A web-system of virtual morphometric globes

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Definitions

Virtual globes – programs implementing interactive three-dimensional (3D) models of planets .

Geomorphometry – quantitative modeling and analysis of the topographic surface and relationships between topography and other components of geosystems.

Objective

To develop a web-system of virtual morphometric globes of the Earth, Mars, and the Moon

Elevation

Local variables

- Slope gradient
- Ориентация склона
- Horizontal curvature
- Vertical curvature
- Mean curvature
- Gaussian curvature
- Minimal curvature
- Maximal curvature
- …..

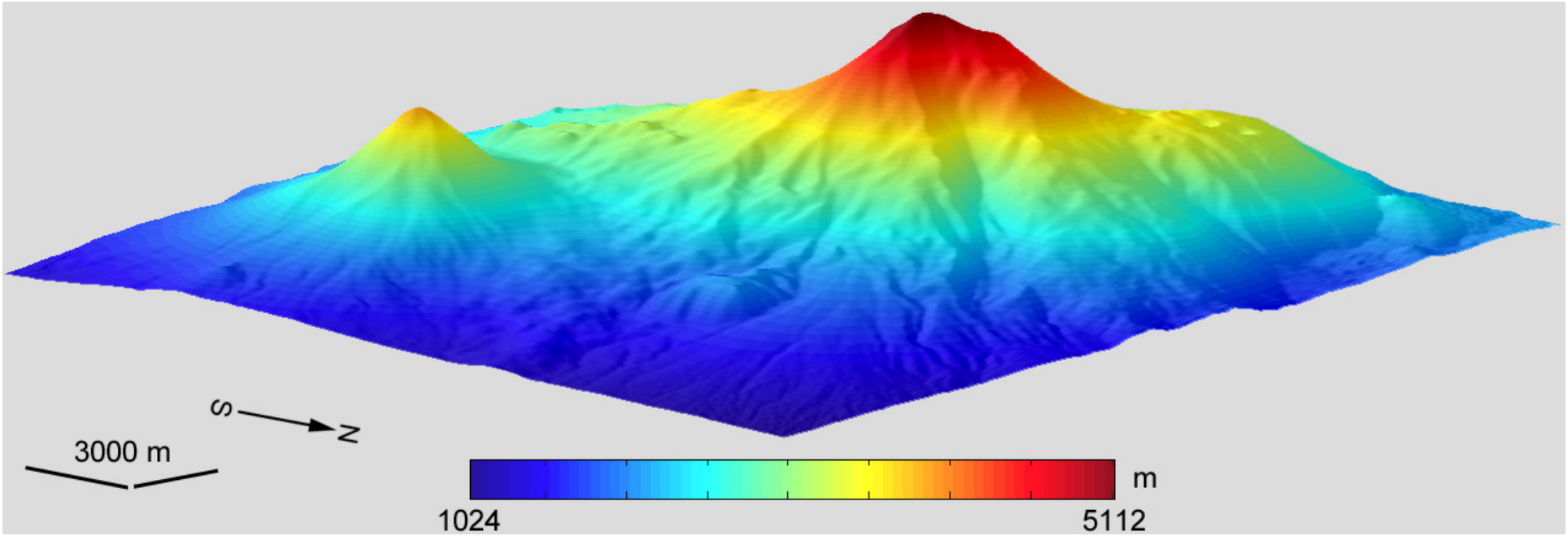
Nonlocal variables

- Catchment area
- Dispersive area
- ….

Combined variables

- Topographic index
- Stream power index
- ….

Elevation – initial data for morphometric calculations



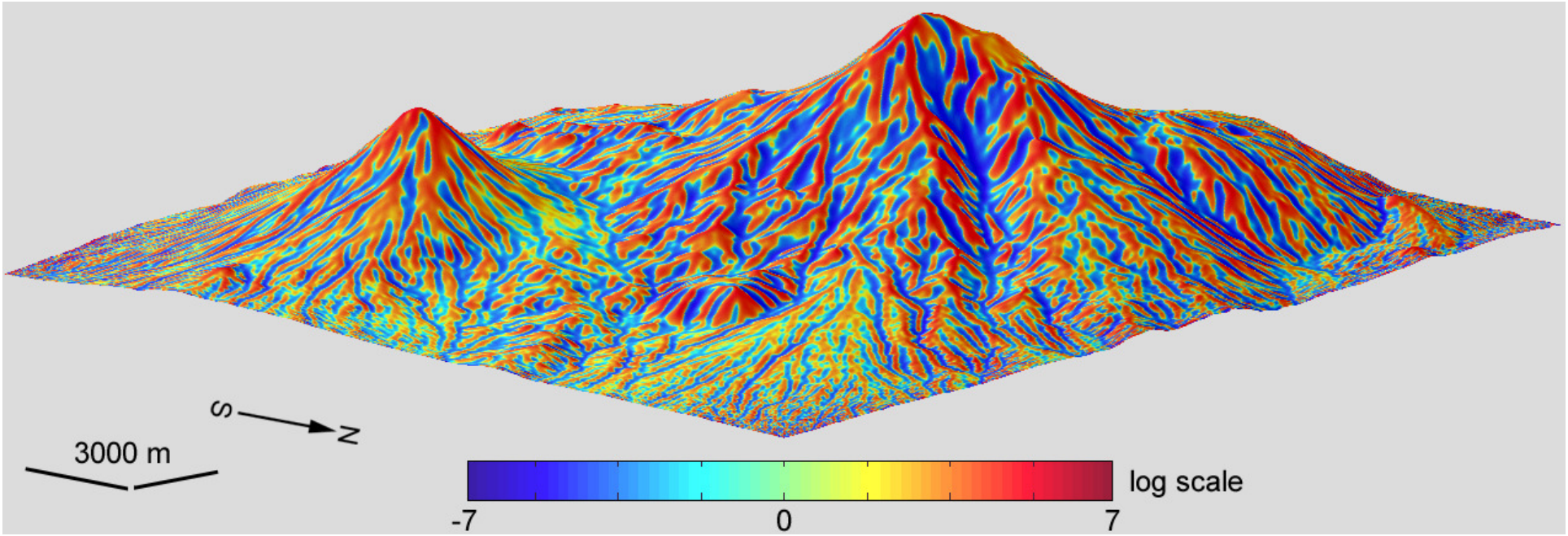
Mount Ararat
SRTM1
779 401 points (the matrix 1081 × 721), $w = 1''$

$$p = \frac{\partial z}{\partial x} \qquad q = \frac{\partial z}{\partial y}$$

Universal spectral analytical method for terrain modeling.

$$r = \frac{\partial^2 z}{\partial x^2} \qquad s = \frac{\partial^2 z}{\partial x \partial y} \qquad t = \frac{\partial^2 z}{\partial y^2}$$

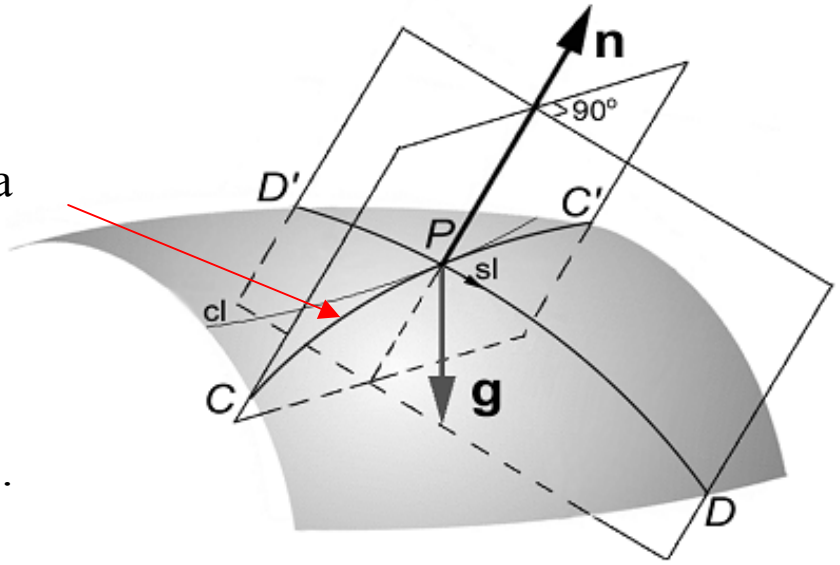
Horizontal curvature



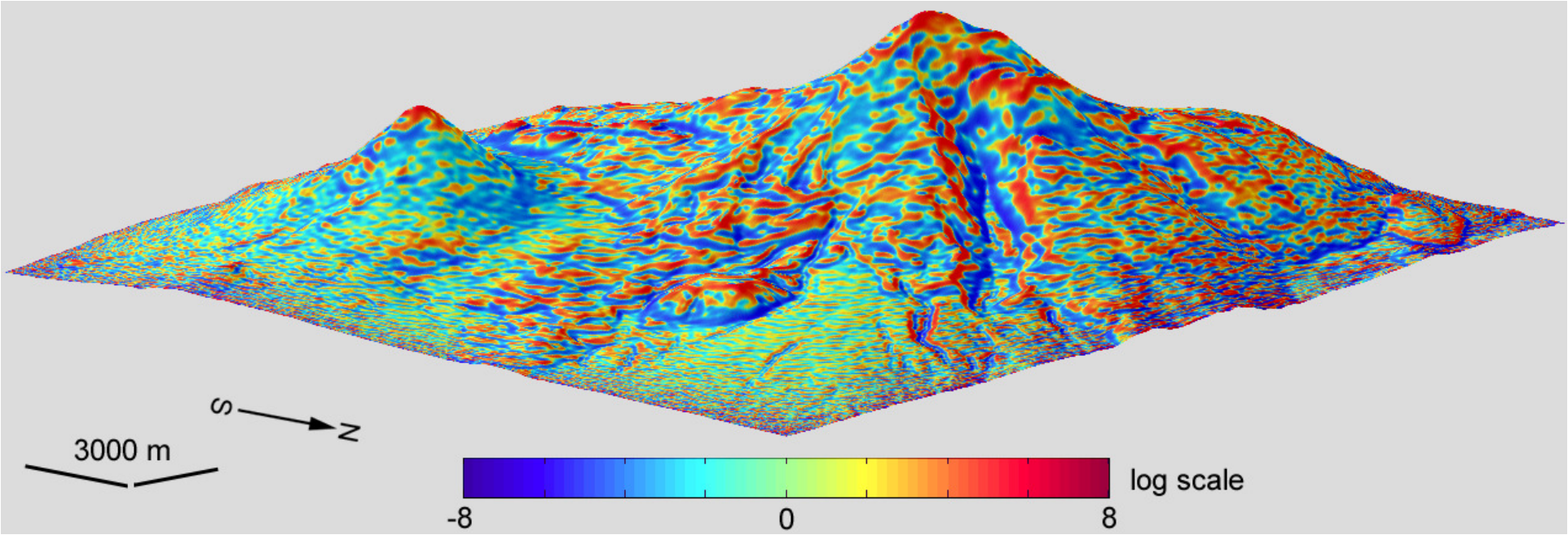
$$k_h = -\frac{q^2 r - 2pqs + p^2 t}{\left(p^2 + q^2\right)\sqrt{1 + p^2 + q^2}}$$

Horizontal (or tangential) curvature is the curvature of a normal section *CC'* tangential to a contour line *cl* at a given point *P* of the topographic surface.

Horizontal curvature is a measure of flow convergence: flows converge where $k_h < 0$; they diverge where $k_h > 0$.

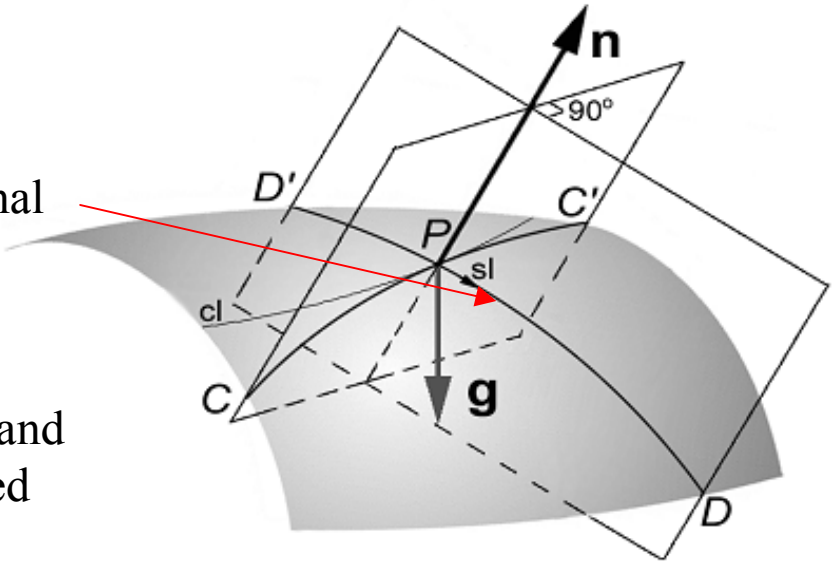


Vertical curvature



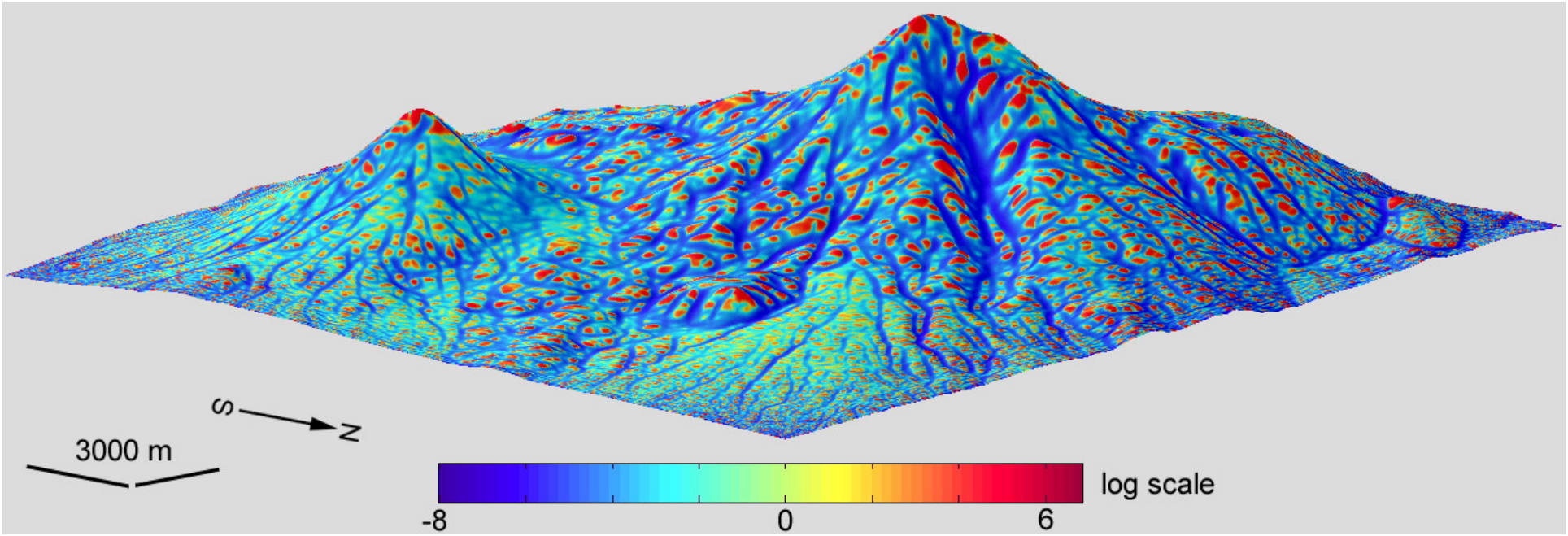
$$k_v = -\frac{p^2 r + 2pqs + q^2 t}{\left(p^2 + q^2\right)\sqrt{\left(1 + p^2 + q^2\right)^3}}$$

Vertical (or profile) curvature is the curvature of a normal section *DD'* having a common tangent line with a slope line *sl* at a given point *P* of the topographic surface.



Vertical curvature is a measure of relative deceleration and acceleration of gravity-driven flows: they are decelerated where $k_v < 0$; they are accelerated where $k_v > 0$.

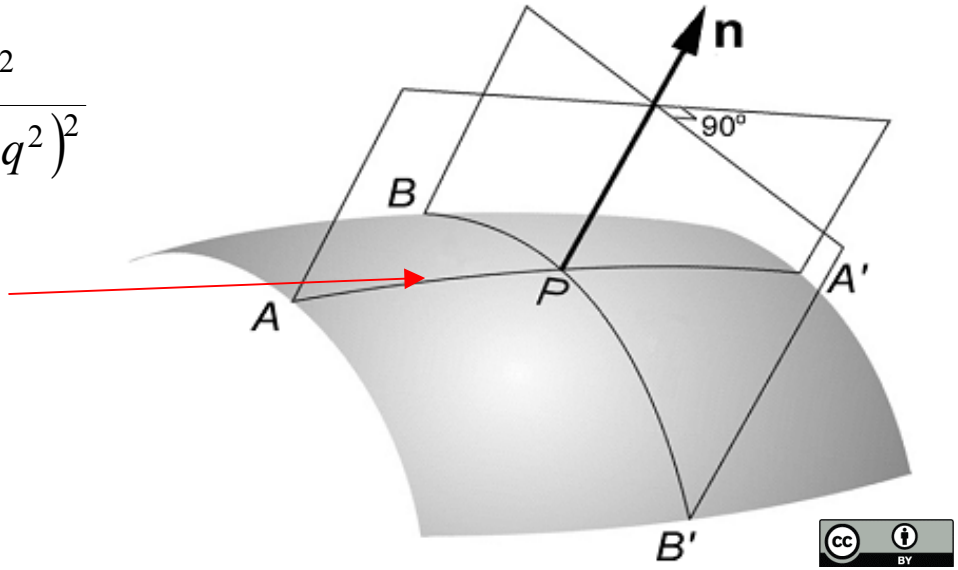
Minimal curvature



$$k_{\min} = H - \sqrt{H^2 - K}$$

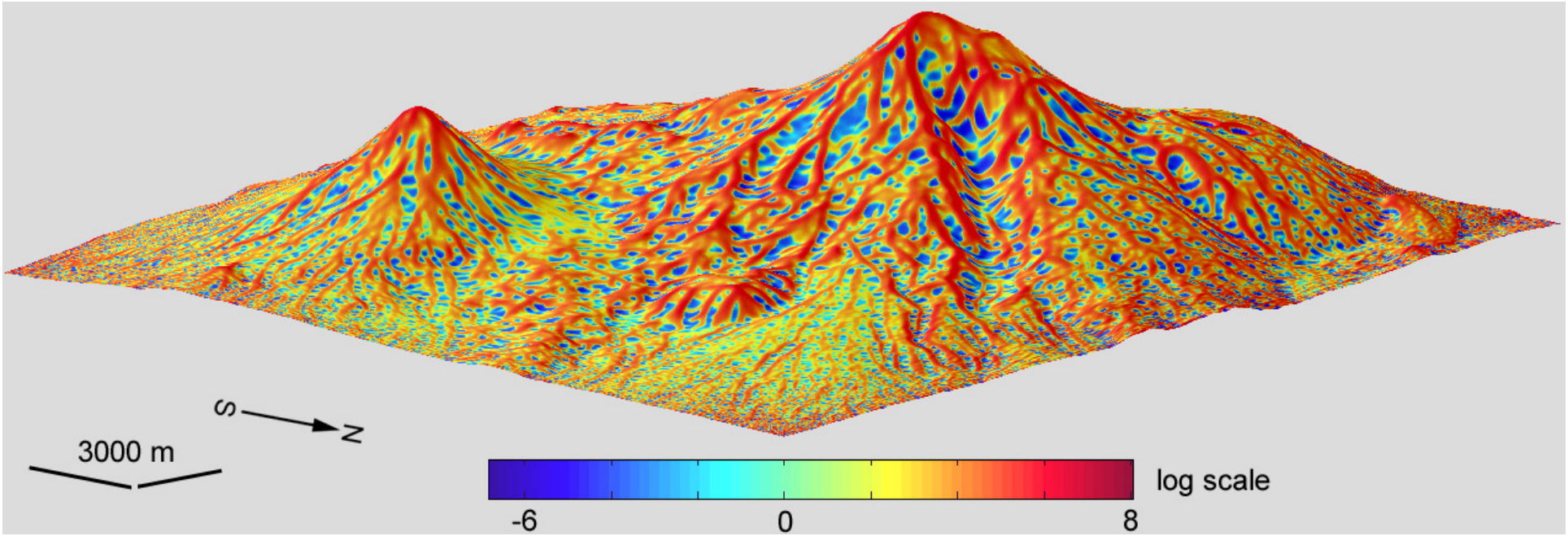
$$H = -\frac{(1+q^2)r - 2pqs + (1+p^2)t}{2\sqrt{(1+p^2+q^2)^3}} \qquad K = \frac{rt - s^2}{(1+p^2+q^2)^2}$$

Minimal curvature is a curvature of a principal section AA' with the lowest value of curvature at a given point P of the surface.



$k_{min} > 0$ correspond to local convex landforms;
$k_{min} < 0$ relate to elongated concave landforms .

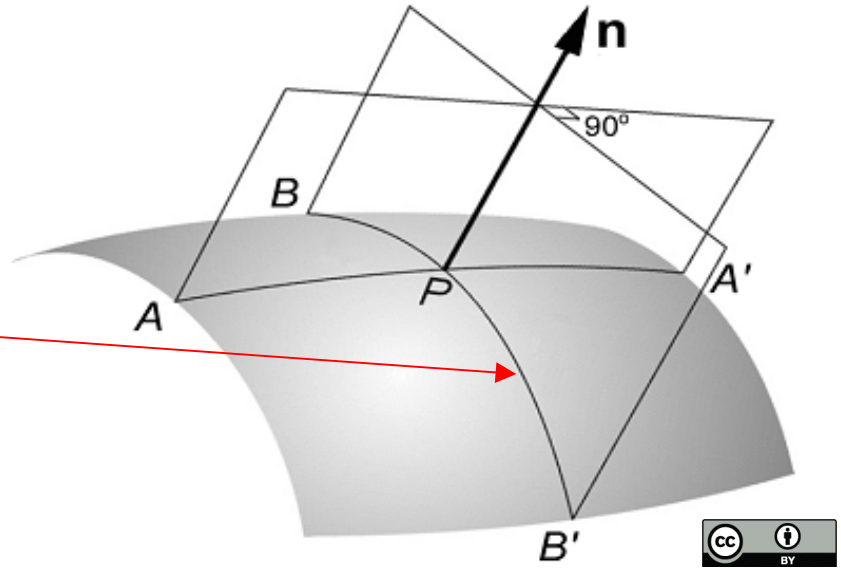
Maximal curvature



$$k_{\max} = H + \sqrt{H^2 - K}$$

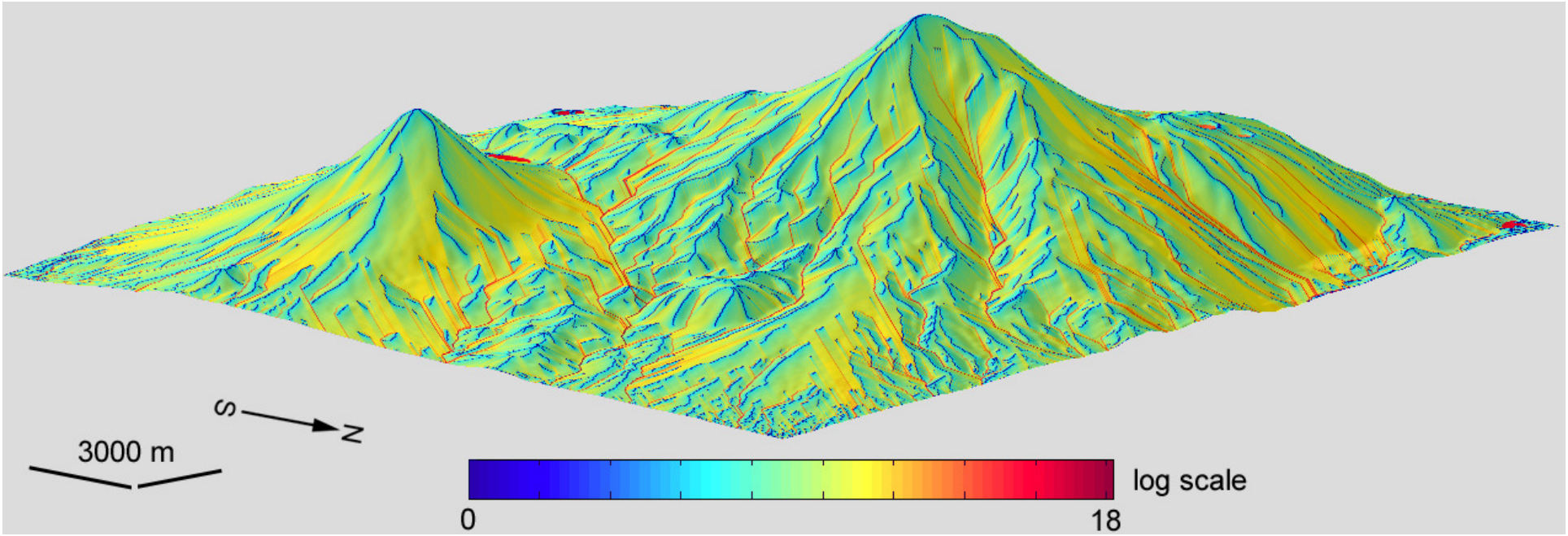
$$H = -\frac{(1+q^2)r - 2pqs + (1+p^2)t}{2\sqrt{(1+p^2+q^2)^3}} \qquad K = \frac{rt - s^2}{(1+p^2+q^2)^2}$$

Maximal curvature is a curvature of a principal section *BB*' with the highest value of curvature at a given point *P* of the surface.



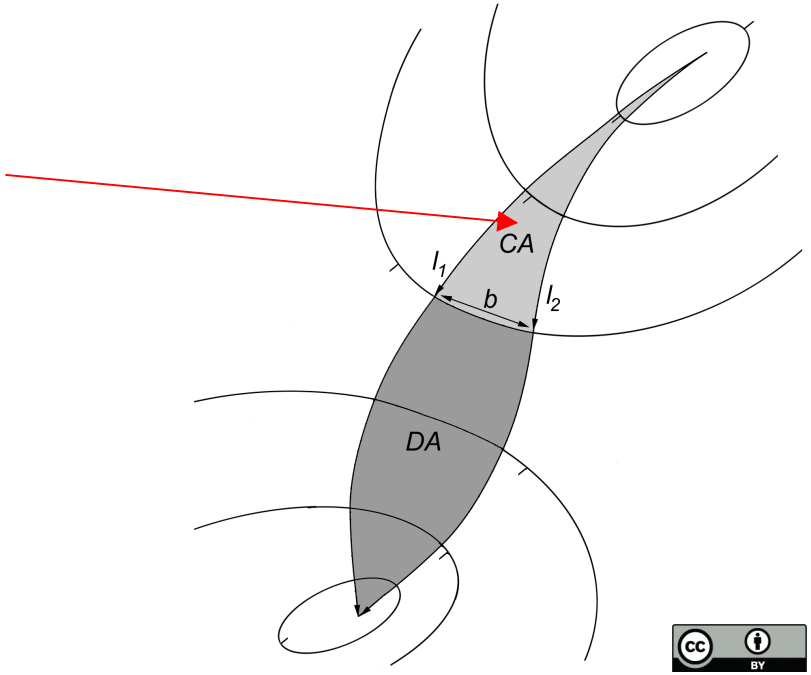
$k_{max} > 0$ correspond to elongated convex landforms;
$k_{max} < 0$ relate to local concave landforms.

Catchment area

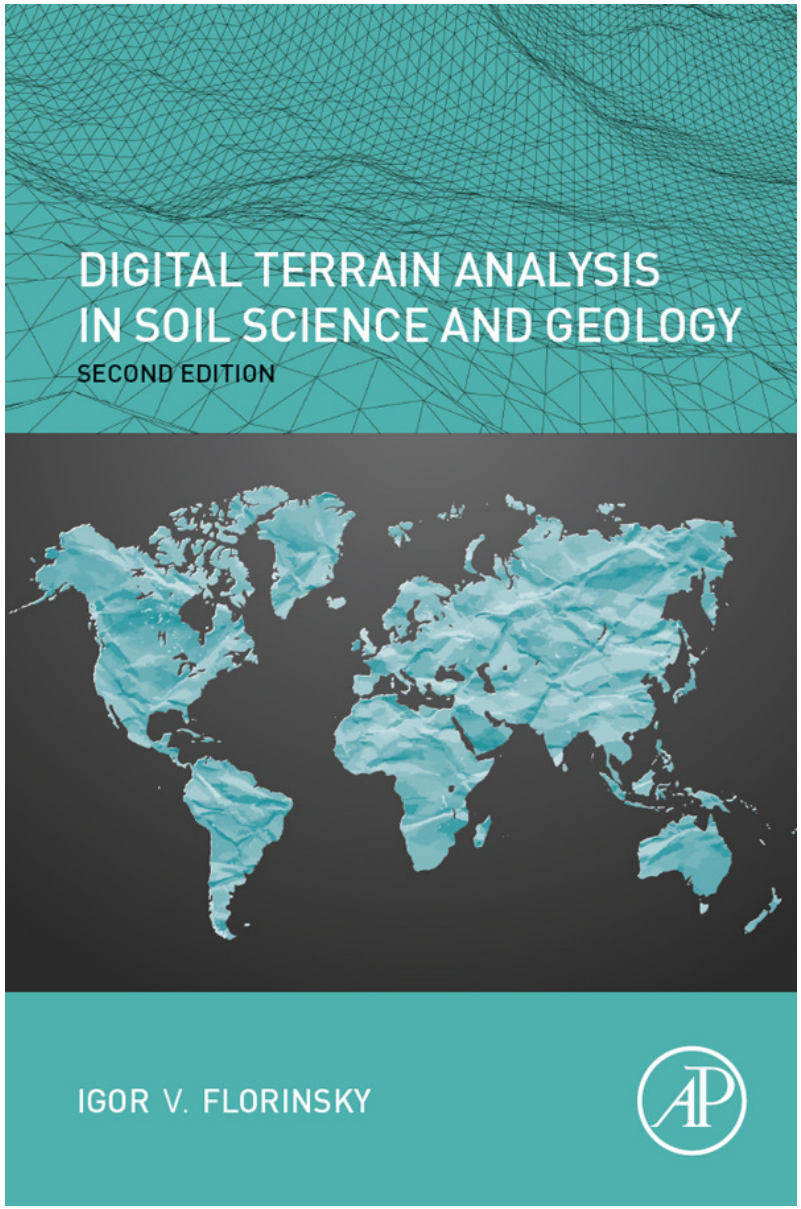


Catchment area is an area *CA* of a closed figure formed by a contour segment *b* at a given point of the topographic surface and two flow lines l_1 and l_2 coming from upslope to the contour segment ends.

Catchment area is a measure of the contributing area.



Reference



DIGITAL TERRAIN ANALYSIS IN SOIL SCIENCE AND GEOLOGY

2nd revised edition

I.V. Florinsky

Elsevier / Academic Press, 2016
Amsterdam, 486 p.

ISBN 978-0-12-804632-6

- **Earth**: SRTM30_PLUS DEM
- **Mars**: Mars Orbiter Laser Altimeter (MOLA) DEM
- **Moon**: Lunar Orbiter Laser Altimeter (LOLA) DEM

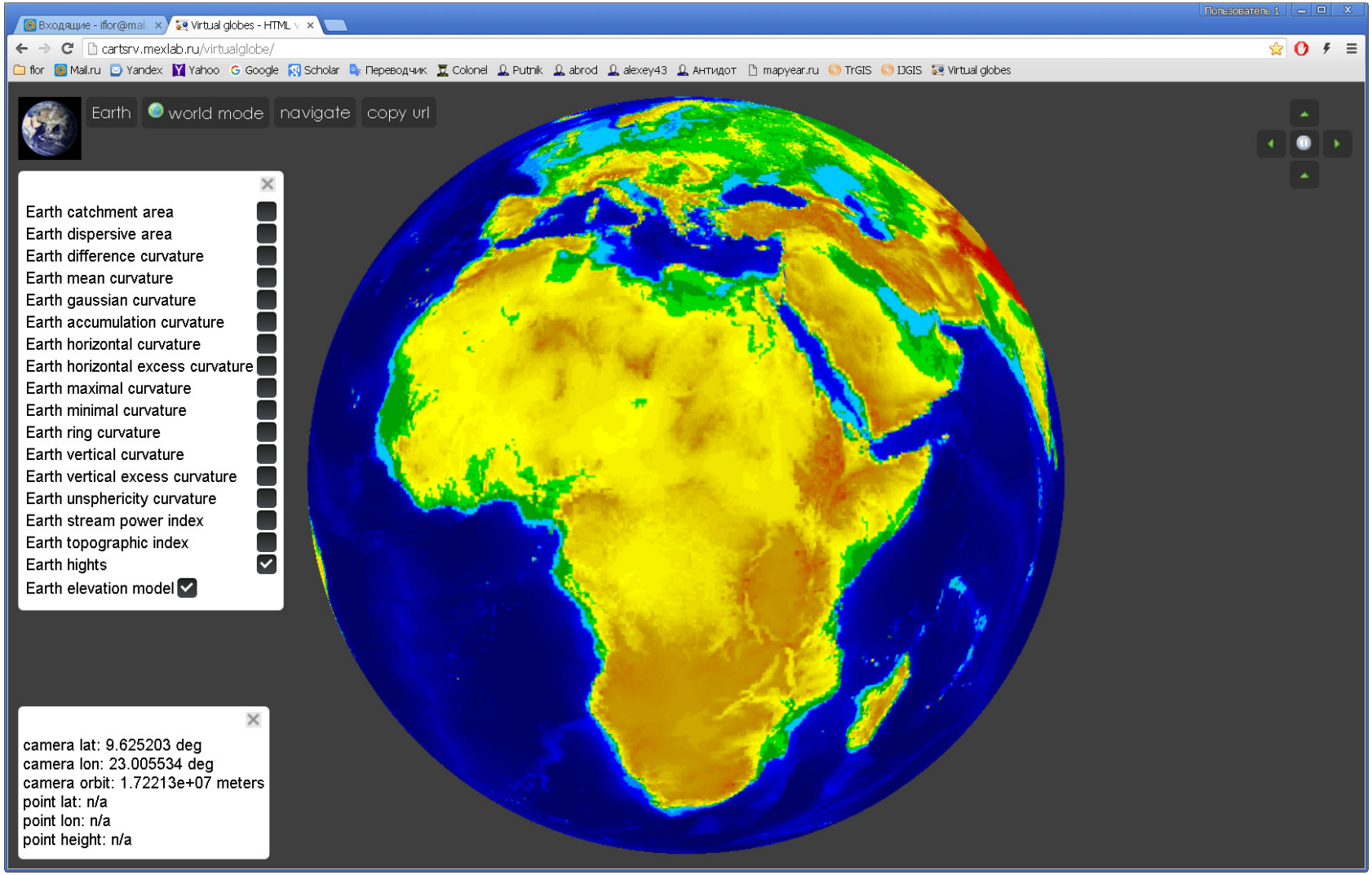
Resolution 15'
1 036 800 points (matrices 1440 × 720)

Softwares

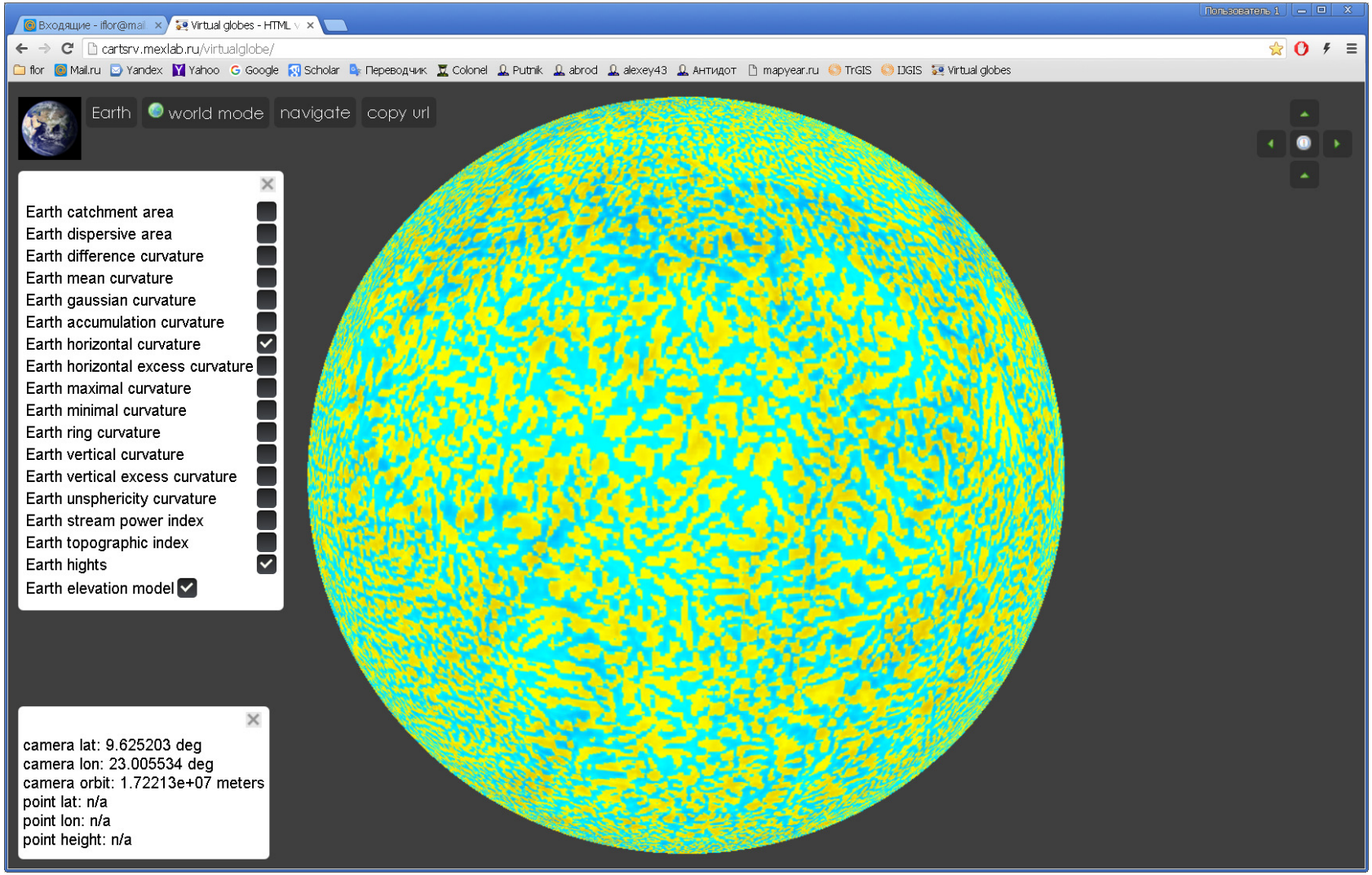
- Morphometric calculations:
  software LandLord (Florinsky, 2012).

- 3D online vizualization:
  web GIS MExLab
  http://cartsrv.mexlab.ru/geoportal.

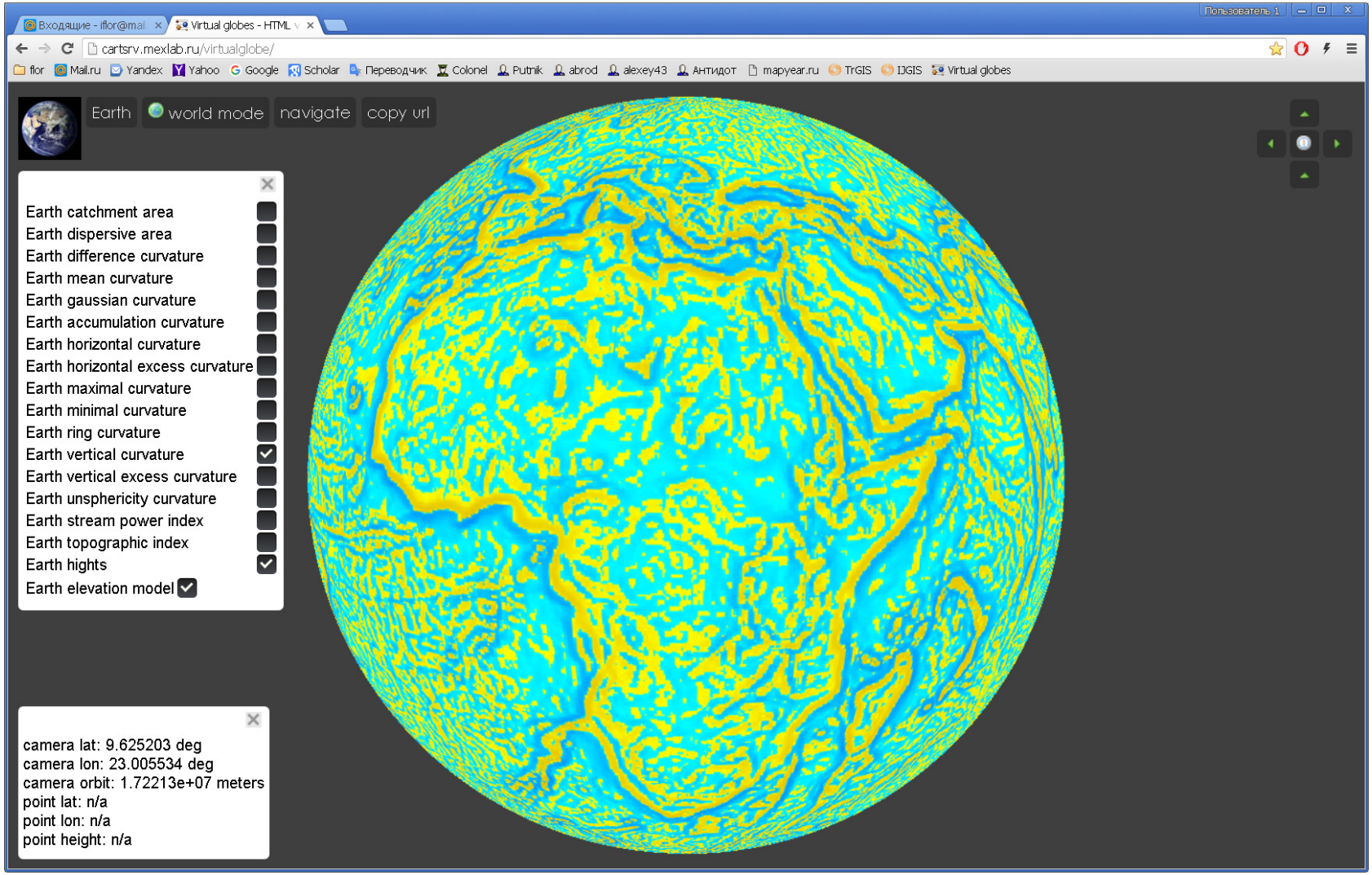
Earth, elevation



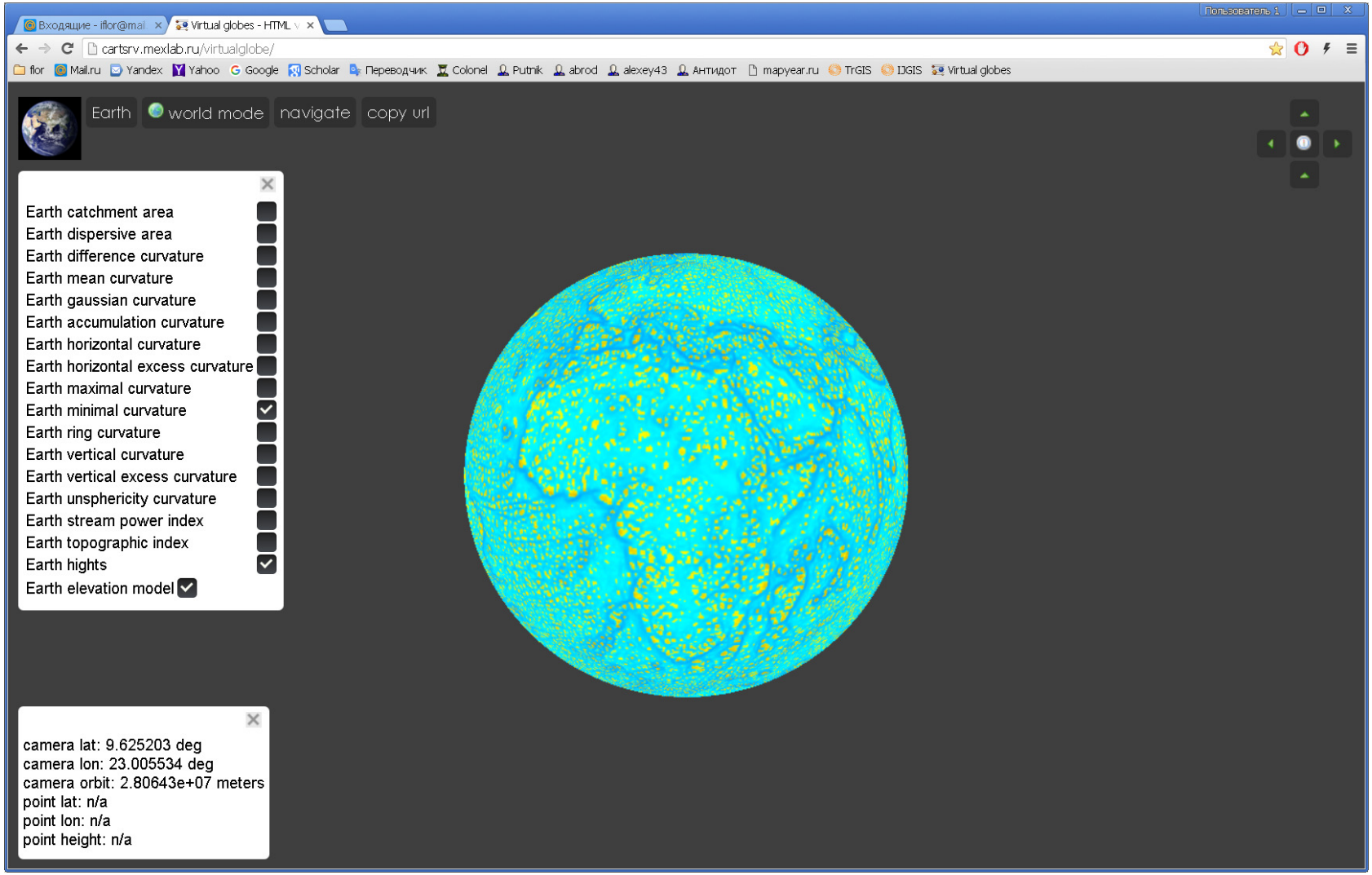
Earth, horizontal curvature



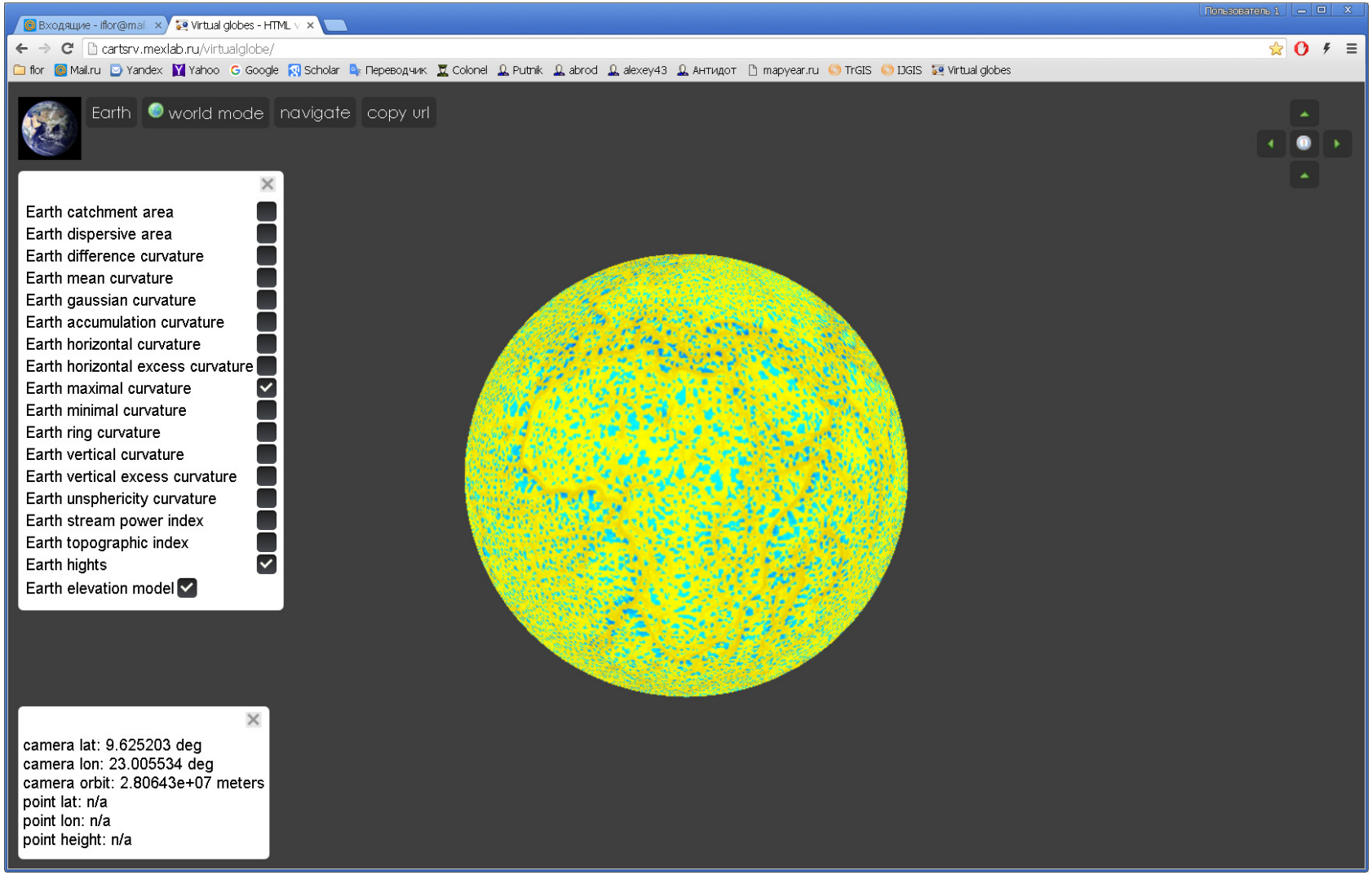
Earth, vertical curvature



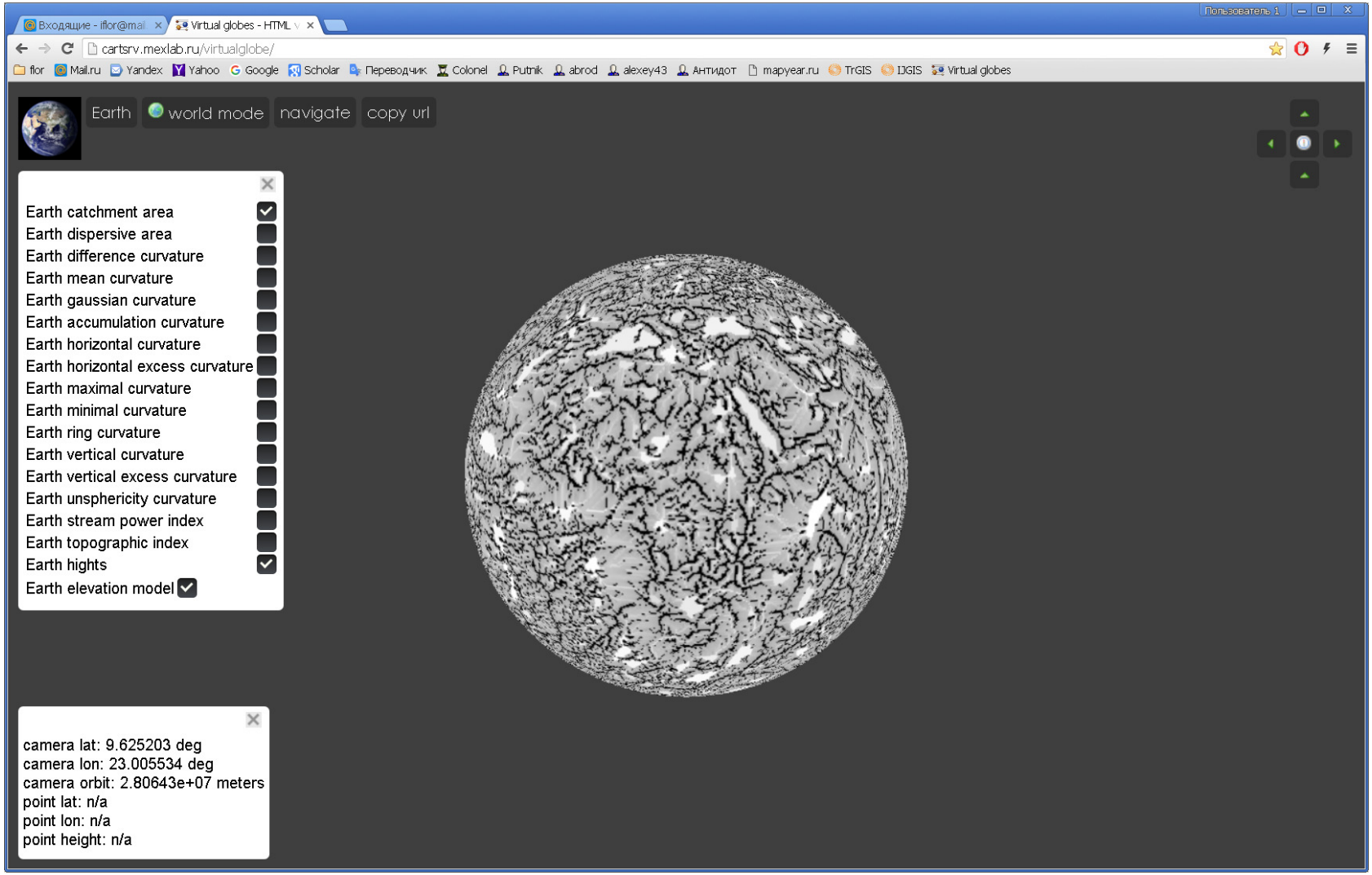
Earth, minimal curvature



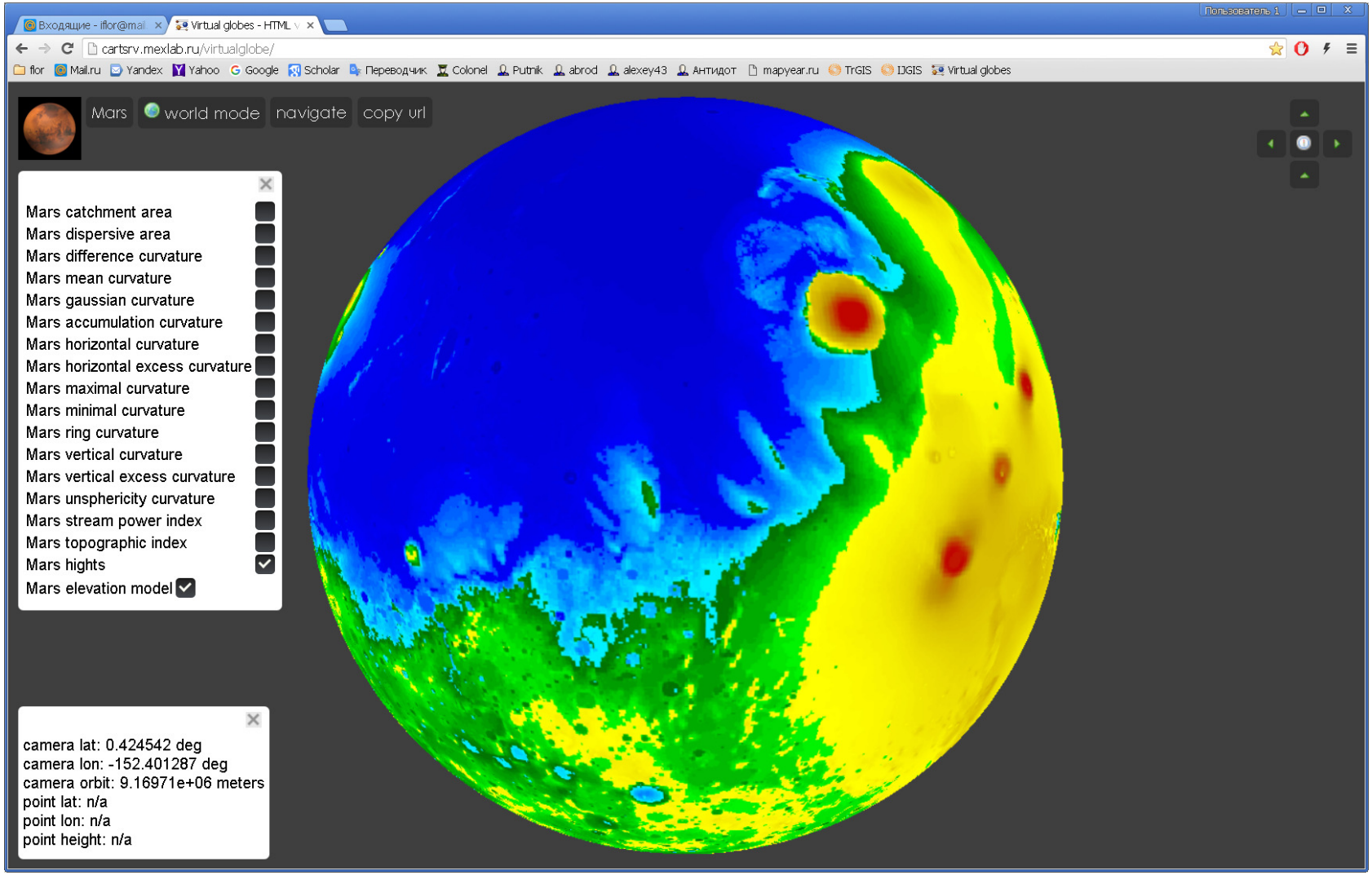
Earth, maximal curvature



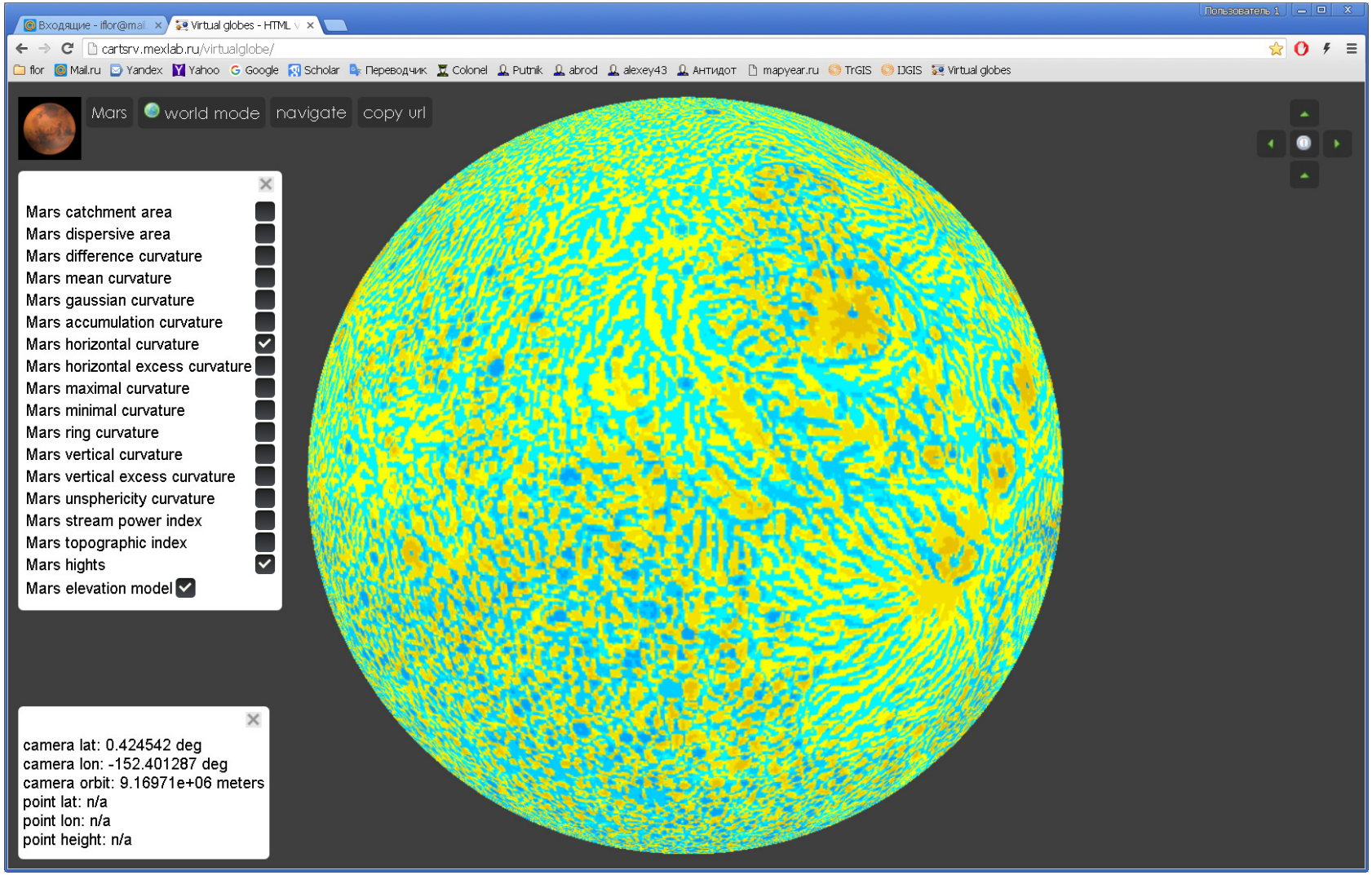
Earth, catchment area



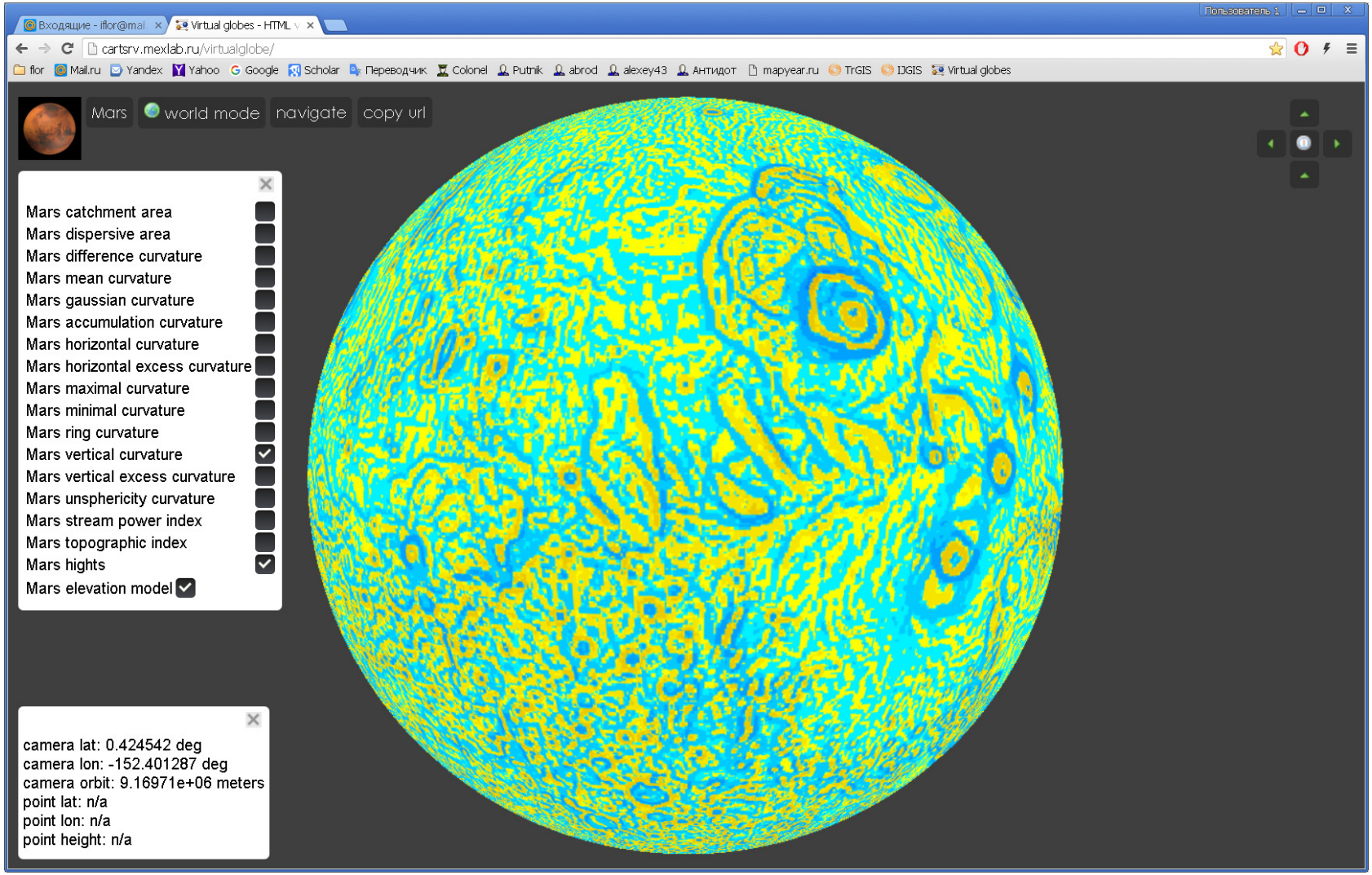
Mars, elevation



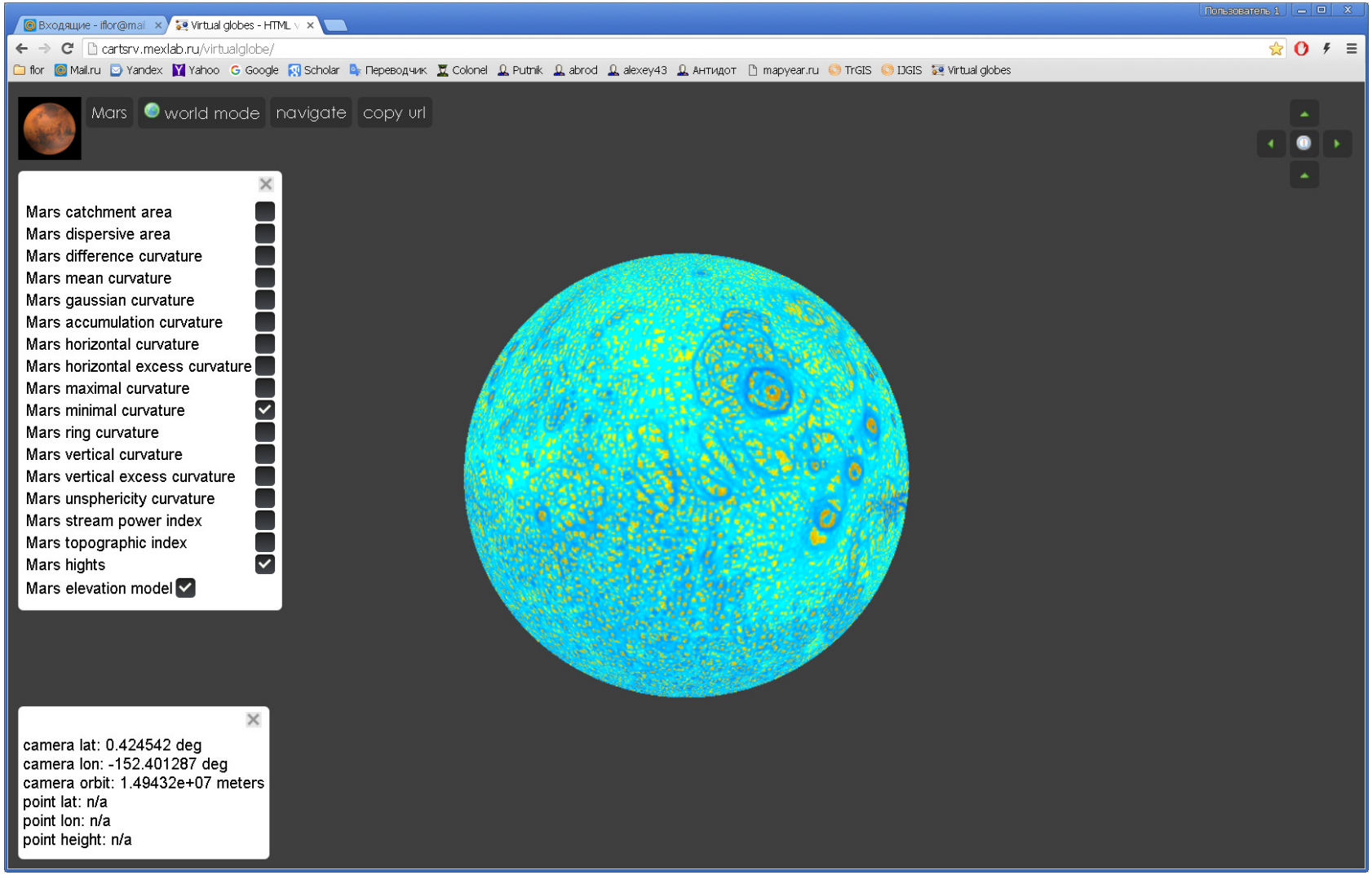
Mars, horizontal curvature



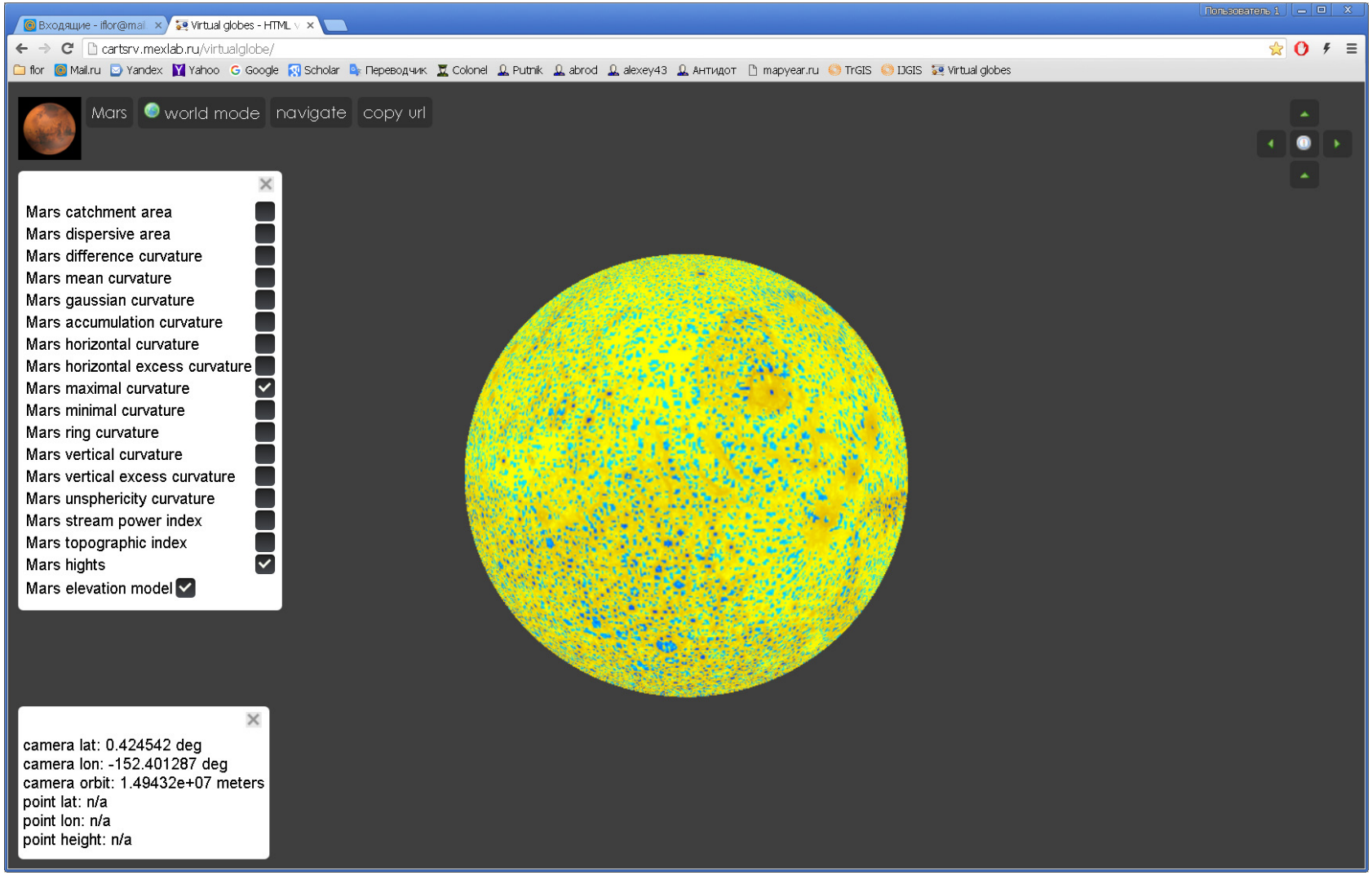
Mars, vertical curvature



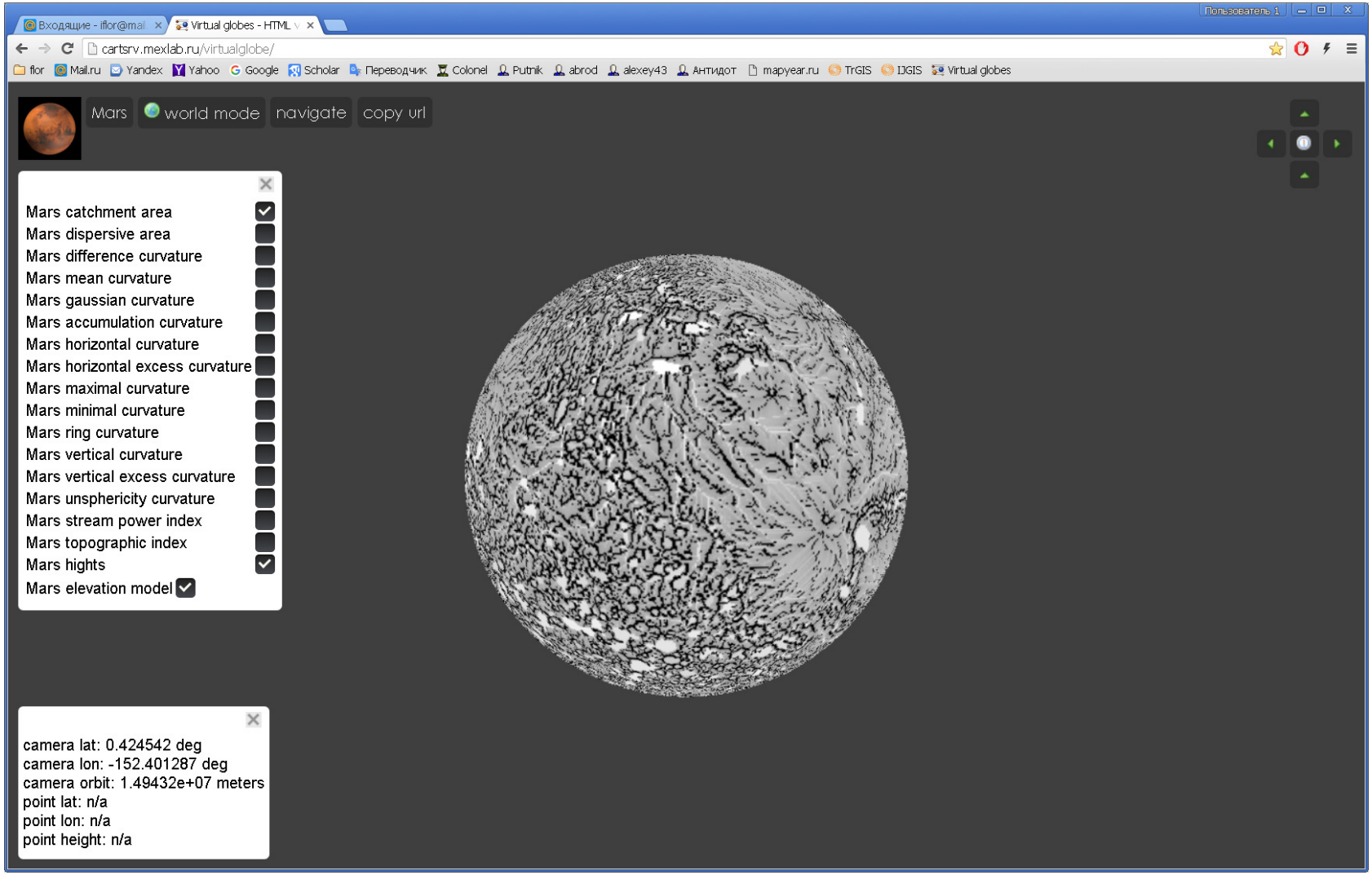
Mars, minimal curvature



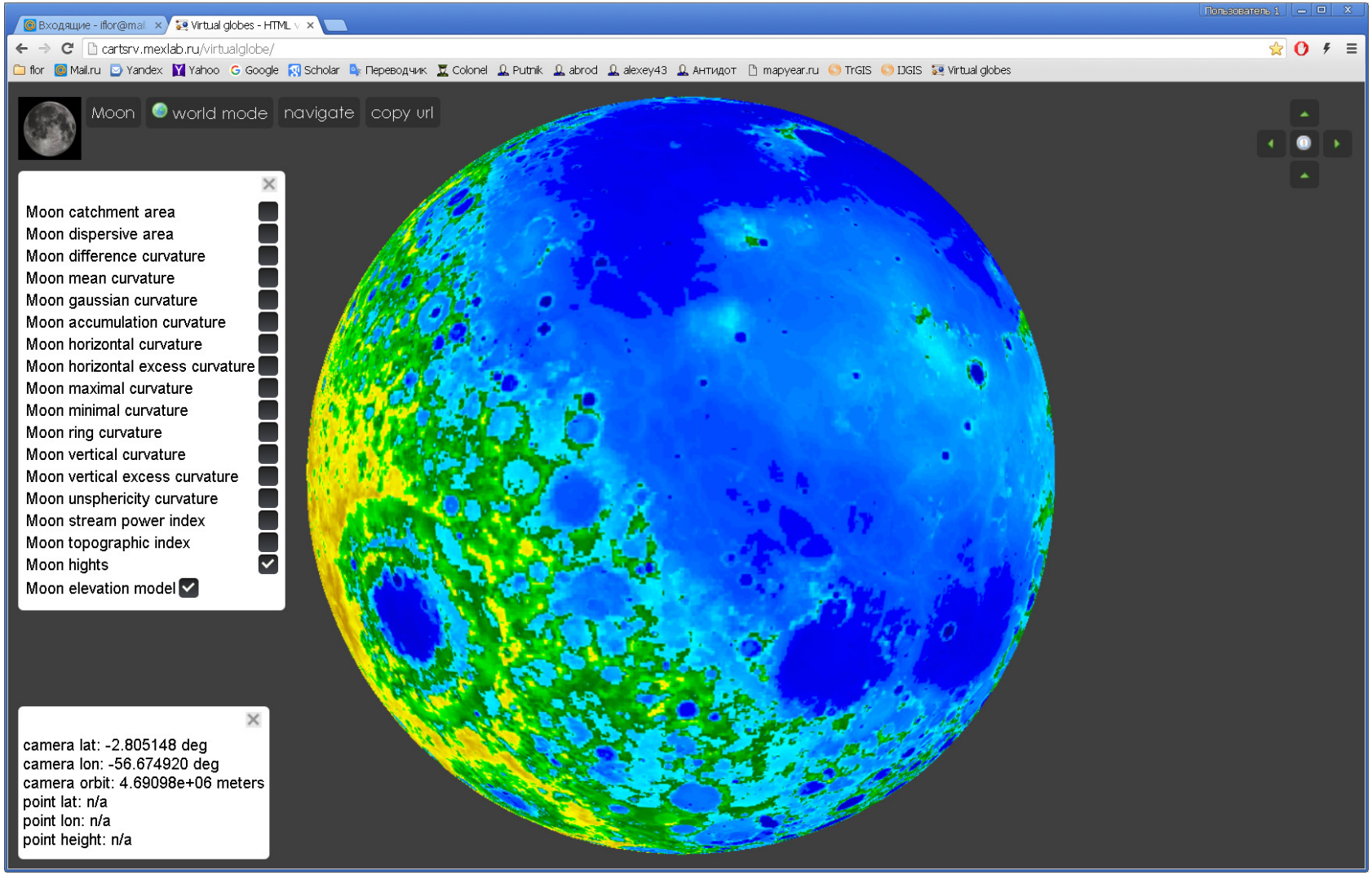
Mars, maximal curvature



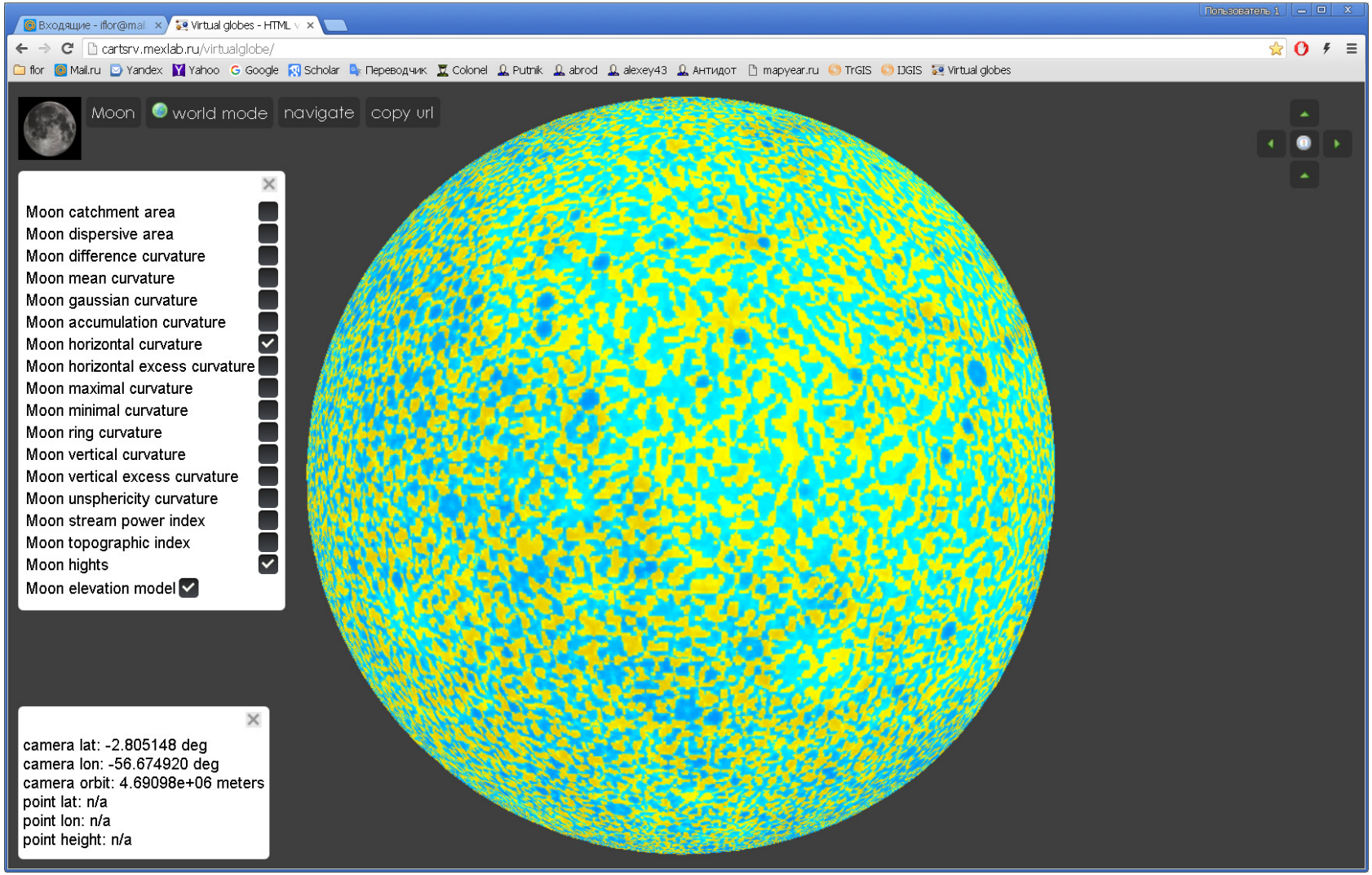
Mars, catchment area



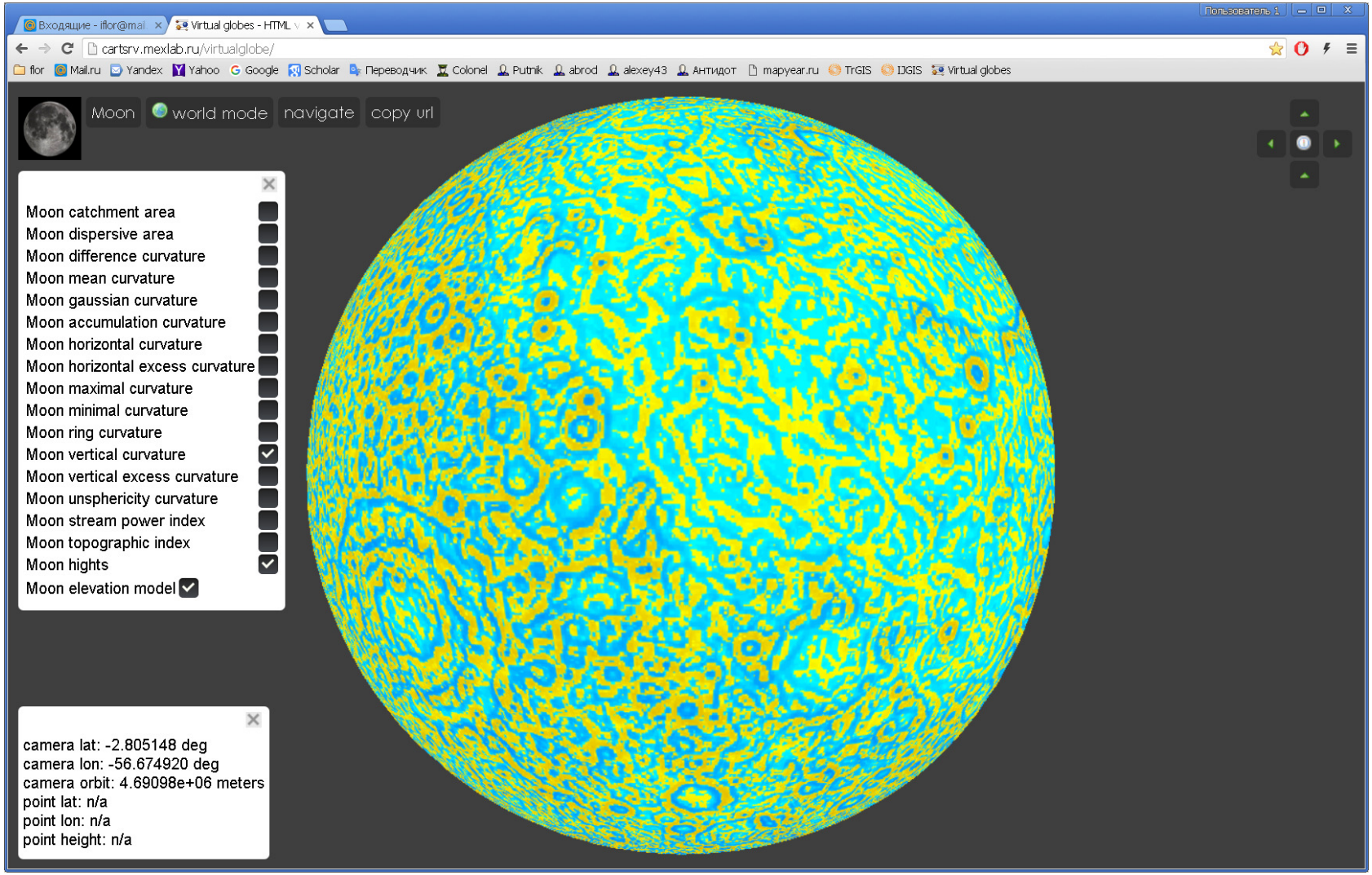
Moon, elevation



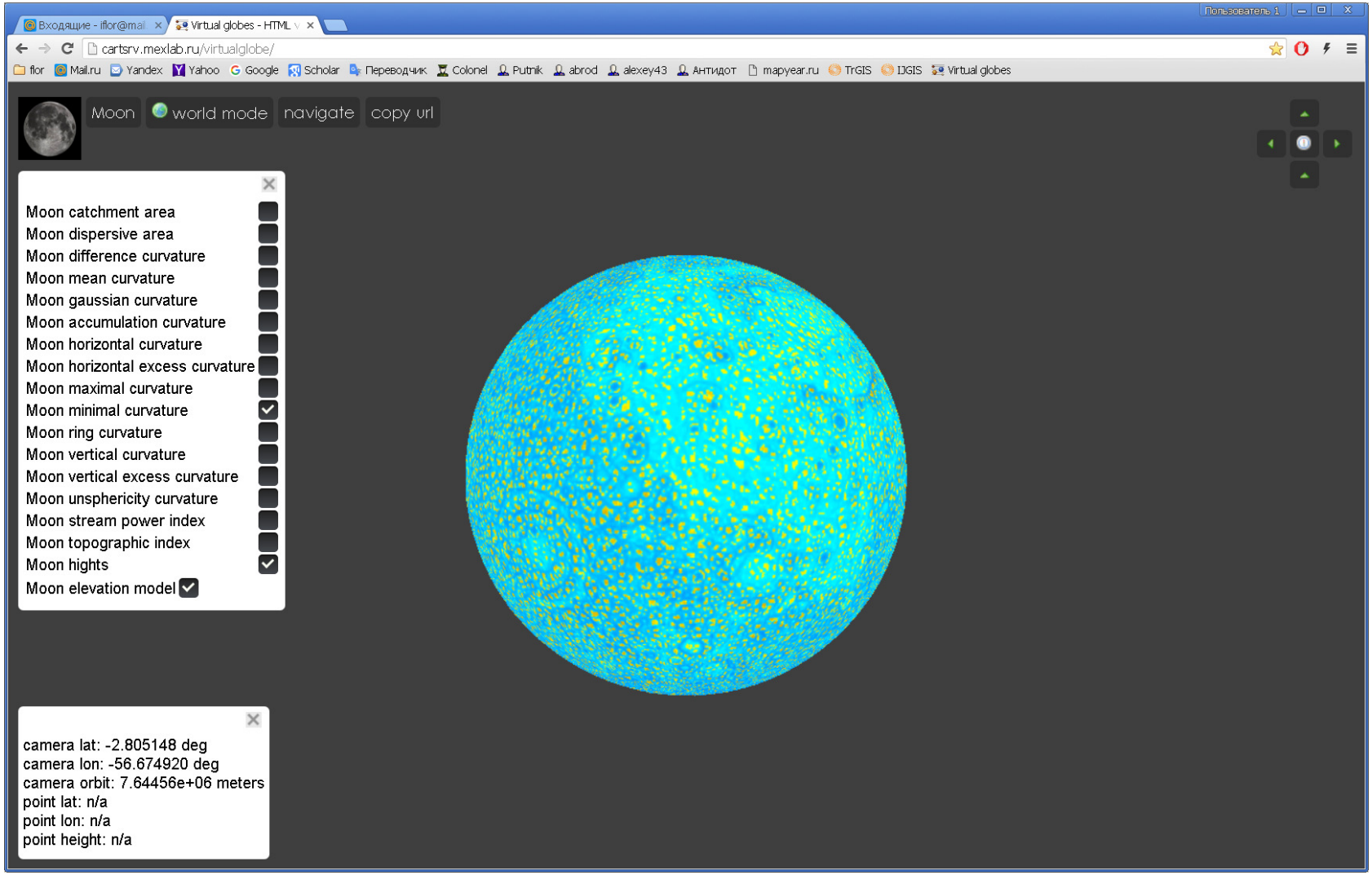
Moon, horizontal curvature



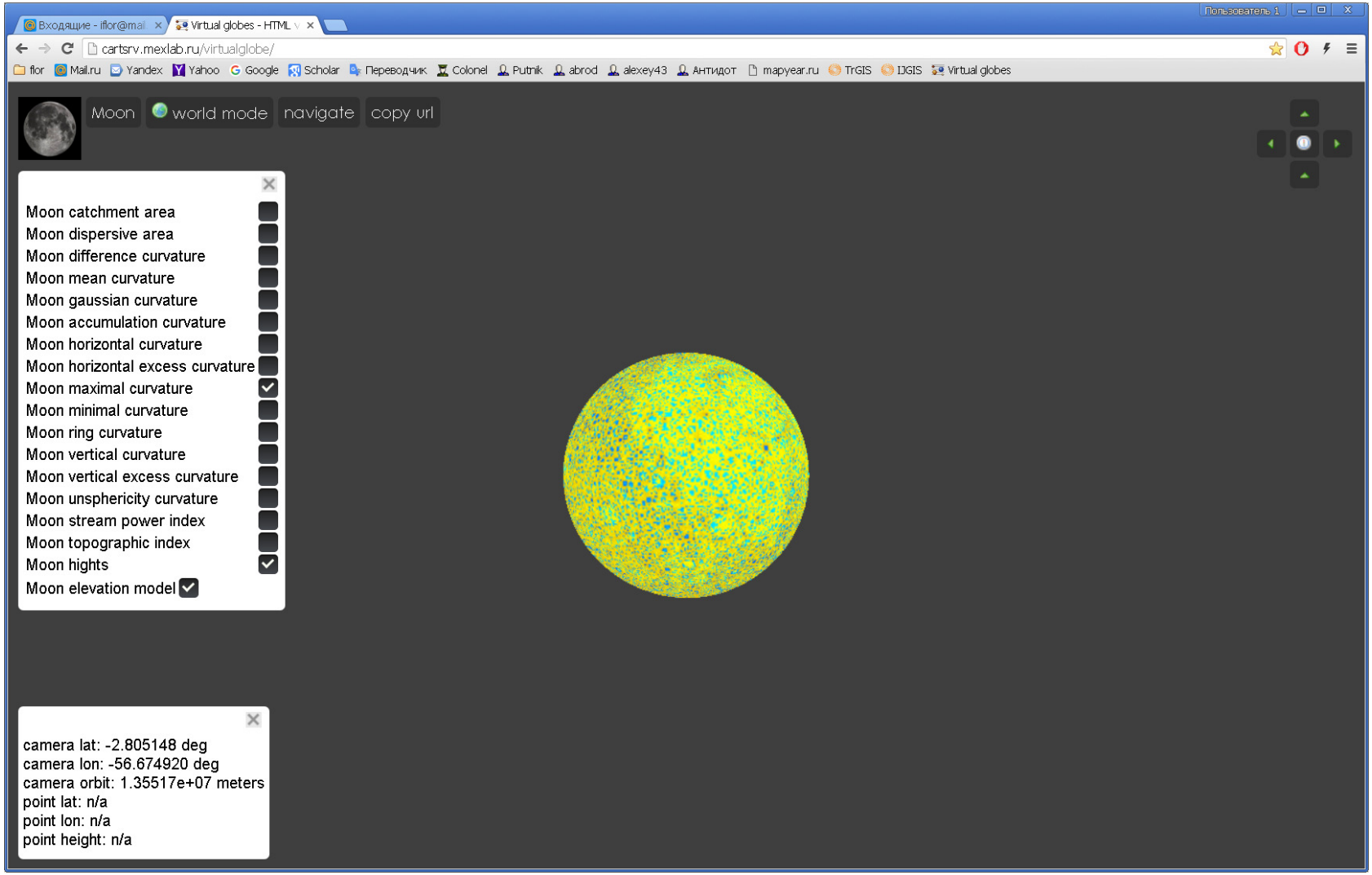
Moon, vertical curvature



Moon, minimal curvature



Moon, maximal curvature



Final version of the system

To implement a multiscale 3D visualization for models of 17 morphometric variables with the resolution from 15' to 30".

To provide free, real-time web access to the system.

http://cartsrv.mexlab.ru/virtualglobe

Acknowledgments

Russian Foundation for Basic Research,
grant 15-07-02484

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