

Deep Frontier

'Challenging one last frontier: Understanding and improving deep rooting'

Publication and Dissemination List

Websites

Deep Frontier Website <https://projects.au.dk/deepfrontier/>

Deep Frontier Danish website <https://icrofs.dk/forskning/dansk-forskning/deep-frontier/>

Scientific Communication

Papers

Han, E.; Dresbøll, D.B.; and Thorup-Kristensen, K. (submitted 2019 – Plant and Soil). Core-labelling technique (CLT): A novel combination of the ingrowth-core method and tracer technique for deep root study (2020). *Plant Methods*, 16 (1), p. 84. <https://orgprints.org/38136/>

Hassan AB, Dresbøll DB, Rasmussen CR, Lyhne-Kjærbye A, Nicolaisen MH, Stokholm MS, Lund OS, Thorup-Kristensen, K. (2019). Root distribution in intercropping systems – a comparison of DNA based methods and visual distinction of roots. *Archives of Agronomy and Soil Science* 67(1):15-28. <https://orgprints.org/38825/>

Liang, Zhi; Elsgaard, Lars; Nicolaisen, Mette H.; Lyhne-Kjærbye, Annemette and Olesen, Jørgen E. (2018). Carbon mineralization and microbial activity in agricultural topsoil and subsoil as regulated by root nitrogen and recalcitrant carbon concentrations. *Plant and Soil* **433**, 65-82. <http://orgprints.org/33966/>

Liang, Zhi; Olesen, Jørgen E.; Jensen, Johannes L. and Elsgaard, Lars (2019). Nutrient availability affects carbon turnover and microbial physiology differently in topsoil and subsoil under a temperate grassland. *Geoderma*, **336**, 22-30. <http://orgprints.org/33793/>

Liang, Zhi; Olesen, Jørgen E.; Nørgaard, Trine; and Elsgaard, Lars. (2020). Extraction and enzymatic assay of glucose in soils with divergent pH, clay and organic carbon contents. *Communications in Soil Science and Plant Analysis* **51**, 380-391. <https://orgprints.org/37962/>

Peixoto, L., Elsgaard, L., Rasmussen, J., Kuzyakov, Y., Banfield, C. C., Dippold, M. A., & Olesen, J. E. (2020). Decreased rhizodeposition, but increased microbial carbon stabilization with soil depth down to 3.6 m. *Soil Biology and Biochemistry* **150**, 108008. <https://orgprints.org/38469/>

Peixoto, Leanne; Rasmussen, Jim; Elsgaard, Lars; and Olesen, Jørgen E. (2021). Nitrogen and phosphorus co-limits mineralization of added carbon in deep subsoil. *European Journal of Soil Science* (in press, doi: 10.1111/ejss.13083) <https://onlinelibrary.wiley.com/doi/abs/10.1111/ejss.13083>

Peixoto, L. et al. (in prep). Deep soil carbon storage from perennial crops of legumes and non-legumes. In preparation.

Rasmussen, Jim; Dresbøll, Dorte Bodin, Enggrob, Kirsten Lønne; and Peixoto, Leanne (2021). A novel ¹⁵N vertical split-root method for *in situ* estimation of N rhizodeposition. *Geoderma* 383, 114782. <https://www.sciencedirect.com/science/article/pii/S0016706120325374>

Rasmussen, Camilla Ruø; Thorup-Kristensen, Kristian; Dresbøll, Dorte Bodin. (2019). Uptake of subsoil water below 2 m fails to alleviate drought response in deep-rooted Chicory (*Cichorium intybus* L.). *Plant and Soil*. <https://orgprints.org/38203/>

- Rasmussen, Camilla Ruø; Thorup-Kristensen, Kristian; Dresbøll, Dorte Bodin. (2020). The effect of drought and intercropping on chicory nutrient uptake from below 2 m studied in a multiple tracer setup. *Plant Soil* **446**, 543–561 <https://orgprints.org/38202/>
- Smith, Abraham Georg; Petersen, J.; Selvan, R.; and Ramussen, C.R. (2020) Segmentation of roots in soil with U-net. *Plant Methods* **16** <https://orgprints.org/38499/>
- Smith, Abraham Georg; Han, E.; Petersen, J.; Olsen, N.A.F.; Giese, C.; Athmann, M.; Dresbøll, D. B.; and Thorup-Kristensen, K. (2020) RootPainter: Deep Learning Segmentation of Biological Images with Corrective Annotation. *bioRxiv* doi: <https://doi.org/10.1101/2020.04.16.044461>
<https://orgprints.org/38500/>
- Thorup-Kristensen, Kristian; Halberg, N.; Nicolaisen, M.; Olesen, J.E.; Crews, T.; Hinsinger, P.; Kirkegaard, J.A.; Pierret, A.; and Dresbøll, D.B. (2020) Digging deeper for agricultural resources, the value of deep rooting. *Trends in Plant Science* **25**(4): 406-417.
[https://www.cell.com/trends/plant-science/pdf/S1360-1385\(19\)30332-2.pdf](https://www.cell.com/trends/plant-science/pdf/S1360-1385(19)30332-2.pdf);
<https://orgprints.org/38823/>
- Thorup-Kristensen, Kristian; Halberg, N.; Nicolaisen, M.; Olesen, J.E.; and Dresbøll, D.B. (2020). Exposing Deep Roots: A Rhizobox Laboratory. *Trends in Plant Science* **25**(4): 418-419, Technology of the Month. <https://www.cell.com/action/showPdf?pii=S1360-1385%2819%2930331-0>;
<https://orgprints.org/38824/>

Presentations

- Dresbøll, Dorte Bodin (2017). Rodudviklingens betydning for planternes forsyning med vand og næringsstoffer. [The importance of root development for plant water and nutrient uptake.]
Speech at: Plantekongres, Herning kongrescenter, 17-18 januar 2017 <http://orgprints.org/32132/>
- Dresbøll, Dorte Bodin (2019). Root growth and deep water uptake of 3 perennial crops. At: Is the future of agriculture perennial? Lund, May 2019 <https://orgprints.org/32132/>
- Han, Eusun (2016). The hidden half of the plants for 'deep-rooted' organic agriculture: IFOAM Asia Organic Youth Forum, The First Farm, Changzhou, China, 28 October 2018
<https://orgprints.org/36655/>
- Han, Eusun; Havmøller, Lisa; Dresbøll, Dorte Bodin; and Thorup-Kristensen, Kristian (2017). Identification of deep-rooting crop species in arable subsoil by the minirhizotron technique. Scientific Conference "Innovative Research for Organic 3.0 at the 19th Organic World Congress organized by ISOFAR/OFAI/TIPI, November 2017, New Delhi, India <https://orgprints.org/36656/>
- Rasmussen, Camilla Ruø; Dresbøll, Dorte Bodin; and Thorup-Kristensen, Kristian (2019) Chicory acquires water from below 2 m depth – but is still hit by topsoil drought, European geoscience Union General Assembly, Vienna, Austria, 7–12 April 2019.
- Thorup-Kristensen, Kristian (2019). Deep nutrient uptake by Kernza and Silphium studied by tracer uptake. At: Is the future of agriculture perennial? Lund, May 2019

Posters

- Czaban, Weronika; Clement, Corentin; Han, Eusun; Dresbøll, Dorte Bodin; and Thorup-Kristensen, Kristian (2018). The effect of Intercropping on the Deep Root Development and Nutrient Uptake in a Sugar Beet – Chicory Mixture. 10th symposium for the international society of root research, July 2018, Tel Aviv, Israel <http://orgprints.org/33979/>
- Dresbøll, Dorte Bodin; Camilla Ruø Rasmussen, Kristian Thorup-Kristensen (2018). Capacity of Deep Rooted Species to Take Up Water and Nutrients from Deep Soil Layers. 10th symposium for the international society of root research, July 2018, Tel Aviv, Israel <http://orgprints.org/34364/>

Han, Eusun; Dorte Bodin Dresbøll; and Kristian Thorup-Kristensen (2018). Determining deep root activity in arable fields by the core-labelling technique (CLT). 10th symposium for the international society of root research, July 2018, Tel Aviv, Israel <http://orgprints.org/33942/>

Liang, Zhi; Lars Elsgaard; and Jørgen E. Olesen (2017). Effect of root litter quality on carbon turnover and soil microbiology in topsoil and subsoil horizons <http://orgprints.org/32133/>

Peixoto, Leanne; Elsgaard, Lars; Rasmussen, Jim; and Olesen, Jørgen E. (2019). N and P co-limitation of carbon turnover in a clayey loam very deep subsoil. 7th International Symposium on Soil Organic Matter, Adelaide, South Australia, 6-11 October 2019.

Rasmussen, Camilla Ruø; Dorte Bodin Dresbøll; and Kristian Thorup-Kristensen (2018). Chicory Grows Roots Below 3 m Is That Beneficial under Water Stress? 10th symposium for the international society of root research, July 2018, Tel Aviv, Israel <http://orgprints.org/34370/>

Other scientific contributions

Liang, Zhi (2019). Organic carbon mineralization and microbiology in subsoil. PhD thesis <https://orgprints.org/37963/>

Rasmussen, Camilla Ruø (2019). Exploring the depths, Uncovering the contribution of deep water and nutrient uptake by chicory. PhD thesis

Annemette Lyhne-Kjærbye (2019). Exploring the microbiota of deep-rooted crops – Culture-independent characterization of the bacterial and fungal communities in association with roots down to 3 m depth. PhD thesis. <https://orgprints.org/38595/>

Sleidrink, Joost, (2020). The role of the deep roots of perennial cereal Kernza in a drying climate. MSc thesis. <https://orgprints.org/37931/>

Boulata, Kyriaki Adelais, (2020). Root growth in different soil depths and sap flow of barley (*Hordeum vulgare* L.) and pea (*Pisum sativum* L.) under drought. MSc thesis. <https://orgprints.org/38553/>

Affendy Hassan (2020). Root methods for intercropping. PhD thesis <https://orgprints.org/38827/>

Corentin Clement (2021 – expected graduation). PhD thesis in preparation Deep water uptake of perennial crops. A case study on intermediate wheatgrass and alfalfa (working title)

Guanying Chen (2021 – expected graduation). PhD thesis in preparation: Differential effects on water and nitrogen uptake from deep soil layers by increasing crop rooting depth: Case studies on chicory and oilseed rape (working title).

Leanne Peixoto (2021 – expected graduation). PhD thesis in preparation: Mitigating climate change: the potential for long-term soil carbon storage in subsoil from deep rooted crops (working title).

Popular Communication

Public media features

Des résultats sur les racines profondes viennent renforcer l'avenir de l'ac (about Deep Frontier featuring PhD Corentin Clément and his research in 'Agronomie, Écologie et Innovation. TCS No 110. November/December 2020). <https://orgprints.org/38777/>

Flerårige afgrøder er ofte mere robuste mod tørke (Landbrugsavisen – MARK, 29. august 2020) <https://landbrugsavisen.dk/avis/mark/fler%C3%A5rige-afgr%C3%B8der-er-ofte-mere-robuste-mod-t%C3%B8rke>

Rodforskere udvikler afgrøder og sorter med større tørketolerance (Landbrugsavisen MARK, 28. august 2020) <https://landbrugsavisen.dk/mark/rodforskere-udvikler-afgr%C3%B8der-og-sorter-med-st%C3%B8rre-t%C3%B8rketolerance>

- P1 Morgen (10 August 2018): <https://www.dr.dk/radio/p1/p1-morgen/p1-morgen-2018-10-08>
(from approximately 1 hour and 19 minutes into the programme)
- TV2 News (5 July 2018): Interview with Kristian Thorup-Kristensen
- Inför höstbruket 2018: Danmark expanderar sitt lantbruk på djupet (Väderstedt magasin (July 2018): Interview with Kristian Thorup-Kristensen)
- Kan et par rødder i Tåstrup sikre dansk landbrugs fremtid (Politiken, 10. juni 2018)
<https://politiken.dk/viden/Viden/art6566032/Kan-et-par-r%C3%B8dder-i-Taastrup-sikre-dansk-landbrugs-fremtid>
- Rodforskning åbner for nye muligheder i landbruget (August 2017, Agro) <http://www.agrar-plus.dk/agro/artikel/96040-rodforskning-abner-op-for-nye-muligheder-i-landbruget>
- Fremtidens afgrøder skal hente bedre vækst dybere nede (Effektivt Landbrug, 27. juni 2017)
- Landbrug i dybden (Weekendavisen, 16 June 2017)
- Forskere i røddernes verden – i fire meter høje urtepotter (Dagbladet Høje-Tåstrup Ishøj, 16. juni 2017)
- Forskere i røddernes verden – i fire meter høje urtepotter (Lokalavisen Tåstrup, 20. juni 2017)
- Kæmpe urtepotter skal sikre fremtidens fødevarer: Kom med forskerne i dybden (Sjællandske Medier On-line, 16. juni 2017)
- Den underjordiske verden synliggøres under forskning i rodudvikling (PLENnews, December 2016 - <http://plen.ku.dk/nyheder/nyheder-2016/den-underjordiske-verden-synliggøres-under-forskning-i-rodudvikling/>)
- Rødder skal vinde de næste merudbytter (Økologi & Erhverv, 17. juni 2016)
- Ti cm rod giver 3hkg mere pr. hektar (Landbrugsavisen, 17. juni 2016)

Articles by Deep Frontier

- Mikroorganismer mange meter under jordens overflade – hvorfor er de vigtige for udvikling af bæredygtig planteproduktion? (Mette Haubjerg Nicolaisen, Aktuel Videnskab – in press)
- Carbon storage in deep soil layers - potentials and interactions with microorganisms (PhD Leanne Peixoto) (Deep Frontier webnews 2021.01.19 and ICROFS webnews 2021.01.19)
<https://projects.au.dk/deepfrontier/news-archive/show/artikel/carbon-storage-in-deep-soil-layers-potentials-and-interactions-with-microorganisms/>
- New insights on water- and nitrogen uptake in deep roots (PhD Guanying Chen) (Deep Frontier webnews 2021.01.19 and ICROFS webnews 2021.01.19)
<https://projects.au.dk/deepfrontier/news-archive/show/artikel/new-insights-on-water-and-nitrogen-uptake-in-deep-roots/>
- New methods developed pave way for new insights (Post Doc Eusun Han) (Deep Frontier webnews 2020.11.17 and ICROFS webnews 2020.11.23)
<https://projects.au.dk/deepfrontier/news/show/artikel/new-methods-developed-pave-way-for-new-insights/>
- Dybe rødder – et spadestik tættere på bæredygtig produktion (Dorte Bodin Dresbøll og Kristian Thorup-Kristensen, Aktuel Naturvidenskab 4-2020) <https://aktuelnaturvidenskab.dk/find-artikel/nyeste-numre/4-2020/dybe-roedder/>
- Kulstoflagring og rødder (Jørgen E. Olesen, Lars Elsgaard, Jim Rasmussen, Zhi Liang, og Leane Peixoto, Aarhus Universitet, Aktuel Naturvidenskab 4.2020)
<https://aktuelnaturvidenskab.dk/find-artikel/nyeste-numre/4-2020/kulstoflagring-og-roedder/>
- Intercropping sugar beet with chicory enhances deep root growth (Post Doc Weronika Czaban) (Deep Frontier webnews 2020.11.03 and ICROFS webnews 2020.11.23)
<https://projects.au.dk/deepfrontier/news/show/artikel/intercropping-sugar-beet-with-chicory-enhances-deep-root-growth/>

Deep-rooted perennial crops. Are they capable of taking up water from deep soil layers? Could they be interesting for agriculture? (PhD Corentin Clement) (ICROFS webnews 2020.11.23 and DeepFrontier webnews 2020.09.16)

<https://projects.au.dk/deepfrontier/news/show/artikel/deep-rooted-perennial-crops-are-they-capable-to-take-up-water-from-deep-soil-layers-could-they-be/>

Der er potentiale i flerårige afgrøder, som kan hente vand og næring i de dybe jordlag (reportage fra Rodens Dag 2020, ICROFS webnews 2020.09.03)

<https://icrofs.dk/aktuelt/nyheder/nyhed/artikel/der-er-potentiale-i-fleraarige-afgroeder-som-kan-hente-vand-og-naering-i-dybe-jordlag/>

Deep Roots connect Denmark with Australia (Deep Frontier webnews 20.05.2020)

<https://projects.au.dk/deepfrontier/news/show/artikel/deep-roots-connect-denmark-with-australia/>

Microbial activity in deep-rooted crops – what goes on down there? (PhD Annemette Lyhne-Kjærbye, KU) (ICROFS webnews 04.05.2020/ICROFS News May 2020 and Deep Frontier webnews)

<https://projects.au.dk/deepfrontier/news/show/artikel/microbial-activity-in-deep-rooted-crops-what-goes-on-down-there/>

<https://mailchi.mp/95003af78fe2/news-from-icrofs>

Førende eksperter inden for rodforskning samlet i København (ICROFS webnyhed 27.11.2019/ICROFS Nyt, December 2019)

<https://icrofs.dk/aktuelt/nyheder/nyhed/artikel/foerende-eksperter-inden-for-rodforskning-samlet-i-koebenhavn/>

<https://mailchi.mp/77f732591ee9/icrofs-nyt-december-2019>

Dybe rødder hjælper afgrøder med at overleve – men ikke nødvendigvis med at trives (PhD Camilla Ruø Rasmussen), (ICROFS webnyhed - Dansk – 12.08.2019/ICROFS Nyt, maj 2020)

<http://icrofs.dk/aktuelt/nyheder/nyhed/artikel/dybe-roedder-hjaelper-afgroeder-med-at-overleve-men-ikke-noedvendigvis-med-at-trives/>

<https://mailchi.mp/d7bbb5f7d86c/icrofs-nyt>

Deep roots help crops to survive – but not necessarily to thrive (PhD Camilla Ruø Rasmussen) (ICROFS Web News - English – 22.07.2019/ICROFS Newsletter, November 2019 and Deep Frontier webnews)

<http://projects.au.dk/deepfrontier/news/show/artikel/deep-roots-help-crops-to-survive-but-not-necessarily-to-thrive/>

<https://mailchi.mp/5825e8b640a6/news-from-icrofs-may-1528941>

Root litter chemistry and soil nutrient availability affect subsoil carbon turnover (Deep Frontiers website - 04.12.18 and ICROFS newsletter - 20.12.2018)

<http://projects.au.dk/deepfrontier/news/show/artikel/root-litter-chemistry-and-soil-nutrient-availability-affect-subsoil-carbon-turnover/>

Gå i dybden med rødderne på Rodens Dag d. 4. juni (ICROFS web-nyheder – 15.05.2018)

<http://icrofs.dk/aktuelt/nyheder/nyhed/artikel/gaa-i-dybden-med-roedderne-paa-rodens-dag-d-4-juni/>

Promising results about carbon turnover in deep soil (ICROFS Newsletter – 29.09.2017)

<http://projects.au.dk/deepfrontier/news/show/artikel/promising-results-about-carbon-turnover-in-deep-soil/>

Masser af viden om de dybe rødder graves frem i den kommende vækstsæson (ICROFS Newsletter – 01.02.2017) <http://projects.au.dk/deepfrontier/news/show/artikel/masser-af-viden-om-de-dybe-roedder-graves-frem-i-den-kommende-vaekstsæson/>

Rodens dag - gå i dybden med rødderne (ICROFS web-nyheder - 02.05.2016)

<http://icrofs.dk/aktuelt/nyheder/nyhed/artikel/rodens-dag-gaa-i-dybden-med-roedderne-1/>

Videos

Deep Frontier research in deep rooted crops (4 videos):

Deep Frontier, the Root Towers facilities for studying deep roots

Deep Frontier, the Deep Root Lab, establishing the field facilities

Carbon storage with deep rooted crops and microorganisms interactions in deep soil layers

Deep Frontier – results, findings and potential for further research

[Deep Frontier Research in Deep rooted crops - YouTube](#)

Interview with Peter Gregory, Emeritus Professor, Reading University, UK, at the International Workshop ‘Deep Rooted Crops for Future Food Production’, 2526 November 2019,

Copenhagen, Denmark <https://projects.au.dk/deepfrontier/international-workshop-november-2019-deep-rooted-crops-for-future-food-production/>

Interview with Michael Schloter, Helmholtz Zentrum München, Germany, at the International Workshop ‘Deep Rooted Crops for Future Food Production’, 2526 November 2019,

Copenhagen, Denmark <https://projects.au.dk/deepfrontier/international-workshop-november-2019-deep-rooted-crops-for-future-food-production/>

Deep Rooted crop research and Agroecology (PhD student Corentin Clément, University of Copenhagen) https://www.youtube.com/watch?v=u02fzxa_7XE&t=16s

Dybe Rødder og lagring af kulstof (Professor Jørgen E. Olesen, Aarhus University)

<https://www.youtube.com/watch?v=3lGOsASo3dk>

Rodbakterier i de dybe rodlag (Associate Professor Mette Haubjerg Nicolaisen, University of Copenhagen) <https://www.youtube.com/watch?v=mnNHZZSXixg>

Testafgrøder i Deep Frontier – Hvorfor teste kruset skræppe (Professor Kristian Thorup-Kristensen, University of Copenhagen)

https://www.youtube.com/watch?time_continue=7&v=iLS0-APXeqE

Other publication and dissemination activities

Joint activity between Deep Frontier/KU research group:

Instagram: <https://www.instagram.com/adeeplookbelowground/>

Facebook: <https://www.facebook.com/Adeeplookbelowground-1907797182649573/>

Twitter: <https://twitter.com/Adeeplookbelow?lang=en>

Visits at the field facilities at Højbakkegård:

2020

Aug. 28 Participants at the ‘Rodens Dag og Seminar om dybe rødder og flerårige afgrøder’ (50 participants)

Juni 29 Vistit from Fagligt Økologisk Forsøgsudvalg

2019

Nov. 25 Participants at the International Workshop ‘Deep Rooted Crops for Future Food Production’, 2526 November 2019, Copenhagen, Denmark (20-25 visitors)

May 2 Ecole des Etablières, France – group of french students.

May Lund University Centre for Sustainability Studies (LUCSUS) – group visit (40-50 people) in relation to a conference in Lund 6-10 May ‘Is the future of agriculture perennial?’ <https://www.lucsus.lu.se/article/is-the-future-of-agriculture-perennial>

2018

Nov. 11 15 consultants (grass seed) from DLF trifolium

Nov 6 Visit from farmers’ ERFA group (10 farmers)

June-August: Students from ISA Lille (Institute of Life Science), Lille, France. Internship –Deep Frontier Field Lab.

June 28 Visit by consultants from AgriNord

June 27 Fremvisning ved undervisning i kursus om Planterforædling

June 22 Plant Biology Europe 2018 conference, conference tour to DeepFrontier and other facilities

June 22 ERFA group from Lolland Falster. 20 farmers and consultants

June 21 20 consultants from Vestjydske Landboforening

June 6 Visit from Ingelby Farms and Forests

June 4 Rodens Dag (Day of the Root) + meeting in Udvalget for konkurrencedygtig planteproduktion

Jan. 4 Besøg fra Norges Life Science Universitet

2017

Dec. 4 L.E. Jackson Prof. emeritus UC Davis

Aug. 25 International plant nutrition colloquium 2017

July 7 Chris Topp, Donald Danforth Plant Science Center

June Rodens Dag (Day of the Root) incl. an evening event for the local community

May Gefion Landboforening – organic crop production advisors Gefion

Apri Section from the Department of Geosciences and Natural Resource Management, University of Copenhagen

2016

Dec. Nordic Beet Research

Sept. Plants in Populations, Communities and Ecosystems

Sept. Gefion Landboforening - crop production advisors

June Rodens Dag (Day of the Root)

June FlowerNet network meeting