EUROPLANET N2
3&5 DWG

In collaboration with
DWG 8 and DWG 1

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Planet(ary) moons and surfaces

The Moon, the moons

Mars: after MarsExpress and the Aurora program

Mercury : Bepi Colombo in 2016

Venus : little will be known by Venus Express: how to complete?

Titan : The surface composition is still a mystery : Post-Cassini, ground-based monitong

Comets, asteroids : Rosetta, Don Quichotte, Deep Impact I and II - what next?

Questions to address :

Interiors and surfaces of satellites

Surface erosion/ evolution

Laboratory experiments and databases

Tectonics : what other bodies besides the Earth have plate tectonics ?

Volcanism/cryovolcanism : origin of volcanoes on Venus and Mars

23/11/2005

Mars, Mercury, comets, moons:

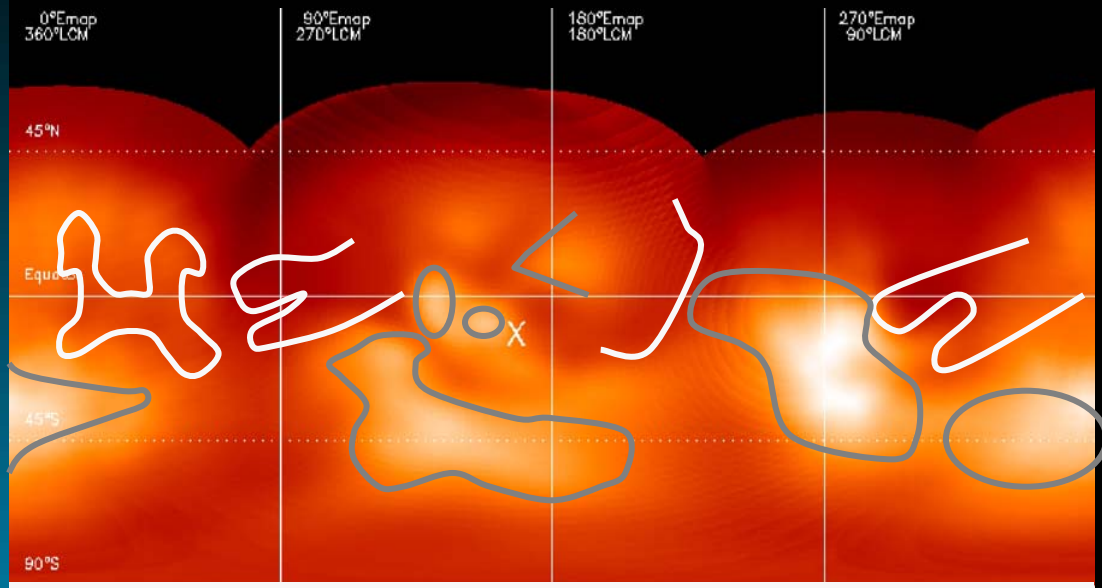
surface-atmosphere interactions

impacts

craters

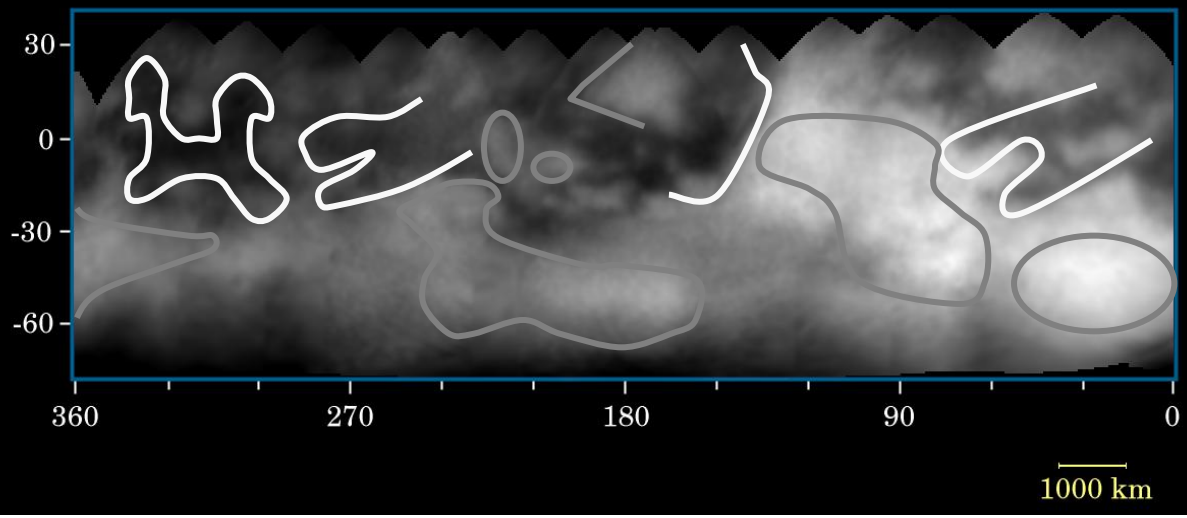
surface properties and evolution

Complete surface mapping



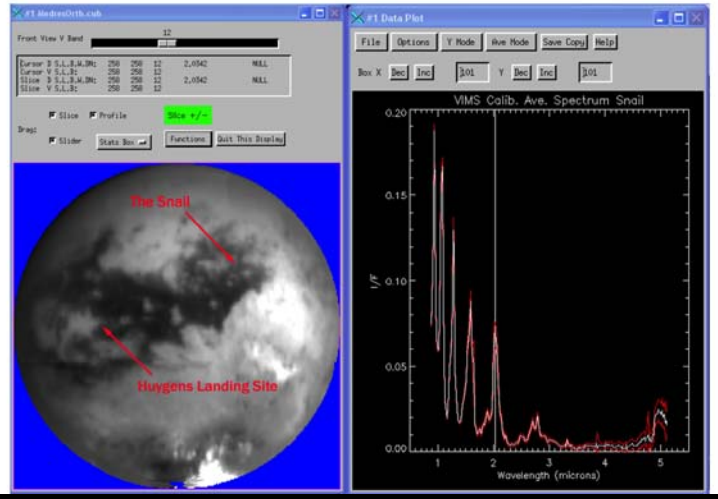
1.28 µm; via NACO (Coustenis *et al*. 2005)

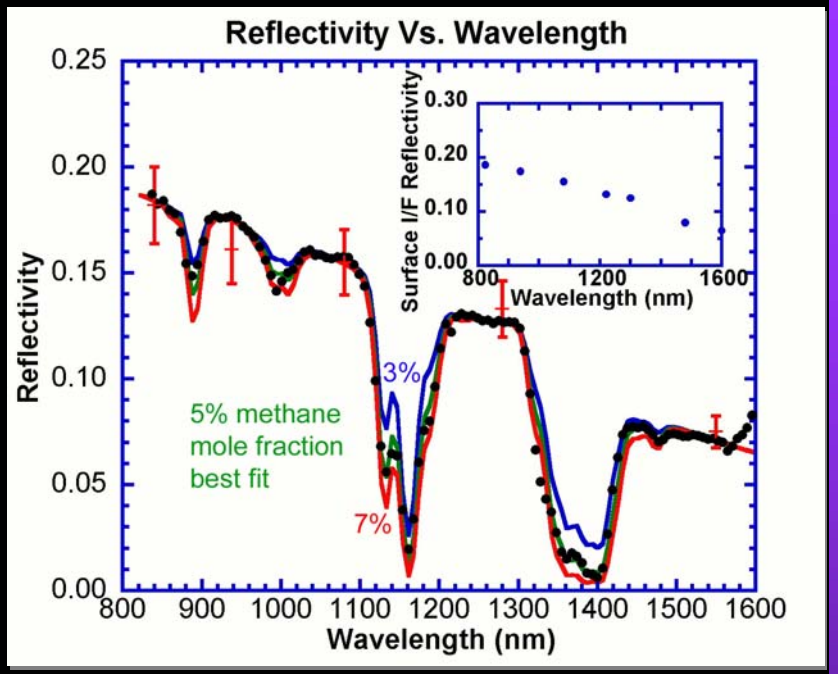
0.94 µm; via Cassini/ISS (TL C. Porco)

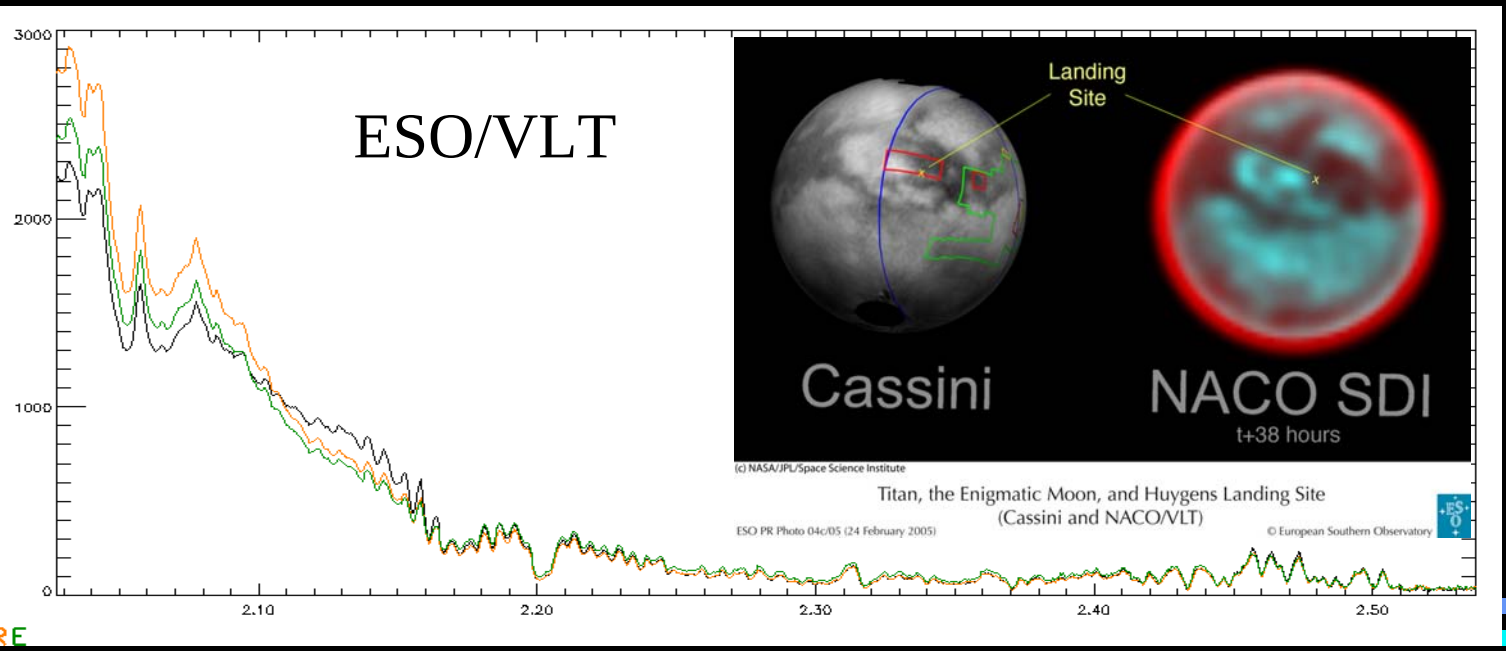


Intercombine data from missions and ground-based

VIMS "Medres" Near Infrared Cubes Acquired on TA - 256 Spectral Channels 0.8-5.2 μm







Planetary atmosphere-surfaces interactions & surface properties (impacts, craters)

Mars, Mercury, moons and comets:

several missions including Cassini-Huygens, MarsExpress and the Aurora program will leave room for further investigation

Questions to address :

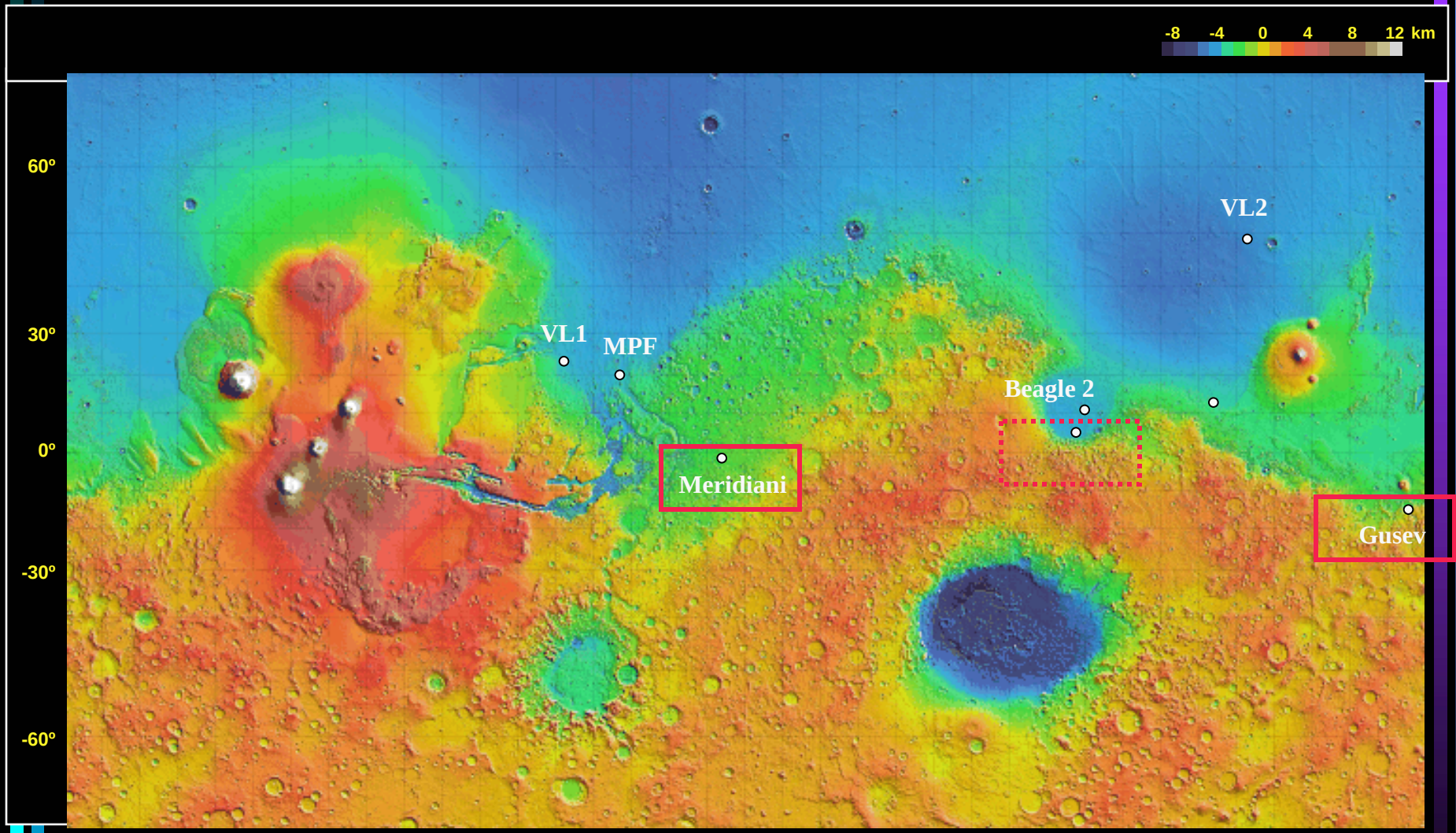
WATER EXCHANGE : Sublimation of ices through a dust layer (Mars, comets, moons): where does the dust humidity seen in the lower atmosphere originate?

how close to the surface is it, how it is maintained - even in the absence of an atmosphere?, => meteorology related to the atmosphere

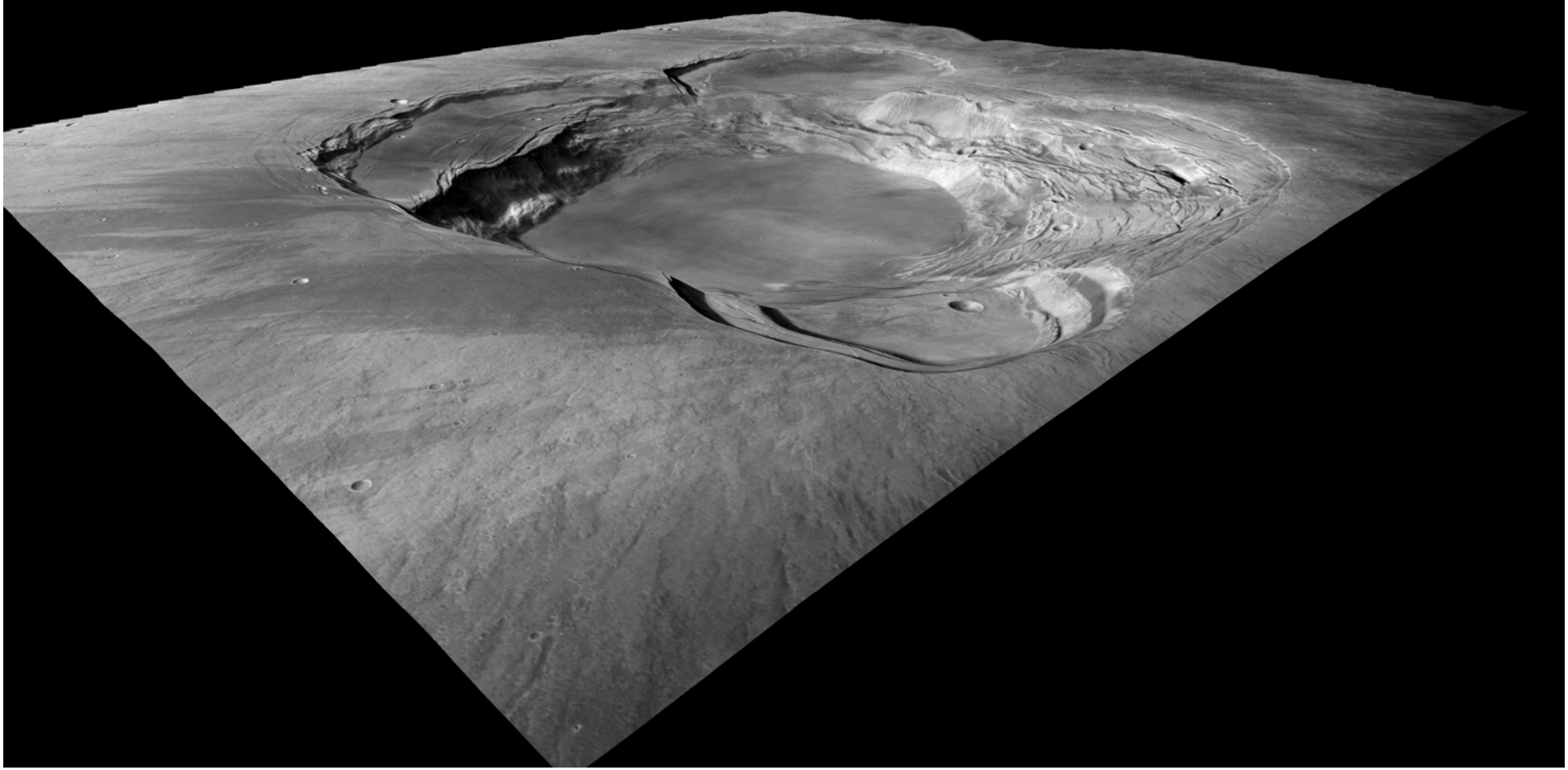
Suggestions: Missions (short-term): MEX, Aurora, but also in situ measurements with more specific instrumentation (neutron spectrometry, drilling, access to deeper layers)

Landing sites selection importance

Landing sites

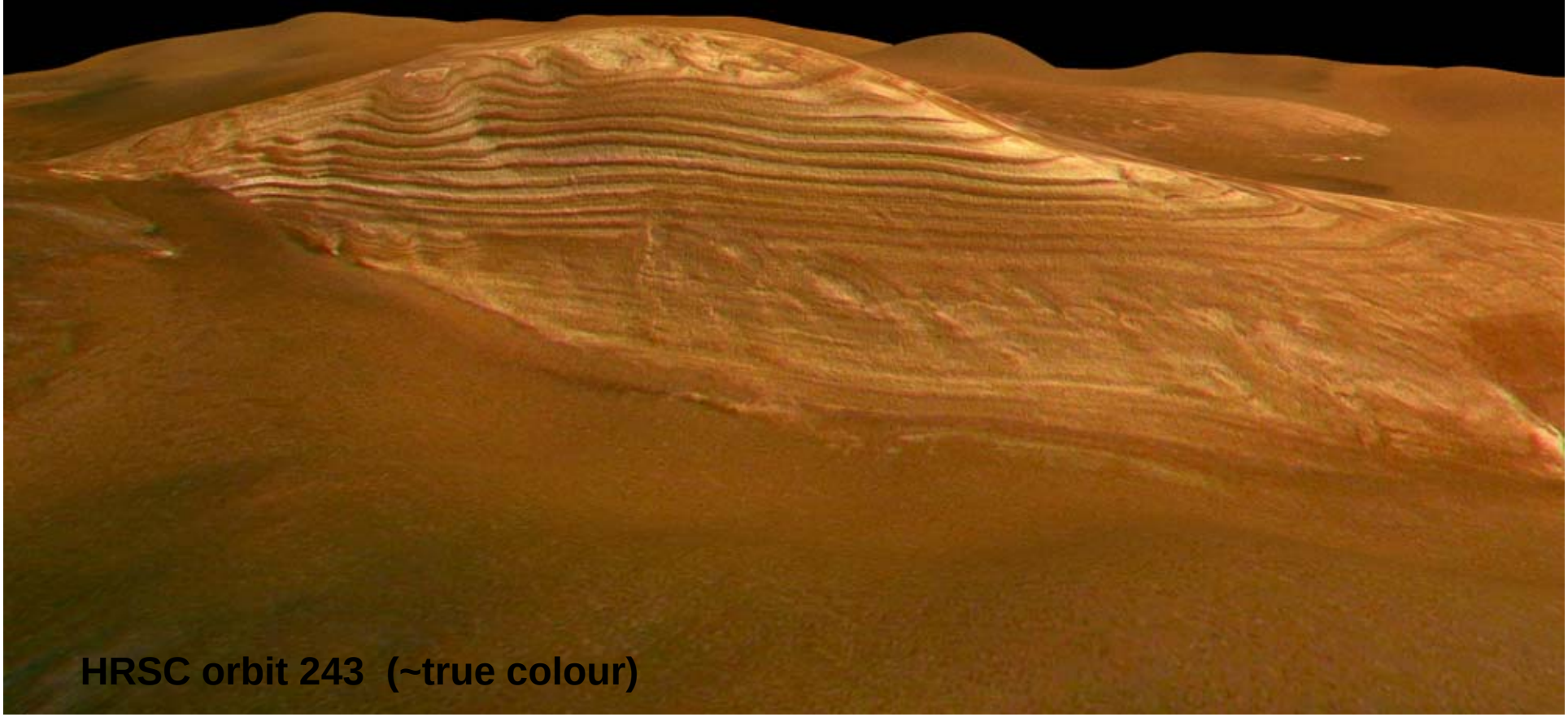


Ascraeus Mons : young caldera (100 Ma)
Origin of the volcanoes, mineralogy of the lava, different episodes of volcanism



Juventae Chasma

Discovery of salts by Omega on Mars Express

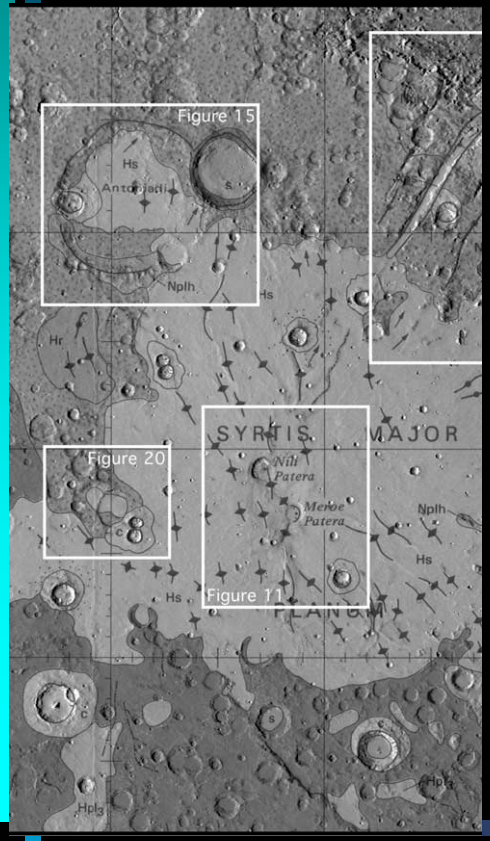


HRSC orbit 243 (~true colour)

Syrtis: surface mineralogy

- composite couleur :

Red = olivine
blue = Augite (CPX)
green = hypersthene (OPX



- Greeley and Guest 1987

-IMPACTS : Impact places on the Moon for SMART-1 (coordinated ground-based observations of the event) and output to serve for longer-term missions : Post-Rosetta and other missions

-Suggestions: localized magnetized locations and/or sunlit regions, crater (?)

Deep-impact III at the surface of the Rosetta target comet 67P (support for project impact rocket to plan for 2015-16); studies or peri- and aphelion by Rosetta or Sun probe on location; high-resolution imaging of the full spectrum from ground-based observations; ground-based coverage of the event;

Impact on Mars and seismography (4 stations?). Impact the orbiters on the surface at the end of the mission?

Meteoritic impact on the Moon to use as a natural experiment (impact flashes are expected); seismic detection from moon probe over short periods of time (10h);

=> Insights on impact hasards on Earth

=> formation and evolution of the Solar System

-CRATERS :
craterization of a planetary bodies
-=> formation and evolution, erosion processes, towards a precise chronology,
distribution of impact densities in the Solar System
=> formation and evolution of the Solar System

-Suggestions: complete space or Earth-bound surface mapping of planetary moons and surfaces with the larger ground-based telescopes offering higher spatial resolution than previously

-BIBLIOGRAPHY
-LABORATORY EXPERIMENTS
-DATA SHARING/ARCHIVING

Surfaces:lab data & other databases

Surface structure and composition :

new observations to complete mapping and composition:

RADAR for objects with an atmosphere (Titan) and high-resolution full coverage spectroscopy (Europa)

lightcurves, higher-resolution mapping, better spectral coverage

Identification odf observed feature

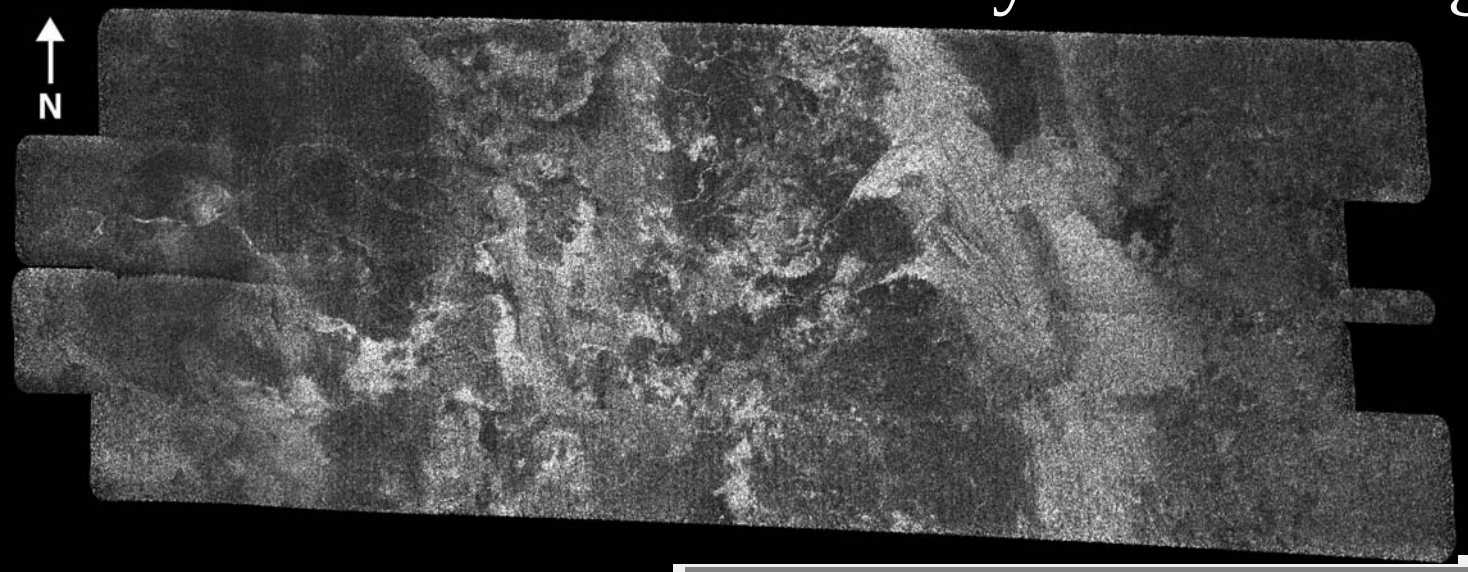
Interpretation of planetary data:

-images require identification of Earth analogues or use Mars and Moon features to interpret features on other planetary objects : Titan, etc :

gain access to data from SPOT, LANDSAT, ASTER (commercial :for N7? Can EUROPLANET invest money or create conventions with ESA, etc?)

- spectroscopic lab databases on ices and minerals and mixtures

Identify Earth analogues



Useful site to download or buy earth images
http://earth.esa.int/descw/
http://earth.jsc.nasa.gov/sseop/efs/
http://edcimswww.cr.usgs.gov/pub/imswelcome/
http://glcfapp.umiacs.umd.edu:8080/esdi

DTM site:
http://seamless.usgs.gov/

Earth Satellites
http://terra.nasa.gov/About/ASTER/about_aster.html
http://www.landsat.org/index.html
http://www.jpl.nasa.gov/radar/sircxsar/
others: SPOT, ERS, ENVISAT, JERS ecc...

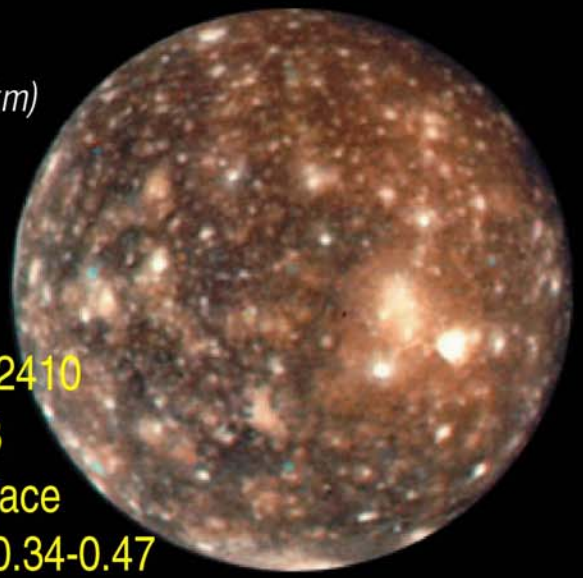
Spectral Library
Aster: http://speclib.jpl.nasa.gov/
Antarctic rocks: http://www.ingv.it/labtel2/LibrerieSpettral/Content.htm

Volcanism, cryovolcanism and tectoncis evidence from high-resolution images of a surface

Main characteristics of large moons

Callisto

(vu de 2 318 000 km)



Rayon (km) : 2410
Densité : 1.83
Fraction de glace
(en masse) : 0.34-0.47

Titan

(vu de 4 000 000 km)

Rayon (km) : 2575
Densité : 1.88
Fraction de glace
(en masse) : 0.30-0.45

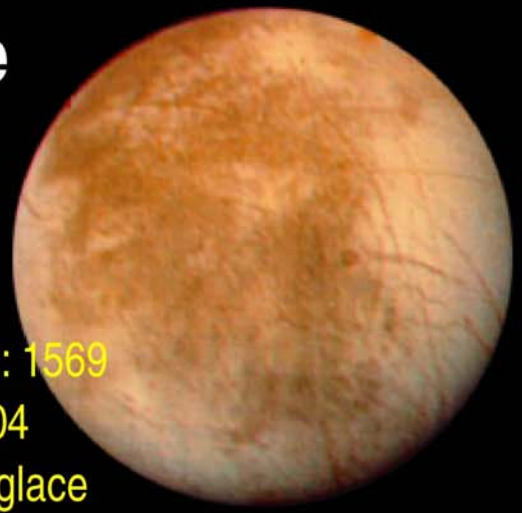
Ganymede

(vu de 2 600 000 km)

Rayon (km) : 2638
Densité : 1.93
Fraction de glace
(en masse) : 0.27-0.42

Europe

(2 000 000 km)



Rayon (km) : 1569
Densité : 3.04
Fraction de glace
(en masse) : 0.06

Image prise par la caméra HRI à 3 km d’altitude indiquant, dans la plaine sombre sur laquelle Huygens va atterrir, un écoulement de fluide autour d’îles plus claires.

Fluvial systems on Titan as seen from Huygens/DISR

Questions concerning the deep interior of icy bodies

Modelling considerations

- Liquid layers: possible existence – theory improvement and possible observations
- Cryovolcanism – how does it work : Key question for Europe (salts) and Titan (methane)
- Heating modes in icy moons - tidal heating for Europe and Titan not fully constrained
- Dynamics of thick liquid layers – nobody works on that…(maybe ROB???)

Experimental considerations

- HP-LT experiments – stability of ice compounds (hydrates, clathrates, ices)
- HP-HT experiments – relevant for metallic core of giants satellites
- IR/visible laboratory experiments on icy surface for providing Titan analogs
- EOS for icy bodies (also required for exoplanet M-R relations DWG6+7)

Questions concerning the deep interior of icy bodies

Surface studies

- Surface/interior relatonships: Description of tectonic/volcanic events, response to impacts, …
- Composition of ices (key point for constraining deep interiors).

Orbital constraints

- Constraints on the tidal heating amount for Titan
- Love numbers – required for describing deep interiors

-INTERIORS : => **DWG 8**

For large icy satellites : Europa,Titan, Callisto, Ganymede, Triton?

Needs : Numerical modeling on mantle and crusts

Liquid layers in the subsurfaces ? What ices were available (H2O, NH3, CH4?) and in what form they existed in the planetesimals that formed the satellite? Amount of NH3 present?

Thickness of crust vs liquid layer?

Composition and compositional variability requires measurements from at least two different bodies.

Heat-flows

-Suggestions: Model possible targets for the exploration and detection of liquid layers in the Solar System bodies.

-Spectroscopic satellite observations for heat-flow properties with right configuration (does the data already exist?).

-Seismic sounders on Post-Cassini-Huygens or Post-Galileo probes (for Europa and then for Ganymede and Titan or Callisto, Triton) for phase transition in the interiors with impact to give access to deeper levels (feasibility of explosion on Titan)? Different RADAR frequencies, double Radars to map the interior structures

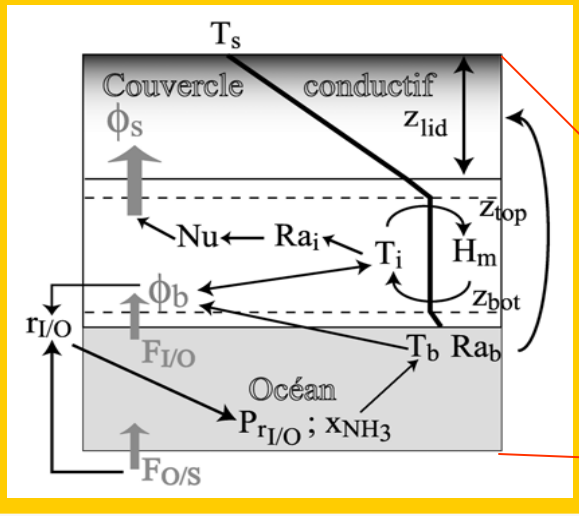
-**INTERIORS** :
For large icy satellites
Needs :
Experimental data HP-LT :
Orbital evolution and tide effects : precise measurements of Love numbers
Precise data on composition and dynamics on the surface

-**Suggestions**: Orbiter and laser altimetry
-Measure volcanism effects, composition on the surface
-Phase diagrams for icy compounds at high pressures
-And for different proportions of silicates

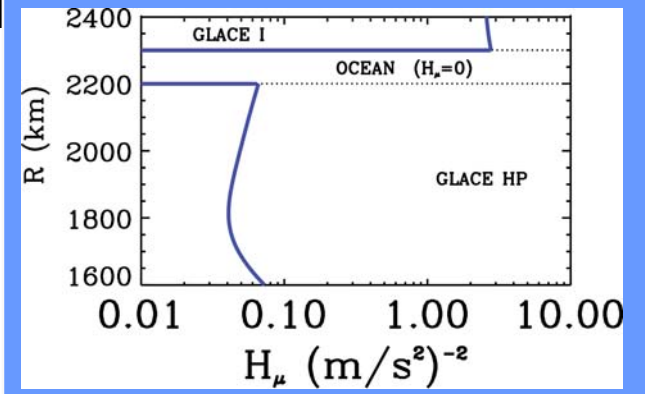
Rotation period?
Positions of orbiters and altimetry measurements?

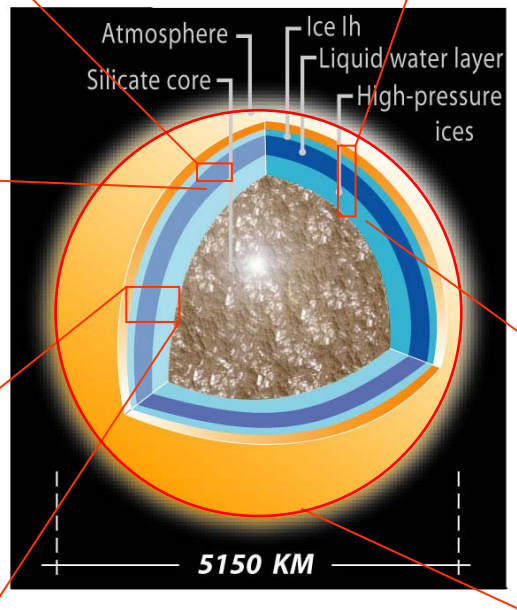
Icy satellites deep interior: several approaches

Modélisation numérique

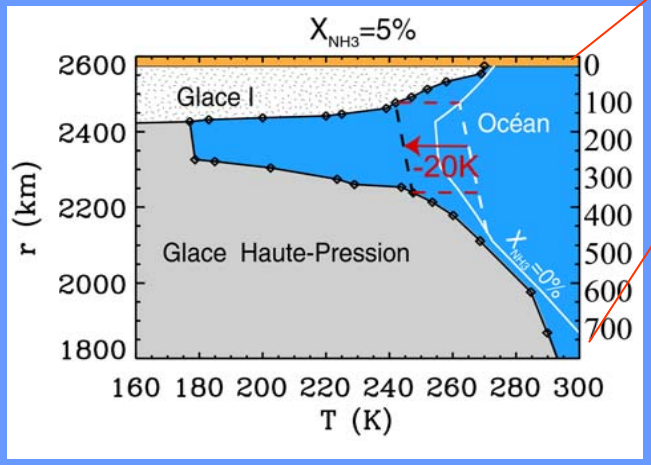


Evolution orbitale et dissipation de marée

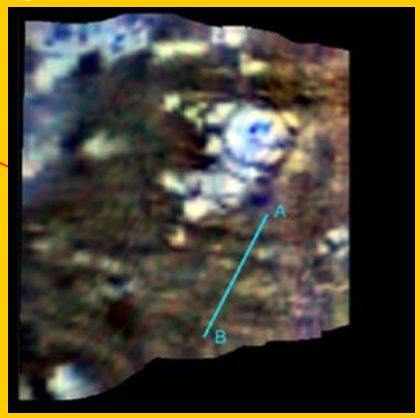




Expériences HP-BT



Découverte de la surface: Composition/volcanisme/…



Aims	Specific suggestions WG3&5
Inducing, and optimizing space missions, follow-up or follow a probe entry, support in case of failure, achieve science objectives : cometary, moon and planet surfaces/subsurfaces composition-structure Usefulness of ground-based observations in relation to space missions	Target selections (comets, moons) and landing sites for SMART-1 (on the Moon) Stereoscopic images of the Moon and other objects Optimize Rosetta return with Deep Impact III on the comet 67P at the end of the mission (2016) The water vapor on Mars: post-MEX with new mission including neutron spectroscopy (ATR) Mercury: observe from the ground at the time of Bepi-Colombo to cross-calibrate the mission data Ex: Cassini-Huygens (DWE- Channel C), Galileo And Lander on pole or other site Titan: RADAR measurements of whole surface during extended Cassini mission. Interpretation of high-resolution DISR images in terms of surface activity and surface-atmosphere interactions
Atmosphere-surface interactions	Sedimentation processes and deposits The water vapor in Mars's lower atmosphere
Extended temporal monitoring: study diurnal or seasonal effects	Completing planetary objects' lightcurves , evolution of the surface properties

Aims	Specific suggestions WG3&5
Extended spatial or global coverage with higher resolution Solar system formation Impact hasards on Earth	Study craterization in the Solar System : combine all available data on crater measurements and complete with new artificial crater (on the Moon?) caused by natural or artificial impactor (deflect small asteroid)
Techniques possible only from the Earth	VLBI radio-tracking of a space mission with probe signal during entry or landing Radar search for solid and liquid extents on moon surfaces
Better understand the volcanism and tectonics on planetary objects (related to interiors -> DWG 8)	High-resolution images (in situ) of all surfaces (as for Titan and Europa) in order to identify and interpret features and tie them to models of interior Seismographs, impact studies, stereo, Radar, laser altimetry
Models of Titan’s surface	CH4 absorption coefficients required with high precision Aerosols/tholin description Comparison with lab ice-rock mixtures

Aims	Specific suggestions WG3&5
Interpretation of surface fceatures	Earth, Mars and Moon analogues and various databases
Test/validation of models	Through observations
Laboratory experiments	Impact, crater and rheological studies Systematic studies of Titan aerosol analogues Lab data required in all fields and in particular ices and mineral systems and mixtures Diffusion studies through dust in vacuum (comets)
Public outreach	All missions, large telescopes, artificial observatories Ex: Mars Express, Deep Impact and Cassini-Huygens missions, VLT, HST EUROPLANET Institutes should make their websites user-friendly and include EP links

Connection with other fields

Surface-atmosphere interactions

- Lower atmospheres, exospheres (DWG1)

Ice and silicates composition

- Small bodies evidences (DWG4+9)
- Magnetic field models (salty liquid layer of Europe, …) – DWG 2

Deep interior

- Full interaction with DWG8
- « Application » of what we know for Ocean-Planets (DWG 6+7)
- Liquid layers – DWG 6+7

Bibliography & collaborations
…to come…

Coustenis, A., **Lorenz, R.** 1998. « Titan ». In *Encyclopedia of the Solar System*, P. R. Weissman, L.-A. McFadden, T.V. Johnson, Eds., Academic Press, pp. 377-404.

Coustenis, A., **Taylor, F**. 1999. « Titan, the Earth-like moon ». World Scientific Publishing, Singapore, Eds.

Coustenis, A. 2000. « The satellites of Saturn ». In *The Encyclopedia of Astronomy and Astrophysics*, D. Emerson, Ed., Inst. of Phys. Publ., Angleterre.

Coustenis, A. 2000. « Titan ». In *The Encyclopedia of Astronomy and Astrophysics*, D. Emerson, Ed., Inst. of Phys. Publ., Angleterre.

Coustenis, A., 2005. « Titan ». In *Encyclopedia of the Solar System*, Second Edition, P. R. Weissman, L.-A. McFadden, T.V. Johnson, Eds., Academic Press.

Coustenis, A., 2005. "Un siècle d'observations de Titan la mystérieuse". In *Au plus près de Saturne*, Vuibert Eds, in press.

Coustenis, A., **Taylor, F.** 2005. « Titan : Exploring an Earth-like World ». World Scientific Publishing, Singapore, Eds., en preparation.

Coustenis, A. 2005. "Titan", chapter in "Le Larousse du Ciel", Ph. De la Cotardière et R. Ferlet, Eds.

Extract from Publication List Walter Schmidt, FMI Helsinki, Finland

A. Spectroscopy (thesis work related 1975-80) LASER-INDUCED FLUORESCENCE OF REACTION BA+CCL4->BACL+CCL3"
SCHMIDT W; SIEGEL A; SCHULTZ A, CHEMICAL PHYSICS 16 (2): 161-173 (1976)

B. Radar work "Calibration of electron densities for the EISCAT UHF radar"
Kirkwood, S., P.N. Collis and W. Schmidt, J. atmos. terr. Phys., 48, 773-775, 1986

C. Solar Wind / SOHO related "SWAN: A Study of Solar Wind Anisotropies on SOHO with Lyman Alpha Sky Mapping"
Bertaux, J. L.; ... Schmidt, W.; ..., Solar Physics, v. 162, p. 403-439 (1995)

"First Results from SWAN Lyman a solar wind mapper on SOHO" Bertaux, J. L.; Quemerais, E.; Lallement, R.; Kyroela, E.; Schmidt, W.;
Summanen, T.; Goutail, J. P.; Berthe, M.; Costa, J.; Holzer, T. Solar Physics, v. 175, Issue 2, p. 737-770 (1997)

"Swan Observations of the Solar Wind Latitude Distribution and its Evolution Since Launch" Bertaux, Jean-Loup; Kyrölä, Erkki; Quemerais, Eric; Lallement, Rosine;
Schmidt, Walter; Summanen, Tuula; Costa, Jorge; Mäkinen, Teemu Space Science Reviews, v. 87, Issue 1/2, p. 129-132 (1999)

"Interplanetary lyman alpha observations of swan during the rising phase of the 23rd solar cycle" Summanen, T.; Mäkinen, J. T. T.; Kyrölä, E.; Schmidt, W.; Pulkkinen, T. I.;
Bertaux, J.-L.; Lallement, R.; Quémerais, E. Advances in Space Research, Volume 29, Issue 3, p.457-462. (2002)

D. Comets / SOHO related "Lyman-alpha observations of comet 46 P/Wirtanen with swan on SOHO: H2O production rate near 1997 perihelion"
Bertaux, J. L.; Costa, J.; Mäkinen, T.; Quémerais, E.; Lallement, R.; Kyrölä, E.; Schmidt, W. Planetary and Space Science, Volume 47, Issue 6-7, p. 725-733 (1999)

(others see Mäkkinen, T.)

E. Comet / Planetary surfaces "Conductivity and Dielectric Characteristics of Planetary Surfaces Measured with Mutual Impedance Probes: From Huygens and Rosetta Lander to Netlanders and Future Missions"
Hamelin, M.; Grard, R.; Laakso, H.; Ney, R.; Schmidt, W.; Simoes, F.;Trautner, R.
Proceedings of the 37th ESLAB Symposium `Tools and Technologies for Future Planetary Exploration', Noordwijk, The Netherlands (ESA SP-543, April 2004)

"The Rosetta Lander experiment SESAME and the new target comet 67P/Churyumov-Gerasimenko" Seidensticker, K. J.; Thiel, K.; Péter, A.; Schmidt, W.; Fischer, H.-H.; Madlener, D.; Schieke, S.; Trautner, R.
The New Rosetta Targets. Observations, Simulations and Instrument Performances. ASTROPHYSICS AND SPACE SCIENCE LIBRARY Volume 311. ISBN 1-4020-2572-6, 10/2004

"Permittivity Probe on Rosetta Lander after Commissioning; Properties of Comet Surface Material" W. Schmidt, Juha Virtanen, R.Trautner, H.Laakso, M.Hamelin, K.Seidensticker, K.Thiel
Proceedings of the Finnish COSPAR 2005

"A sophisticated lander for scientific exploration of Mars: scientific objectives and implementation of the Mars-96 Small Station" Linkin, V.; Harri, A.-M.;... Schmidt, W.; ..., Planetary and Space Science, v. 46, p. 717-737 (1998)

"SMART-1 mission to the moon: Technology and science goals" Foing, B. H.; Racca, G. D.; Marini, A.; Heather, D. J.; Koschny, D.; Grande, M.; Huovelin, J.; Keller, H. U.; Nathues, A.; Josset, J. L.; Malkki, A.; Schmidt, W.; Noci, G.; Birkl, R.; Iess, L.; Sodnik, Z.; McManamon, P. Advances in Space Research, Volume 31, Issue 11, p. 2323-2333. (2003)

"Solar Wind-Induced Atmospheric Erosion at Mars: First Results from ASPERA-3 on Mars Express", Lundin, R.; Barabash, S.;... Schmidt, W.; ... Science, Volume 305, Issue 5692, pp. 1933-1936 (2004)

F. Planetary Plasma Simulations "A Global Hybrid Model of Titan's Ion Escape"
Sillanpaa, I.; Kallio, E.; Janhunen, P.; Schmidt, W.;Harri, A.; Makinen, T.; Mursula, K.; Vilppola, J.; Tanskanen, P. American Geophysical Union, Fall Meeting 2004, abstract #P42A-07, 12/2004

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SELECTED PUBLICATIONS

Kossacki K. J., N. I. Komle, G. Kargl and G. Steiner, 1994.
The Influence of Grain Sintering on the Thermoconductivity of Porous Ice.
Planetary and Space Science 42, 383 – 389

Kossacki K. J. and R. D. Lorenz, 1996.
Hidding Titan's Ocean: Densification and Hydrocarbon Storage in an Icy Regolith
Planetary and Space Science 44, 1029 – 1037

Kossacki K. J., N. I. Komle, J. Leliwa – Kopystynski and G. Kargl, 1997 Laboratory Investigation of the Evolution of Cometary Analogs: Results and Interpretation.
Icarus 128, 127 – 144

Eluszkiewicz J., J. Leliwa – Kopystynski and K. J. Kossacki, 1998.
Metamorphism of Solar System Ices.
In Solar System Ices (edited by Schmitt, de Bergh and Festou), 119 – 138,
Kluwer Academic Publishers, Dordrecht, The Netherlands

Kossacki K. J., S. Szutowicz and J. Leliwa-Kopysty¥'nski, 1999.
Comet 46P/Wirtanen: Evolution of the Subsurface Layer.
Icarus, 142, 202 – 218

Kossacki K. J., W. J. Markiewicz, Y. Skorov and N. I. Komle, 1999.
Sublimation Coefficient of Water ice under Simulated Cometary-Like Conditions
Planetary and Space Science, 47, 1521 – 1530

Kossacki K. J. and W. J. Markiewicz, 2002.
Martian Seasonal CO2 Ice in Polygonal Troughs in Southern Polar Region: Role of the Distribution of Subsurface H2O Ice.
Icarus, 160, 73 – 85

Kossacki K. J., W. J. Markiewicz and M. D. Smith, 2003.
Surface temperature of Martian regolith with polygonal features: influence of the subsurface water ice.
Planetary and Space Science, 51, 569 – 580

Kossacki K. J. and J. Leliwa-Kopystynski, 2004.
Non-uniform Seasonal Defrosting of Subpolar Dune Field on Mars.
Icarus, 168, 201 – 204

Kossacki K. J., and W. J. Markiewicz, 2004.
Seasonal melting of surface water ice condensing in Martian gullies. 2004
Icarus

Kossacki K. J., and S. Szutowicz, 2006.
Comet 67P/Churyumov-Gerasimenko: modeling of orientation and structure.
Planetary and Space Science (in press).

Combination of data
Collaboration of teams
Synergy
Tests
Laboratory work
Models
Recommendations for models, observations, experiments…