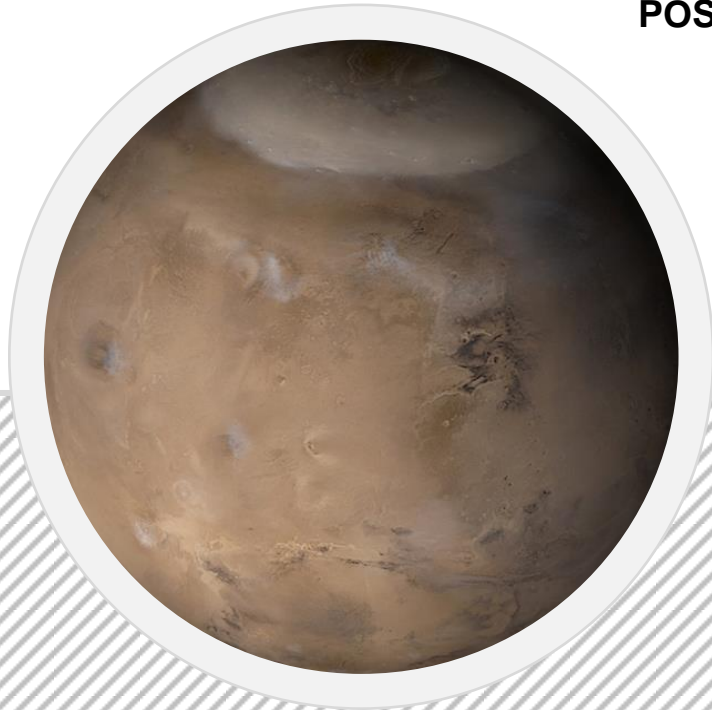
ATMOSPHERE

GRAVITATION

**EXOGENIC
DYNAMICS**

SURFACE CHANGES ON MARS

WHAT CAN WE EXPECT?



POSITION IN SPACE

IMPACT CRATERING

INCLINED AXIS

WEATHER DYNAMICS

ATMOSPHERE

POLAR DYNAMICS

GRAVITATION

MASS MOVEMENT

SURFACE CHANGES ON MARS

WHEN AND WHERE DO THEY OCCUR?
...AND WHAT DO THEY TELL US?





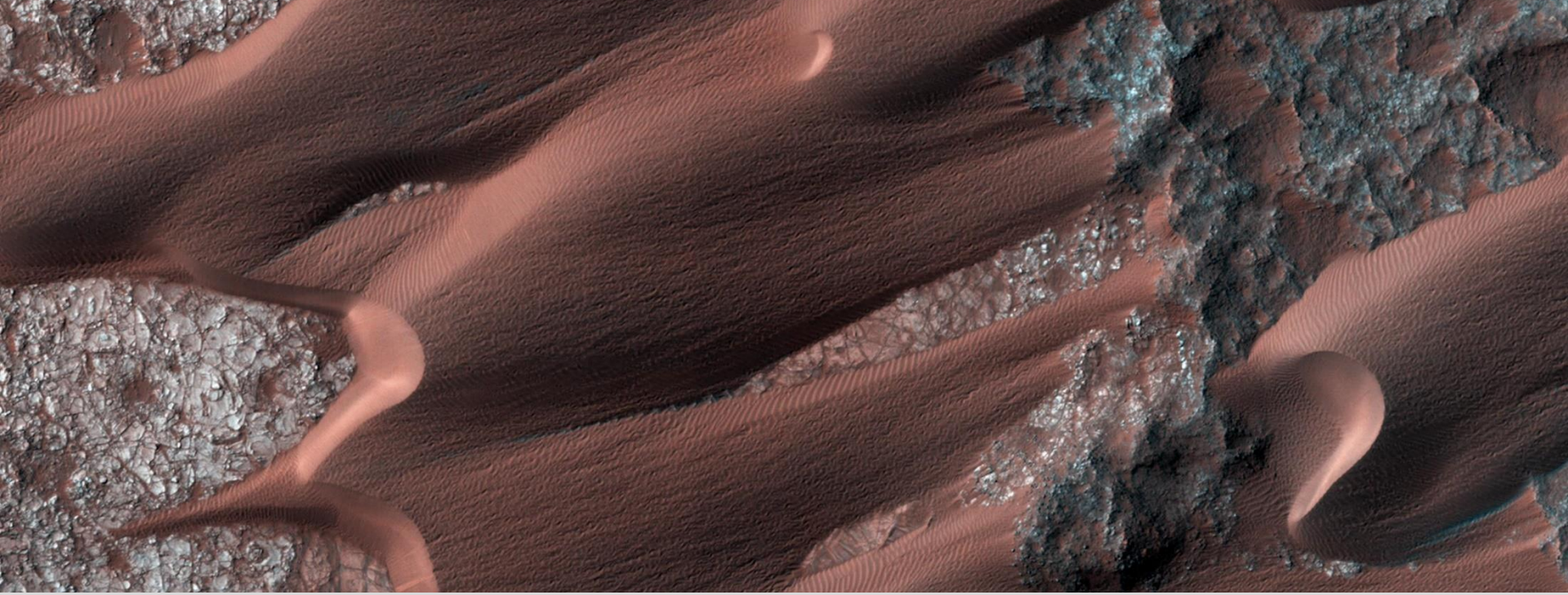
26 JUN 2001



4 SEP 2001

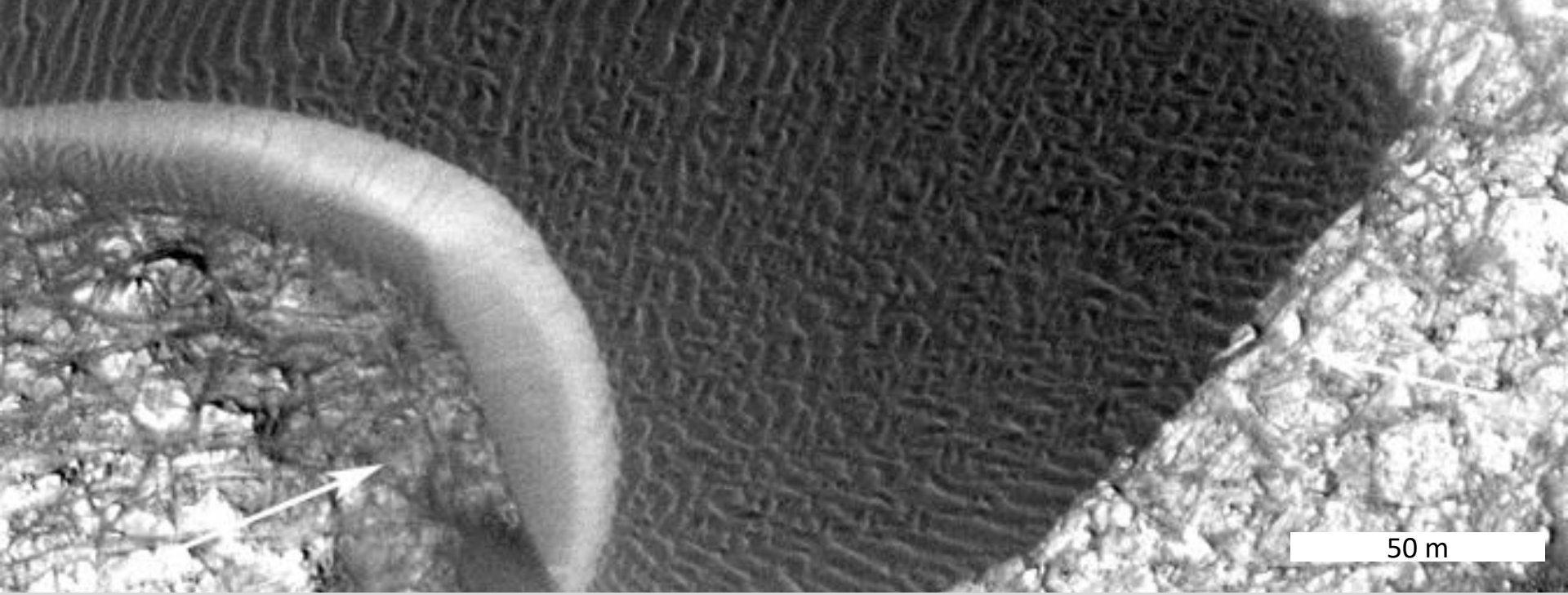
SEASONAL CHANGES OF DUST LOAD

ATMOSPHERIC DYNAMICS AT GLOBAL SCALES



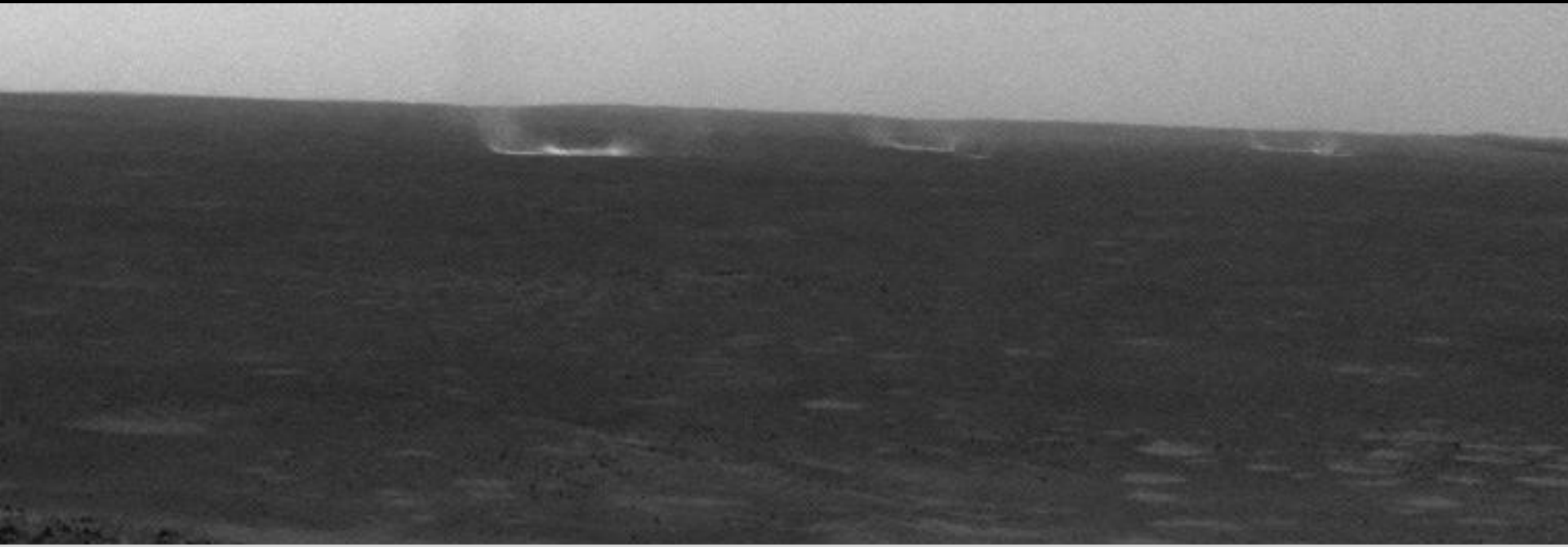
CHANGES BY WIND: AEOLIAN PROCESSES

ATMOSPHERIC DYNAMICS AT LOCAL SCALES



CHANGES BY WIND: AEOLIAN PROCESSES

ATMOSPHERIC DYNAMICS AT LOCAL SCALES



CHANGES BY WIND: AEOLIAN PROCESSES

DUST DEVILS AS SEEN BY SPIRIT, 2005



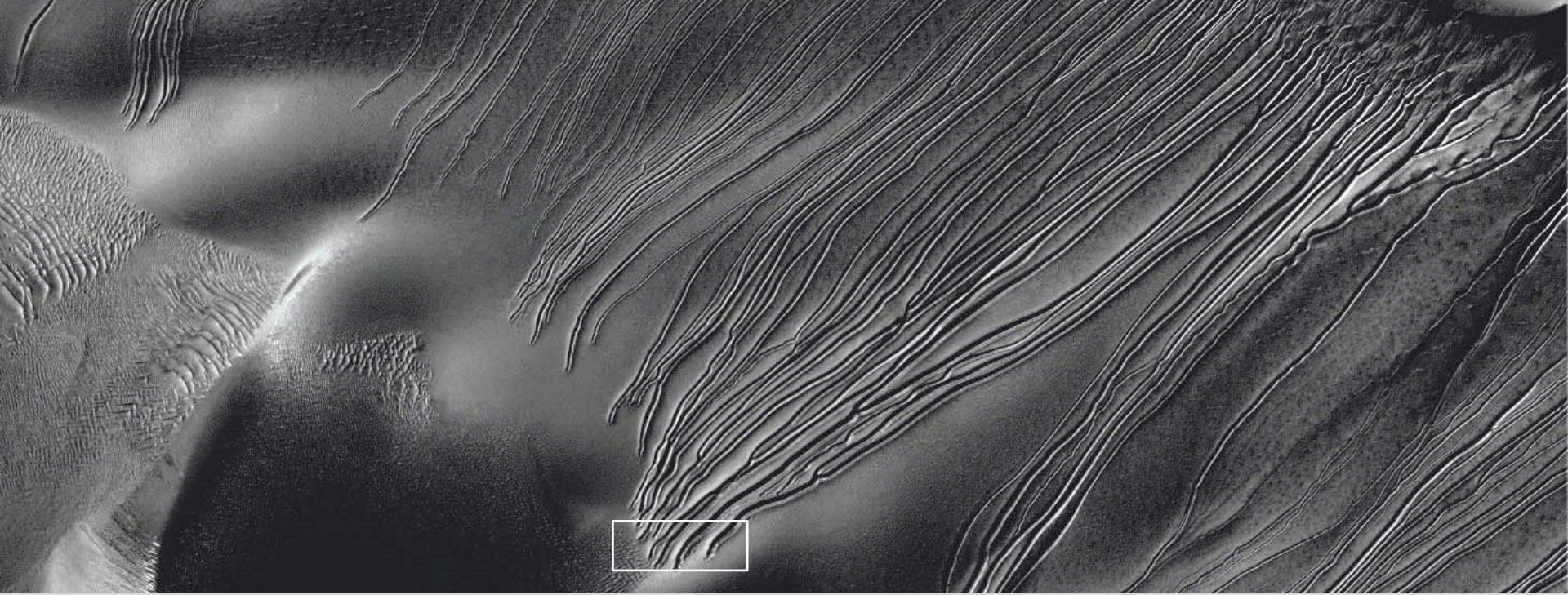
ACTIVE DUST DEVILS IN MID LATITUDES

DUST DEVIL AS SEEN BY HiRISE



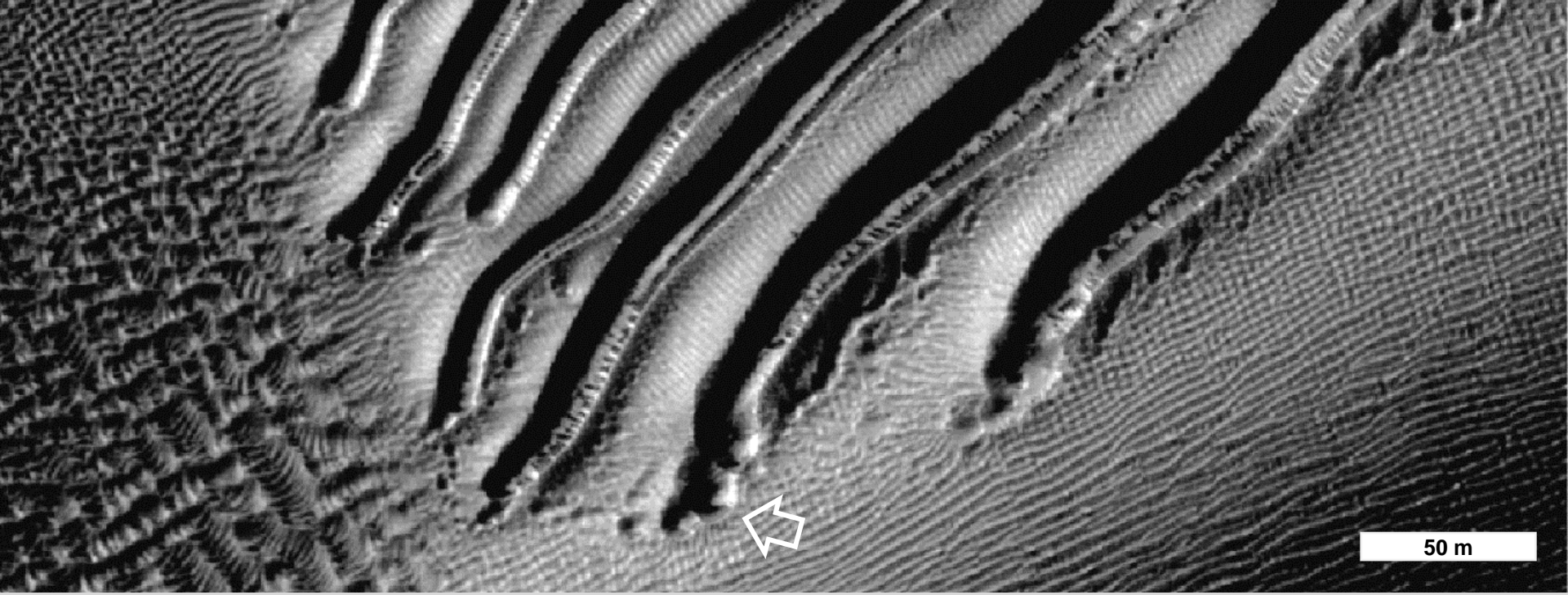
CHANGES IN THE RUSSELL CRATER DUNE FIELD

DUST DEVILS AS SEEN BY HiRISE



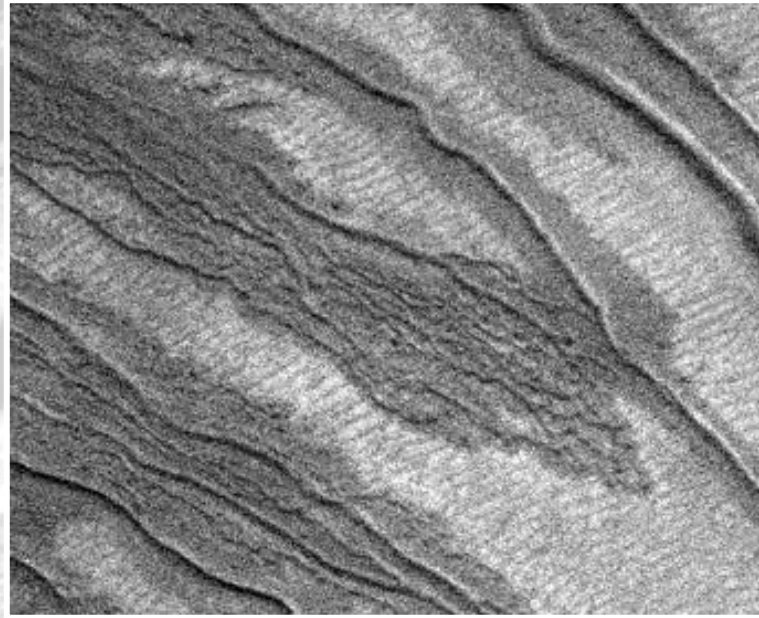
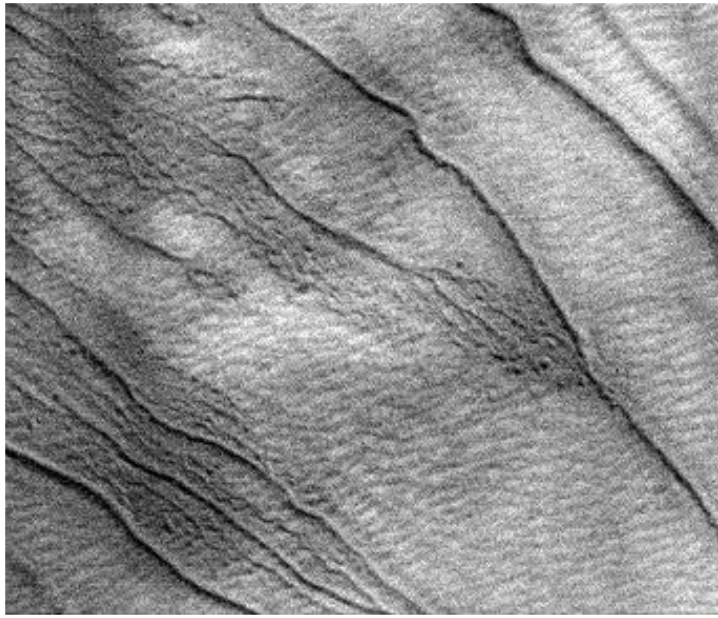
LINEAR GULLIES IN THE RUSSELL CRATER DUNEFIELD

CO₂ SLABS MOVING DOWNHILL

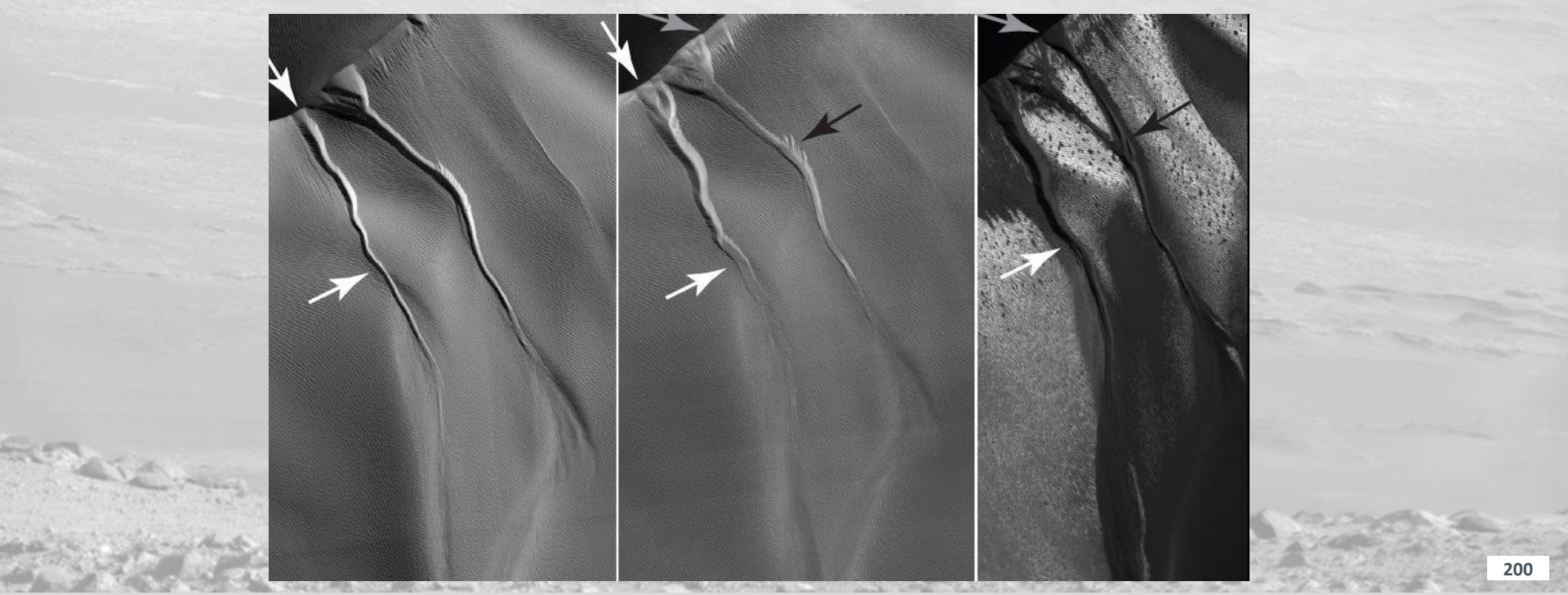


LINEAR GULLIES IN THE RUSSELL CRATER DUNEFIELD

CO₂ SLABS MOVING DOWNHILL

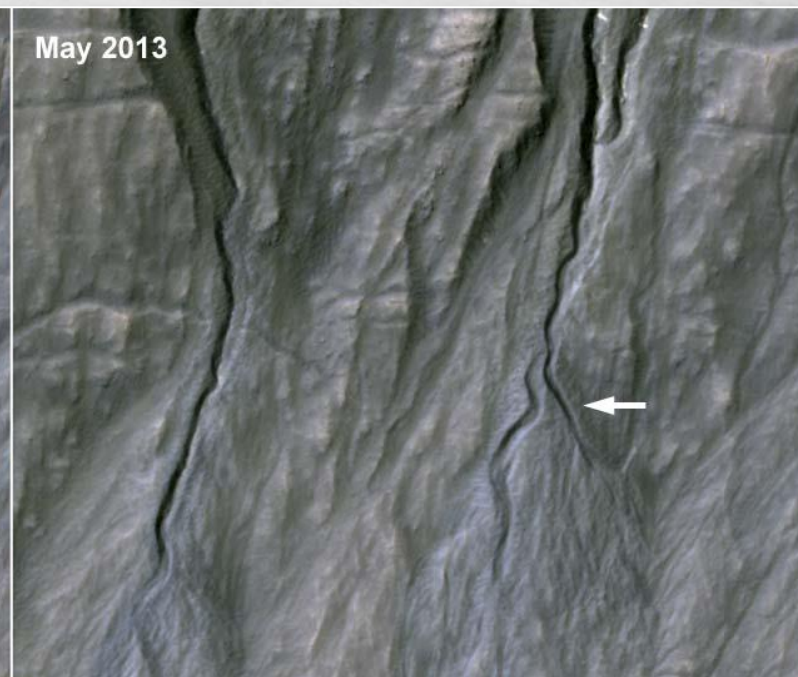
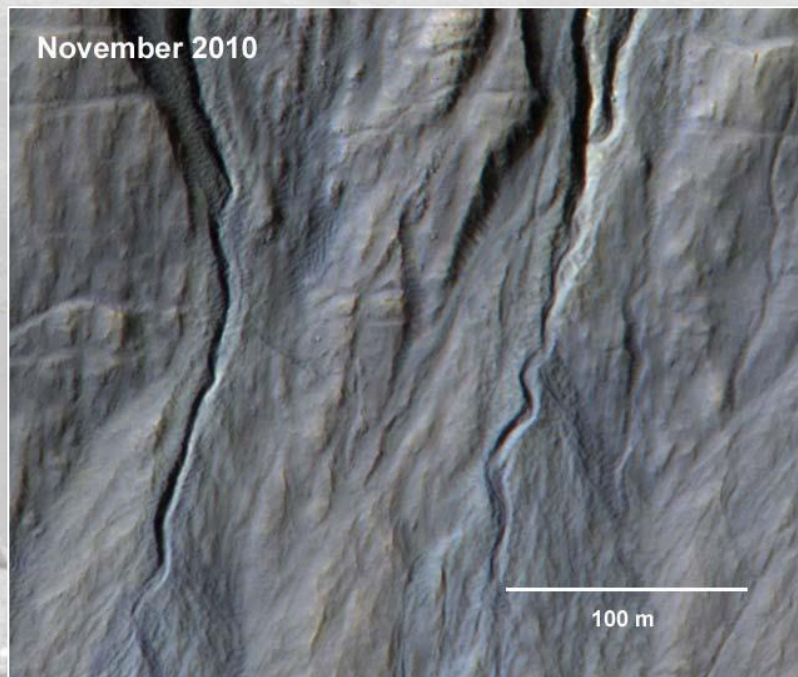


LINEAR GULLIES IN THE RUSSELL CRATER DUNEFIELD
CO₂ SLABS MOVING DOWNHILL



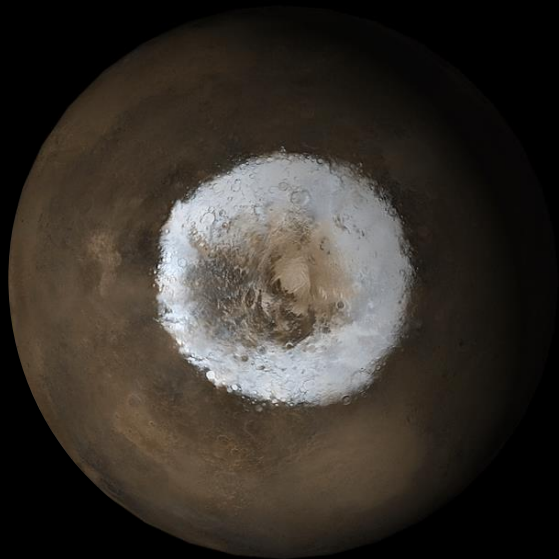
GULLIES IN THE MATARA CRATER

SEASONAL CARBON DIOXIDE ICE

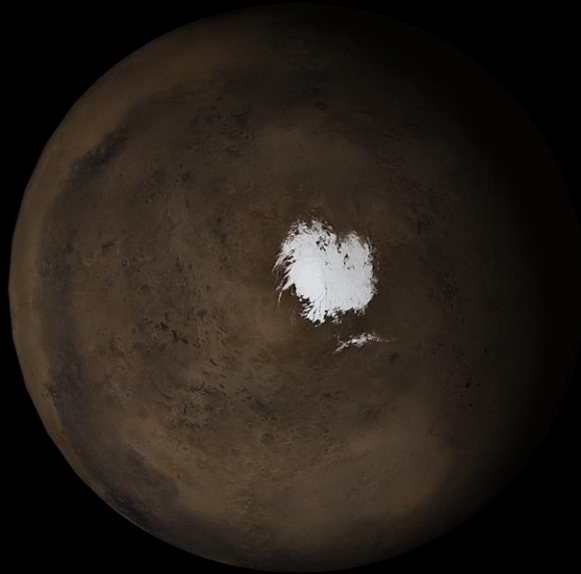


GULLIES IN THE RUSSELL CRATER DUNEFIELD

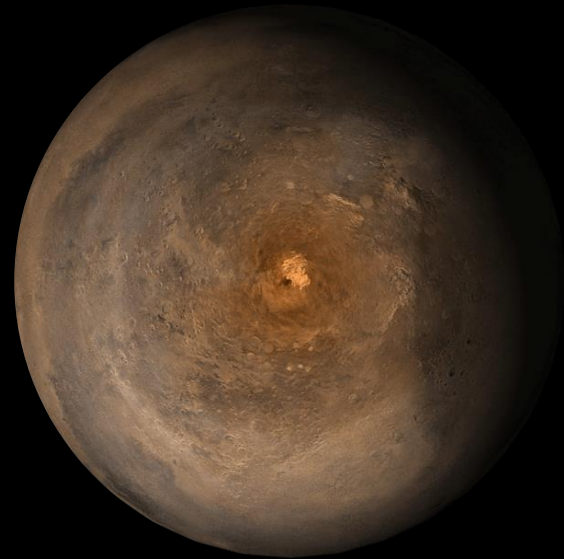
SEASONAL WATER



$L_S=211^\circ$



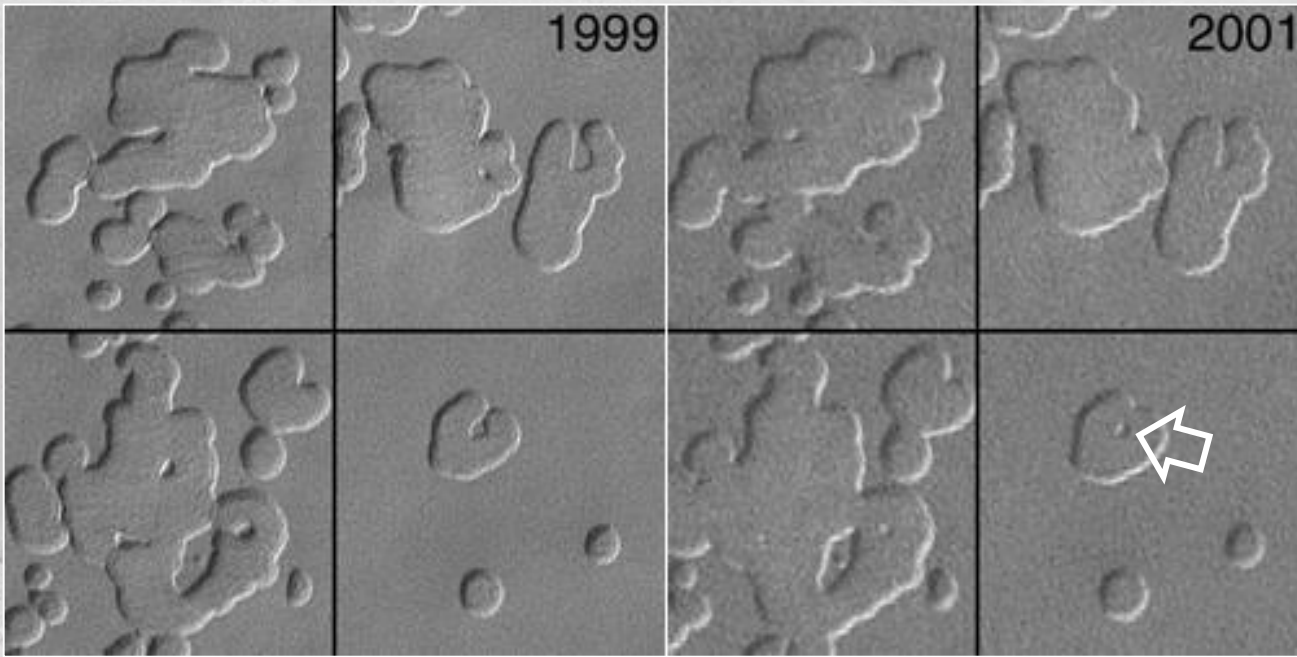
$L_S=269^\circ$



$L_S=357^\circ$

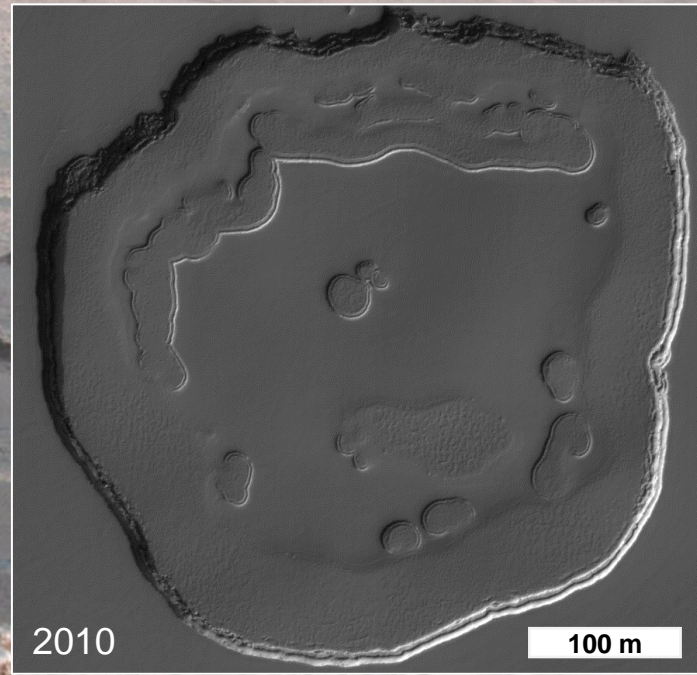
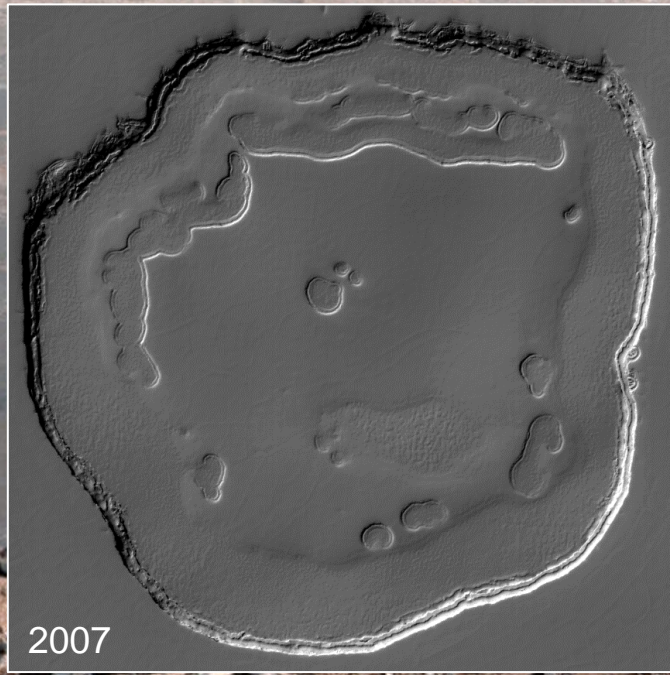
SEASONAL CHANGES OF POLAR CAPS

ATMOSPHERIC DYNAMICS AT GLOBAL SCALES



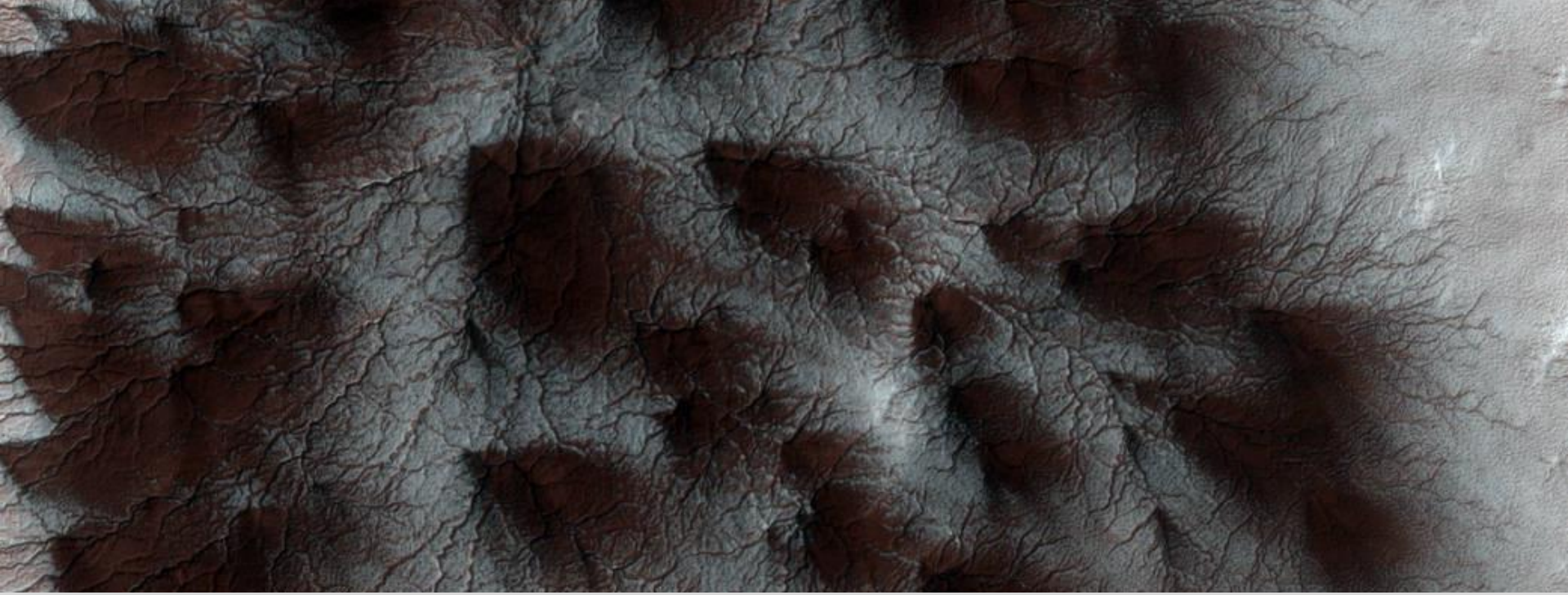
THE MARTIAN POLAR SWISS CHEESE TERRAIN

CLIMATE CHANGE SUGGESTED FOR MARS?



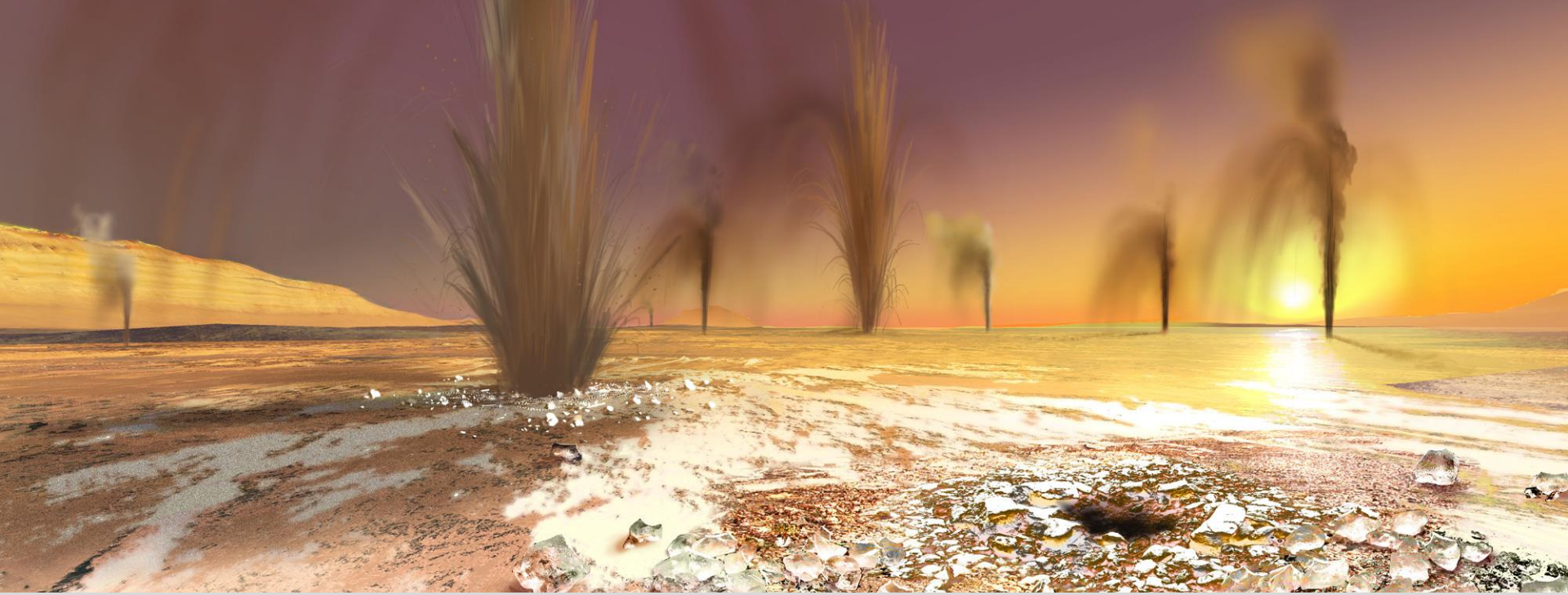
HAPPY FACE SWISS CHEESE AS SEEN BY HIRISE

CLIMATE CHANGE? PROBABLY NOT...



STARBURST SPIDERS OF MARS

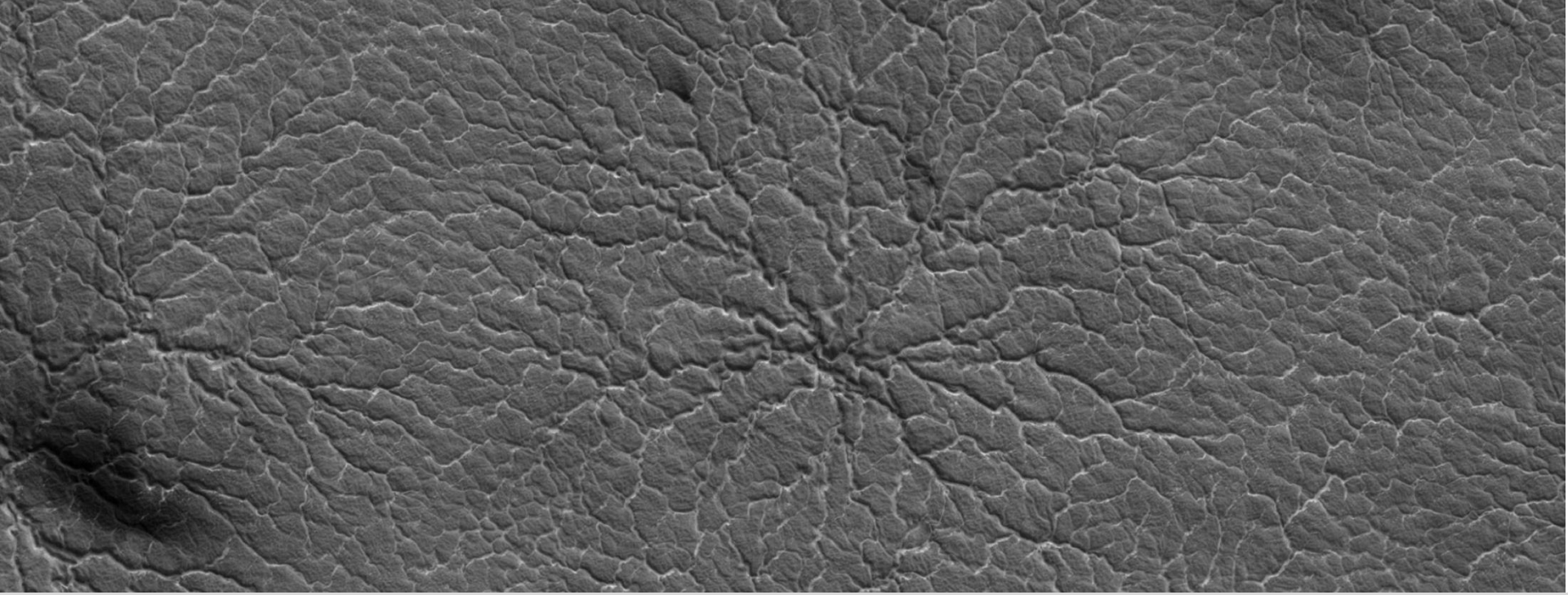
POLAR CARBON DIOXIDE GEYSERS



'ARANEIFORMS' OF MARS

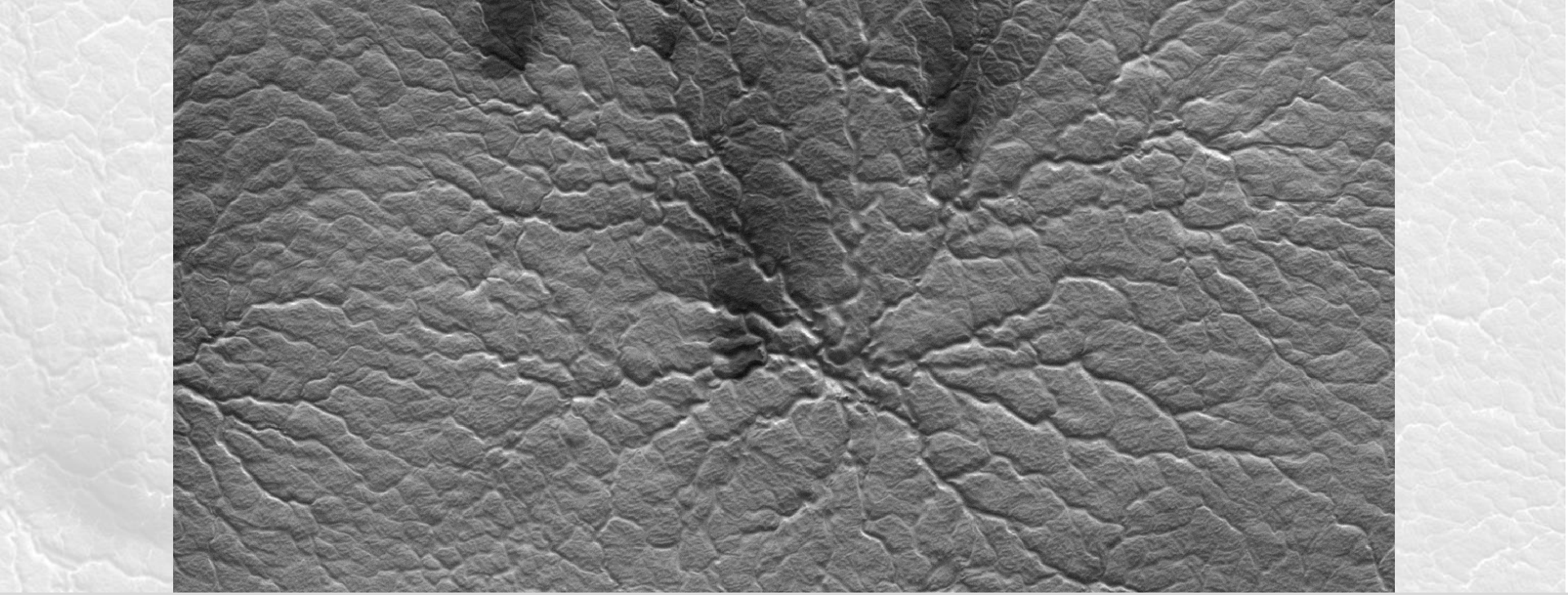
POLAR CARBON DIOXIDE GEYSERS

NASA/JPL-CALTECH/ARIZONA STATE UNIVERSITY/RON MILLER



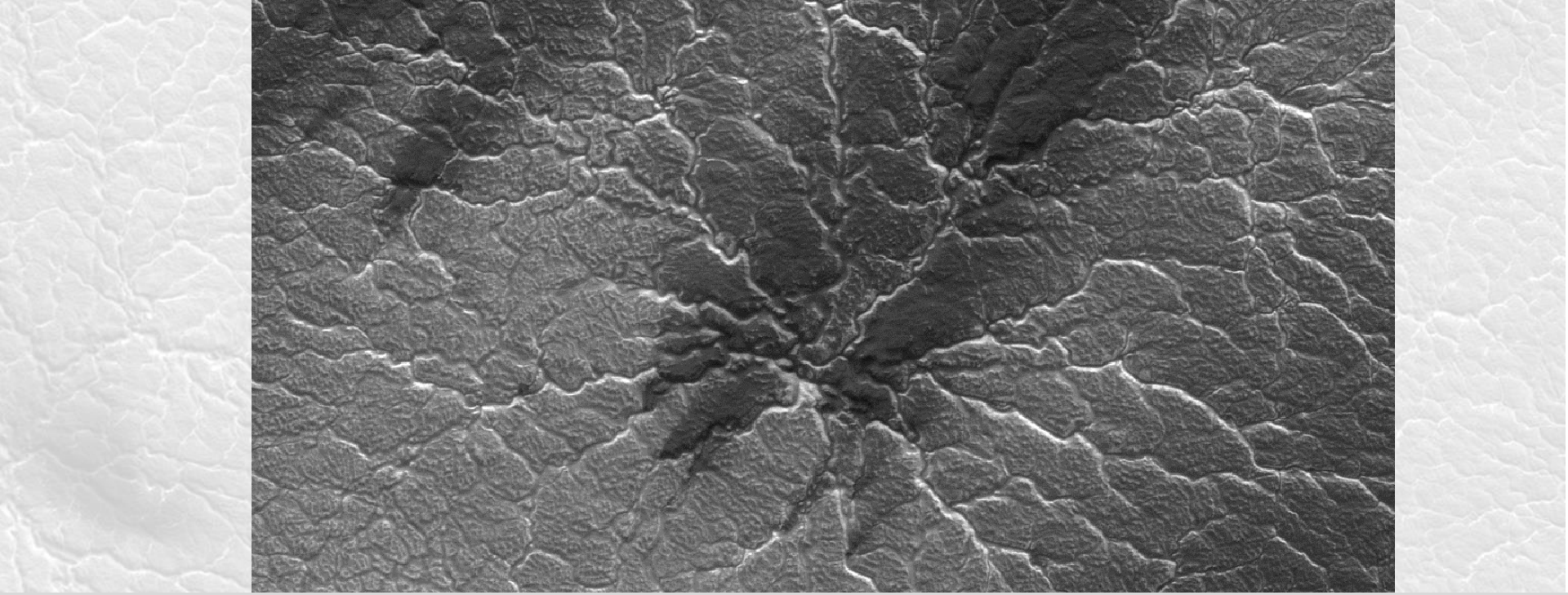
SPIDERS OF MARS: POLAR CO₂ GEYSIRS

SOUTH POLAR SPRING AT L_s=181°



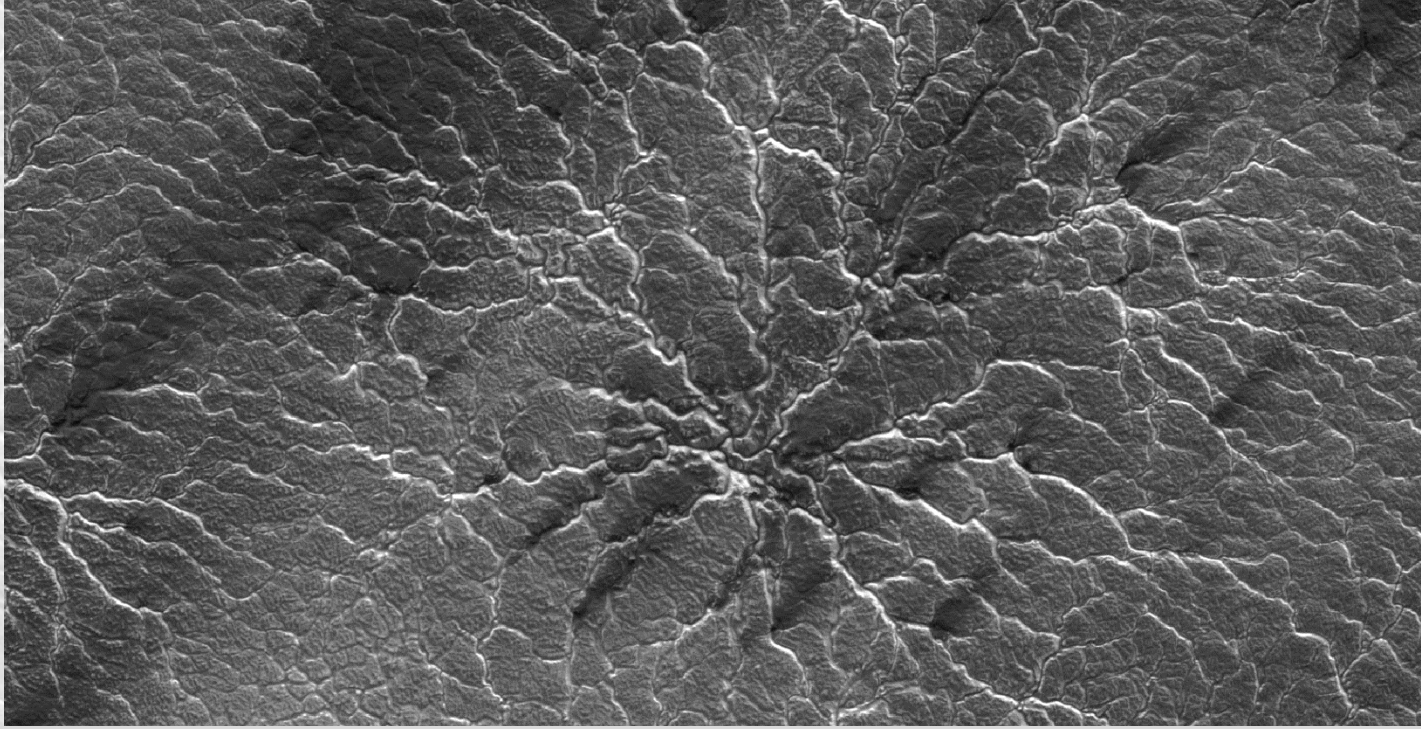
SPIDERS OF MARS: POLAR CO₂ GEYSIRS

SOUTH POLAR SPRING AT L_s=195°



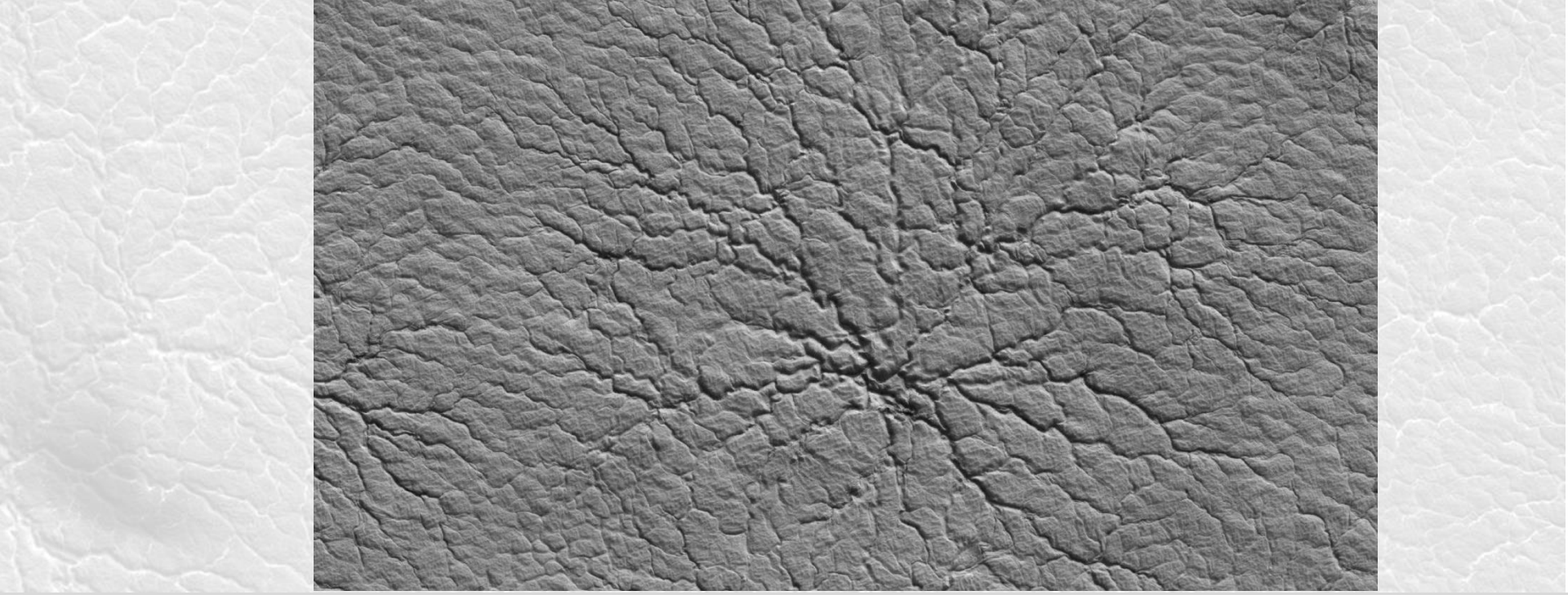
SPIDERS OF MARS: POLAR CO₂ GEYSIRS

SOUTH POLAR SPRING AT L_s=226°



SPIDERS OF MARS: POLAR CO₂ GEYSIRS

SOUTH POLAR SPRING AT L_s=233°



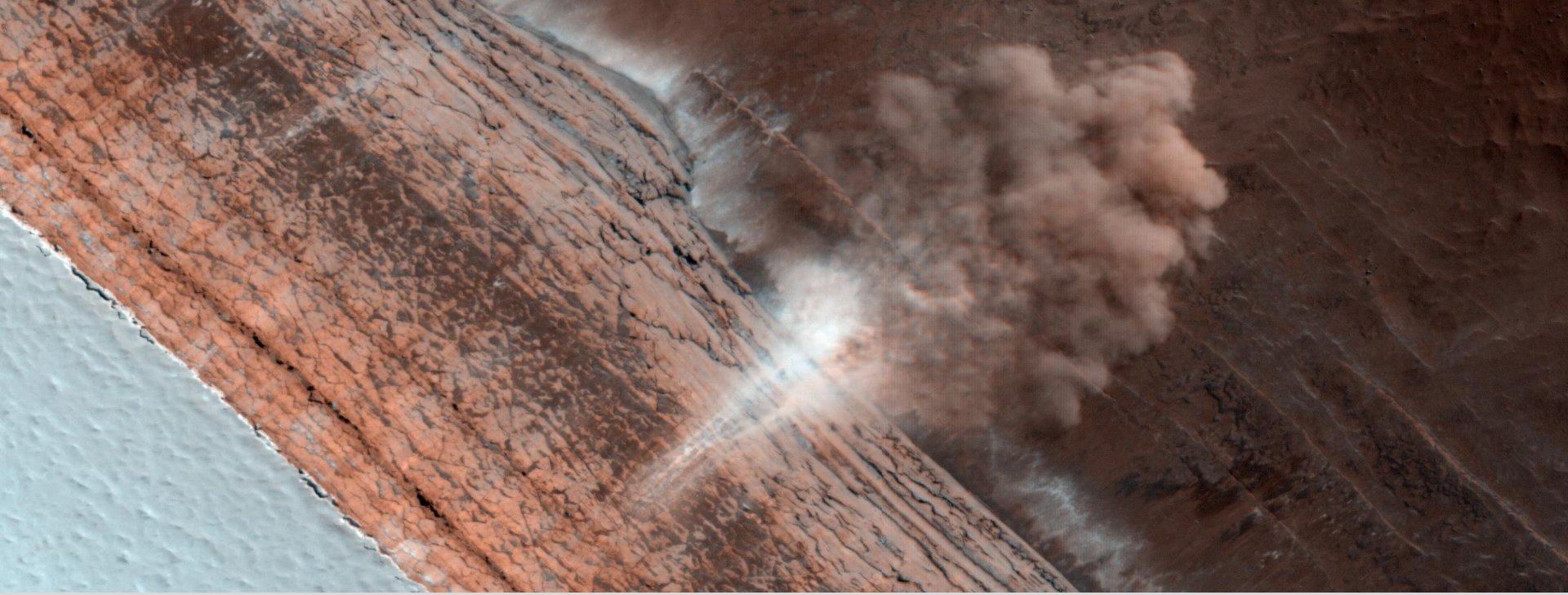
SPIDERS OF MARS: POLAR CO₂ GEYSIRS

SOUTH POLAR SPRING AT L_s=325°



NORTH POLAR FROST AVALANCHES CAUGHT IN THE ACT

NORTHERN SPRING CARBON DIOXIDE FROST

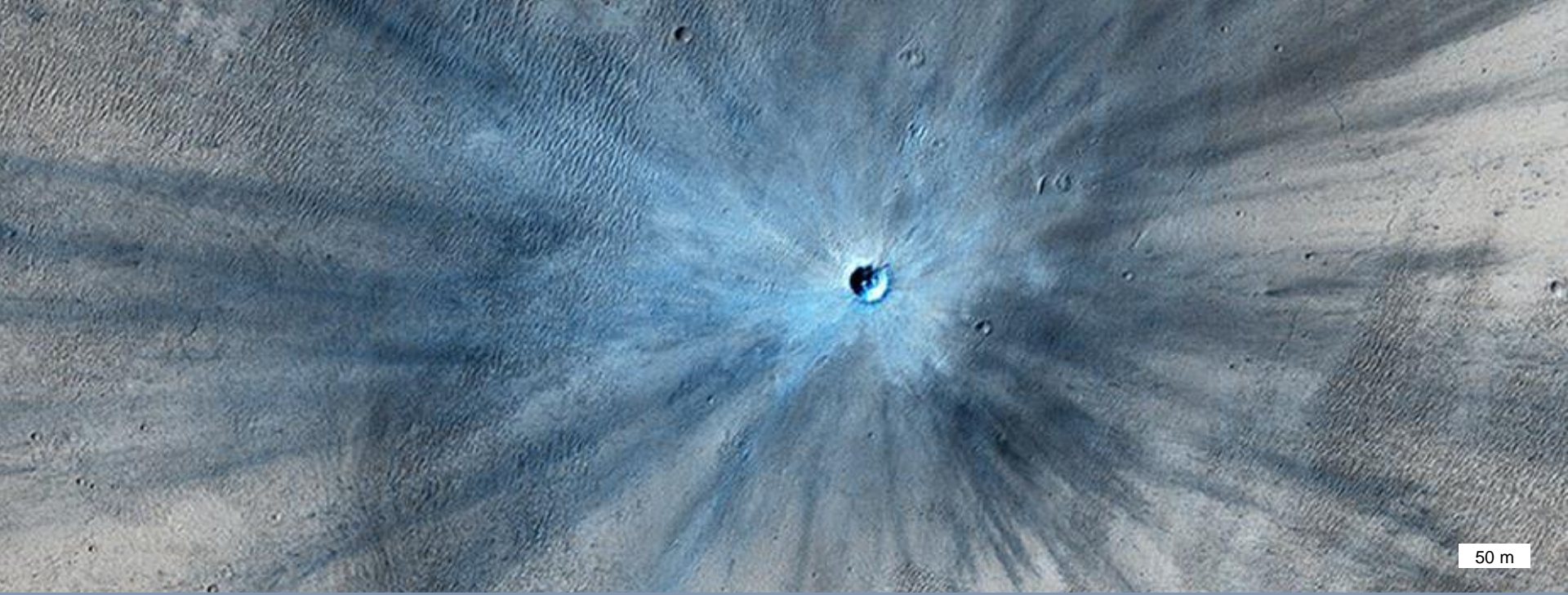


NORTH POLAR AVALANCHES CAUGHT IN THE ACT

SOUTH POLAR SPRING AT $L_s=325^\circ$



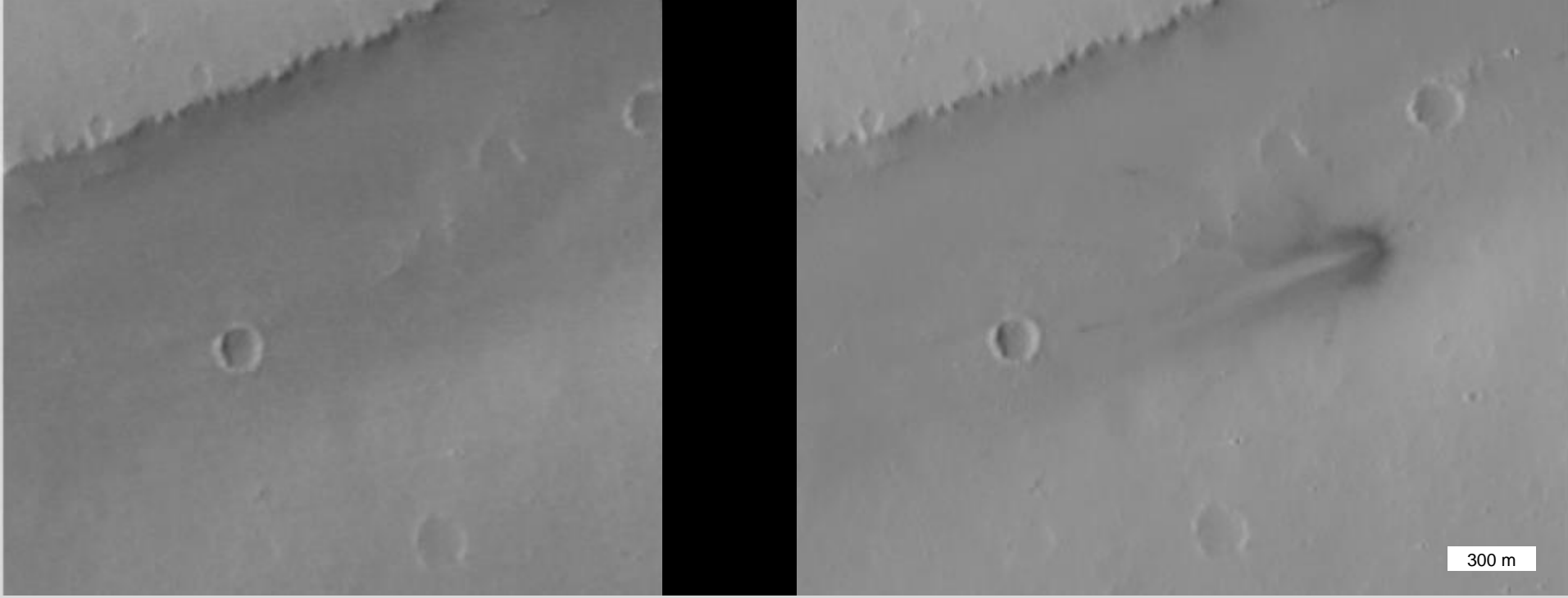
NORTHERN DUNE DEFROSTING



50 m

IMPACT CRATERING

A UBIQUITOUS GEOLOGICAL PROCESS



IMPACT CRATERING

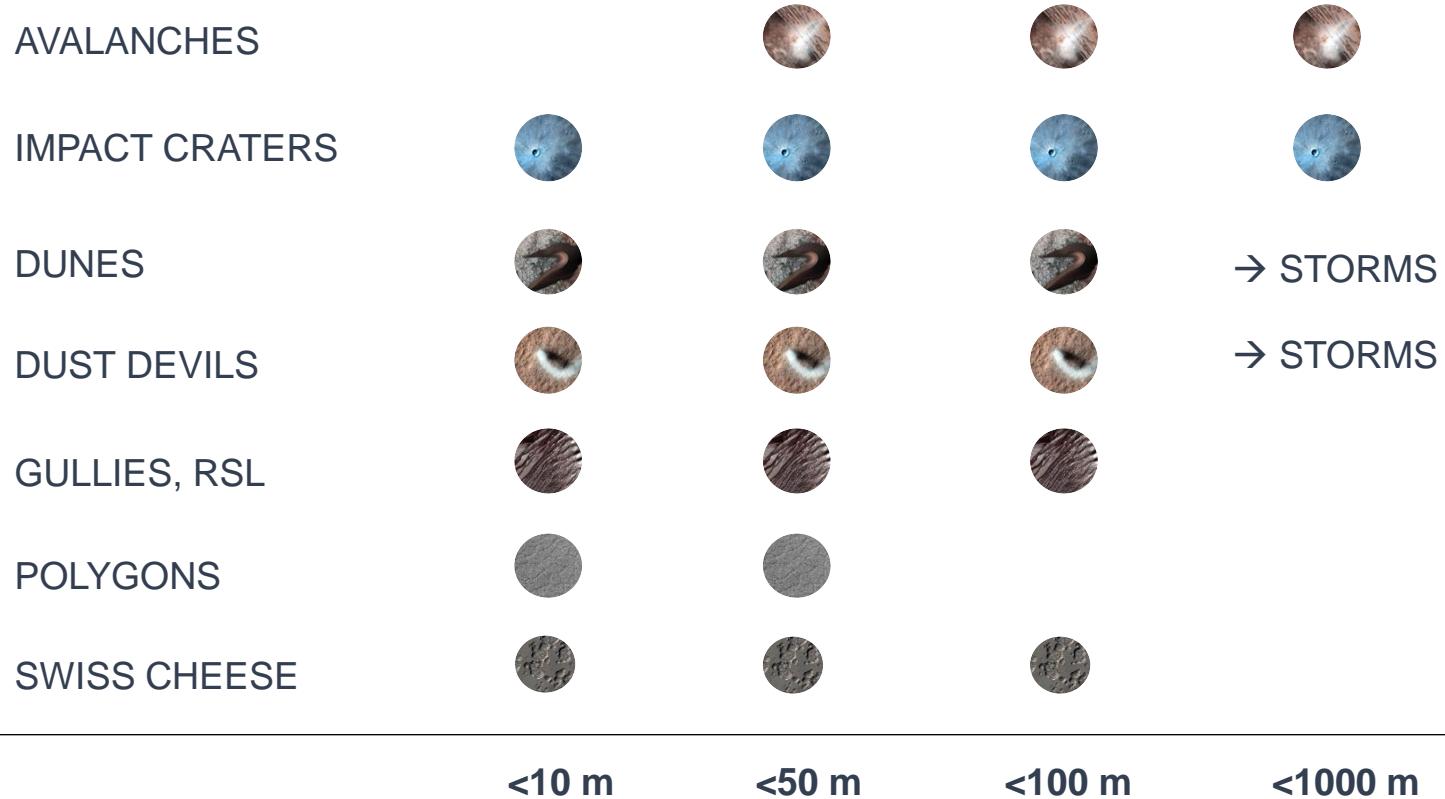
A RECENT IMPACT IN ELYSIUM PLANITIA



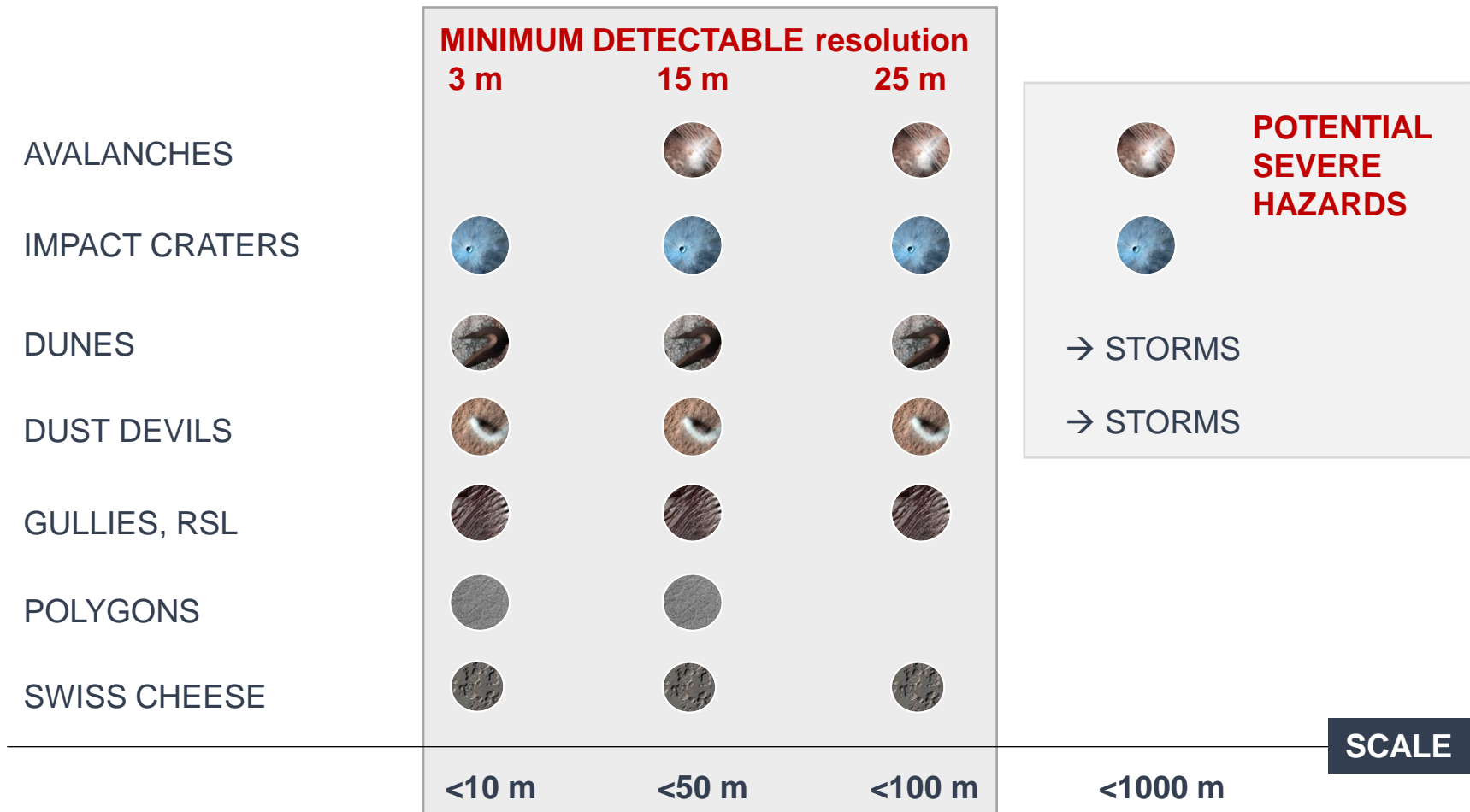
IMPACT CRATERING

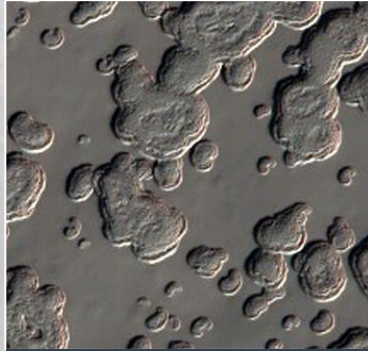
A RECENT IMPACT IN ELYSIUM PLANITIA

SCALES AND DETECTABILITY

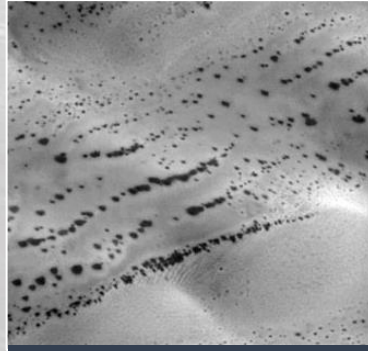


SCALE

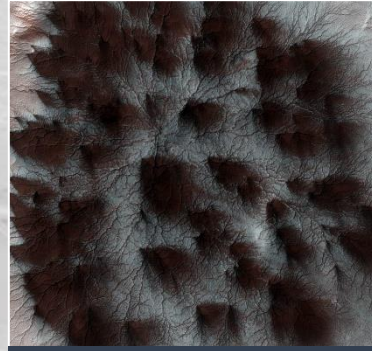




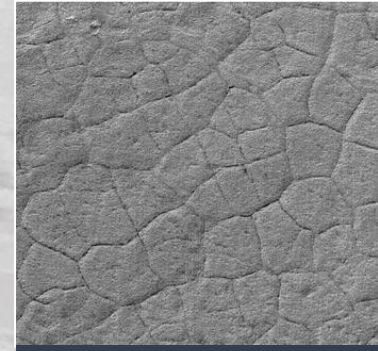
SWISS CHEESE



DALMATIAN SPOTS



ARANEIFORMS



POLAR POLYGONS

SEASONAL WATER AND CARBON DIOXIDE CYCLE

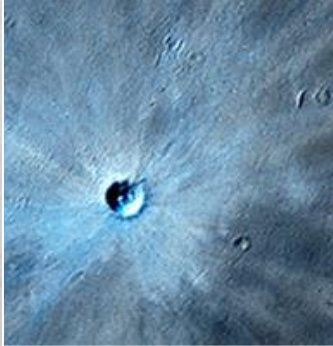
INTERACTION OF CARBON DIOXIDE AND WATER

DEPOSITIONAL ENVIRONMENT

RESURFACING AND EROSION



DUST DEVILS



IMPACTS



AVALANCHES



GULLIES S.L.



DUNES

IMPACT RATES AND IMPACT CRATER SIZES: BOMBARDMENT

SPATIO-TEMPORAL DISTRIBUTION OF GRAVITATIONAL MASS MOVEMENT

WIND SPEEDS AND ABRASION EFFECTS

WATER, CARBON DIOXIDE AND BRINES IN MID-LATITUDES



DETECTION OF RESERVOIRS AND RESOURCES

ASSESSMENT OF RISK FOR HUMANS AND FOR ROBOTIC SPACECRAFT

SURFACE CHANGES

PROCESSES INTERACT CONTINUOUSLY

Change has been observed from orbiting spacecraft as well as landers and rovers at various scales.

Change detection allows us to quantify processes when put into a temporal context... and to compare them eventually.



SURFACE CHANGES

PROCESSES INTERACT CONTINUOUSLY

The type of change could be predicted.

The level of change, however, is mostly unknown.

Change could only be detected using high-resolution repeat imaging and clever data processing.

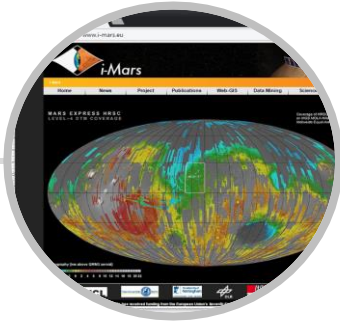


HOW TO DETECT SURFACE CHANGES

MANUAL VS: AUTOMATIC DETECTION

Manual change detection is reliable but it is time consuming and not efficient for larger areas. Interactive community platforms often seem feasible when it comes to time-critical studies.

Automatic detection is possible, but the demands for man and machine appear high.



THANK YOU
FOR YOUR TIME



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