Space observations in Geophysics and Planetary Sciences

Overview of research carried out at the Department of Geophysics

J. Velímský, M. Běhounková, O. Čadek, H. Čížková, K. Kalousová, M. Kuchta, Z. Martinec, V. Plicka, K. Sládková, O. Souček, L. Šachl, Ľ. Valentová, M. Walterová

Department of Geophysics
Faculty of Mathematics and Physics
Charles University
V Holešovičkách 2
180 00 Praha 8
http://geo.mff.cuni.cz
mailto:geo@mff.cuni.cz
http://goo.gl/maps/YOj6C

10 Years of the Czech Republic in ESA, November 14, 2018

A trip through the Solar System. . .

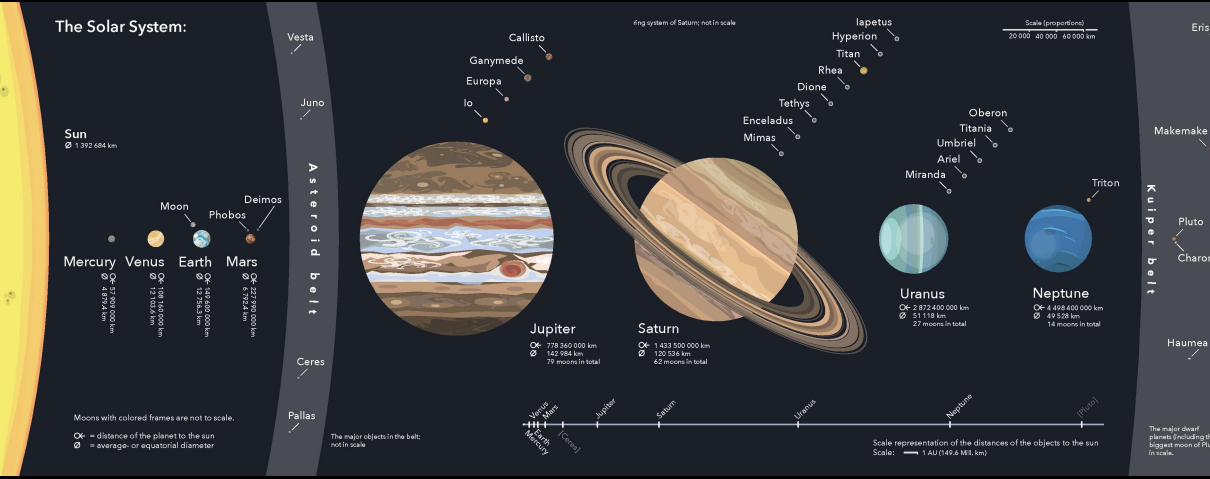
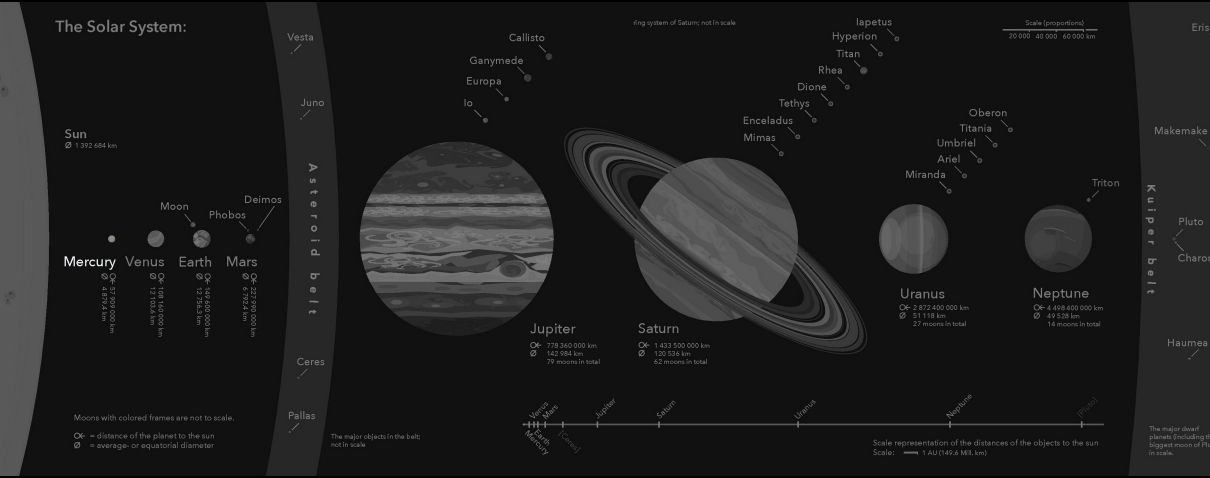


Image by Wikipedia, user Beinagehut, CC4.0

Mercury


The Solar System:
Sun
Ø 1 392 684 km
Moon
Phobos
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Moons with colored frames are not to scale.
= distance of the planet to the sun
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Scale representation of the distances of the objects to the sun
Scale: 1 AU (149.6 Mill. km)

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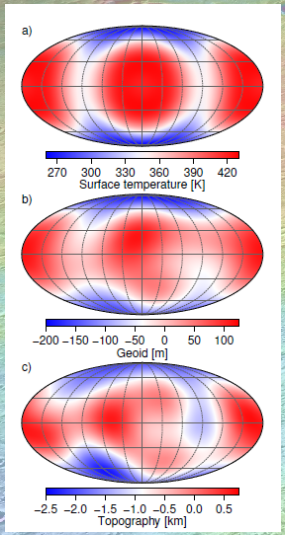
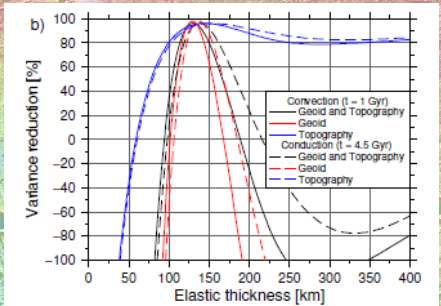
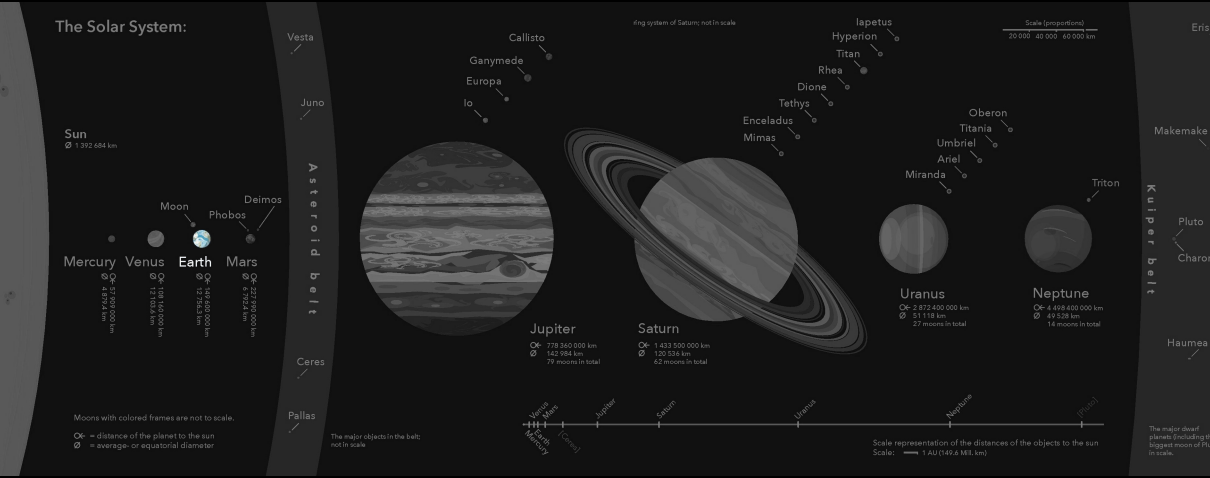


- tidally-locked planet
- spin-orbit resonance 3:2
- irregular surface insolation
- MESSENGER: topography and gravity data
- elastic shell loaded by density anomalies induced by lateral temperature variations (Tosi *et al.* 2015)



Earth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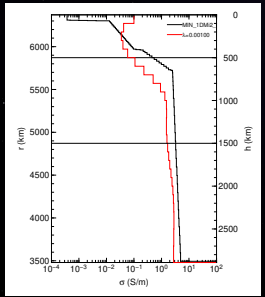
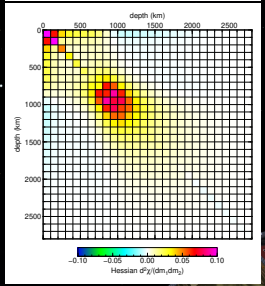
Swarm: Electrical conductivity of the Earth's mantle





- accurate measurements of geomagnetic field from low orbits
- electrical conductivity as an important geophysical parameter related to the temperature, chemical and mineralogical composition of the Earth's mantle
- part of the Level 2 chains and products
- radial conductivity profiles with sensitivity estimates
- towards 3-D conductivity models (Velímský 2013)

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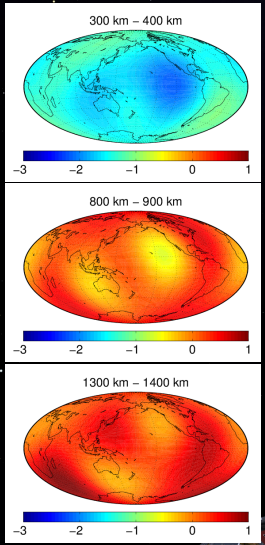

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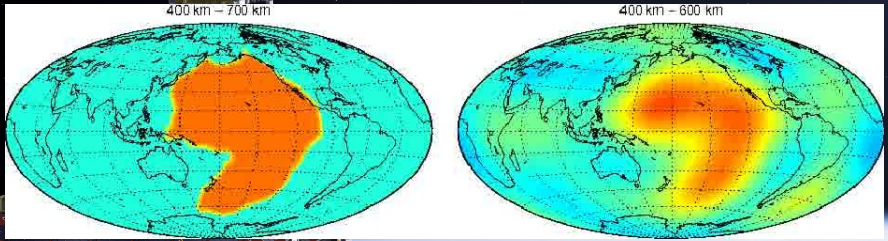
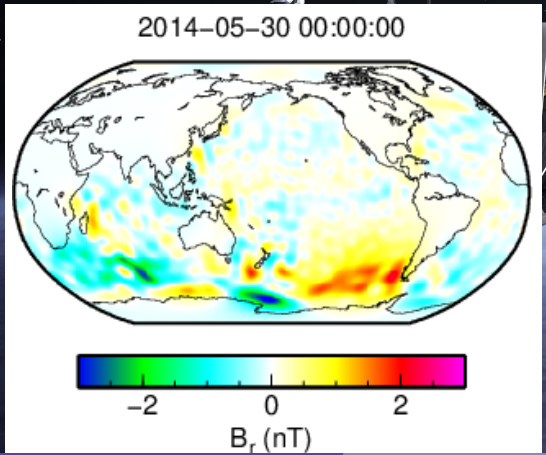
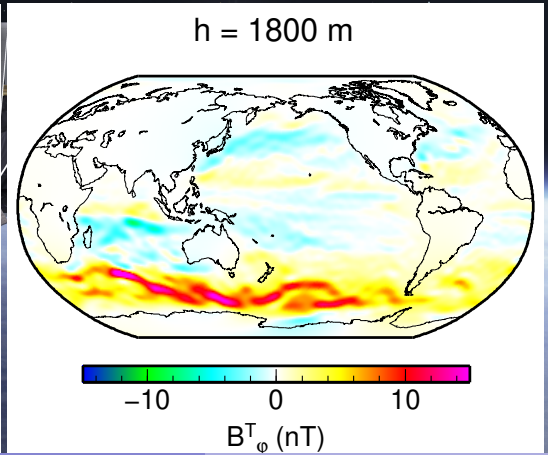


Swarm: Magnetic Signatures of Ocean Circulation

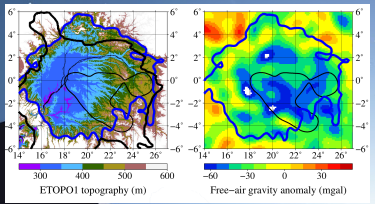
- wind- and temperature-driven ocean circulation induces secondary magnetic field
- weak field on the surface but much stronger at ocean depths (Velímský *et al.* 2018)
- can we detect it in magnetic Swarm data?
- can we monitor long-term variability of ocean currents by satellite magnetic measurements?

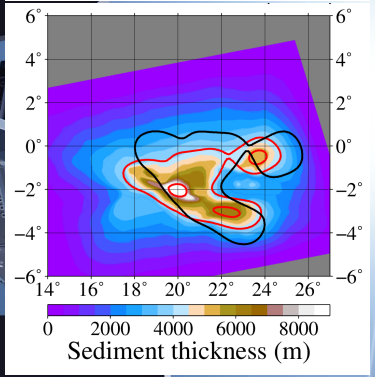




GOCE: Congo Basin

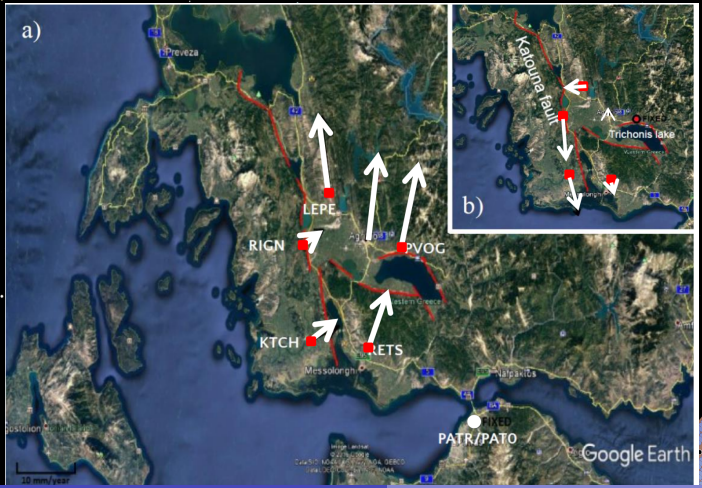
- accurate measurements of vertical gravity and vertical gravity gradient from GOCE
- model GOCO03S up to degree 220
- Helmert transformation
- derivation of a refined sedimentary model
- improved sedimentary model used to determine the vertical density stratification in the southeast Congo Basin (Martinec & Fullea 2014)
- surface density contrast with respect to surrounding rocks: 0.24–0.28 g/cm^3
- decrease with depth of 0.05–0.25g/cm^3 per 10 km





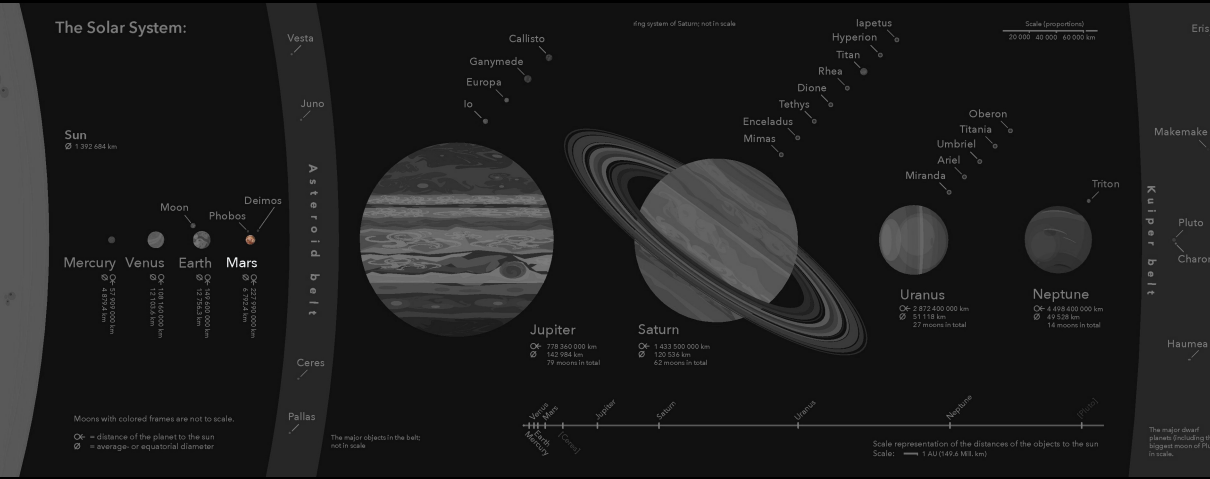
PPGNET: GNSS Network in Western Greece

- cooperation with University of Patras and the Research Institute of Geodesy, Topography and Cartography; five GNSS stations; observation since November 2013
- reconstruction of relative motions



- with respect to Patras (PATR/PAT0): Paravola (PVOG) 12 $^{mm}/_{year}$ NNE; Retsina (RETS) 9 $^{mm}/_{year}$ NNE; $\rightarrow$ Trichonis Lake normal fault system depicts a slip rate of 3 $^{mm}/_{year}$
- with respect to Paravola (PVOG): Rigani (RGNI) and Katochi (KTCH) display SSE movement in accordance with the Katouna strike-slip fault $\rightarrow$ existence of a microplate in the area

Mars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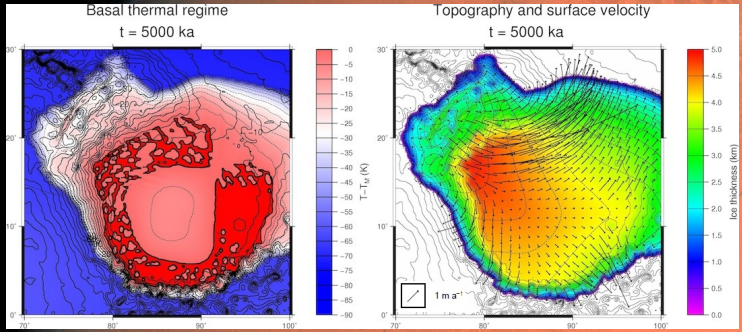
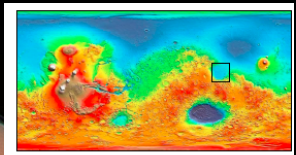
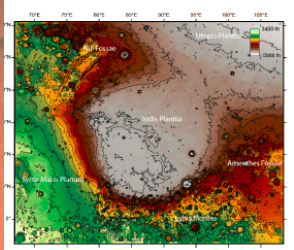
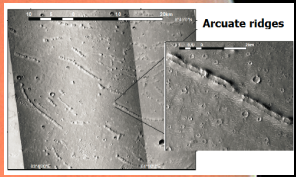
Mars

- Mars Global Surveyor: puzzling surface features in Isidis Planitia
- Hypothesis: massive paleoglaciation $>$ 3Gyr
- Joint numerical (Souček *et al.* 2015) and geomorphological study (Guidat *et al.* 2015)
- Glaciation hypothesis allows explanation of surface features and their spatial relations

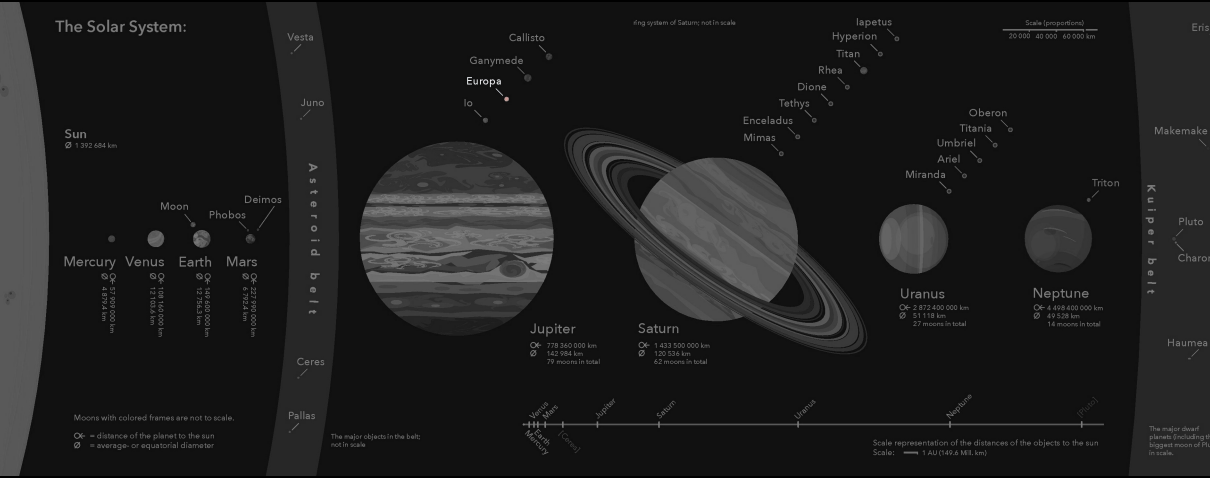








Europa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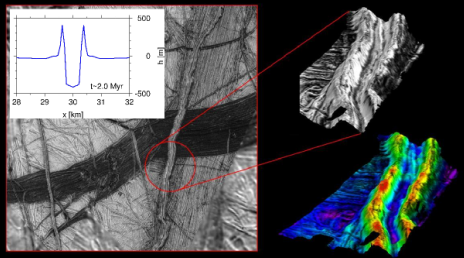
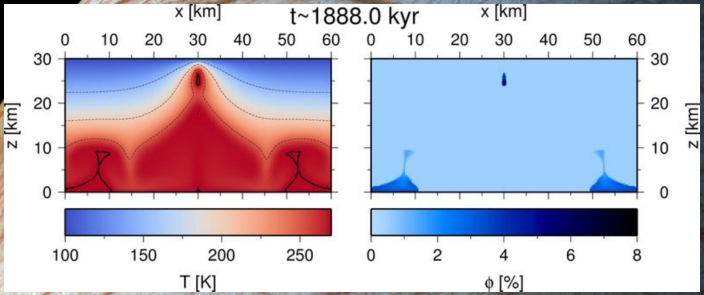
Europa: Formation of Double Ridges

- GALILEO: double ridges along faults: unique in the solar system
- friction on the fault may lead to melting → subsurface water lenses
- lenses are gravitationally unstable, water is quickly extracted (Kalousová et al., *JGR*, 2014)
- possible mechanism for double ridges formation (Kalousová et al., *JGR*, 2016)



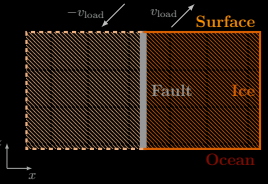


Europa: Friction on Strike-Slip Faults

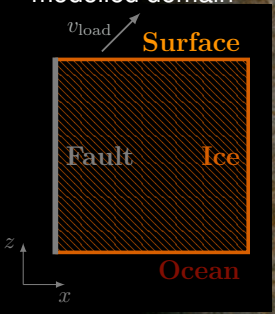
- morphological observations: near surface water
- possible explanation?
- friction on strike-slip faults (e.g. double ridge)

→ model: tidally loaded strike-slip fault within the ice shell

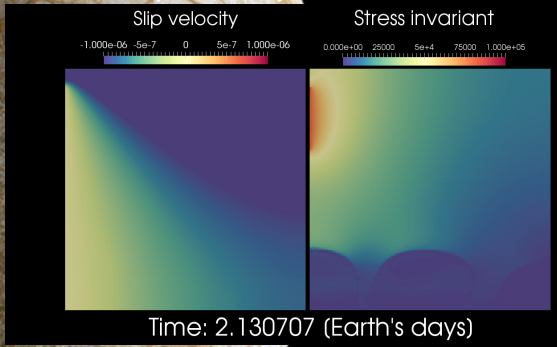
sketch of strike-slip fault



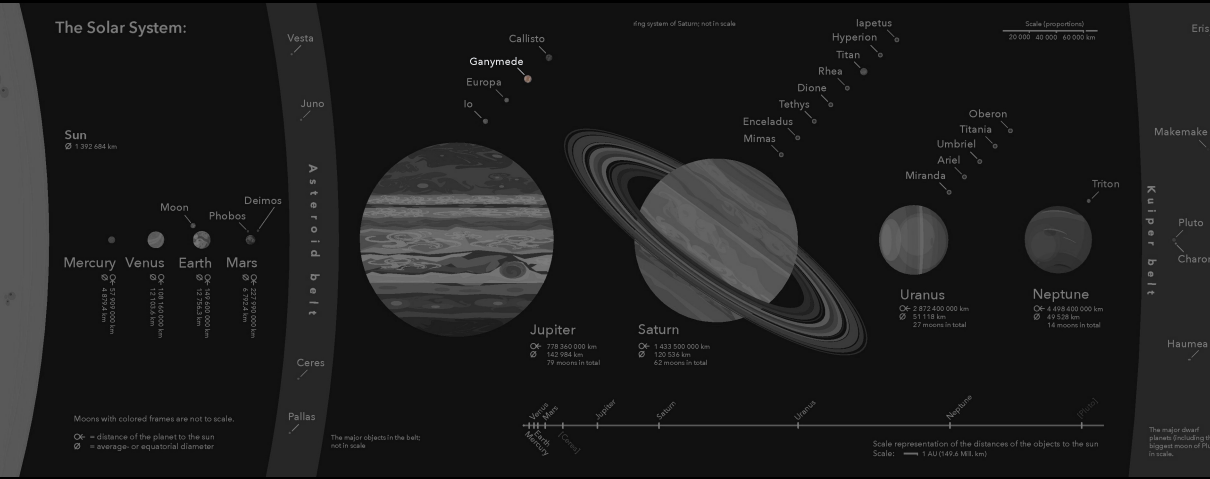
modelled domain



periodically loaded fault



Ganymede and Titan



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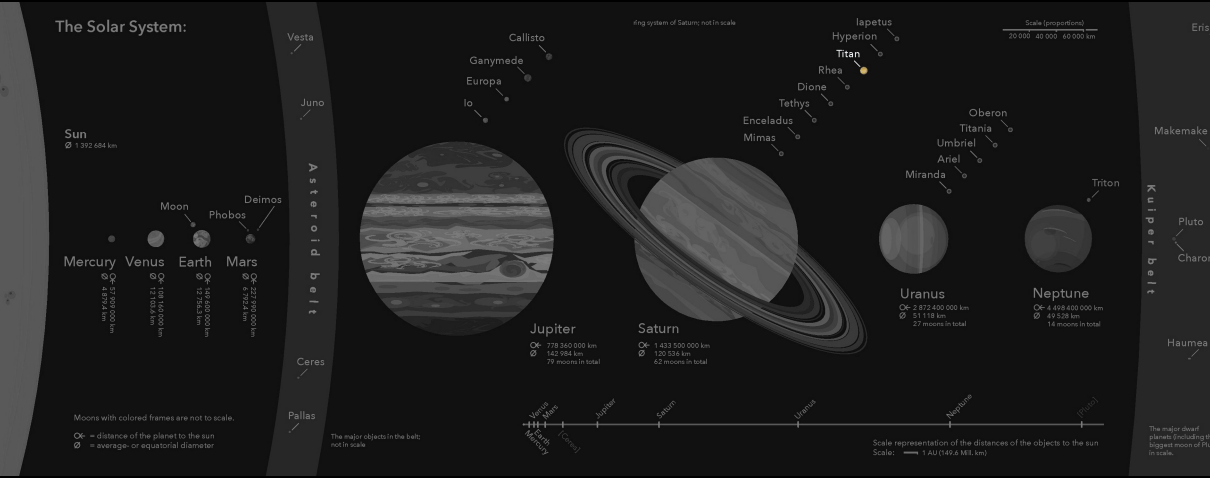
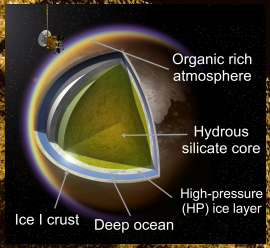
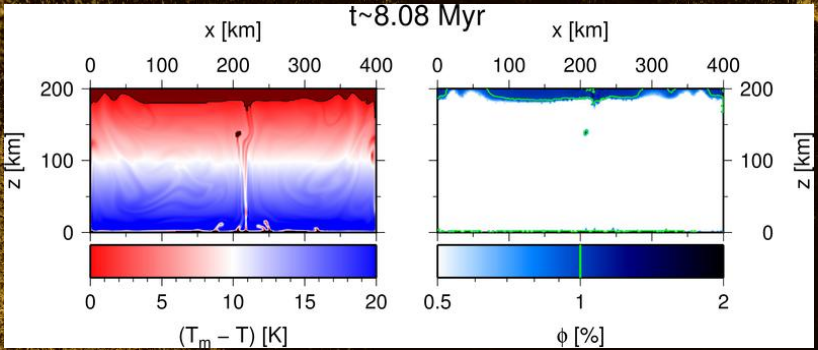


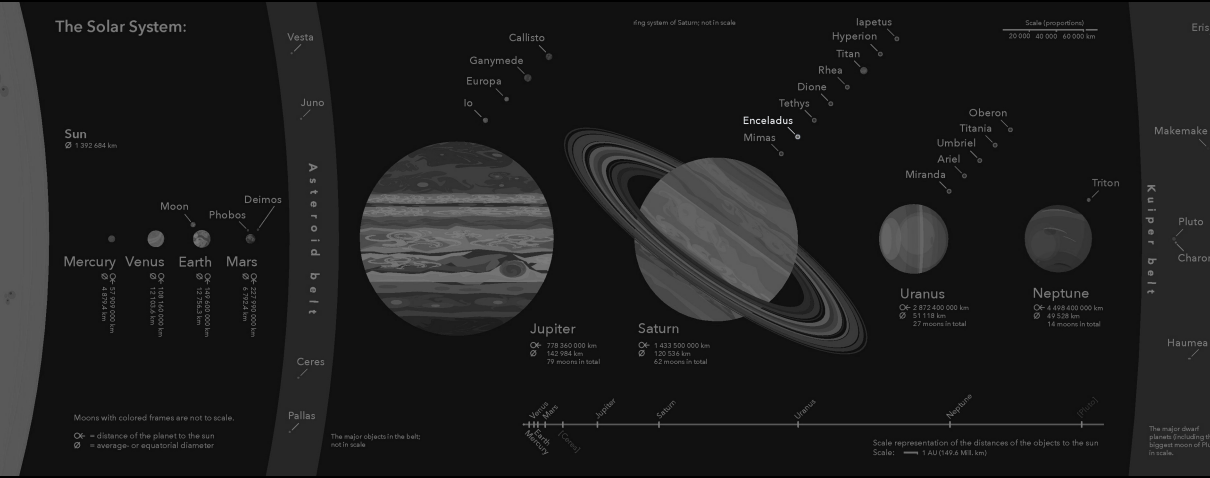
Ganymede and Titan

- GALILEO & CASSINI: ocean sandwiched between two ice layers
- Titan: exchange of CH_4 a Ar between the core and the atmosphere?
- melting and water transport through the HP ice layer
- exchange of volatiles is possible
- Ganymede: already ceased, Titan: may be ongoing (Kalousová et al. 2018; Kalousová & Sotin 2018)





Enceladus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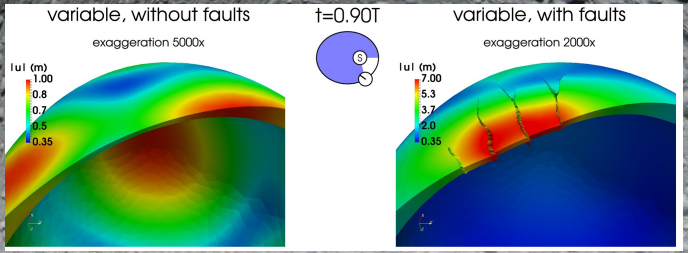
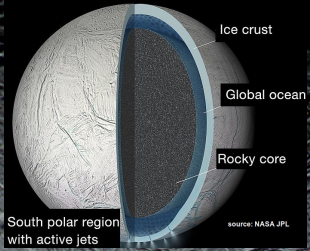
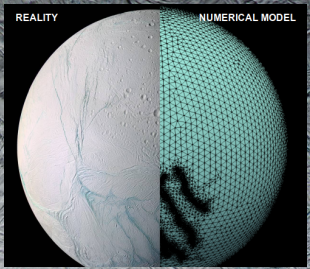
Enceladus

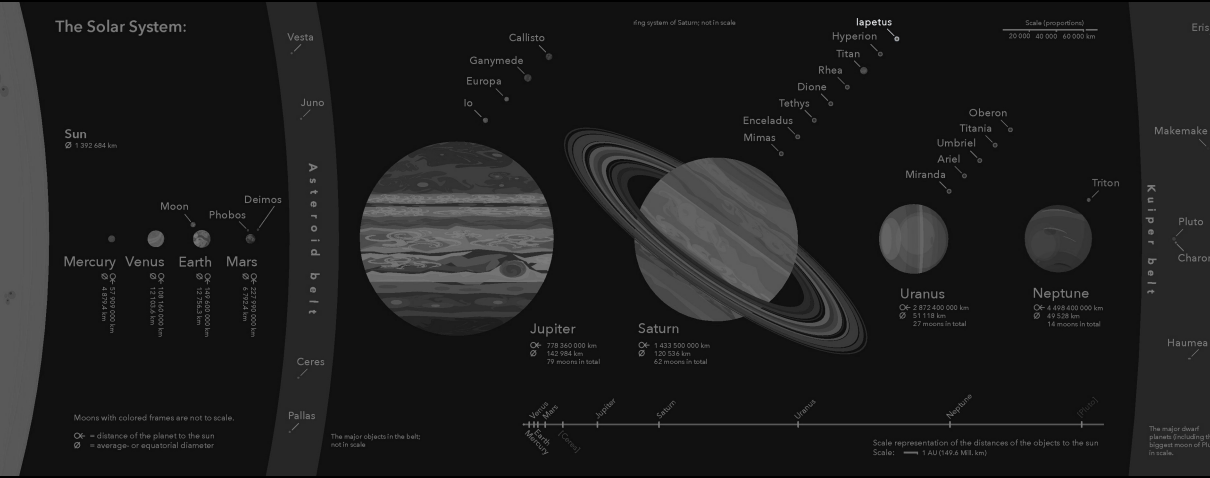
- Cassini: global subsurface ocean, jets in the south polar region
- Tiger stripes: faults at the south pole
- Numerical modeling (Souček *et al.* 2016, Běhounková *et al.* 2017): huge impact of tiger stripes on tidal deformation of the moon and dissipation in its shell







Iapetus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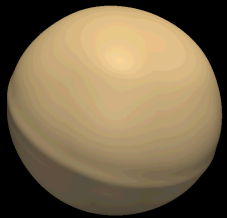
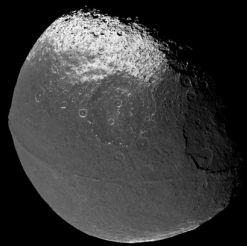
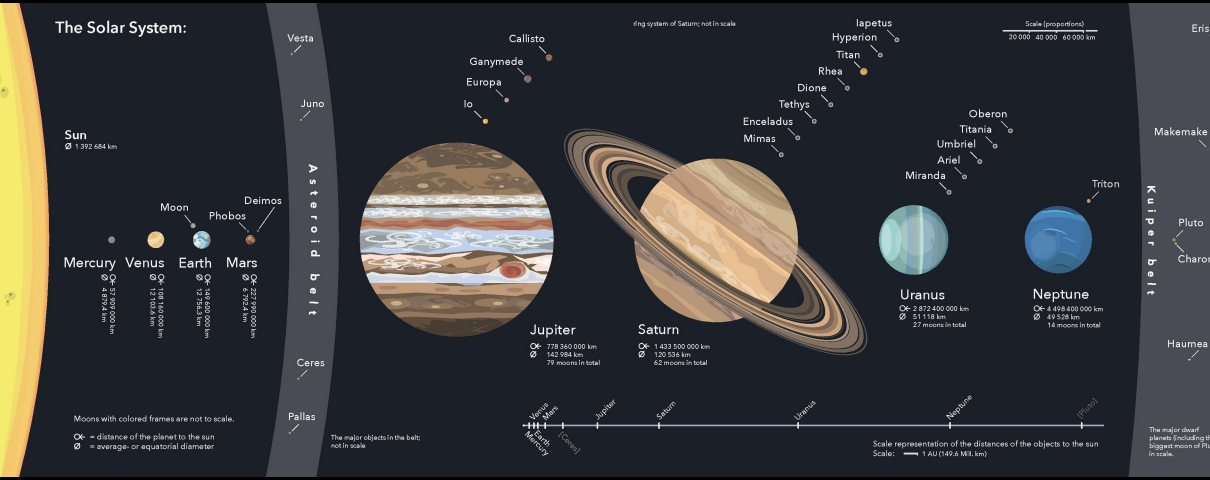




- CASSINI: equatorial ridge: a unique feature in the Solar System
- large flattening not consisent with current spin rate
- possible explanation: collision with another celestial body (Kuchta *et al.* 2015)
- creation of the ridge depends on initial temperature, rotation, and grain size

A trip through the Solar System. . .

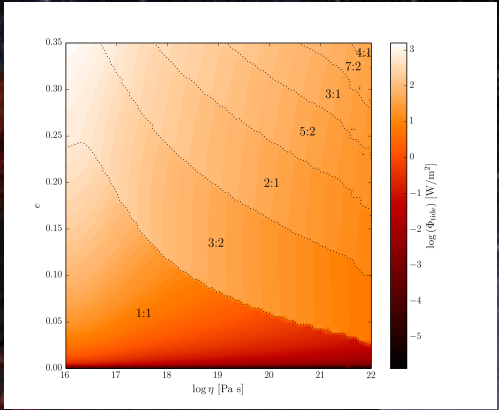


A trip through the Solar System. . . and beyond

Image by ESO, CC4.0

Tidal heating and spin-orbit locking of exoplanets

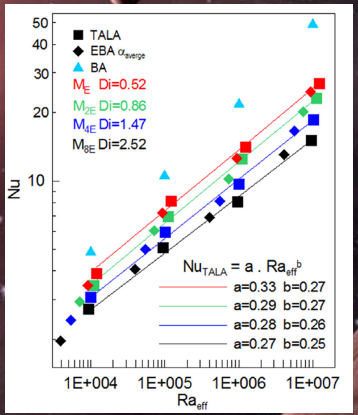
- Close-in exoplanets: extreme environments, influence of host star, strong tidal loading
- How much do they differ from the plantes in the Solar system?
- Are they habitable?
- What is their interior structure and composition?
- Joint modelling of interior structure with the orbital and spin rate evolution
- Tidal locking → large temperature contrast on the surface

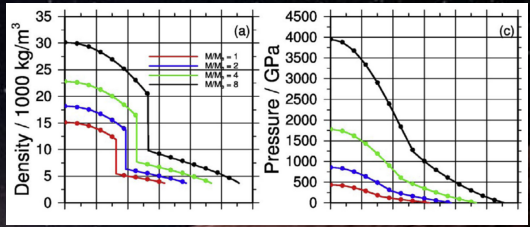


Proxima Centauri b
Even small eccentricity of the orbit leads to an extensive tidal heating (volcanic world?)

Heat transport in large terrestrial exoplanets

- large terrestrial exoplanets are subject to much higher self-compression than the Earth mantle





- numerical models that are used to study their internal dynamics often neglect the compressible effects
- our results demonstrate that compressibility effects are important for mantle dynamic processes and consequently also for formation of planetary atmospheres and the existence of magnetic field through thermal coupling of mantle and core dynamic systems (Čížková *et al.* 2017)

A trip through the Solar System. . . and beyond

Our department offers a unique opportunity to students at undergraduate, graduate, and doctoral levels in the area of geophysical and planetological studies, deeply embedded into advanced physical and mathematical framework.

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Space observations in Geophysics and Planetary Sciences

Overview of research carried out at the Department of Geophysics

J. Velímský, M. Běhounková, O. Čadek, H. Čížková, K. Kalousová, M. Kuchta, Z. Martinec, V. Plicka, K. Sládková, O. Souček, L. Šachl, Ľ. Valentová, M. Walterová

Department of Geophysics
Faculty of Mathematics and Physics
Charles University
V Holešovičkách 2
180 00 Praha 8
http://geo.mff.cuni.cz
mailto:geo@mff.cuni.cz
http://goo.gl/maps/YOj6C

10 Years of the Czech Republic in ESA, November 14, 2018