



Cyprus
University of
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Faculty of Engineering
and Technology

Doctoral Dissertation

**Forest Dynamics Monitoring Through Novel Remote Sensing
Techniques**

Christos Theocharidis

Limassol, May 2026

CYPRUS UNIVERSITY OF TECHNOLOGY
FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING AND GEOMATICS

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Relevant Publications

Journal Papers

- **Theocharidis C**, Eliades M, Kolokoussis P, Miltiadou M, Danezis C, Gitas I, Kontoes C, Hadjimitsis D. Exploring Sentinel-1 Radar Polarisation and Landsat Series Data to Detect Forest Disturbance from Dust Events: A Case Study of the Paphos Forest in Cyprus. *Remote Sensing*. 2025; 17(5):876. <https://doi.org/10.3390/rs17050876>
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Conference Papers

- **C. Theocharidis et al.**, "What do Long-Term Satellite Data Reveal about Forest Dynamics in the Paphos Forest?," IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium, Athens, Greece, 2024, pp. 3650-3654, doi:10.1109/IGARSS53475.2024.10641705.
- **Theocharidis, C.**, Eliades, M., Gitas, I., Danezis, C., & Hadjimitsis, D. (2024, September). Monitoring forest dynamics between 1987-2023: an NDVI analysis of three dominant species in Paphos Forest, Cyprus. In Tenth International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2024) (Vol. 13212, pp. 127-136). SPIE.

Abstract / Conference presentations

- **Theocharidis, C.**, Gitas, I., Danezis, C., & Hadjimitsis, D. (2023, May). Satellite times-series analysis and assessment of the BFAST algorithm to detect possible

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Additional Publications (not directly related to this thesis)

- **Theocharidis, C.**, Papoutsas, C., Themistocleous, K., Mettas, C., & Hadjimitsis, D. (2025, October). Detection of water pipeline leakages using high-resolution satellite imagery and auxiliary ground data in Cyprus: case study of community councils of Doros and Monagri. In Earth Resources and Environmental Remote Sensing/GIS Applications XVI (Vol. 13671, pp. 286-301). SPIE.
- **Theocharidis, C.**, Eliades, M., Themistocleous, K., Neocleous, K., Kontoes, C., & Hadjimitsis, D. G. (2025). Shoreline Change Assessment in Varosha, Famagusta, Cyprus: A Case Study of a Ghost Town Using Aerial Photographs and Very High-Resolution Satellite Data (1963–2024). ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 1-6.

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- Tzouvaras, M., Alatza, S., Prodromou, M., **Theocharidis, C.**, Fotiou, K., Argyriou, A. V. & Hadjimitsis, D. G. (2023). Synergy of advanced processing techniques using Copernicus SAR and optical satellite imagery to detect ground displacements: the case studies of Pyrgos and Parekkklisia villages in Cyprus. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences-ISPRS Archives*, 48(1/W2-2023).
- **Theocharidis, C.**, Argyriou, A. V., Tsouni, A., Kaskara, M., & Kontoes, C. (2023, September). Comparative analysis of Sentinel-1 and PlanetScope imagery for flood mapping of Evros River, Greece. In *Ninth International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2023)* (Vol. 12786, pp. 465-474). SPIE.
- Prodromou, M., **Theocharidis, C.**, Fotiou, K., Argyriou, A., Polydorou, T., Hadjimitsis, D., & Tzouvaras, M. (2023, May). Fusion of Sentinel-1 and Sentinel-

2 satellite imagery to rapidly detect landslides through Google Earth Engine. In EGU General Assembly Conference Abstracts (pp. EGU-12618).

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ABSTRACT

This PhD thesis develops, applies, and benchmarks novel multi-sensor remote sensing methodologies for monitoring forest dynamics in semi-arid Mediterranean ecosystems, with the Paphos Forest, Cyprus, as the primary study area. The thesis is organised around three interacting axes of forest dynamics: long-term internal change, abiotic disturbance, and biotic disturbance and integrates the full Landsat archive (1984–2024), Sentinel-2 MSI, Sentinel-1 C-band SAR, and ancillary climate and ecological datasets within a cloud-native Google Earth Engine framework. Four research studies are presented: multi-decadal canopy growth dynamics from Landsat trend analysis (1991–2022); climate-mediated species transitions among *Pinus brutia*, *Quercus alnifolia*, and the endemic *Cedrus brevifolia* (1984–2024) modelled through multinomial logistic regression with climate–elevation interactions; detection of forest disturbance from dust events (2015–2019) using the BFAST family of change-detection algorithms; and a transferable framework for mapping pine processionary moth canopy stress across four European pine forests. The work demonstrates that integrating multi-decadal optical and SAR archives with rigorous statistical modelling enables operationally relevant forest-dynamics monitoring across abiotic and biotic disturbance regimes.

Keywords: forest dynamics monitoring, multi-sensor remote sensing, Mediterranean forest, species transitions, pine processionary moth

Περίληψη

Η παρούσα διδακτορική διατριβή αναπτύσσει, εφαρμόζει και αξιολογεί σύγχρονες μεθοδολογίες πολυαισθητηριακής δορυφορικής τηλεπισκόπησης για την παρακολούθηση της δυναμικής των δασών σε ημίξηρα μεσογειακά οικοσυστήματα, με κύρια περιοχή μελέτης το Δάσος της Πάφου στην Κύπρο. Η διατριβή οργανώνεται γύρω από τρεις αλληλένδετους άξονες δασικής δυναμικής: τη μακροπρόθεσμη εσωτερική μεταβολή των δασικών οικοσυστημάτων, τις αβιοτικές διαταραχές και τις βιοτικές διαταραχές. Για την ανάλυση αυτή αξιοποιείται το πλήρες αρχείο Landsat (1984–2024), σε συνδυασμό με δεδομένα Sentinel-2 MSI, Sentinel-1 SAR, καθώς και επιπλέον κλιματικά και οικολογικά σύνολα δεδομένων, τα οποία επεξεργάζονται μέσω της πλατφόρμας Google Earth Engine. Στο πλαίσιο της διατριβής παρουσιάζονται τέσσερις επιμέρους μελέτες. Η πρώτη εξετάζει τη μακροχρόνια δυναμική της κόμης μέσω ανάλυσης τάσεων δεδομένων Landsat για την περίοδο 1991–2022. Η δεύτερη διερευνά τις κλιματικά ελεγχόμενες μεταβάσεις ειδών μεταξύ των *Pinus brutia*, *Quercus alnifolia* και του ενδημικού *Cedrus brevifolia* για την περίοδο 1984–2024, χρησιμοποιώντας πολωνυμική λογιστική παλινδρόμηση (multinomial logistic regression) και αναλύοντας τις αλληλεπιδράσεις μεταξύ κλιματικών παραγόντων και υψομέτρου. Η τρίτη μελέτη εστιάζει στην ανίχνευση δασικών διαταραχών που σχετίζονται με επεισόδια μεταφοράς σαχάριας σκόνης (2015–2019), μέσω της εφαρμογής της οικογένειας αλγορίθμων BFAST. Τέλος, η τέταρτη μελέτη αναπτύσσει ένα μεταφερόμενο πλαίσιο για τη χαρτογράφηση της καταπόνησης της κόμης που προκαλείται από την πιτυοκάμψη των πεύκων σε τέσσερα ευρωπαϊκά δασικά οικοσυστήματα. Τα αποτελέσματα της διατριβής καταδεικνύουν ότι ο συνδυασμός πολυδεκαετών δορυφορικών δεδομένων οπτικών και ραντάρ αισθητήρων με προηγμένες στατιστικές προσεγγίσεις επιτρέπει την αξιόπιστη και επιχειρησιακά αξιοποιήσιμη παρακολούθηση της δασικής δυναμικής. Η προσέγγιση αυτή συμβάλλει στην κατανόηση των επιπτώσεων τόσο των αβιοτικών όσο και των βιοτικών παραγόντων στις μεσογειακές δασικές εκτάσεις και υποστηρίζει τη λήψη αποφάσεων για τη βιώσιμη διαχείρισή τους.

Λέξεις-κλειδιά: παρακολούθηση δασικής δυναμικής, πολυαισθητηριακή τηλεπισκόπηση, μεσογειακό δάσος, μεταβάσεις ειδών, πιτυοκάμψη