The 2018 drought and its consequences: Investigating the resilience of different tree species based on comprehensive long-term monitoring of forest hydrology

Theresa Blume

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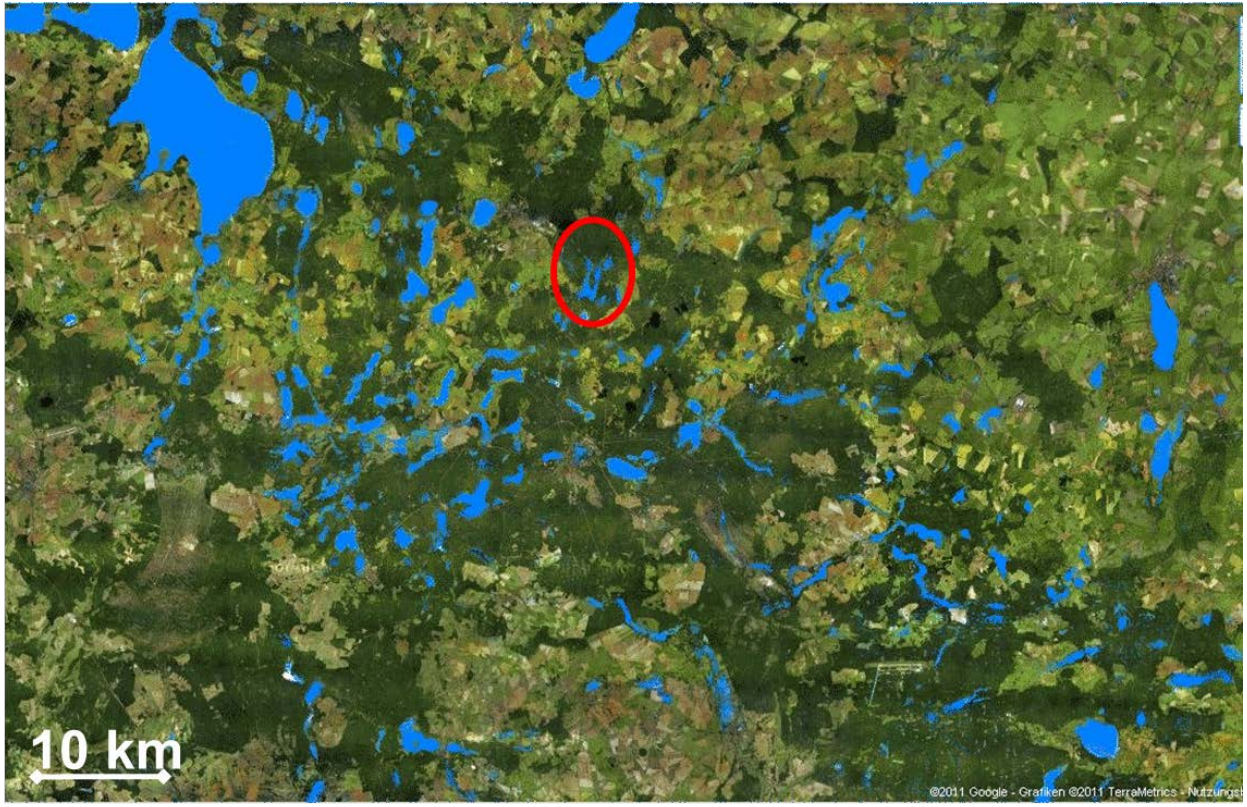
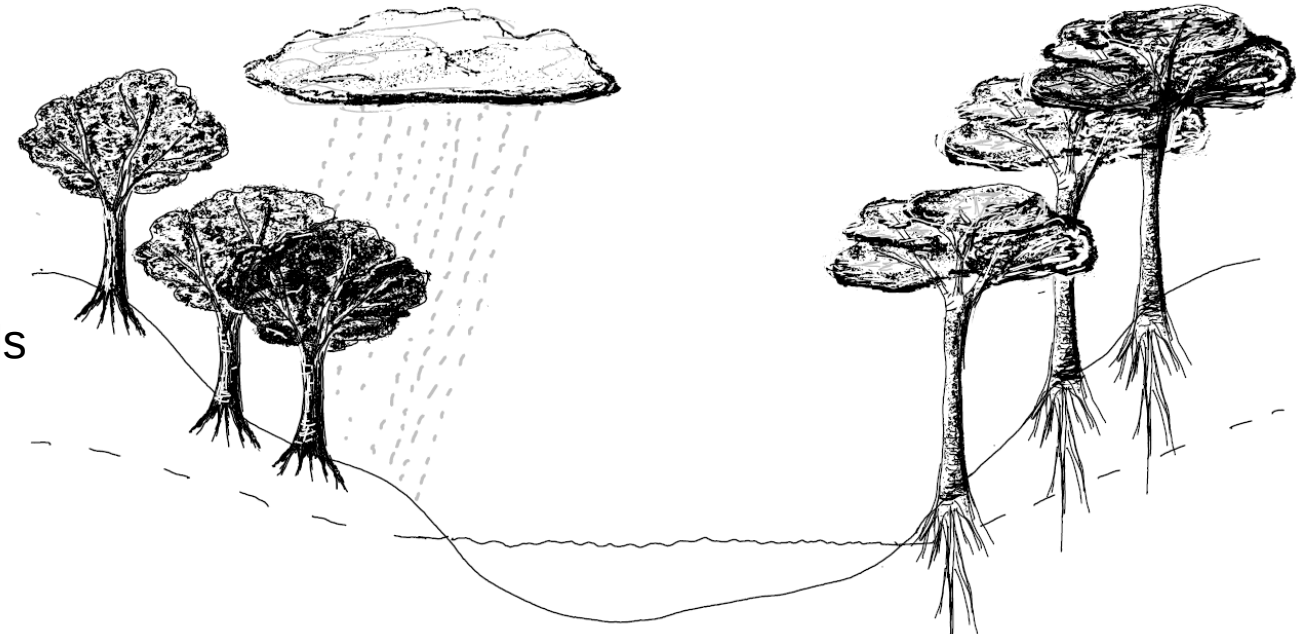
GFZ Helmholtz Centre Potsdam

Müritz-Nationalpark

The North-Eastern German Lowlands TERENO Observatory



General study design

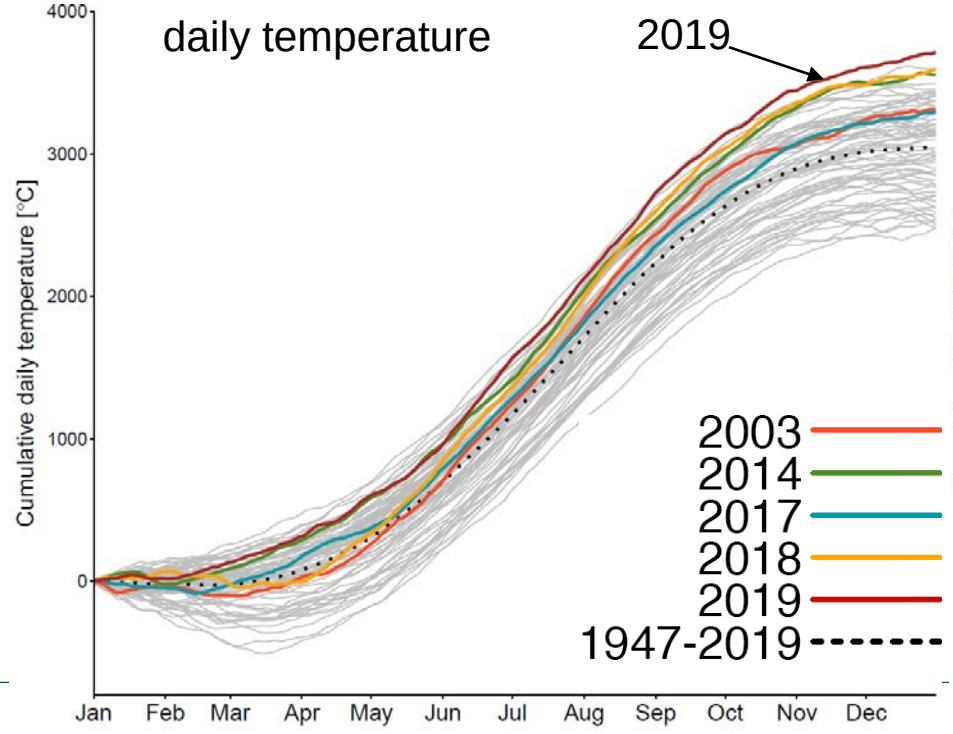


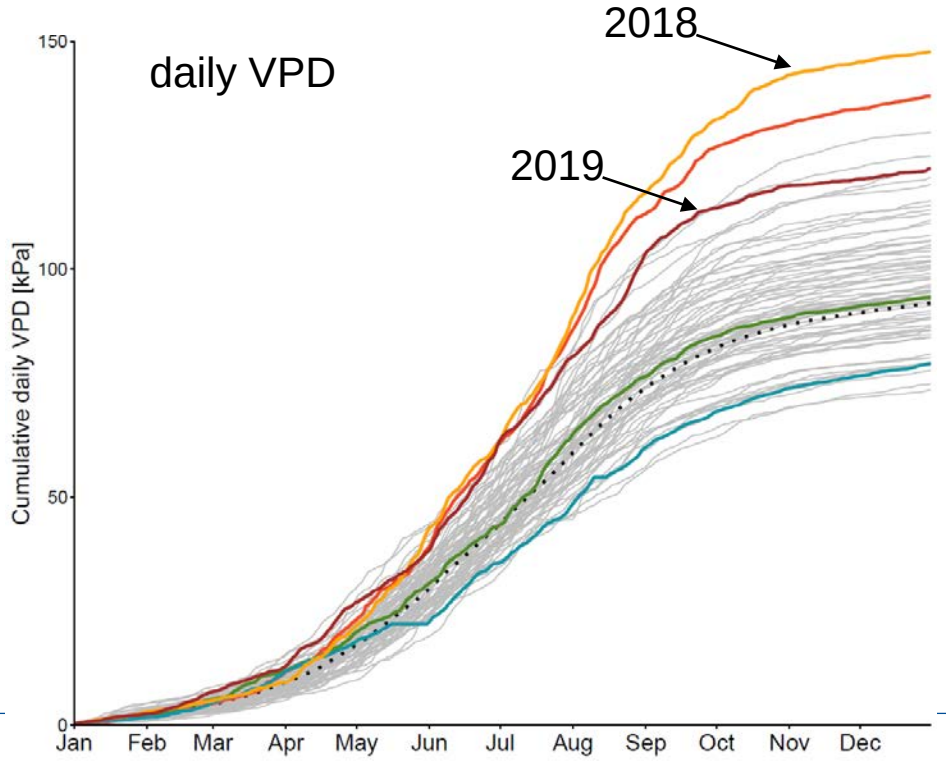
We compare upslope and downslope sites and different tree species/forest stands

Instrumentation

- Soil moisture sensors
- Observation wells
- Gravimeter
- Sap flow sensors
- Dendrometers

How do 2018 and 2019 compare to other years?





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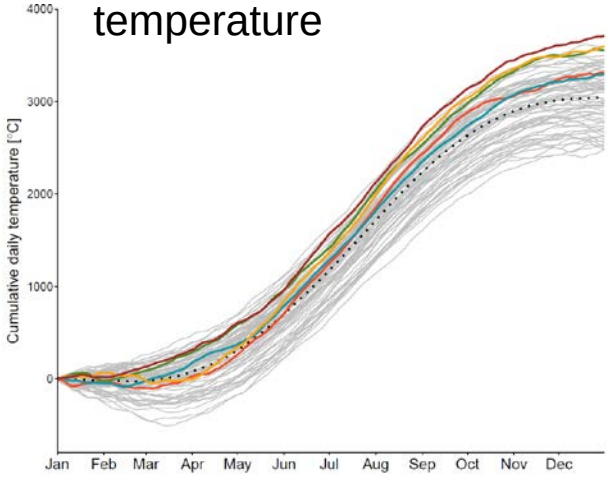
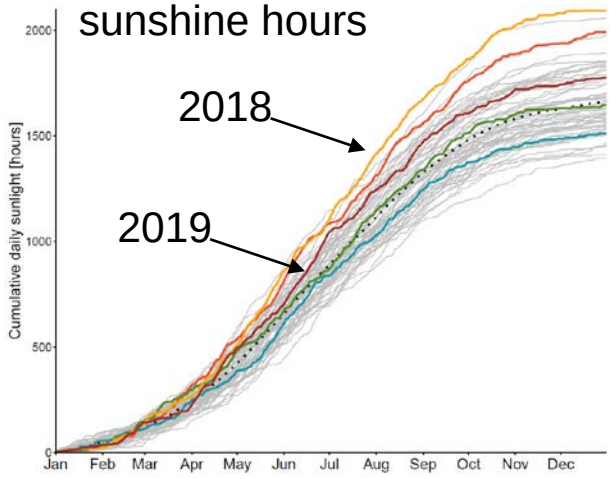
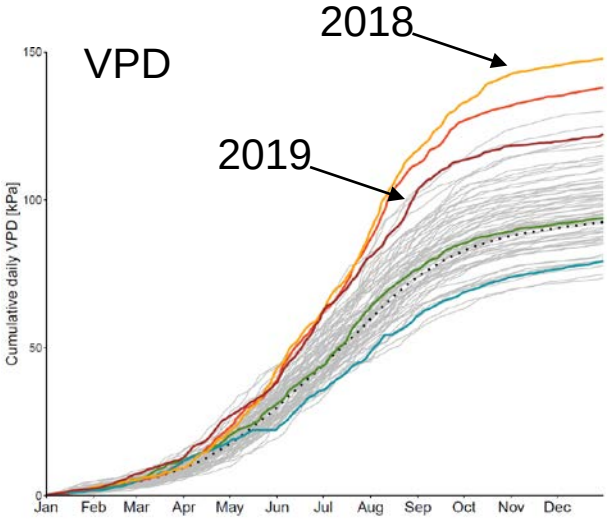
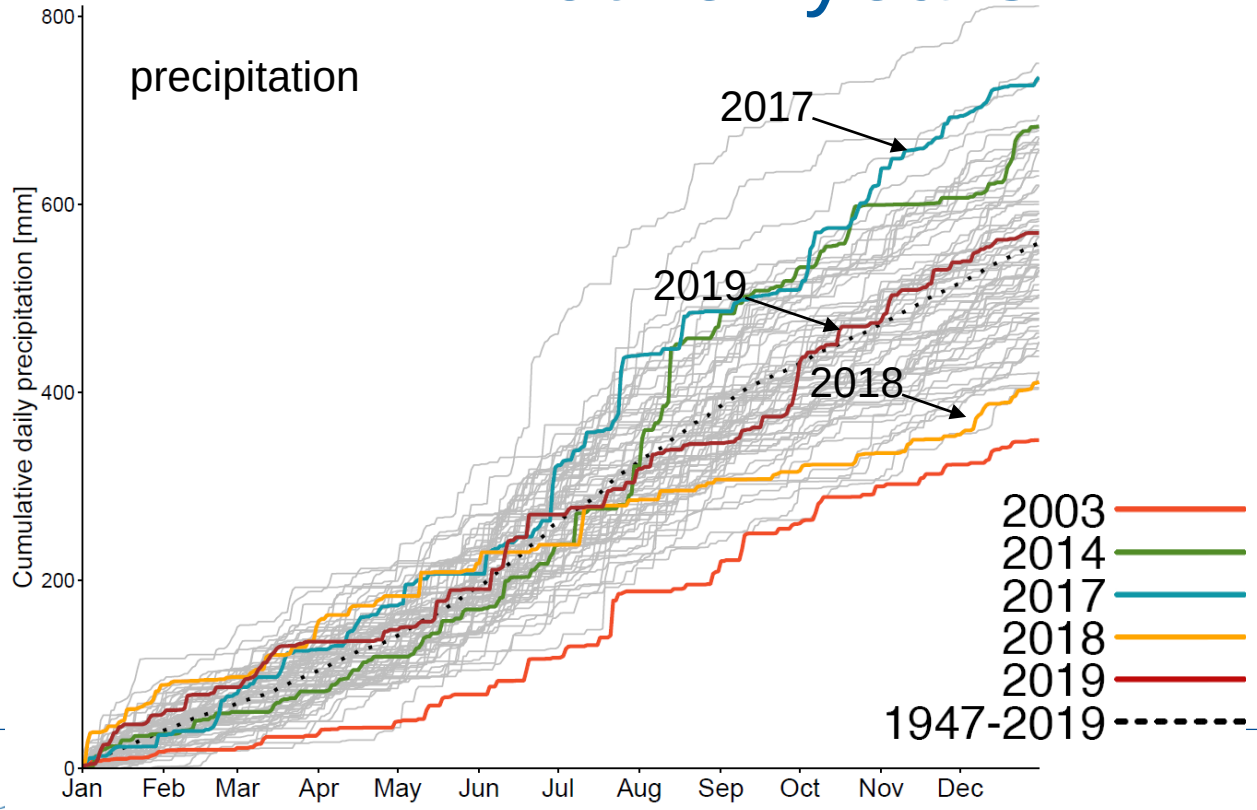


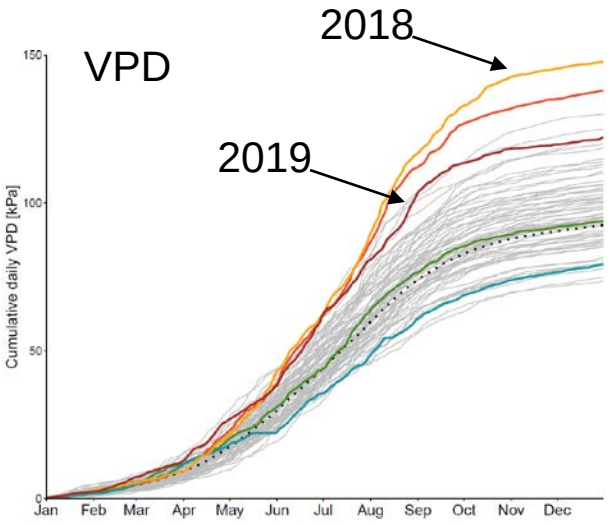




2003
2014
2017
2018
2019
1947-2019

How do 2018 and 2019 compare to other years?

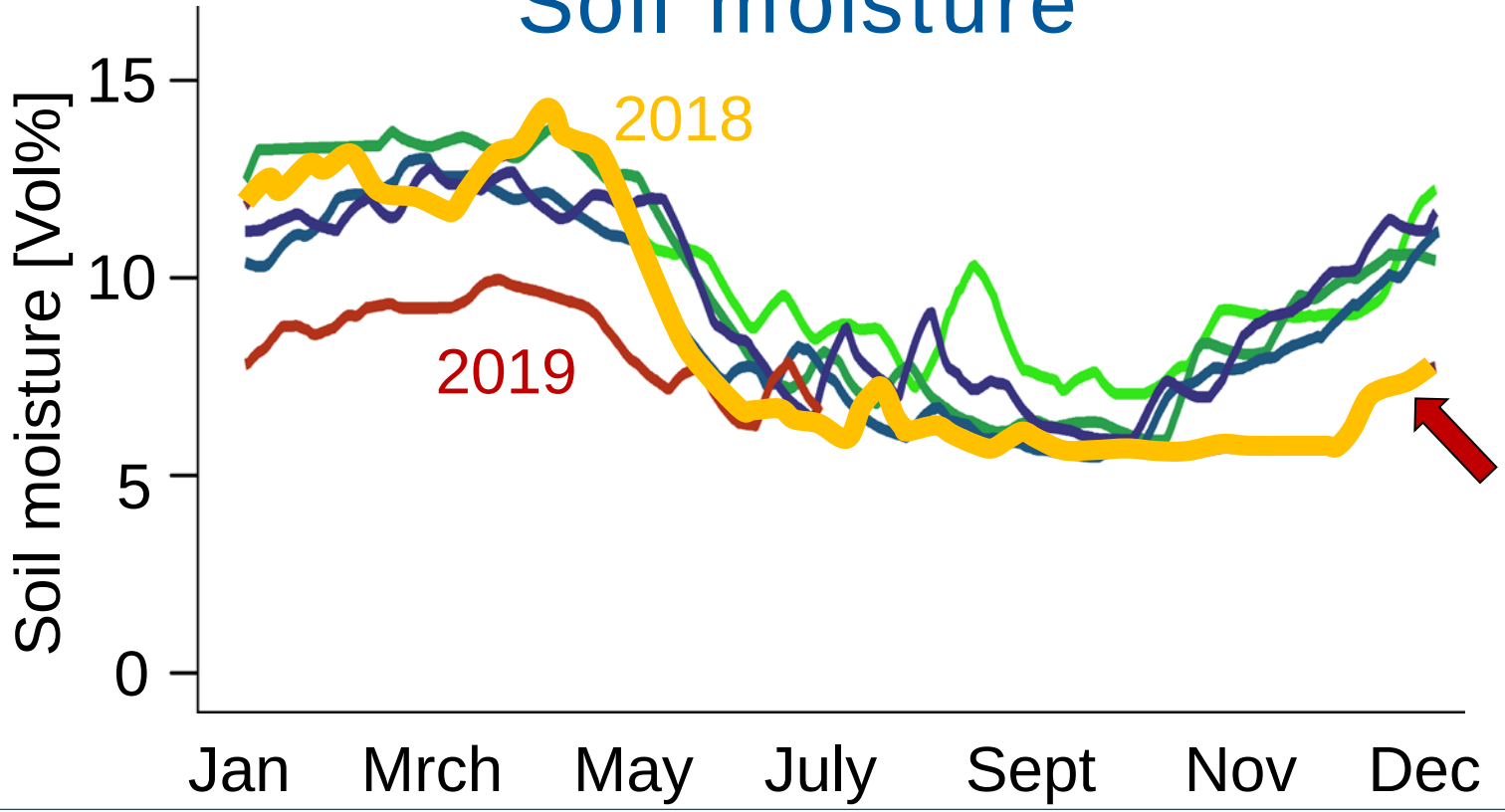




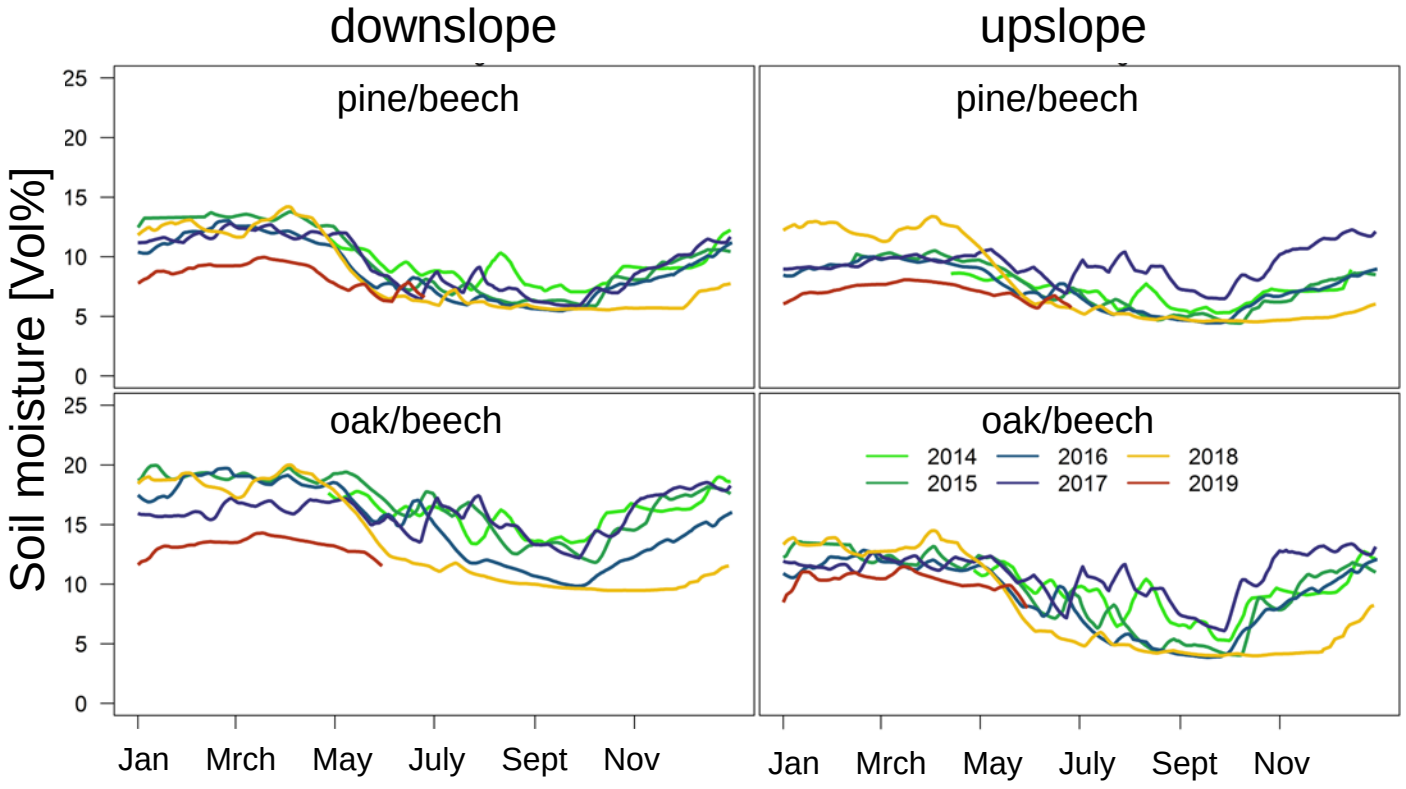
How do 2018 and 2019 compare to other years?

- 2018 started wet and was then very dry
- The fall/winter of 2018/19 did not deliver sufficient recharge
- 2019 was hot, but had more rainfall than 2018

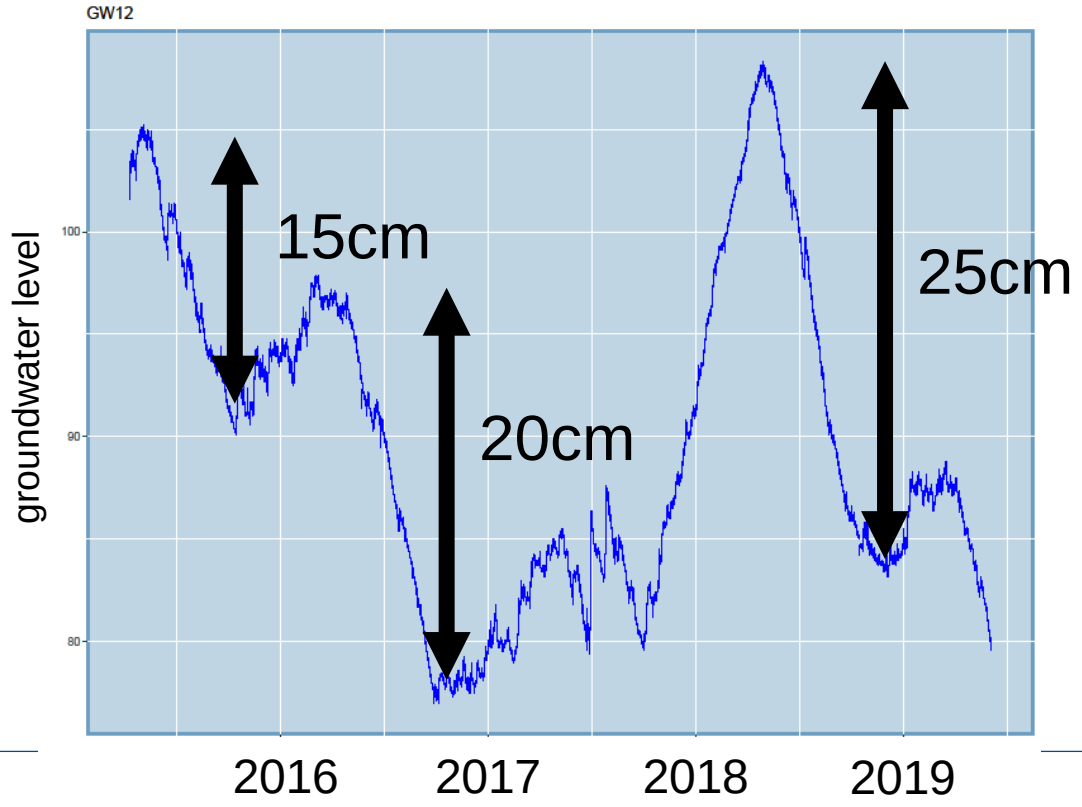
Soil moisture



Soil moisture



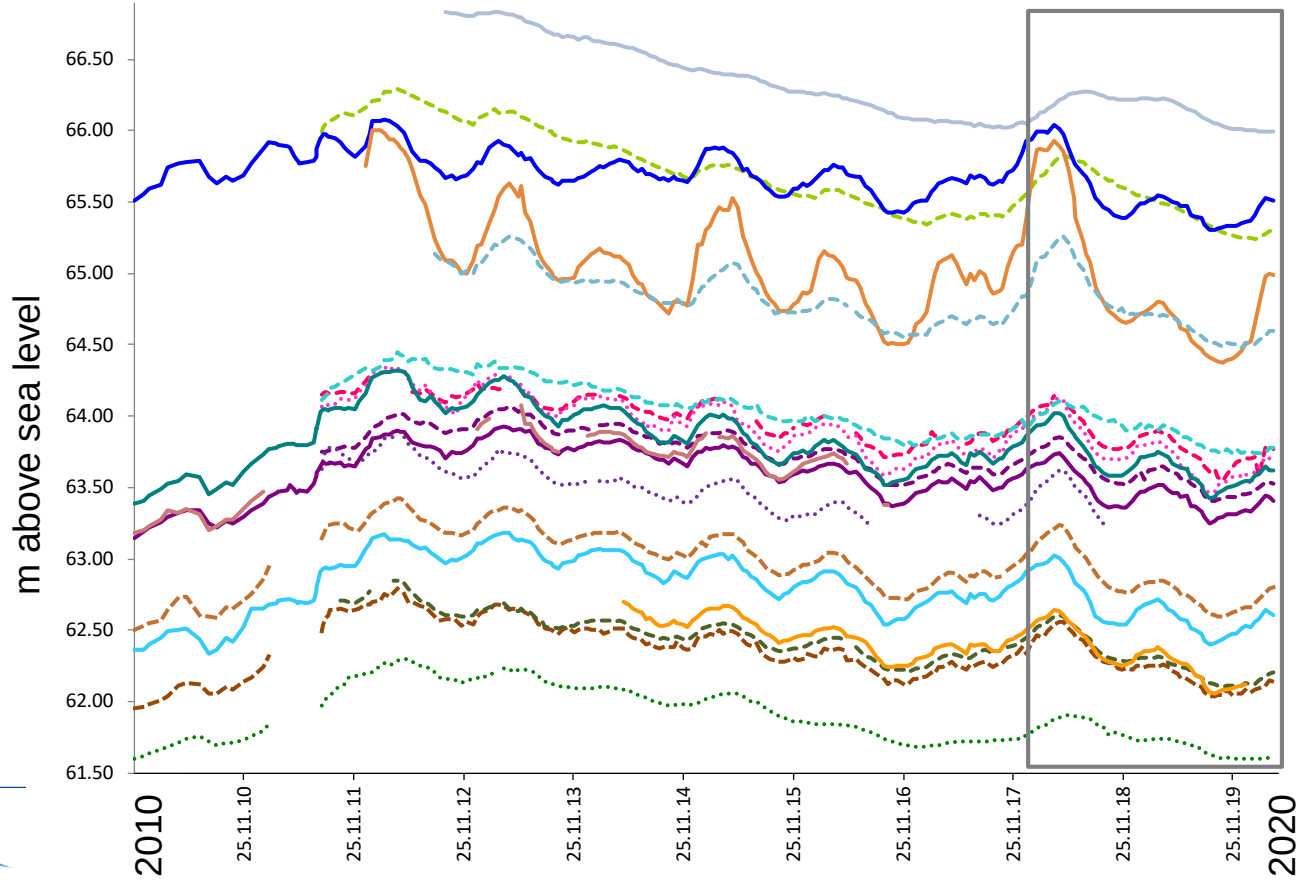
Groundwater level dynamics



2018: big drawdown (luckily we started out wet)

Winter 18/19: too little recharge

Groundwater and lake level fluctuations



lakes
groundwater

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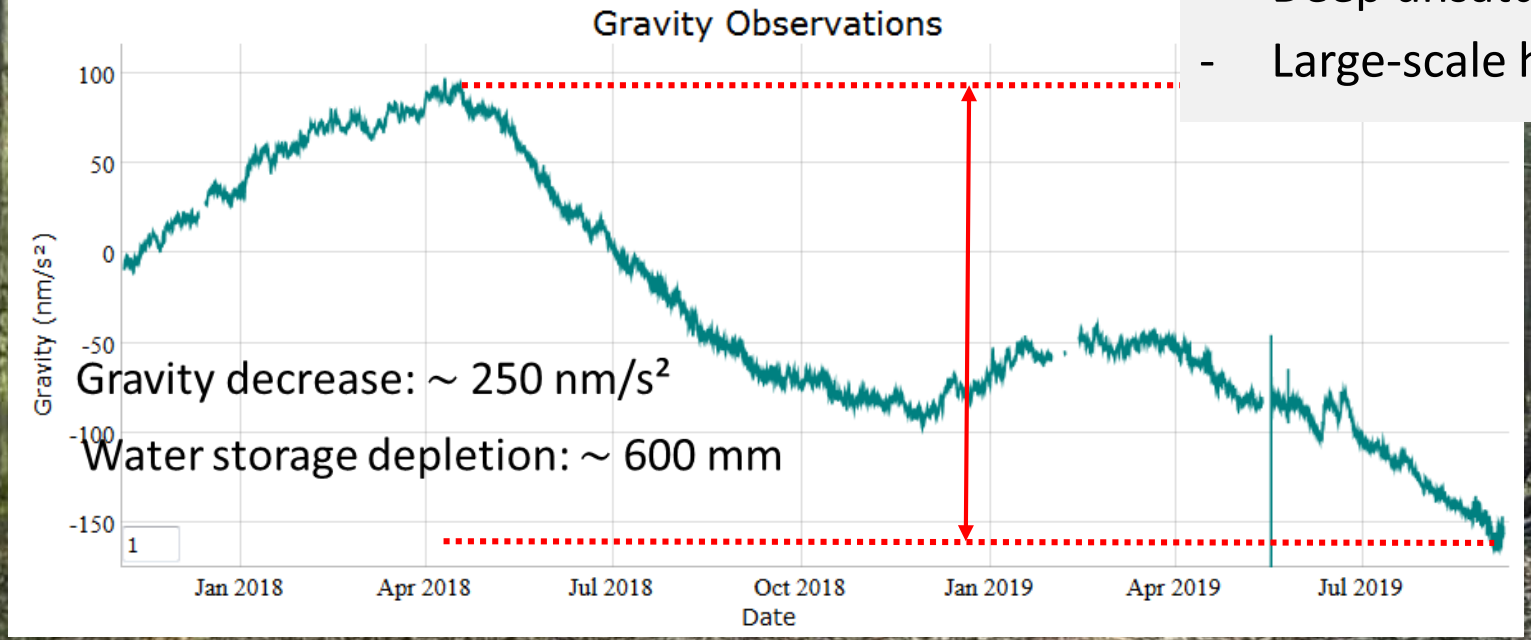
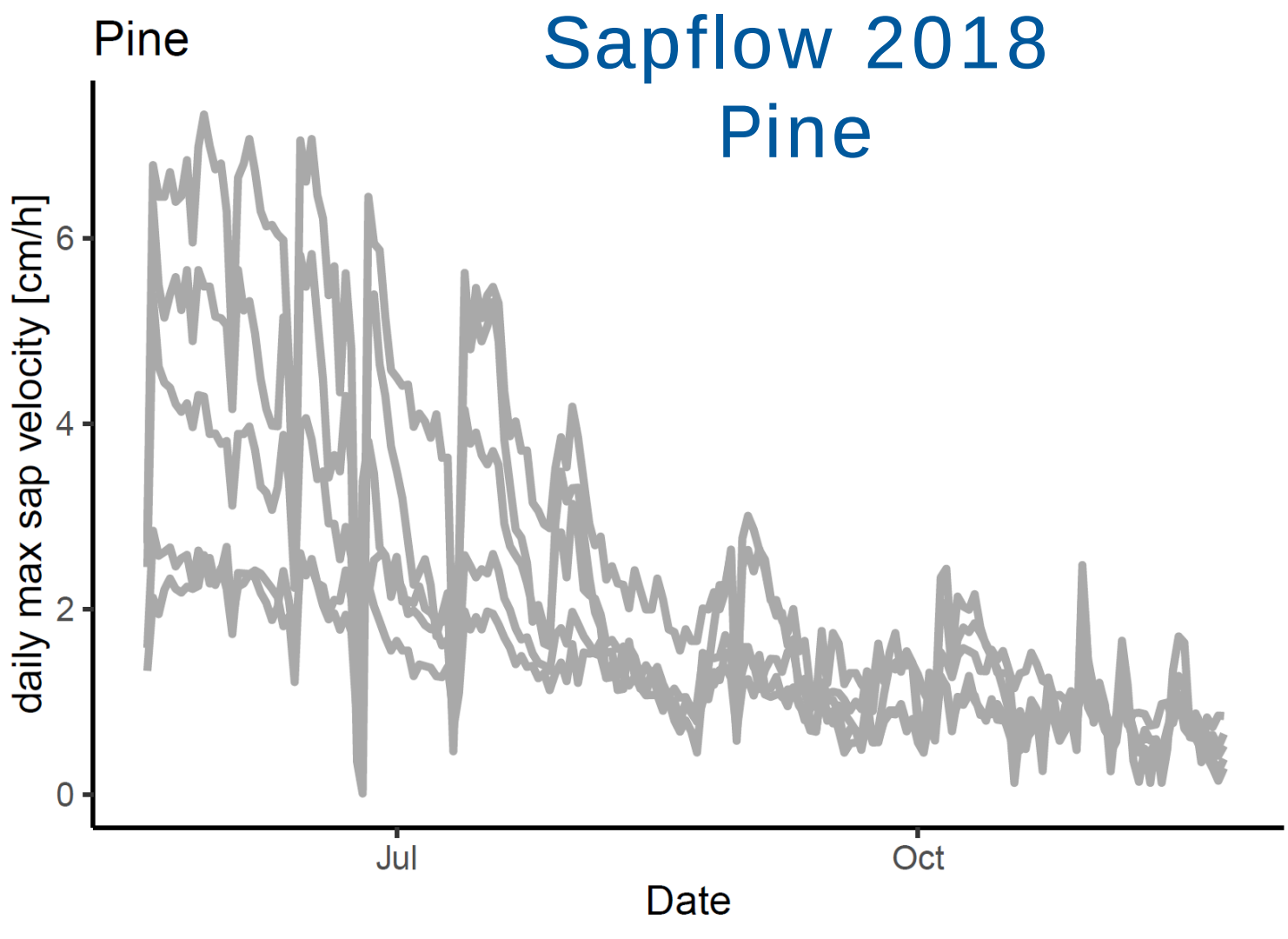
Gravimetry: Total water storage changes

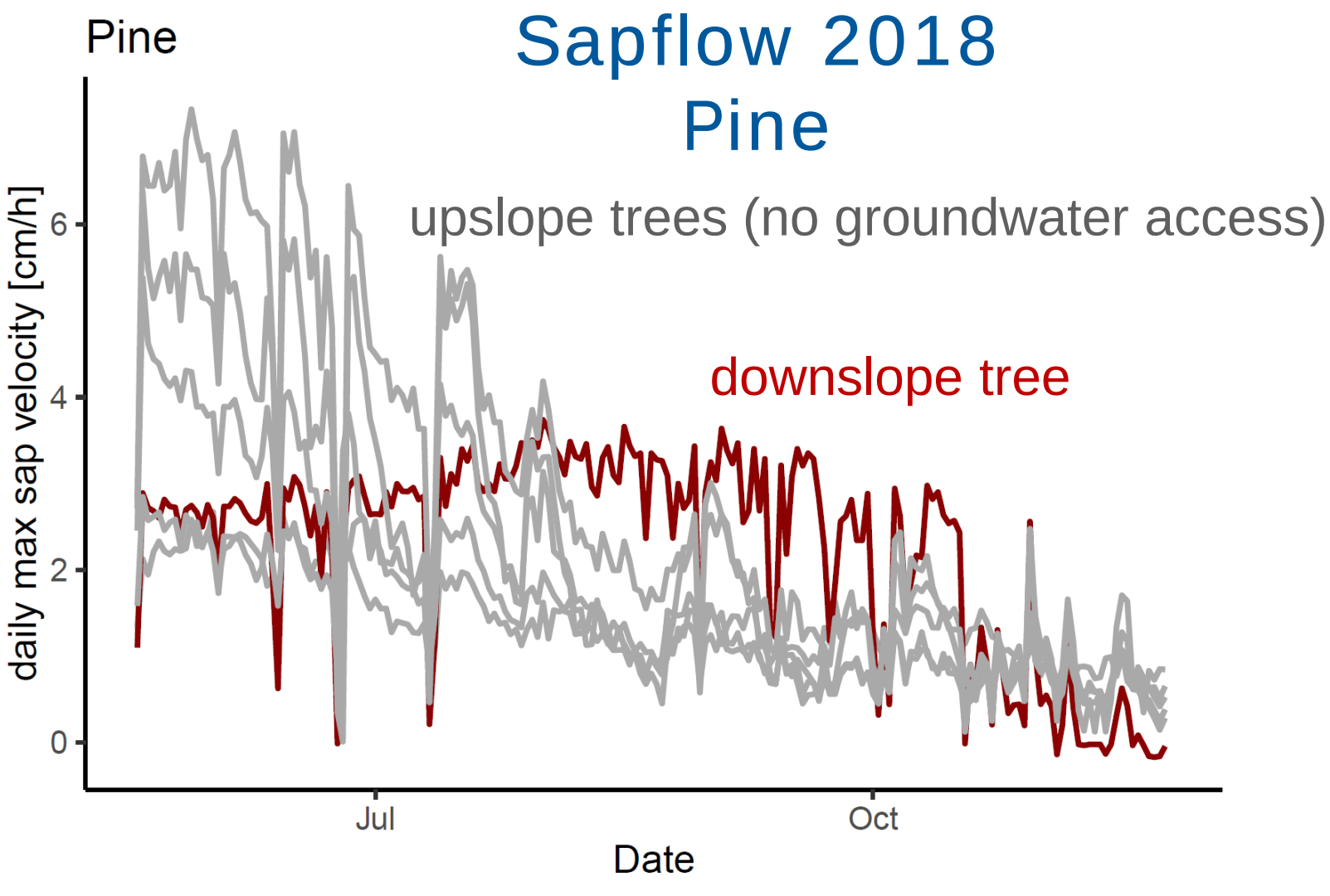
Other possible reasons for the huge gravity decrease:

- Instrumental issues (drift)
- Deep unsaturated zone
- Large-scale hydrology

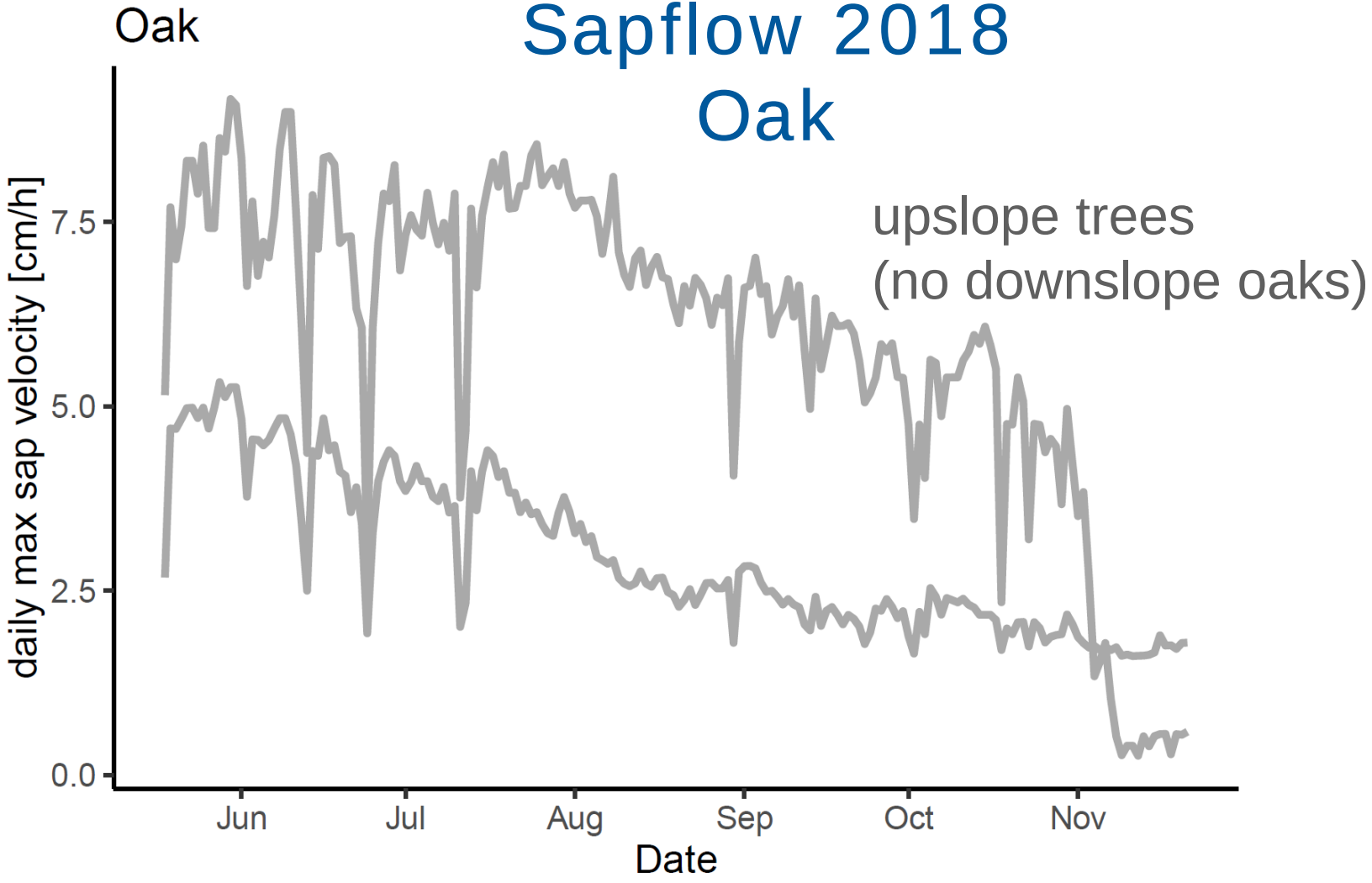


Two dry and hot summers – what does that mean for the trees?

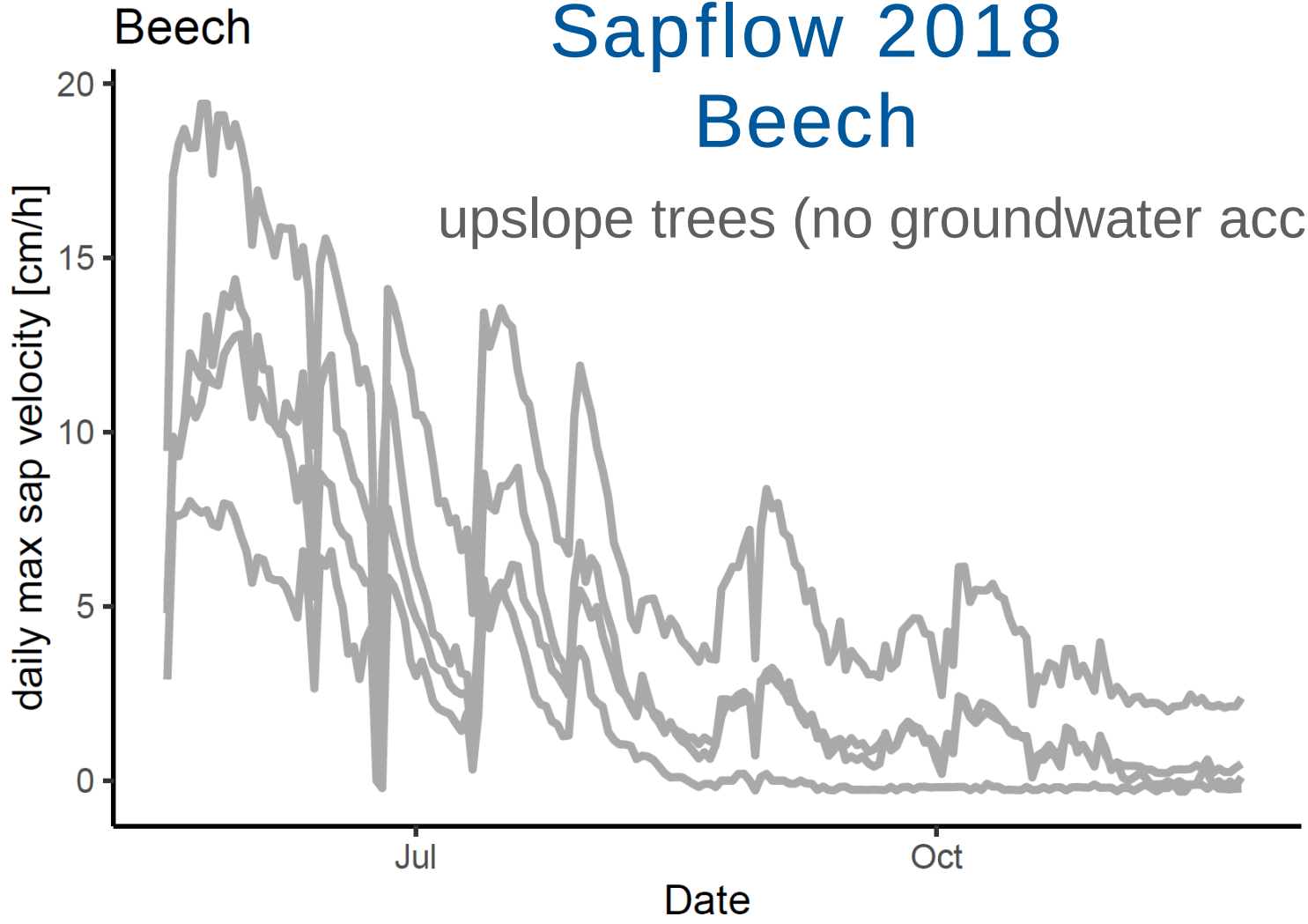

Pine
Sapflow 2018
Pine
daily max sap velocity [cm/h]
0
2
4
6
Jul
Oct
Date


Pine
Sapflow 2018
Pine
upslope trees (no groundwater access)
downslope tree
daily max sap velocity [cm/h]
0
2
4
6
Jul
Oct
Date

Sapflow 2018
Oak

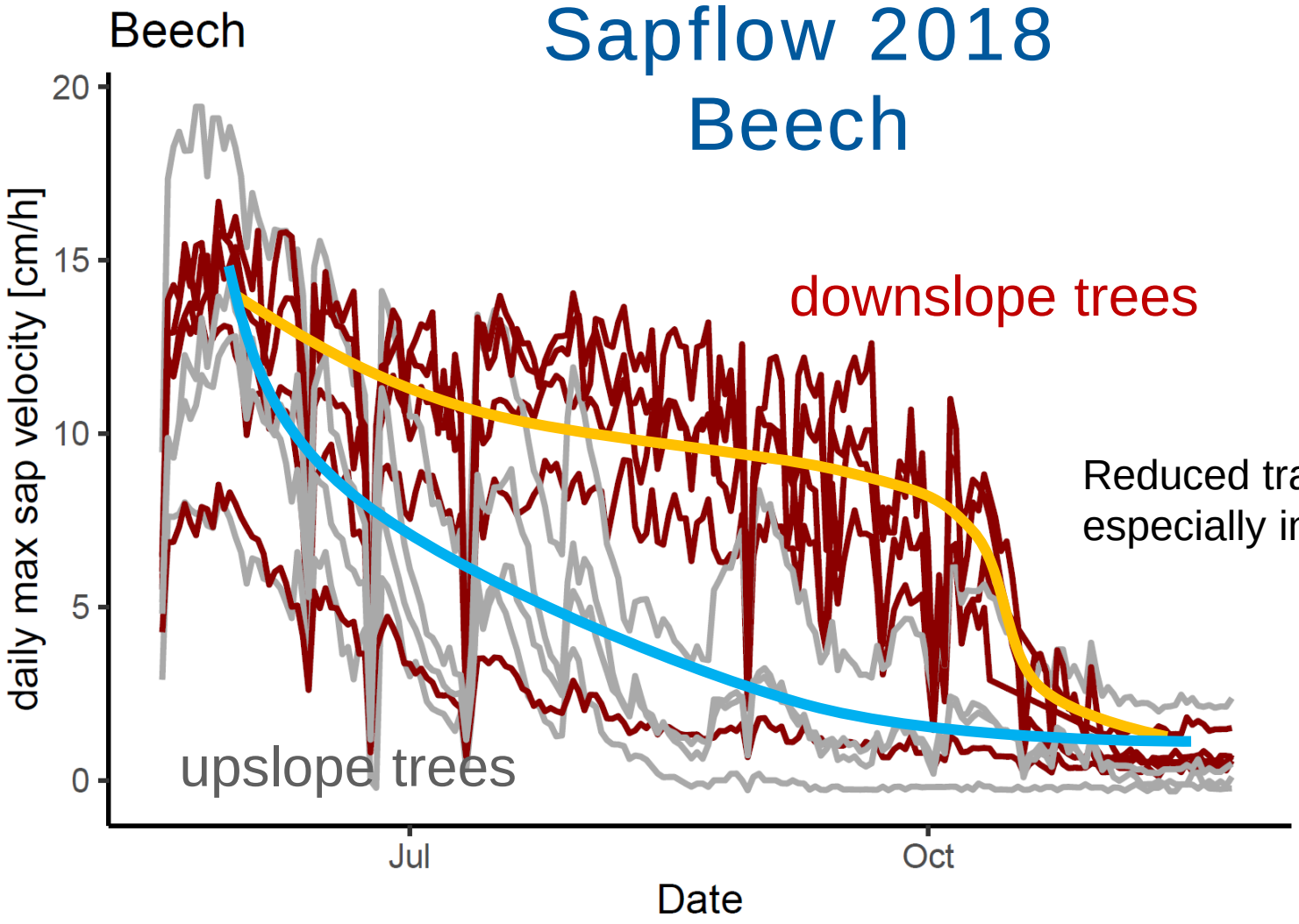


Sapflow 2018
Beech



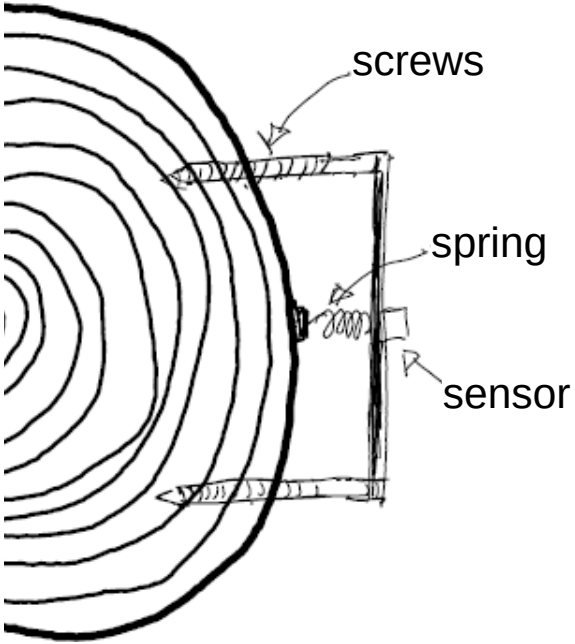
upslope trees (no groundwater access)

Sapflow 2018
Beech

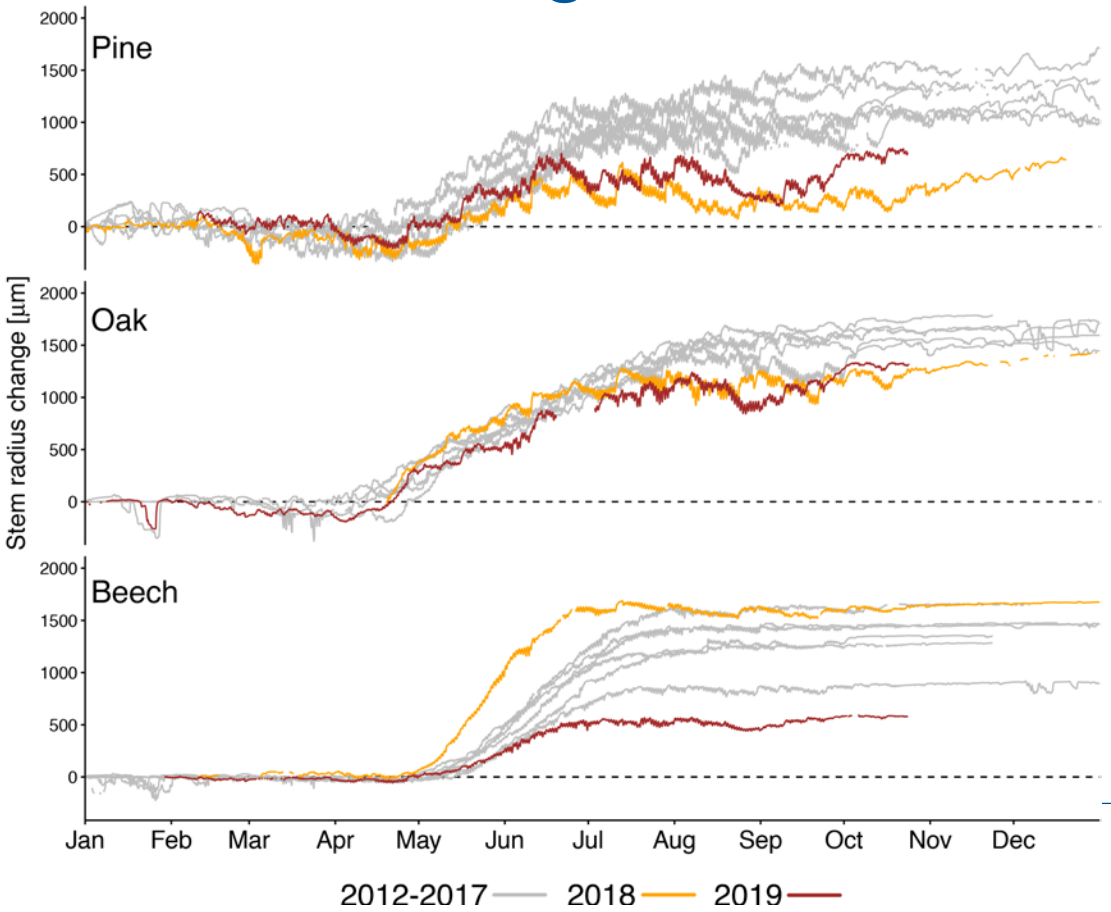


Reduced transpiration,
especially in upslope trees

Dendrometer Measurements



Tree growth



Reduced growth

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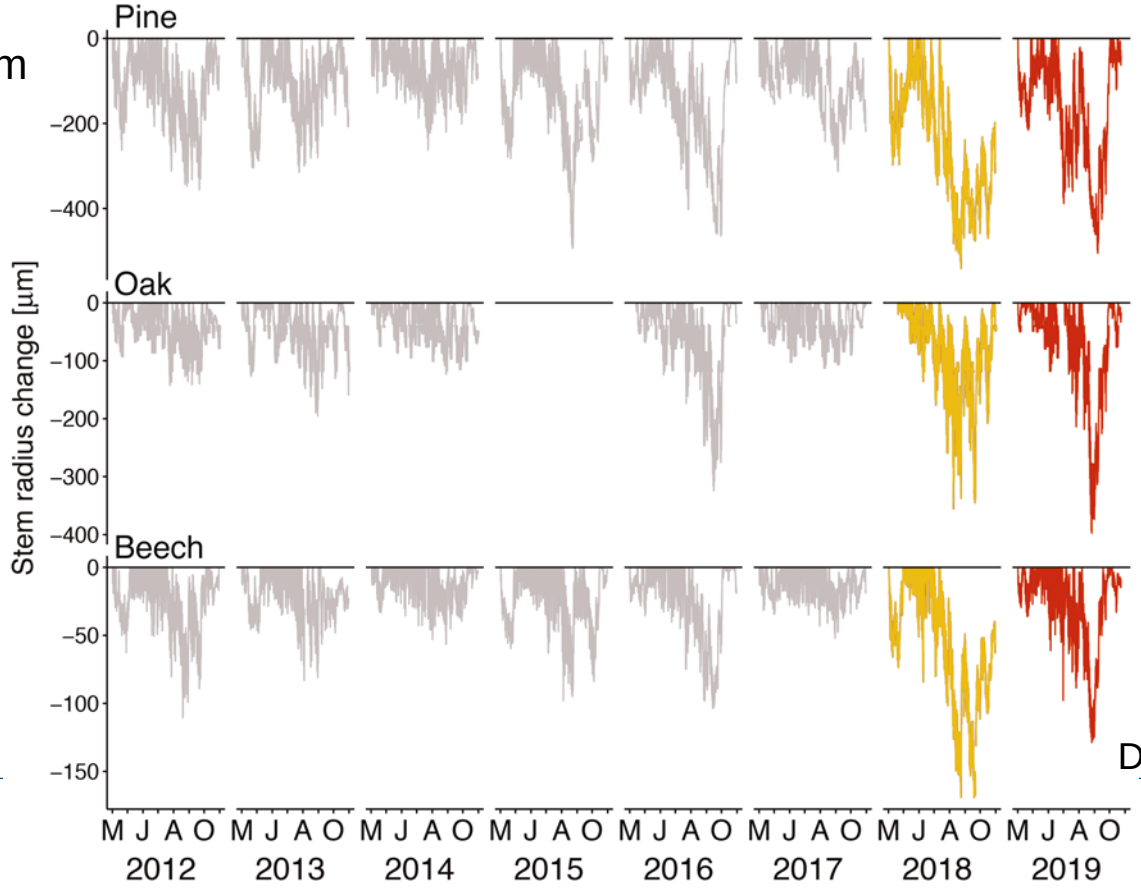
Tree water deficit

based on tree stem shrinkage



Longer periods of tree water deficit

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method: Zweifel et al. (2016)

Summary

- 2018 and 2019 were exceptional years:
  - very dry and hot (2018), very hot (2019)
- Soil moisture and groundwater were depleted and did not recover over the winter
- All tree species showed signs of water stress
- Tree growth was negatively affected for all species, but least for oak