



Estimation de la biomasse forestière et caractérisation de la structure verticale des peuplements de conifères par radar VHF et radar sondeurs aéroportés

Jean-Michel Martinez

► To cite this version:

Jean-Michel Martinez. Estimation de la biomasse forestière et caractérisation de la structure verticale des peuplements de conifères par radar VHF et radar sondeurs aéroportés. Sciences du Vivant [q-bio]. ENGREF (AgroParisTech), 2000. Français. NNT: . pastel-00000036

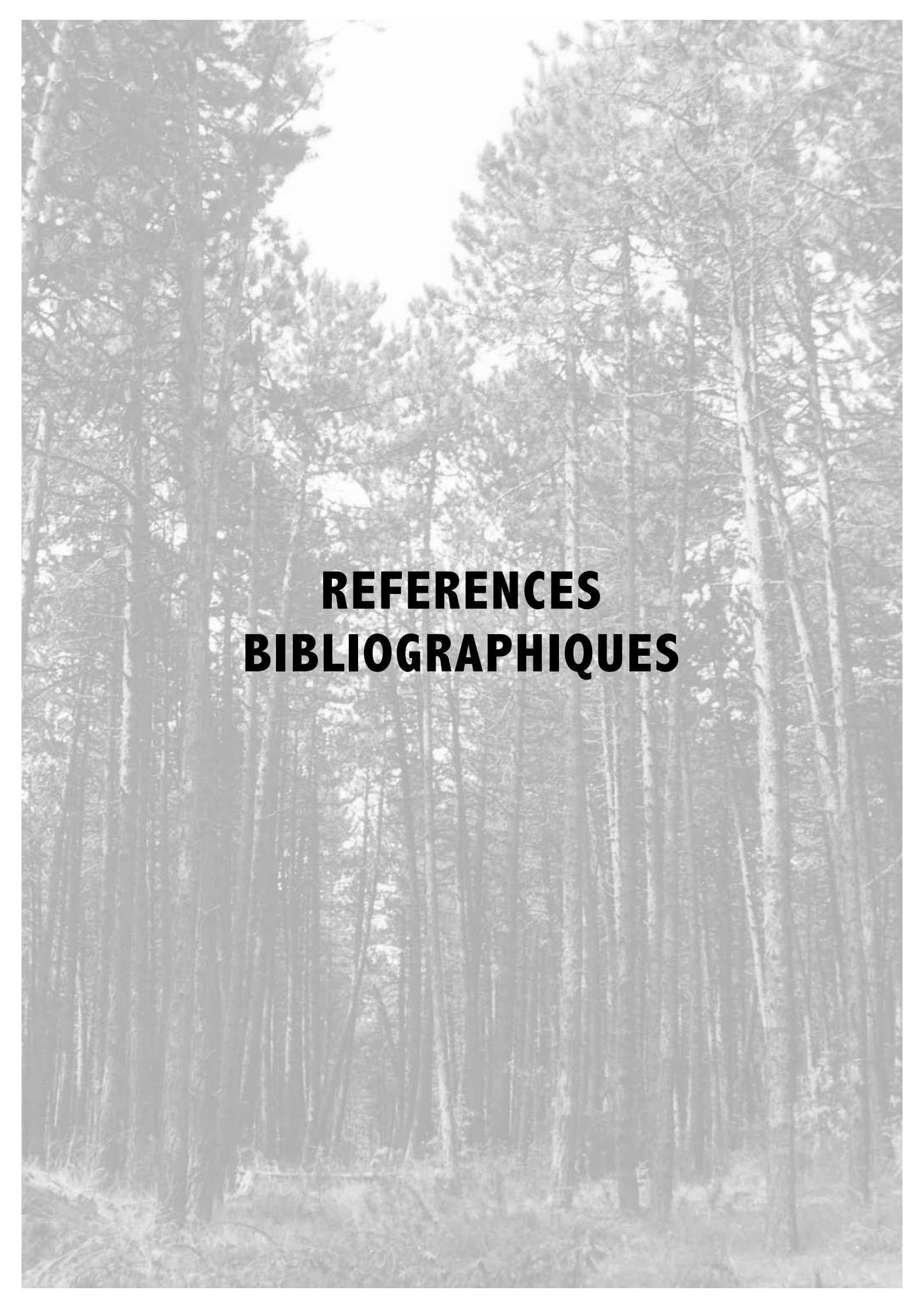
HAL Id: pastel-00000036

<https://pastel.hal.science/pastel-00000036>

Submitted on 19 Mar 2002

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



A black and white photograph showing a dense forest of tall, thin trees, likely pines or similar conifers. The trees are closely packed, creating a vertical pattern. The sky is visible through the branches at the top.

REFERENCES BIBLIOGRAPHIQUES

Bibliographie

- Attema, E.P.W. and Ulaby, F.T. Vegetation modeled as a water cloud, *Radio Science*, vol. 13(2), pp. 357-364, 1978.
- Barczi, J.F., Castel, T., Caraglio, Y., Beaudoin, A., Rey, H., Chetaille, S. and Castagnas, L. AMAP2SAR, AMAP sorter V1.0, user manual. *ESA/ESTEC contract n° 163014/96/NL*, 73 p, 1997.
- Barthelemy, D., Blaise, F., Fourcaud, T., and Nicolini, E. Modélisation et simulation de l'architecture des arbres : bilan et perspectives. *Revue Forestière Française*, Vol. XLVII, No sp., 71-95, 1995.
- Beaudoin, A. Observation de la terre par radar imageur : estimation de la biomasse forestière. Thèse de doctorat, Université Paul Sabatier, Toulouse, 172 p., 1992.
- Beaudoin A., Le Toan, T., Goze, S., Nezry, E., Lopes, A., Mougin, E., Hsu, C.C., Han, H.C., Kong, J.A. and Shin, R.T. Retrieval of forest biomass from SAR data. *International Journal of Remote Sensing*, 15(14):2777-2796, 1994.
- Beaudoin, A., Castel, T. et Deshayes, M.. Apport des données SAR multi-fréquence polarimétrique (SIR-C/X-SAR) pour le suivi de la ressource forestière (Phase 1). *Rapport final, convention CNES#94/CNES/0268*, 35 p, 1994.
- Beaudoin A., et Castel T., Rabaute T., 1995. Apport des produits interférométriques ERS à des fins d'inventaire forestiers. *Rapport final convention CNES # 94/CNES/0239*, 40 p., 1995.
- Bergen K.M., Dobson M.C. Integration of remotely sensed radar imagery in modeling and mapping of forest biomass and net primary production. *Ecological Modelling*, 122 :257-274, 1999.
- Brown, S. Forests and climate change : role of forest lands as carbon sinks. *XI congrès forestier mondial*, Vol. 1, Antalya, Turquie, 13-22 Octobre 1997.
- Castel, T. Estimation de la ressource forestière par télédétection Radar à Synthèse d'Ouverture. Thèse de Doctorat ENGREF, 250 p., 1998
- Castel, T., Beaudoin, A., Stach, N., Stussi N., Le Toan, T. and Durand P. Sensitivity of spaceborne SAR data to forest parameters over sloping terrain. Theory and experiment. *International Journal of Remote Sensing*, sous presse 2000.
- Chandrasekhar, S. Radiative Transfer. Dover, 1960.
- Cloude S.R. and E. Pottier. A review of target decomposition theorems in radar polarimetry. *IEEE Transactions on Geoscience and Remote Sensing*, 34(2):498-518, 1996.

De Reffye, P. Modèle mathématique aléatoire et simulation de la croissance et de l'architecture du caféier Robusta. 1ère Partie. Etude du fonctionnement des méristèmes et de la croissance des axes végétatifs. *Café Cacao Thé*, 25(2):83-104, 1981a.

De Reffye, P. Modèle mathématique aléatoire et simulation de la croissance et de l'architecture du caféier Robusta. 2ème Partie. Etude de la mortalité des méristèmes plagiotropes. *Café Cacao Thé*, 25(2):219-230, 1981b.

De Reffye, P. Modèle mathématique aléatoire et simulation de la croissance et de l'architecture du caféier Robusta. 3ème Partie. Etude de la ramification sylleptique des rameaux primaires et de la ramification proleptique des rameaux secondaires. *Café Cacao Thé*, 26(2):77-96, 1982.

De Reffye, P. Modèle mathématique aléatoire et simulation de la croissance et de l'architecture du caféier Robusta. 4ème Partie. Programmation sur micro-ordinateur de tracé en trois dimensions de l'architecture d'un arbre. Application au caféier. *Café Cacao Thé*, 27(1):3-20, 1983.

De Reffye, P. Elguero, E., and Costes, E. Growth units construction in trees : a stochastic approach. *Acta Biotheoretica*, 39:325-342, 1991.

Deshayes, M., Mushinzima E., and Stach, N. Assessment of FLIM reflectance model : case study Lozère, France. In, *MARIE-F (Monitoring and Assesment of Resources in Europe – Forest) project final report, contract ENV4-CT96-0316*, pp 5.1-5.56, Décembre 1999.

Ewe, H.T., Chuah, H.T. A Multilayer Scattering Model for a Dense Vegetation Medium. *Progress In Electromagnetic and Remote Sensing Symposium*, Boston, 2000.

FAO - Organisation des Nations Unies pour l'alimentation et l'agriculture. Forest Resources Assessment 1990 - Global Synthesis. *Etude FAO*, Rome, Italie, 1995.

Floury N. "Modélisation radar des forêts. Application à la télédétection". Thèse de Doctorat Université Paris VII, 1999.

Floury, N., Picard, P., Le Toan, T., Kong, J.A., Castel, T., Beaudoin, A., Barczi J.F. On the coupling of backscatter models with tree growth models: 2) RT modelling of forest backscatter. *Proceedings of IGARSS'97 Symposium*, Singapoure, pp. 787-789, 1997.

Foldy, L.L. The multiple scattering of waves. *Physical review*, 67:107-119, 1945.

Fourcaud, T. Analyse du comportement mécanique d'une plante en croissance par la méthode des éléments finis. Thèse de Doctorat, Université de Bordeaux I, Bordeaux, 148 p., 1995.

Fransson, J.E.S., Walter, F. and Ulander, L.M.H. Estimation of forest parameters using CARABAS-II VHF SAR Data. Submitted to *IEEE Transactions on Geoscience and Remote Sensing*, 1999.

Freeman A. and S.Durden "A three component scattering model for polarimetric SAR data". *IEEE Transactions on Geoscience and Remote Sensing*, 36(3):963-973, 1998.

Fung, A.C., Chen, M.F., Lee K.K. Fresnel field interaction aplied to scattering from a vegetation layer. *Remote Sensing Environment.*, 23:35-50, 1987.

Fung A.K., Li, Z., Chen, K.S. Backscattering from a randomly rough dielectric surface. *IEEE Transactions on Geoscience and Remote Sensing*, 30(2):356-369, 1992.

Godin, C., Guédon, Y., Costes, E., and Caraglio, Y. Chapter 4 : Measuring and analysing plants with the AMAPmod software." Plants to ecosystems, advances in computational life sciences, M. T. Michalewicz, ed., CSIRO, Australia, 53-84, 1996.

Godin, C., Costes, E., and Caraglio, Y. Exploring plant topological structure with the AMAPmod software: an outline." *Silva Fennica*, 31(3): 357-368, 1997.

Hagberg, J. O., Ulander, L. M. H., and Askne, J. Repeat-pass SAR interferometry over forested terrain. *IEEE Transactions on Geoscience and Remote Sensing*, 33(2):331-340, 1995.

Hallé, F., et Oldeman, R. A. A. Essai sur l'architecture et la dynamique de croissance des arbres tropicaux. Masson & Cie, Paris,France, 178 p., 1970.

Hallé, F., Oldeman, R. A. A., and Tomlinson, P. B.. Tropical trees and forests - an architectural analysis. Springer Verlag, Berlin, Allemagne,441 p., 1978.

Hallikainen, M., Hyppä, J., Haapanen, J., Tares, T., Ahola, P., Pulliainen, J., and Toikka, M. A helicopter-borne eight-channel ranging scatterometer for remote sensing - Part I: system description. *IEEE Transactions on Geoscience and Remote Sensing*. 31(1):161 – 169, 1993.

Häme T. et al. Forest monitoring in Europe with remote sensing (FMERS). Final Report JRC/CEO, contract 13105-97, March 1998

Hellsten H., Ulander, LM.H, Gustavsson, A. and Larsson B.. Development of VHF CARABAS II SAR ». *Proceedings of Radar Sensor technology*, SPIE, vol. 2747, Orlando, Etats-Unis, p 48-60, 8-9 Avril 1996.

Hsu C.C., H.C. Han, R.T. Shin, J.A. Kong, A. Beaudoin, T. Le Toan. Radiative Transfer theory for polarimetric remote sensing of forest at P band. *International Journal of Remote Sensing*, 15(14):2943-2954, 1994.

Hyppä, J., Hyppä, H., Inkkinen, M., Engdahl, M., Linko S., Zhu, Y.H. Accuracy comparison of various remote sensing data sources in the retrieval of forest stand attributes. *Forest Ecology Management*, 128:109-120, 2000.

Imhoff, M. L. A theoretical analysis of the effect of forest structure on Synthetic Aperture Radar backscatter and the remote sensing of biomass. *IEEE Transactions on Geoscience and Remote Sensing*, 33(2):341-352, 1995.

Imhoff, M.L., Milne A.K., Sisk, T.D., Lawrence, W.T. and Brennan, K. Mapping vegetation structure for biodiversity analysis using synthetic aperture radar. *Proceedings of IGARSS*, Singapour, Vol. 4:1624-1625, 1997.

Israelsson, H., Ulander L.M.H., Askne, J.I.H., Fransson J.E.S., Frölind, P.-O., Gustavsson, A. and Hellsten H. Retrieval of forest stem volume using VHF SAR. *IEEE Transactions on Geoscience and Remote Sensing*, 35(1):36-40, 1997.

Israelsson, H., Ulander, L.M.H., Martin, T., and Askne J. A coherent scattering model to determine forest backscattering in the VHF-band. *IEEE Transactions on Geoscience and Remote Sensing*, 38(2):238-248, 2000.

Jaeger, M., and De Reffye, P. Basic concepts of computer simulation of plant growth. *Journal of Biosciences*, 17(3):275-291, 1992.

Jolly, A., Le Toan, T. Atelier Besoin Pléiades : thème forêts. Mars 2000. Site internet : <http://www-projet.cst.cnes.fr:8060/PLEIADES/Fr/index.html>.

Karam, M.A., Fung, A.K.. Electromagnetic scattering from a layer of finite length, randomly oriented, dielectric, circular cylinders over a rough interface with application to vegetation. *International Journal of remote Sensing*. 9(6):1109-1134, 1988.

Karam M. A., Fung A. K., Lang R. H., Chauhan S.N. A microwave scattering model for layered vegetation. *Remote Sensing Environment*, 30(4):767-784, 1992.

Kimball, J. S., Keyser A.R., Running S. W. and Saatchi S.S. Regional assessment of boreal forest productivity unsing an ecological process model and remote sensing parameter maps. *Tree Physiology*, 20:761-775, 2000.

Kwoh, L.H., Liew, S.C., Padmanabhan, K., Lim, O.K. Tropical Forest Fire Scar Studies Using Multi-Temporal ERS 1/2 INSAR Data. Proceedings of IGARSS, Seattle, 6-10 Juillet 1998.

Lax, M.. Multiple scattering of waves. *Review of Modern Physics*, 23 :287-310, 1951.

Le Toan, T., Beaudoin, A. et Lo Seen Chong, D.. Study of microwave interaction with the earth's surface. *Technical Report 8447/89/NL/PB(SC)*, ESA/ESTEC, 1990.

Le Toan T., A. Beaudoin, J.Riom, D. Guyon. Relating forest biomass to SAR data. *IEEE Transactions on Geoscience and Remote Sensing*, 30(2):403-411, 1992.

Levy, A. Pour mieux connaître la forêt domaniale de Mende. Mémoire de 3ème année de l'ENITEF, 71 p., 1982.

Martinez, J.M., Beaudoin, A., Le Toan, T., Wegmüller, U. and Strozzi, T. Influence of biophysical, meteorological and topographic factors on multidate ERS tandem data acquired over forested terrain, *Proceedings of IGARSS*, Seattle, 6-10 Juillet 1998.

Massonet, D., and Rabaute, T. Radar interferometry : limits and potential. *IEEE Transactions on Geoscience and Remote Sensing*, 31:455-464, 1993.

Office Nationale des Forêts, Aménagement de la forêt domaniale de Mende, 173 p., 1989.

Oliver, C.J.. Rain forest classification based on SAR texture. *Second International Workshop on Retrieval of Bio- & Geo-physical parameters from SAR data for Land Applications*, ESTEC, Noordwijk, Hollande, 21-23 Octobre 1998.

Peng, C.. Growth and Yield Models for Uneven-Aged Stands: Past, Present and Future. *Forest Ecology and Management*, sous presse 2000.

Persson, R.. 1974 World Forest Ressources. Review of the world's forest ressources in the early 1970s. Department of Forest Survey. Research Notes No 17. 1974.

Persson, R., Janz, K.. Assesment and monitoring of forest and tree ressources. *XI congrès forestier mondial*, Antalya, Turquie, 13-22 Octobre 1997, Vol. 1.

Pulliainen, J. T., Heiska, K., Hyppä, J., and Hallikainen, M. T. Backscattering properties of boreal forests at the C- and X-bands. *IEEE Transactions on Geoscience and Remote Sensing*, 32(5):1041-1050, 1994.

Quegan, S., Le Toan, T. Analysing multitemporal SAR images. Dans Proc. Segunda jornada latino americana de sensoriamento remoto por radar, Santos, Brazil, 17-25, 1998.

Quegan, S., Le Toan, T., Yu, J.J., Ribbes, F., Flourey, N.. Multitemporal ERS SAR analysis applied to forest mapping. *IEEE Transactions on Geoscience and Remote Sensing*, 38(2):741-753, 2000.

Raven, P. Biological resources and global stability. In Kawano, S., Connell, J.H. and Hidaka, T. (eds.). *Evolution and Coadaptation in Biotic Communities*. University of Tokyo Press, Tokyo, 1988.

Ribbes, F., Le Toan, T., Bruniquel, J., Flourey, N., Stussi N., Liew, S.C. and Wasrin U.R. Deforestation monitoring in tropical regions using multitemporal ERS/JERS SAR and INSAR data. *Proceedings of IGARSS*, Singapour, Vol. 4:1560-1562, 1997.

Saatchi, S.S., Nelson, B., Podest, E., Holt, J. Mapping land cover types in the Amzon basin using 1 km JERS-1 mosaic. *International Journal of Remote Sensing*, 21(6-7):1201-1234, 2000.

Schimel, D., Enting, I.G., Heimann, M., Wigley, T.M.L., Reyneud, D., Alves, D., et Seigenthaler, U. CO₂ and the carbon cycle. Dans J.T.Houghton, L.G.Meira Fil-ho, J.Bruce, H.Lee, B.A.Callender, E.Haites, N.Harris et K.Maskell (éd.), *Climate change 1994 radiative forcing of climate change and an evaluation of the IPCC IS92 scenarios*, publié pour le GIEC, Cambridge University Press, Cambridge, p.35-71, 1995.

Smith, G., Ulander, L.M.H. Forest biomass retrieval using VHF SAR. *Second International Workshop on Retrieval of Bio- & Geo-physical parameters from SAR data for Land Applications*, ESTEC, Noordwijk, Hollande, 21-23 Octobre 1998.

Smith, G., Dammert, P. G. B., Santoro, M., Fransson, J. E. S., Wegmüller, U., and Askne, J. I. H. Biomass retrieval in Boreal forest using ERS and JERS SAR. *Second International Workshop on Retrieval of Bio- and Geo-physical Parameters from SAR data for Land Applications*, ESTEC, Noordwijk, Hollande, 21-23 Octobre 1998.

Smith, G. and Ulander L.M.H. A model relating VHF-band backscatter to stem volume of coniferous boreal forest. *IEEE Transactions on Geoscience and Remote Sensing*, 38(2):728-740, 2000.

Strozzi, T. and Wegmüller, U.. Forest mapping with ERS-SAR interferometry, *Proceedings of Third ERS Symposium on Space at the service of our Environment*, Florence, 17-21 Mars 1997, 357-362.

Sun, G., and Ranson, K. J. A three-dimensional radar backscatter model for forest canopies. *IEEE Transactions on Geoscience and Remote Sensing*. 33(2):372-382, 1995.

Tsang, L., Kong, J.A. and Shin R.T. Theory of microwave remote sensing. Wiley-Interscience, 1985.

Ulaby, F. T., Moore, R. K., and Fung, A. K. Microwave remote sensing : active and passive, Artech House, Norwood, 1982.

Ulaby, F. T., Sarabandi, K., Mc Donald, K., Whitt, M., and Dobson, M. G. Michigan. Microwave canopy scatterring model. *International Journal of Remote Sensing*, 11(7):1223-1253, 1990.

Ulaby, F.T. SAR biophysical retrievals : lessons learned and challenges to overcome. *Second International Workshop on Retrieval of Bio- & Geo-physical parameters from SAR data for Land Applications*, ESTEC, Noordwijk, Hollande, 21-23 Octobre 1998.

Ulander L.M.H., Frölind, P.O. and Martin T. Processing and Calibration of Ultra-Wideband SAR data from CARABAS-II. *Procedings of CEOS SAR Workshop*, Toulouse, 273-278, 1999.

Yueh, S.H., Kong, J.A., Jao, J.K., Shin, R.T. and Le Toan, T. Branching model for vegetation. *IEEE Transactions on Geoscience and Remote Sensing*, 30(2):390-402, 1992.

Zebker, H. A., Werner, C., Rosen, P. A., and Hensley, S. Accuracy of topographic maps derived from ERS-1 interferometric radar. *IEEE Transactions on Geoscience and Remote Sensing*, 32(4):823-836, 1994.