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**Samuel Patrick Dennis Birch**


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**Email:** sbirch@mit.edu**Webpage:** <https://geomorph-sbirch.com>**Phone:** 617-417-1722**Current Address:**77 Massachusetts Ave., 54–1122  
Cambridge, MA 02139**PROFESSIONAL HIGHLIGHTS**

Published 8 first author papers, advisor for 4 student's papers, co-authored 23 more. NESSF Fellow (2015). 51 Pegasi b Fellow (2020). Cassini RADAR Associate Team Member. Rosetta OSIRIS Graduate Student Collaborator. CAESAR Co-Investigator. NEAT Co-Investigator. Trident Co-Investigator. AGU Planetary Sciences Section Early Career Representative (2019–2021). GSA PGD Officer (2020–current). Co-advisor for 15 graduate, undergraduate and high school students (6 presently).

**CURRENT AFFILIATION**


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*Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology*
**EDUCATION**

- **Ph.D.** – *Cornell University, Ithaca NY* December 2017
  - Concentration: Planetary Science (Minors: Geophysics/Astronomy)
- **B.A. (High Honors)** – *University of California Berkeley, Berkeley, CA* May 2014
  - Concentration: Geophysics

**ACADEMIC AWARDS AND FELLOWSHIPS**

- Heising-Simons Foundation 51 Pegasi b Postdoctoral Fellowship 2020
- Department of Earth and Atmospheric Sciences Excellence in Research Award 2018
- NASA Group Achievement Award – Cassini RADAR 2018
- NASA Earth and Space Science Fellowship 2015
- Berkeley Distinguished Honors in Geophysics 2014

**PROFESSIONAL APPOINTMENTS**

- Massachusetts Institute of Technology – *51 Pegasi b Postdoctoral Fellow* 2020 – 2023
- Cornell University – *Research Associate* 2018 – 2020
- Cornell University – *Ph.D. Student* 2014 – 2018
- Cornell University – *REU Summer Intern* 2013
- University of California Berkeley – *Geological Fluid Dynamics Lab* 2013 – 2014

**CURRENT RESEARCH INTERESTS**

- **Theme:** Connecting the Evolution of Planetary Landscapes with Long-Term Climate Change
- Titan Geomorphology & Surface Processes
- Cometary (and Small Body) Geology & Surface Processes
- Sublimation-Driven Erosion on Icy Moons
- Numerical Landscape Evolution Modeling

**JOURNAL PUBLICATIONS (\* = student advisee)**

- h-index: 13      i10-index: 19      Citations: 513      Researcher ID: L-1249-2017**
- [35] \*S.A. Moruzzi, P. Corlies, **S.P.D. Birch**, A.G. Hayes, J.M. Soderblom, and N.W. Kutsop, and P. Helfenstein. Investigating Sub-Resolution Surface Properties of Comet 67P/Churyumov-Gerasimenko from Optical Photometry and Hapke Modeling. *Planetary Science Journal*, in review (2021).
  - [34] J-B. Vincent, **S.P.D. Birch**, \*A.S. Jindal, K. Zacny, A.G. Hayes, N. Oklay, and P. Cambianica. Bouncing boulders on Comet 67P. *MNRAS*, in review (2021).
  - [33] \*A.S. Jindal, **S.P.D. Birch**, O.M. Umurhan, A.G. Hayes, J-B. Vincent, and D. Bodewits. Evolution of the Imhotep Basin on Comet 67P/Churyumov-Gerasimenko. *GRL*, in review (2021).
  - [32] **S.P.D. Birch**, J.T. Perron, J.M. Soderblom, \*J.W. Miller, and G. Parker. Reconstructing River Flows on Earth, Titan, and Mars. *Nature*, in review (2021).
  - [31] J.D. Hofgartner, **S.P.D. Birch**, and 15 others. Hypotheses for Triton's Plumes: New Analyses and Future Remote Sensing Tests. *Icarus*, in review (2021).
  - [30] O.M. Umurhan, W.M. Grundy, R. Beyer, J.T. Keane, L. Young, S.A. Stern, and **S.P.D. Birch**. A Near Surface Temperature Model of Arrokoth. *Planetary Science Journal*, in review (2021).
  - [29] S.M. MacKenzie, E.P. Turtle, **S.P.D. Birch**, E. Karkoschka, and S. Le Mouélic. Titan's Poles as seen by IR imaging: Further evidence for hydrological control. *Icarus*, in review (2021).
  - [28] A.M. Schoenfeld, R.M.C. Lopes, M.J. Malaska, A. Solomonidou, D.A. Williams, **S.P.D. Birch**, and 8 others. Geomorphological map of the South Belet Region of Titan. *Icarus* 366, 114516 (2021).

- [27] \*J.W. Miller, **S.P.D. Birch**, A.G. Hayes, M.J. Malaska, R.M.C. Lopes, A.M. Schoenfeld, P.M. Corlies, D.M. Burr, T.G. Farr, and J.T. Perron. Fluvial Features on Titan: Lessons from Planform Images in Low-resolution SAR. *Planetary Science Journal* 2, 4 (2021).
- [26] S.M. MacKenzie, **S.P.D. Birch**, and 31 others. Titan: Earth-like on the Outside, Ocean World on the Inside. *Planetary Science Journal* 2, 112 (2021).
- [25] J.W. Barnes, A.G. Hayes, J.M. Soderblom, S.M. MacKenzie, J.D. Hofgartner, R.D. Lorenz, E.P. Turtle, J. Radebaugh, D. Burr, J. Lora, G. Neumann, S. Vance, R. Lopes, C. Nixon, P. Corlies, L. Regoli, E. Sciamma-O'Brien, R. Schindhelm, S. Rodriguez, P. Coll, S. Le Mouélic, M. Heslar, R. Dhingra, J. Steckloff, E. Sittler, A. Solomonidou, M.J. Malaska, C. Neish, N. Teanby, S. Vinatier, **S. Birch**, and 42 others. New Frontiers Titan Orbiter. *Bulletin of the AAS* 53 (2021).
- [24] B. Davidsson, **S.P.D. Birch**, G. Blake, D. Bodewits, J. Dworkin, D. Glavin, Y. Furukawa, J. Lunine, J. Mitchell, A. Nguyen, S. Squyres, A. Takigawa, J.-B. Vincent, and K. Zacny. Airfall on Comet 67P/Churyumov-Gerasimenko. *Icarus* 354, 114004 (2021).
- [23] K. Nakamura-Messenger, A.G. Hayes, S. Sandford, C. Raymond, S.W. Squyres, L.R. Nittler, **S. Birch**, and 18 others. The Case for Non-Cryogenic Comet Nucleus Sample Return. *arXiv:2009.14366* (2020).
- [22] J.D. Hofgartner, A.G. Hayes, D.B. Campbell, J.I. Lunine, G.J. Black, S.M. MacKenzie, **S.P.D. Birch**, C. Elachi, R.D. Kirk, A. Le Gall, R.D. Lorenz, and S.D. Wall. The Root of Anomalous Specular Reflections from Solid Surfaces on Saturn's Moon Titan. *Nature Communications* 11, 2829 (2020).
- [21] M.J. Malaska, J. Radebaugh, R. Lopes, K.L. Mitchell, T. Verlander, A.M. Schoenfeld, M.F. Florence, A. Le Gall, A. Solomonidou, A.G. Hayes, **S.P.D. Birch**, M.A. Janssen, L. Schurmeier, T. Cornet, C. Ahrens, T.G. Farr, and the Cassini RADAR Team. Labyrinth Terrain on Titan. *Icarus* 344, 113764 (2020).
- [20] **S.P.D. Birch**, A.G. Hayes, and 10 others. Migrating Scarps as a Mechanism for Recycling Material on Comet 67P/Churyumov-Gerasimenko. *GRL* 49, 12794-12804 (2019).
- [19] R.M.C. Lopes, M.J. Malaska, A.M. Schoenfeld, A. Solomonidou, **S.P.D. Birch**, M. Florence, A.G. Hayes, D.A. Williams, J. Radebaugh, T. Verlander, E.P. Turtle, A. Le Gall, and S. Wall. A Global Geomorphologic Map of Saturn's Moon Titan. *Nature Astronomy* 4, 228-233 (2019).
- [18] A. Solomonidou, A. Le Gall, M. Malaska, **S.P.D. Birch**, and 17 others. Spectral and emissivity analysis of the raised ramparts around Titan's northern lakes. *Icarus* 344, 113338 (2019).
- [17] R.M.C. Lopes, S.D. Wall, C. Elachi, **S.P.D. Birch**, and 44 others. Titan as Revealed by the Cassini RADAR. *Space Science Reviews*, 215:33 (2019).
- [16] V. Poggiali, M. Mastrogiuseppe, A.G. Hayes, R. Seu, J.P. Mullen, **S.P.D. Birch**, and M.C. Raguso. High-resolution Topography of Titan Adapting the Delay/Doppler Algorithm to the Cassini RADAR Altimeter Data. *IEEE Transactions on Geoscience and Remote Sensing* 57, 7262-7268 (2019).
- [15] \*Y. Tang, **S.P.D. Birch**, A.G. Hayes, R. Kirk, N. Kutsop, J.-B. Vincent, and S. Squyres. Generation of Photoclinometric DTMs for Application to Transient Changes on the Surface of Comet 67P/Churyumov-Gerasimenko. *Astronomy & Astrophysics* 630, A10 (2019).
- [14] S.M. MacKenzie, J.W. Barnes, J.D. Hofgartner, **S.P.D. Birch**, and 5 others. The case for seasonal surface changes at Titan's lake district. *Nature Astronomy* 3, 506-510 (2019).
- [13] **S.P.D. Birch**, A.G. Hayes, and 7 others. Raised Rims around Titan's Sharp-Edged Depressions. *GRL* 46, 5846-5854 (2018).
- [12] **S.P.D. Birch**, A.G. Hayes, and 9 others. Morphological evidence that Titan's southern hemisphere basins are paleoseas. *Icarus* 310, 140-148 (2017).
- [11] A.G. Hayes, **S.P.D. Birch**, and 12 others. Topographic constraints on the evolution and connectivity of Titan's lacustrine basins. *GRL* 44, 11745-11753 (2017).
- [10] P. Corlies, A.G. Hayes, **S.P.D. Birch**, R.D. Lorenz, B. Stiles, R.L. Kirk, V. Poggiali, H. Zebker, and L. Iess. Titan's topography and shape at the end of the Cassini mission. *GRL* 44, 11754-11761 (2017).
- [9] M. Mastrogiuseppe, A.G. Hayes, V. Poggiali, J.I. Lunine, R.D. Lorenz, R. Seu, A. Le Gall, C. Notarnicola, K. Mitchell, M. Malaska, and **S.P.D. Birch**. Bathymetry and Composition of Titan's Ontario Lacus derived from Monte Carlo-based waveform inversion of Cassini RADAR altimetry data. *Icarus* 300, 203-209 (2017).
- [8] **S.P.D. Birch**, \*Y. Tang, A.G. Hayes, and 10 others. Geomorphology of Comet 67P/Churyumov-Gerasimenko. *MNRAS* 469, S50-S67 (2017).
- [7] **S.P.D. Birch**, A. Hayes, and 19 others. Geomorphologic Mapping of Titan's polar terrains: Constraining Surface Processes and Landscape Evolution. *Icarus* 282, 214-236 (2017).
- [6] V. Poggiali, M. Mastrogiuseppe, A.G. Hayes, R. Seu, **S.P.D. Birch**, R. Lorenz, C. Grima, and J.D. Hofgartner. Liquid-filled canyons on Titan. *GRL* 43, 7887-7894 (2016).
- [5] M.J. Malaska, R.M.C. Lopes, D.A. Williams, C.D. Neish, A. Solomonidou, J. Soderblom, A.M. Schoenfeld, **S.P.D. Birch**, A.G. Hayes, A. Le Gall, M.A. Janssen, T.G. Farr, R.D. Lorenz, J. Radebaugh, and E. Turtle. Geomorphologic map of the Afekan Crater region, Titan: Terrain relationships in Titan's blandlands. *Icarus* 270, 130-161 (2016).
- [4] **S.P.D. Birch**, A. Hayes, A.D. Howard J. Moore, and J. Radebaugh. Alluvial Fan Morphology, Distribution and Formation on Titan. *Icarus* 270, 238-247 (2016).

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- [3] Radebaugh, J., D. Ventra, R.D. Lorenz, T. Farr, R. Kirk, A. Hayes, M.J. Malaska, **S. Birch**, and 8 others. Alluvial and fluvial fans on Saturn's moon Titan reveal processes, materials and regional geology. *In, Ventra, D. & Clarke, L. E. (eds) Geology and Geomorphology of Alluvial and Fluvial Fans: Terrestrial and Planetary Perspectives. Geological Society, London, Special Publications 440* (2016).
- [2] R.M.C. Lopes, M. J. Malaska, A. Solomonidou, A. Le Gall, M. A. Janssen, C.D. Neish, E.P. Turtle, **S.P.D. Birch**, A.G. Hayes, J. Radebaugh, A. Coustenis, B.W. Stiles, R.L. Kirk, K.L. Mitchell, and K.J. Lawrence. Nature, Distribution, and Origin of Titan's Undifferentiated Plains, *Icarus* 270, 162-182 (2015).
- [1] **S.P.D. Birch**, M. Manga, B. Delbridge, and M. Chamberlain. Penetration of spherical projectiles into wet granular media, *Physical Review E* 90, 032208 (2014).

## TECHNICAL/MANAGEMENT PERFORMANCE

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### Funding Proposals:

- Co-I\* of Rosetta Data Analysis Program (0.5 FTE) 2019 – 2022
  - Co-I of Discovery Data Analysis Program (0.17 FTE) 2019 – 2022
- \*Cornell did not allow postdocs to be a PI

### Journal Reviewer:

- Journal of Geophysical Research (3); Journal of Geophysical Research-Planets (3); Monthly Notices of the Royal Astronomical Society (2); Planetary and Space Science (1); Astronomy & Astrophysics (2); Nature Communications (1); Planetary Science Journal (1); Icarus (2); Nature Astronomy (1).

### Community Service/Engagement:

- AGU Planetary Sciences Section Early Career Representative (2019 – Current)
- GSA Planetary Geology Division: Secretary/Treasurer (2020 – 2021), 2<sup>nd</sup> Vice-Chair (Current)
- AGU Fall Meeting OSPA Judge (2018-2021), LPSC Dwornik Award Judge (2019)
- Co-Chair Titan Surface Workshop (2016); Session Co-Chair/Chair AGU Fall Meeting (2018-2021); Session Chair DPS (2020); Session Co-Chair EPSC (2021).
- Organizing Committee LPSC 2021–2022
- NASA ROSES Review Panelist (2x)

### White Paper Co-Authorships for the Planetary Science & Astrobiology Decadal Survey 2023-2032:

- Titan Science; New Frontiers Titan Orbiter; Comet Surface Sample Return

## MISSION PARTICIPATION

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- NEAT [NASA SIMPLEX 3] – Science Investigation Lead; *Co-Investigator* Current
- CAESAR [NASA New Frontiers 5] – Comet Surface Science Lead; *Co-Investigator* Current
- Trident (Not Selected) [NASA Discovery] – Geology Working Group; *Co-I (Post-Launch)* 2019 – 2021
- Dragonfly [NASA New Frontiers 4] – *Associate Team Member* Current
- Rosetta [ESA] – OSIRIS; *Graduate Student Collaborator* 2017 – 2019
- Cassini [NASA/ESA/ASI] – RADAR Team; *Associate Team Member* 2016 – 2019
- Oceanus (Not Selected) [NASA New Frontiers 4] – Science Team; *Graduate Student Co-I* 2016 – 2017
- CAESAR (Not Selected) [NASA New Frontiers 4] – Science Team; *Graduate Student Co-I* 2015 – 2019
- Perseverance Rover [NASA Flagship] – Mastcam-Z; *Landing Site Selection/Mapping* Current

## INVITED TALKS & COLLOQUIA

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### 2021

- Directly Measuring Erosion & Fallback on Comet 67P, NASA Small Bodies Assessment Group, June
- Piecing Together Planetary Surfaces. EAPS Colloquium (*Faculty Interview*), MIT, February

### 2019:

- Evolution of Cometary Surfaces. Department of Geological Sciences Colloquium, University of Idaho, June
- The Lakes and Seas of Titan. Geology & Geophysics Seminar, Woods Hole Oceanographic Institute, April

### 2018:

- Sediment Transport and Landscape Evolution on Comet 67P/C-G. PICS Seminar, MIT, April
- Investigating the Morphology and Topography of Titan's Polar Lacustrine Features. PALS Seminar, University of Maryland, March

## PUBLIC OUTREACH & EDUCATION

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- Invited speaker for Tecnológico de Costa Rica's planetary science webinar August 2020
- Invited speaker for Cornell's *Frontiers of Cornell Astronomy* event November 2019
- Keynote speaker at *AstroFest*, Kopernik Observatory, Vestal NY October 2018
- Cornell Astronomy "Ask an Astronomer" Team Member 2015 – 2020
- Volunteer with New York 4-H summer program "Focus for Teens" 2015 – 2020
- Volunteer with Cornell's Spacecraft Planetary Imaging Facility 2014 – 2020

## Samuel Birch

- Creator of Winnipeg Planet Walk (under development) Current
- Consultant for James Cameron's *Lightstorm Entertainment* 2015 – 2016
- Named "Winnipeg Lacus," and "Buzzell Planitia" on Titan

### **SELECTED RECENT CONFERENCE TALKS (>30 total author/co-author abstracts in the last 3 years)**

#### **2021:**

- Reconstructing River Flows on Earth, Mars, and Titan. With Dimensionless Hydraulic Geometry *AGU Fall Meeting*, San Francisco, December
- Reconstructing River Flows on Titan. *Titan Through Time 5*, August

#### **2020:**

- NEAT: A Multi-Comet Flyby Mission that Performs Discovery-Level Science on a SIMPLEx Budget. *DPS*, October

#### **2019:**

- Deposition and Detectability of Deltas on Titan. *AGU Fall Meeting*, San Francisco, December
- Local Migration of Smooth Terrain Material in Imhotep on Comet 67P. *EPSC-DPS*, Geneva, September
- A Numerical Landscape Evolution Tool with Applications to Titan. *Titan After Cassini*, Madrid, September
- Migrating Scarps on Comet 67P. *LPSC 50*, Woodlands, March

#### **2018:**

- Raised Rims around Titan's Small Lakes. *COSPAR 2018*, Pasadena, July
- Numerical Landscape Evolution Simulations Applied to Comet 67P. *Rosetta SWT 49*, Rhodes, June
- The Raised Rims of Titan's Small Lakes. *LPSC 49*, Woodlands, March

### **TEACHING EXPERIENCE**

Cornell University; *Lead Lecturer & Course Designer*

- EAS/Astro3150: "Geomorphology" Spring 2019
  - Average Evaluation: 4.7/5 (n=14)

Cornell University; *Guest Lecturer*

- Astro1102: "Our Solar System" (2x) Spring 2018
- Astro2202: "A Spacecraft Tour of the Solar System" (2x) Fall 2016 & (4x) Fall 2017 – 2019
- Astro2212: "The Solar System: Planets, Small Bodies, New Worlds" (1x) Fall 2017 & 2018
- Astro6577: "Planetary Surface Processes" (2x) Spring 2017 & 2020

Cornell University; *Teaching Assistant*

- Astro1102: "Our Solar System" Spring 2015 & 2016
- Astro6577: "Planetary Surface Processes" Spring 2017

University of California Berkeley; *Grader*

- EPS 3: "The Water Planet" Spring 2014
- EPS 20: "Earthquakes in your Backyard" Fall 2013

### **ADVISING**

#### **Graduate (\*on secondary projects related to work with their primary advisor):**

- Megan Barrington; Cornell University; 04/2019 – Current
  - A Comprehensive Catalog of Change Detection on Comet 67P
  - *Drafting a manuscript that will form a thesis chapter (expected Spring 2022)*
- Ngoc Truong; Cornell University; 01/2019 – Current
  - Modeling Volatile Entrapment in Cometary Ices
  - *Finalizing a manuscript that will form a thesis chapter (expected Fall 2021)*
- Abhinav Jindal; Cornell University; 06/2018 – Current
  - Measuring Fallback & Modelling Erosional Processes on Comet 67P
  - *Finalizing two manuscripts (one submitted) that will form a thesis chapter (Fall 2021)*

#### **Undergraduate:**

- Fiona Powers Ozyurt; Wellesley College; 08/2020 – Current
  - Modeling Cometary Smooth Terrains using High Resolution Topography
- Isabella Torres; MIT; 08/2020 – Current
  - Calibration of Europa Clippers EIS camera & NEAT Science Development
- Alexandro Ochoa (Summer REU); 05/2019 – 08/2019
  - Evolution of 67P's Imhotep Region
- Samantha Moruzzi; Cornell University; 07/2018 – Current
  - Photometric modeling of smooth terrains on 67P
  - *Submitted a manuscript to the Planetary Science Journal (Fall 2021)*
- Julia Miller; Cornell University; 08/2017 – 08/2021

## Samuel Birch

- A Complete Mapping of Titan's Hydrology
  - *Published a manuscript in the Planetary Science Journal in July 2021*
- Alexandra Dobbs (Summer REU); 05/2018 – 08/2018
  - Photometric modeling of smooth terrains on 67P
- Andrew Nowak (Summer REU); 05/2018 – 08/2018
  - SAR Backscatter Modeling of Representative Terrains on Titan
- Harry Tang; Cornell University; 04/2015 – 08/2018
  - Photoclinometry on 67P to Understand Transient Changes
  - *Published a manuscript in Astronomy & Astrophysics in August 2018*
- Ian Cullings; Cornell University; 01/2017 – 12/2018
  - The longevity of the Jezero crater delta using DTMs
- Ryan de Freitas Bart; Cornell University; 04/2015 – 04/2017
  - Generating a fully three-dimensional model of Comet 67P/C-G

### High School:

- Leslie VanDeMark; Ithaca High School; New Visions Program; 11/2014 –05/2015
  - Hydraulic mapping on Titan
- Nathan Degree; Regeneron STS Competition; 05/2018 –05/2019
  - An inter-comparison of Titan & Terrestrial Geology in Cassini SAR

### REFERENCES

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- Professor Alexander Hayes, Cornell University  
**Relationship:** Ph.D. Thesis Advisor **Email:** hayes@astro.cornell.edu
- Professor J. Taylor Perron, MIT  
**Relationship:** Postdoc Advisor **Email:** perron@mit.edu
- Professor Steven Squyres, Cornell University  
**Relationship:** Ph.D. Co-Advisor **Email:** squyres@astro.cornell.edu
- Dr. Rosaly Lopes, Jet Propulsion Lab  
**Relationship:** Collaborator **Email:** rosaly.m.lopes@jpl.caltech.edu
- Dr. Jeffrey Moore, NASA Ames Research Center  
**Relationship:** Collaborator **Email:** jeff.moore@nasa.gov
- Dr. Jason Soderblom, MIT  
**Relationship:** Collaborator **Email:** jms4@mit.edu
- Professor Michael Manga, UC Berkeley  
**Relationship:** Undergraduate Advisor **Email:** manga@seismo.berkeley.edu
- Dr. Michael Malaska, Jet Propulsion Lab  
**Relationship:** Collaborator **Email:** michael.j.malaska@jpl.nasa.gov
- Dr. Steven Wall, Jet Propulsion Lab  
**Relationship:** Collaborator **Email:** swall@jpl.caltech.edu
- Professor Jani Radebaugh, Brigham Young University  
**Relationship:** Collaborator **Email:** janirad@byu.edu
- Professor Dennis Bodewits, Auburn University  
**Relationship:** Collaborator **Email:** dennis@auburn.edu
- Professor Jonathan Lunine, Cornell University  
**Relationship:** Collaborator **Email:** jlunine@astro.cornell.edu
- Dr. Orkan Umurhan, NASA Ames Research Center  
**Relationship:** Collaborator **Email:** orkan.umurhan@gmail.com