From leaf to forests

Measuring vegetation water stress across scales

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Water Stress Detection Using Radar

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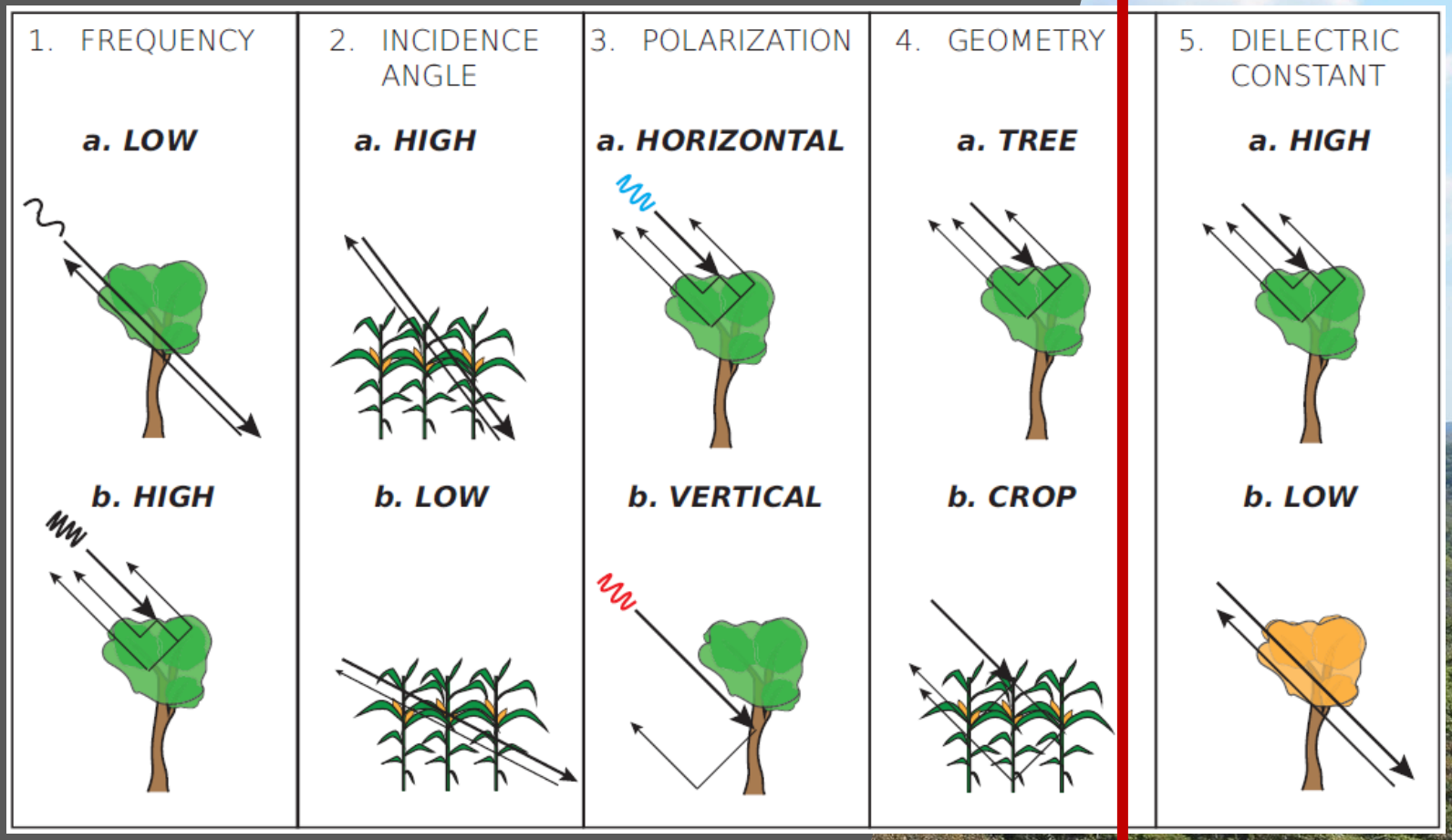
Hypothesis:

Vegetation water stress has an observable effect on radar backscatter

Radar is sensitive to vegetation

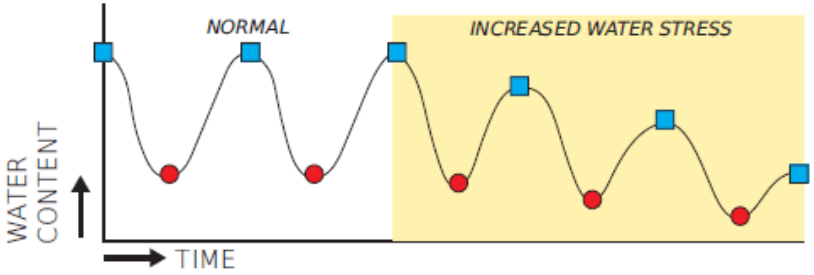
Function of water content!



Diurnal variations

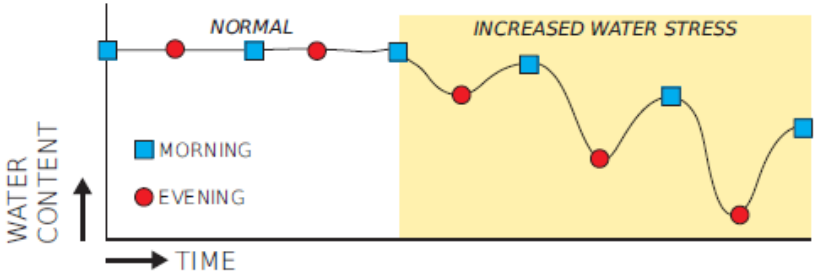
A. ANISOHYDRIC PLANT SPECIES
EXAMPLE: GOUPIA GLABRA

B. ANISOHYDRIC PLANT SPECIES -
WATER CONTENT



D. ISOHYDRIC PLANT SPECIES
EXAMPLE: CORN

E. ISOHYDRIC PLANT SPECIES -
WATER CONTENT

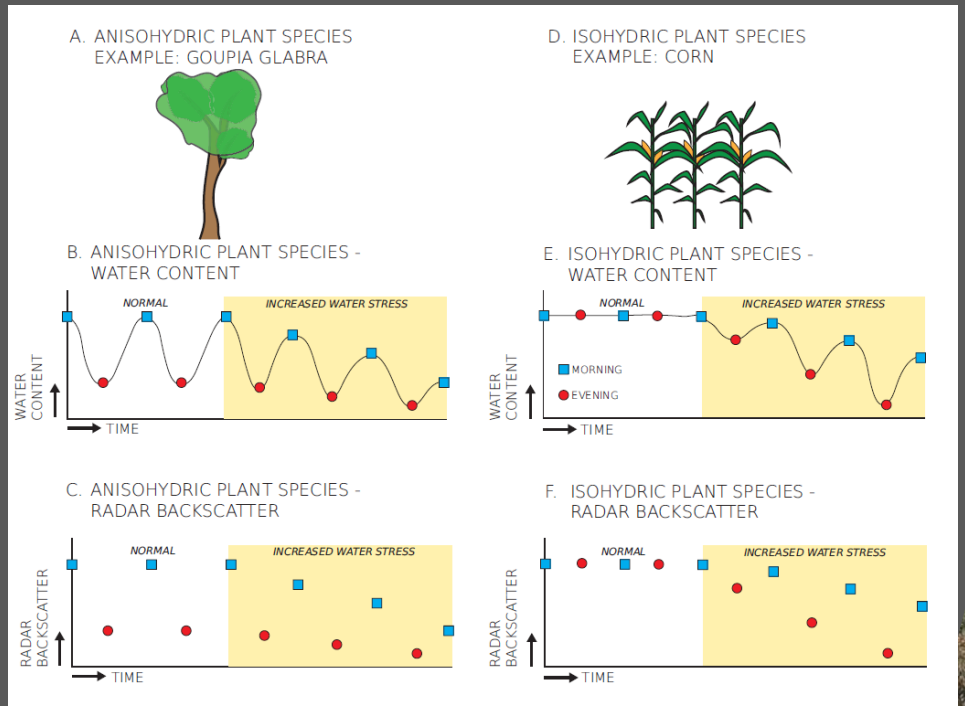


Are diurnal differences a sign of water stress?

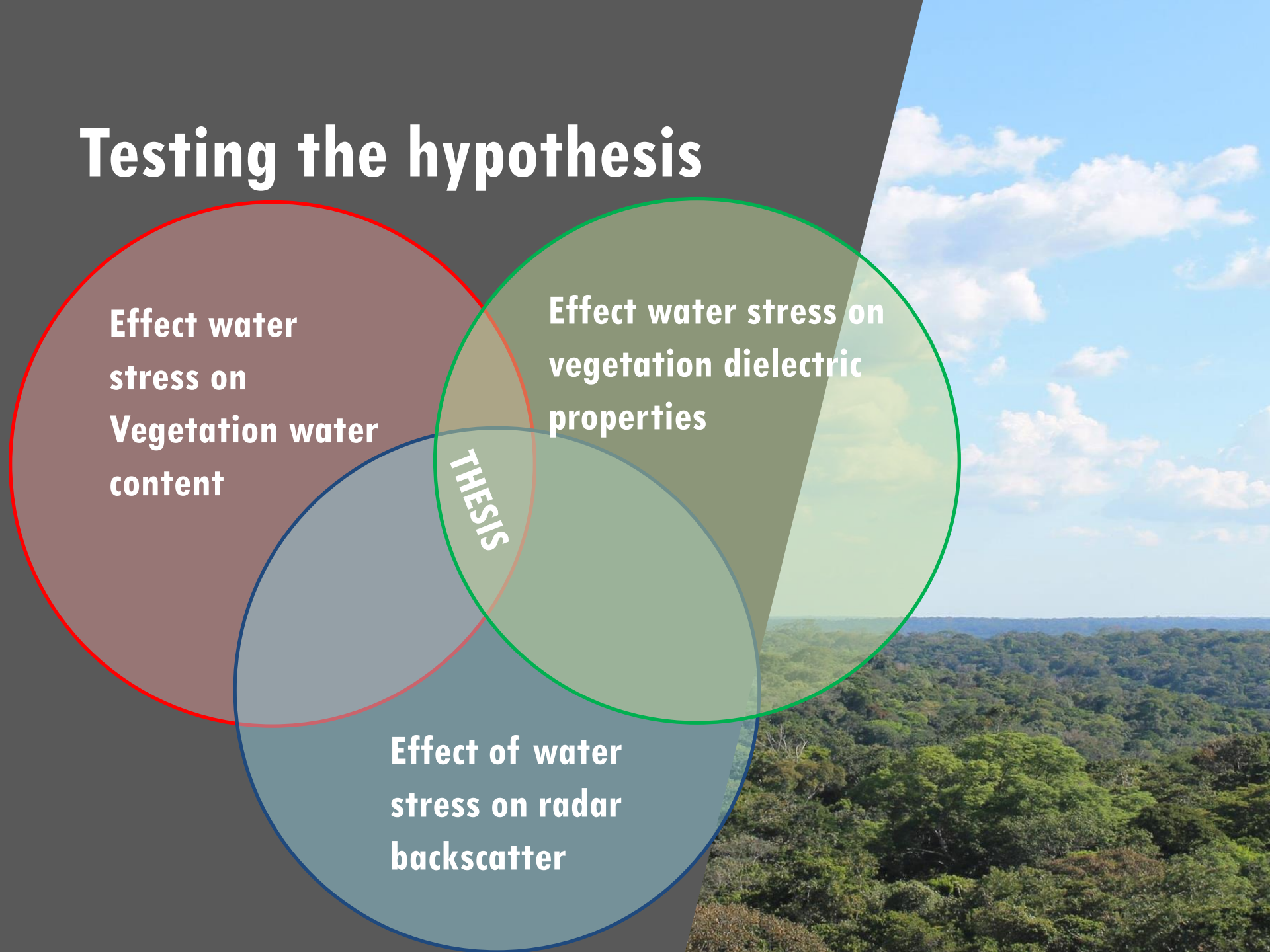
- **Vegetation water content** (Slayter, 1967; Tardieu et al., 1993)
- **Dielectric properties** (Zimmermann et al., 1995; McDonald et al., 1990)
- **Radar** (Birrer et al., 1982; Frolking et al., 2011; Friesen, 2008)

Hypothesis:

Vegetation water stress has an observable effect on radar backscatter



Testing the hypothesis



Testing the hypothesis

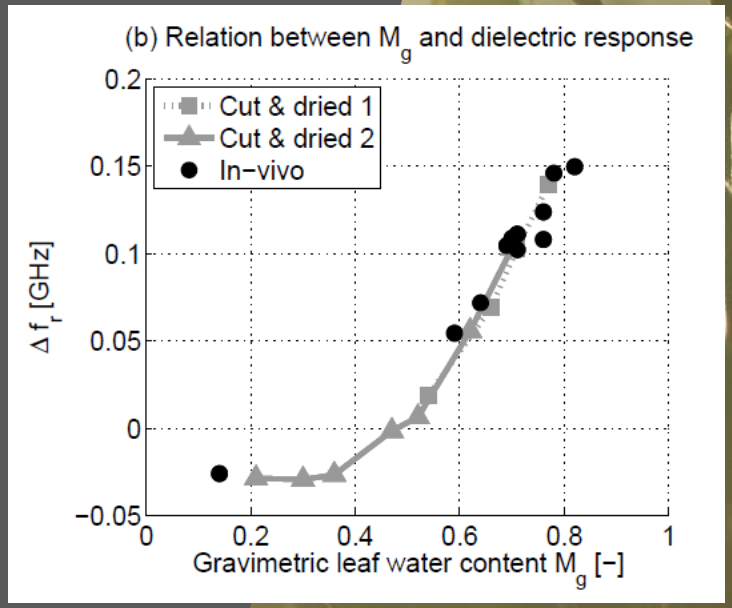
Test new sensors

What's the effect of water stress on the plant?

How is this connected to radar backscatter?

Part I: Crops

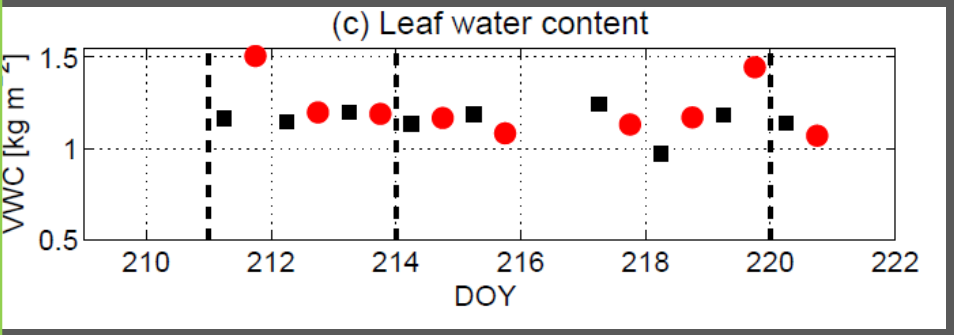
Measuring dielectric properties *in vivo*



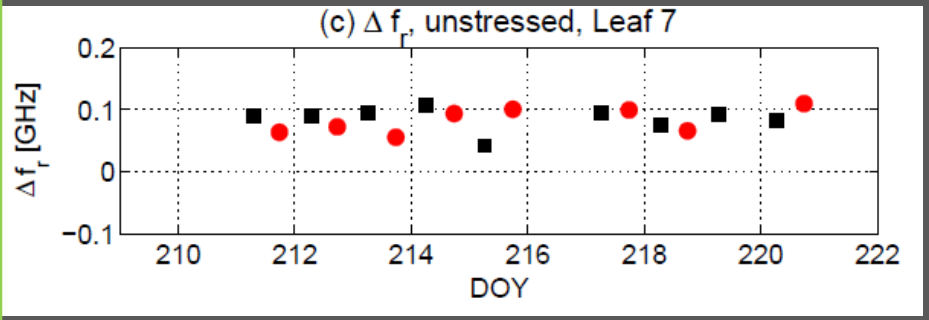
van Emmerik et al., 2015a, 2017a

Part I: Crops

Vegetation water content

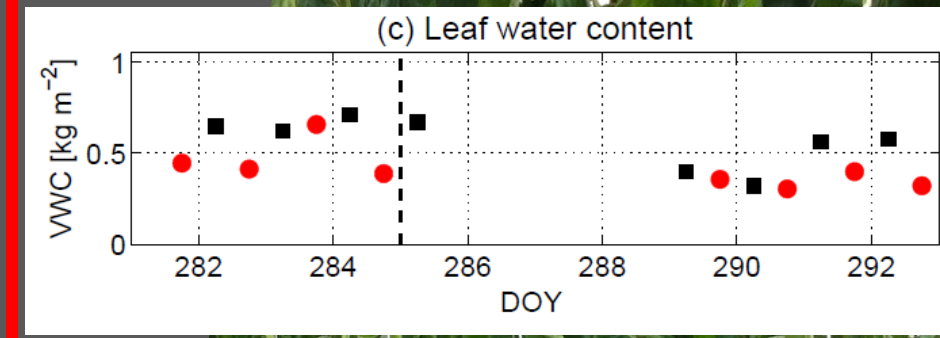


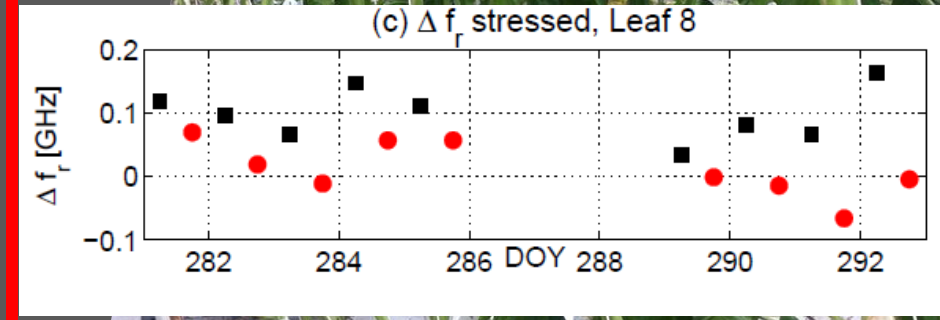
Dielectric properties



Unstressed

van Emmerik et al., 2017a





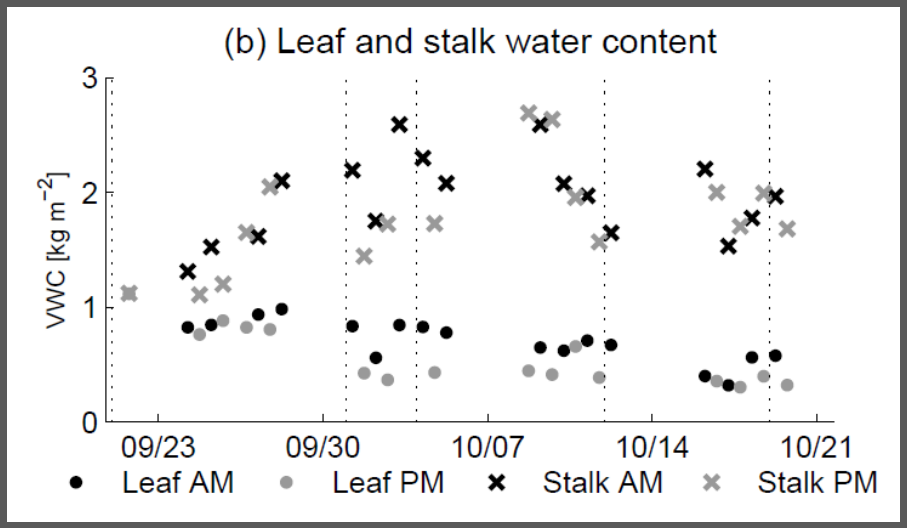
Stressed

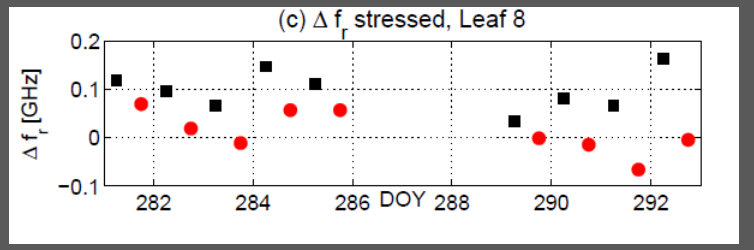
Part I: Crops

Vegetation water content

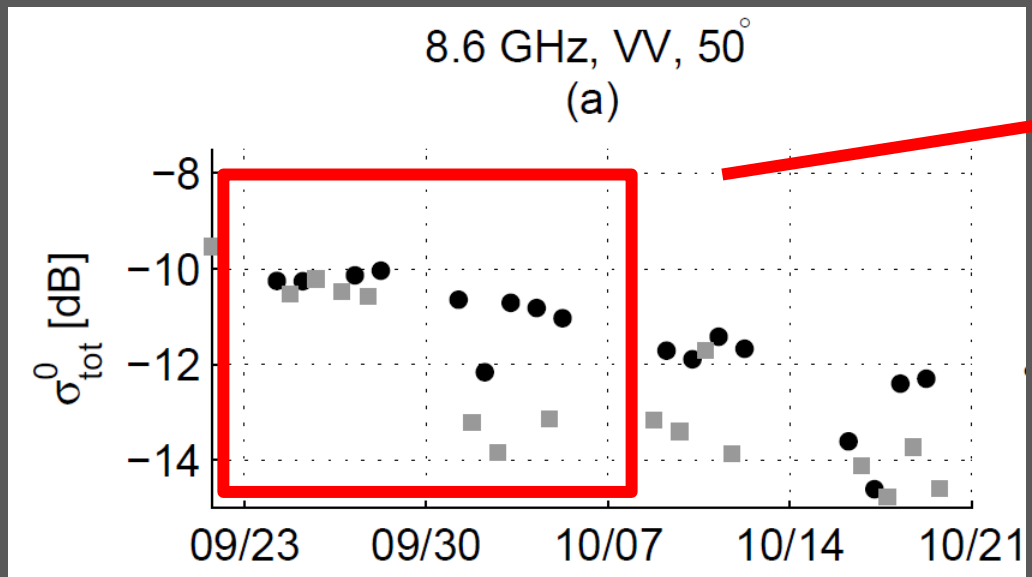
van Emmerik et al., 2015a

Dielectric properties





Backscatter



Diurnal differences up to 4dB during stress!

Part II: Tropical rainforest

Measuring water stress effects using accelerometers

van Emmerik et al., 2017b

Figure 5.1: Picture of an accelerometer installed on a tree.

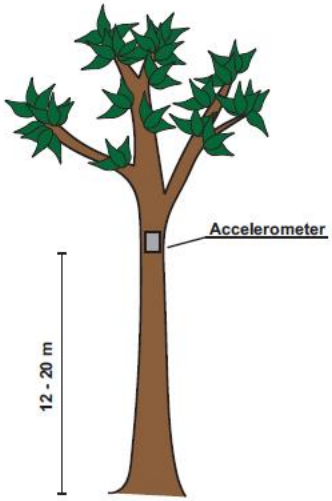
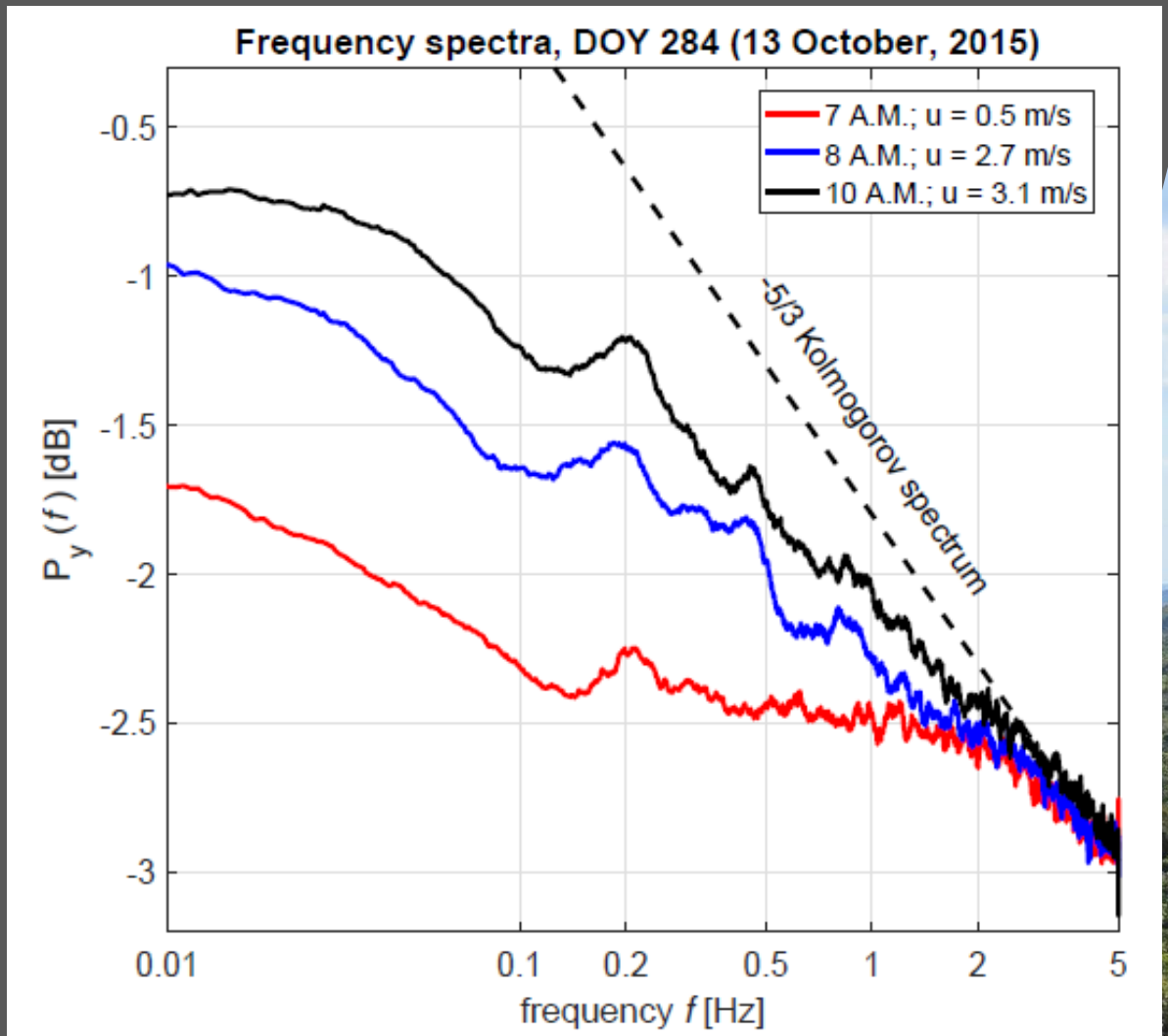


Figure 5.2: Illustration of mounting position of accelerometer in a tree.

Figure 5.3: Location of the field site in the Amazon, Brazil.

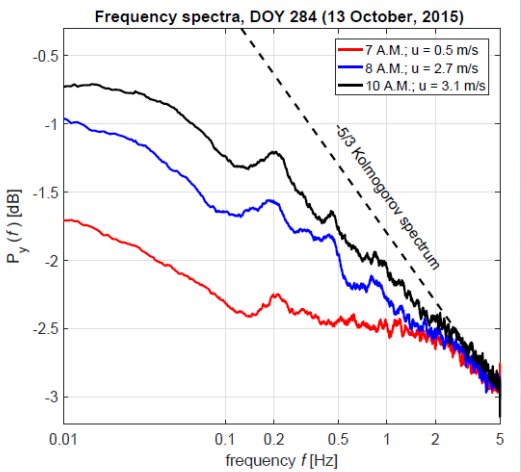
Part II: Tropical rainforest

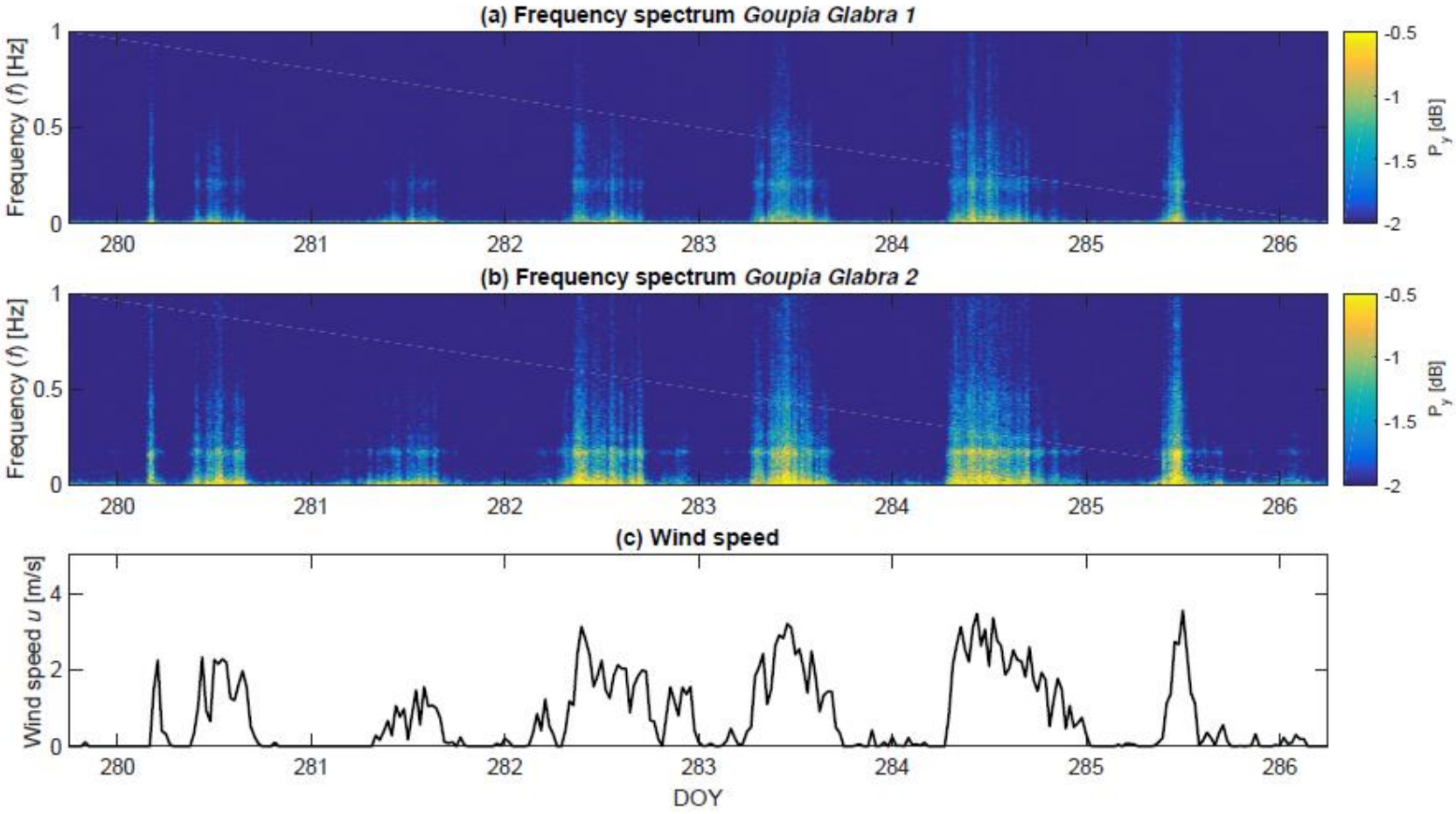


van Emmerik et al., 2017b

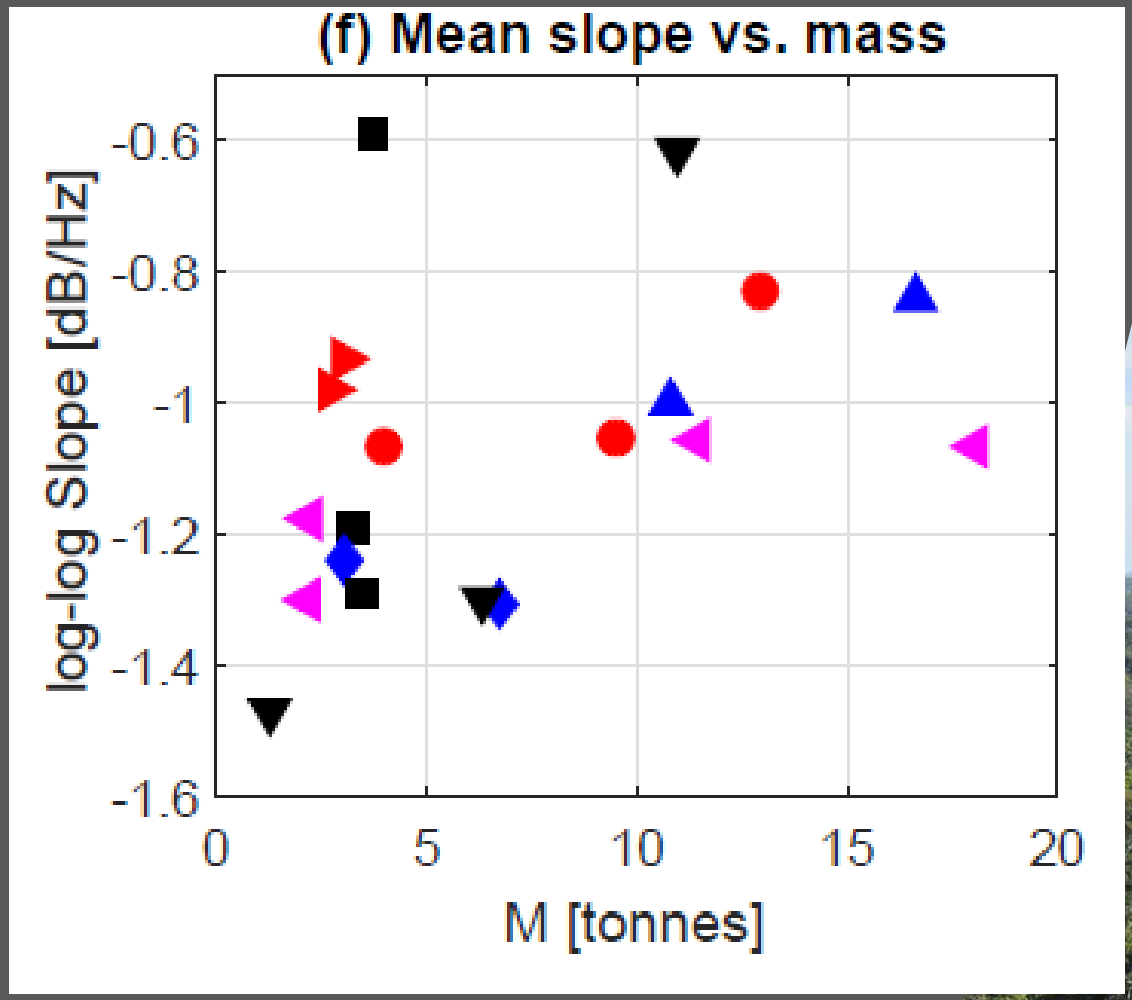
Part II: Tropical rainforest

van Emmerik et al., 2017b





Part II: Tropical rainforest



van Emmerik et al., 2017b

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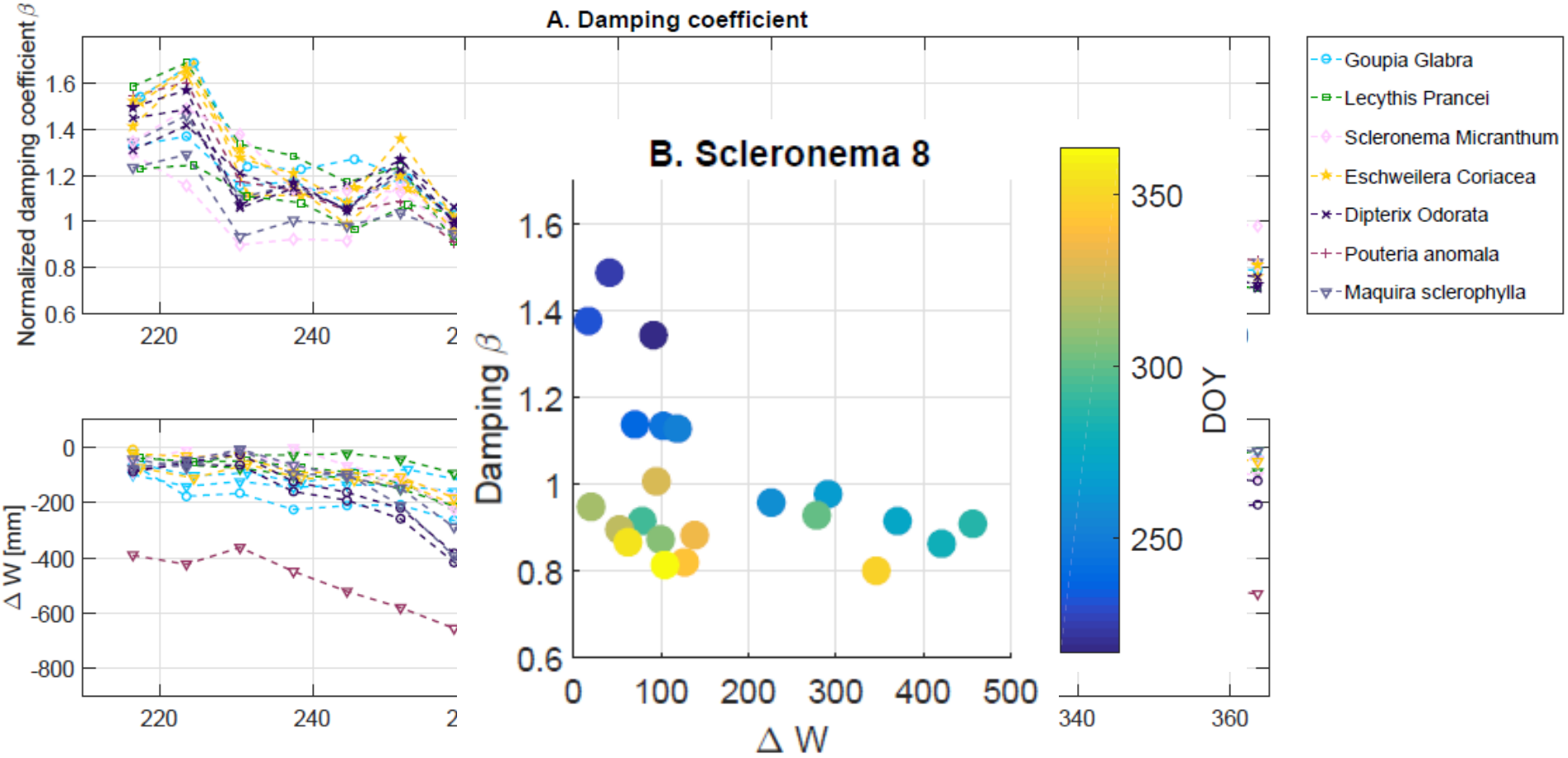

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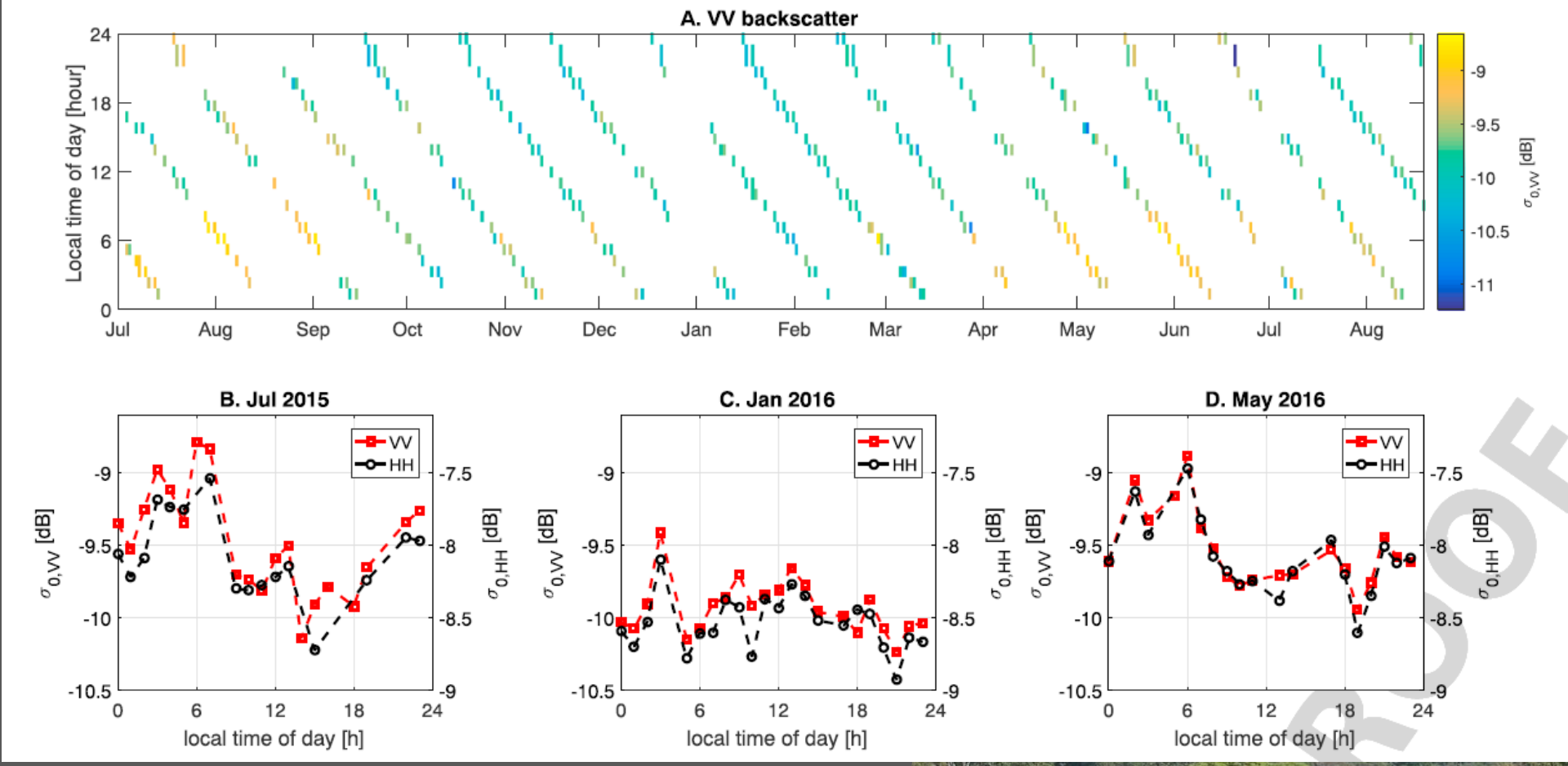
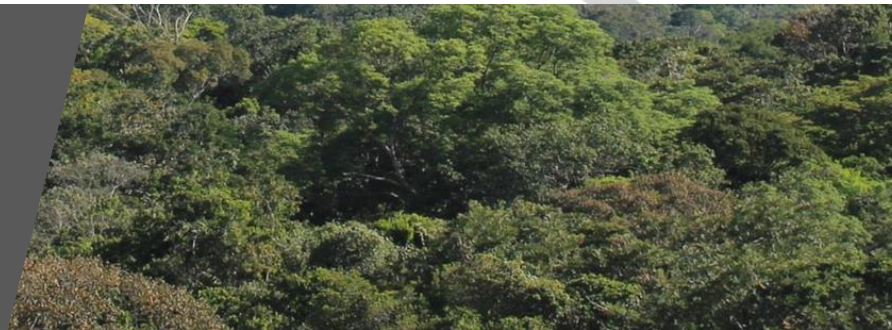
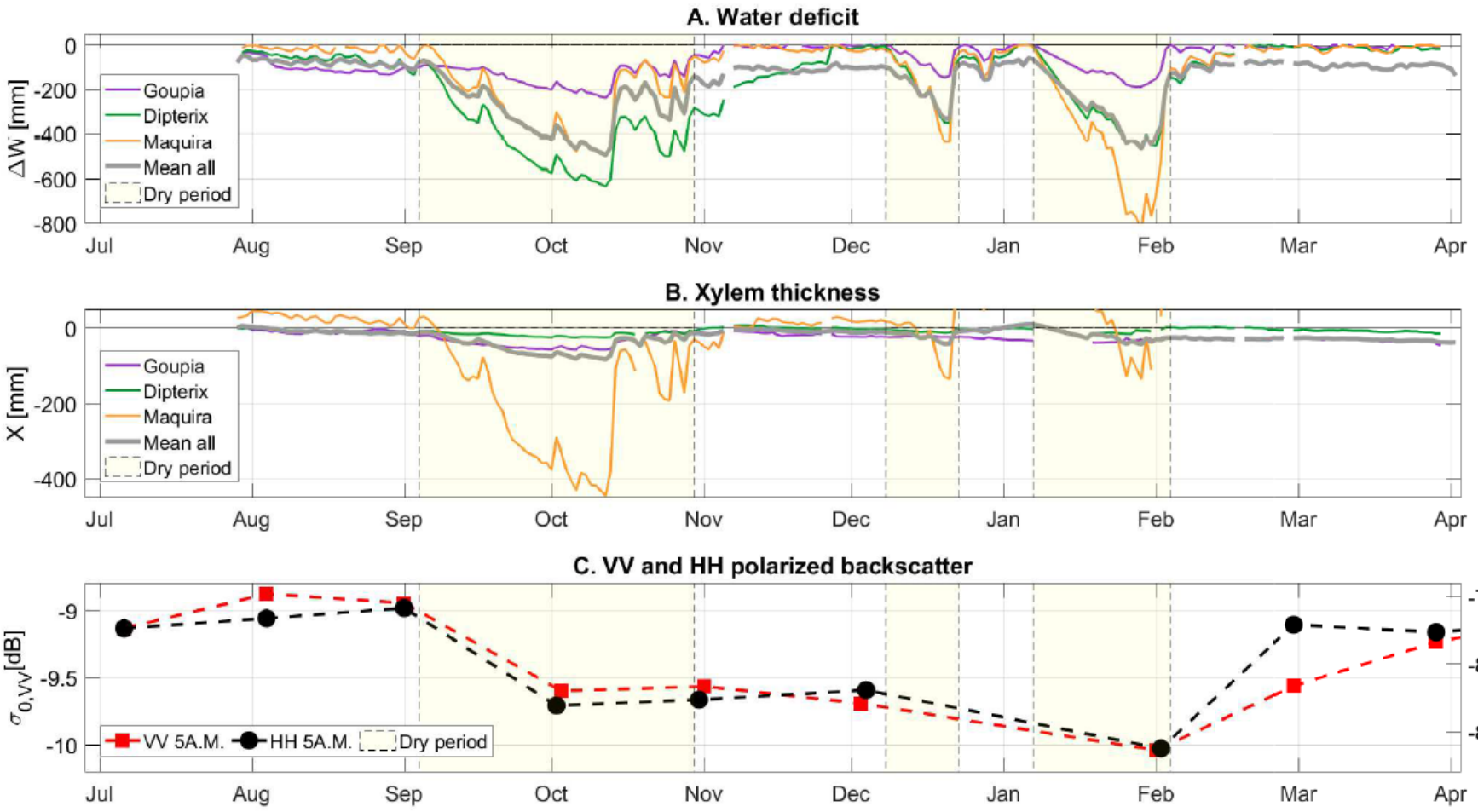


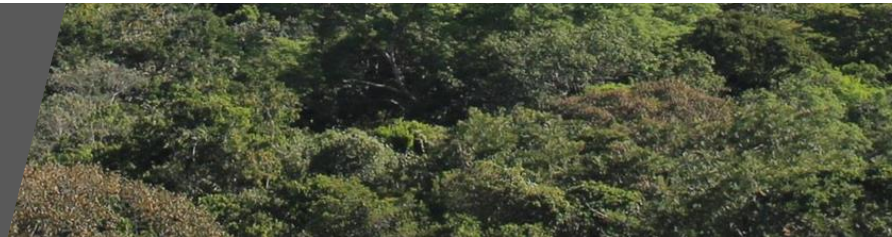
van Emmerik et al., 2017c



Part II: Tropical rainforest



van Emmerik et al., 2017c



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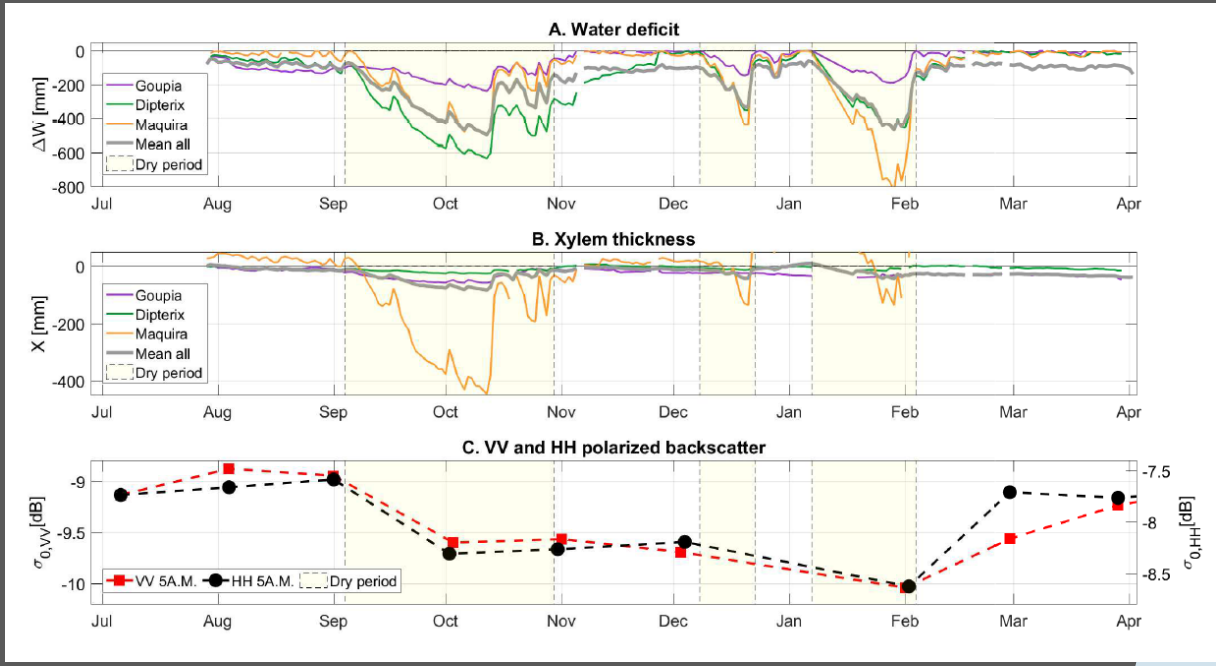

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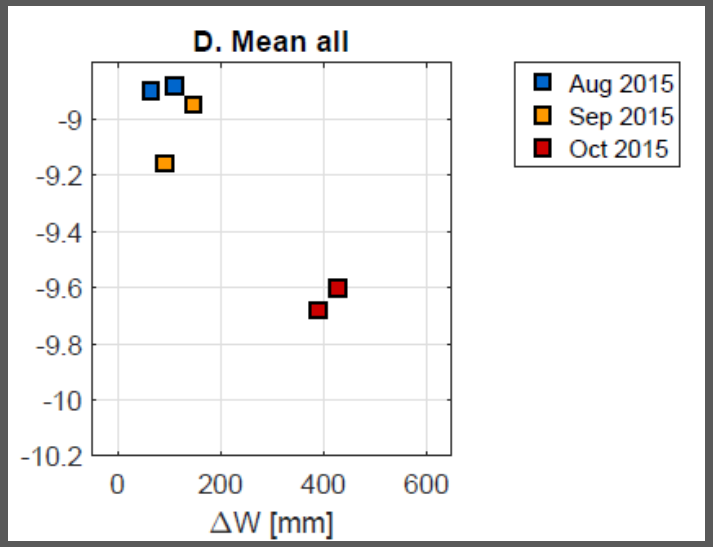

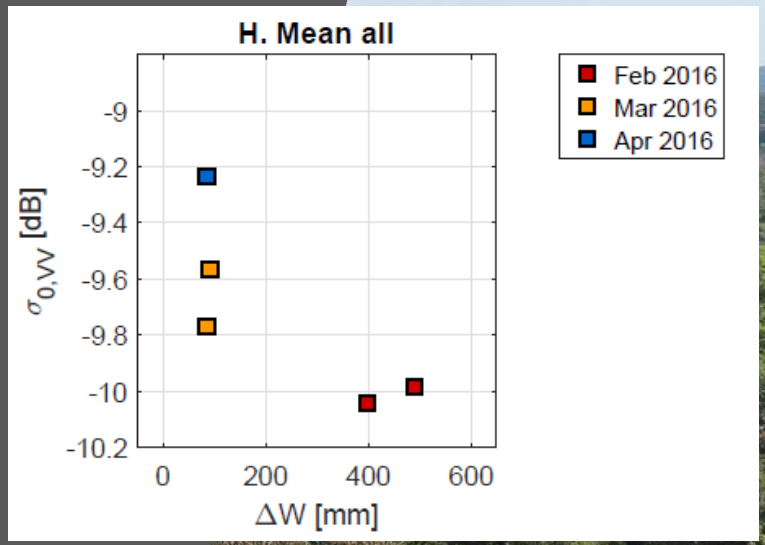

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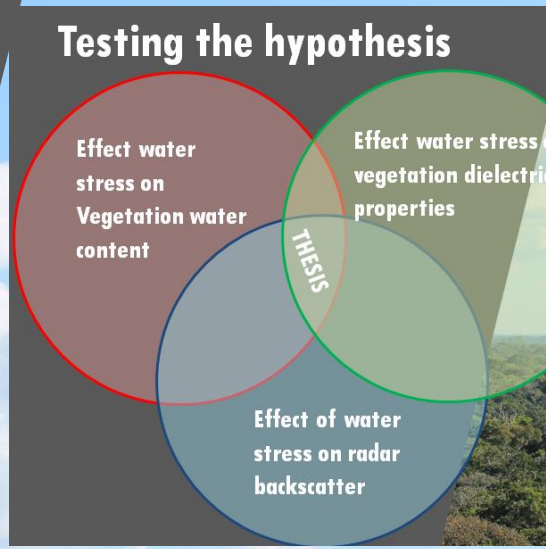

Water stress significantly affects (diurnal differences in) vegetation water content

Water stress significantly affects (diurnal differences in) leaf dielectric properties

Water stress significantly affects (diurnal differences) in radar backscatter

→ **Water stress has an observable effect on radar backscatter!**

References

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- van Emmerik, T., S. Steele-Dunne, J. Judge, and N. van de Giesen (2015b), **A comparison between leaf dielectric properties of stressed and unstressed tomato plants**. IGARSS 2015, pp. 275–278, IEEE, Milan, Italy, 26–31 Jul.

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- van Emmerik, T., S. C. Steele-Dunne, R. Hut, P. Gentine, M. Guerin, R. S. Oliveira, J. Wagner, J. Selker, and N. van de Giesen (2017b), **Measuring tree properties and responses using low-cost accelerometers**, Sensors, 17(5), 1098

- van Emmerik, T., S. Steele-Dunne, A. Paget, R. S. Oliveira, P. R. L. Bittencourt, F. de V.Barros, and N. van de Giesen (2017c), **Water stress detection in the Amazon using radar**, Geophys. Res. Lett., 44, doi:10.1002/2017GL073747.

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