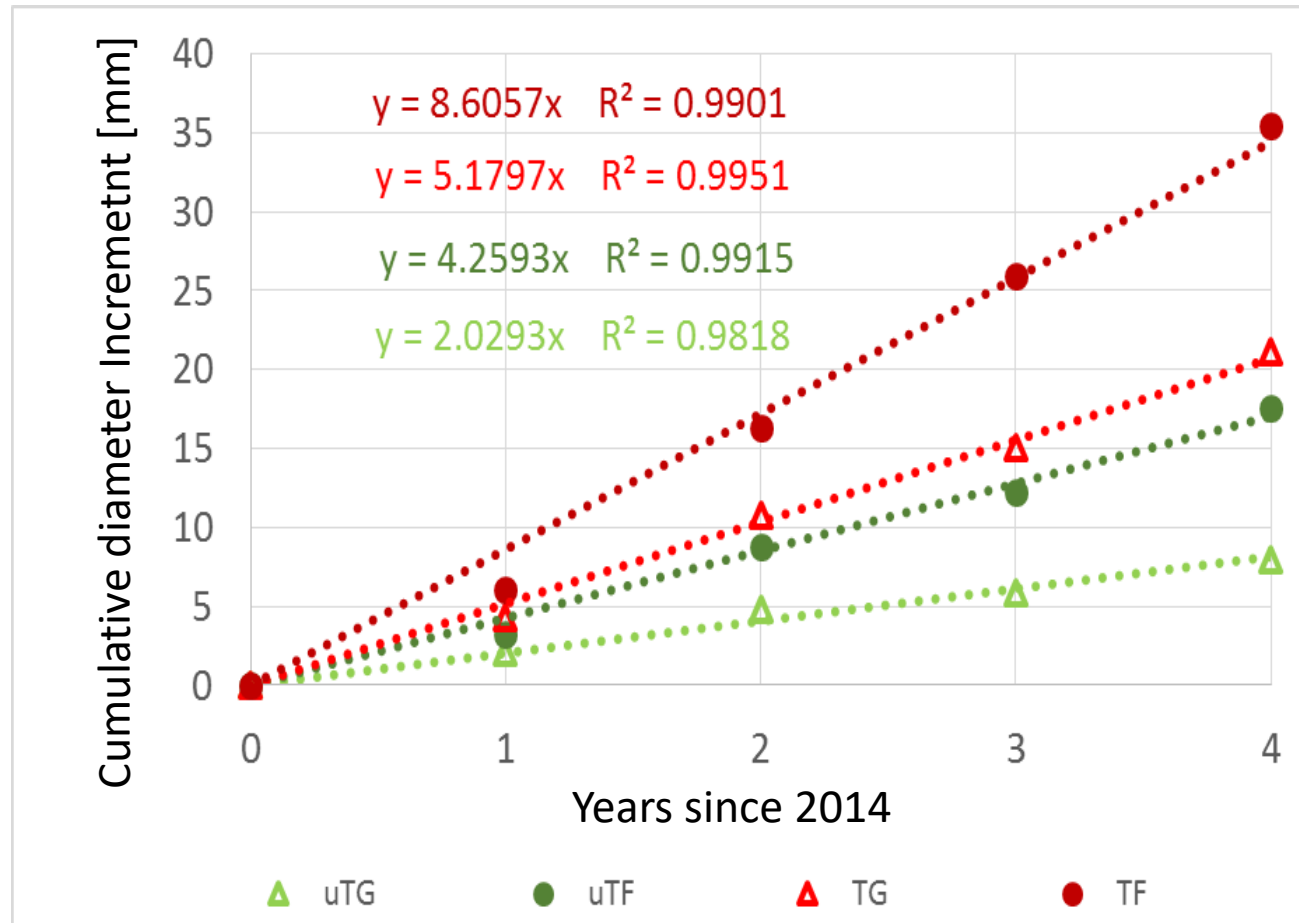# Some thoughts about the inclusion of the wind effect into growth models

Thiéry Constant, Jana Dlouha, Meriem Fournier
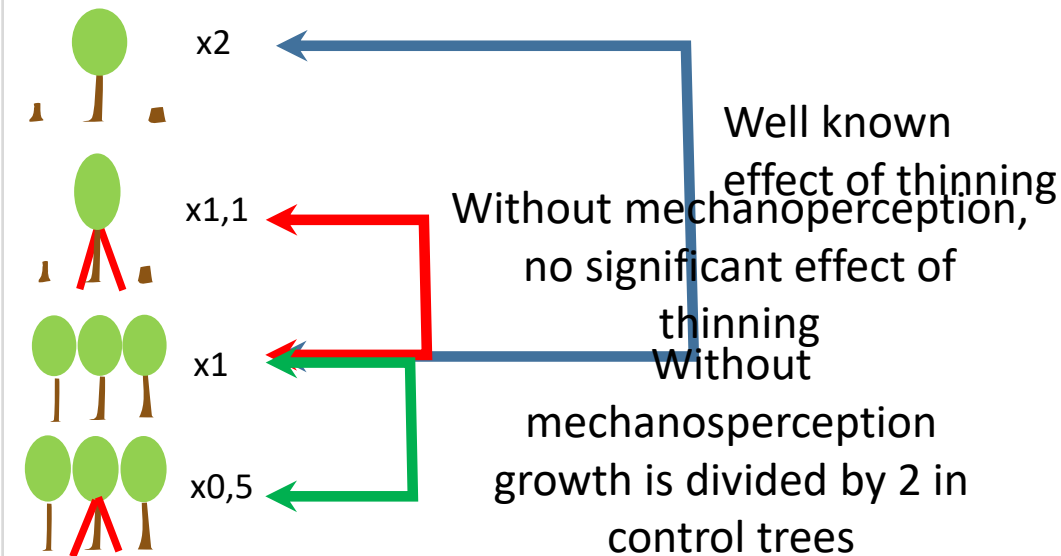
Context:

## Strong Effect of mechanoperception on DBH

Mechanical Signal : ON/OFF by guying

$y = 8.6057x \quad R^2 = 0.9901$

$y = 5.1797x \quad R^2 = 0.9951$

$y = 4.2593x \quad R^2 = 0.9915$

$y = 2.0293x \quad R^2 = 0.9818$

Cumulative diameter Incremetnt [mm]

Years since 2014

△ uTG   ● uTF   △ TG   ● TF

x2

x1,1

x1

x0,5

Well known effect of thinning

Without mechanoperception, no significant effect of thinning

Without mechanosperception growth is divided by 2 in control trees

Results issued from VentEclair experiment on beech, 10 poles per treatment
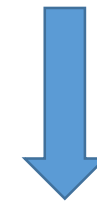
2

Context :

Strong effect of mechanoperception on diametral growth
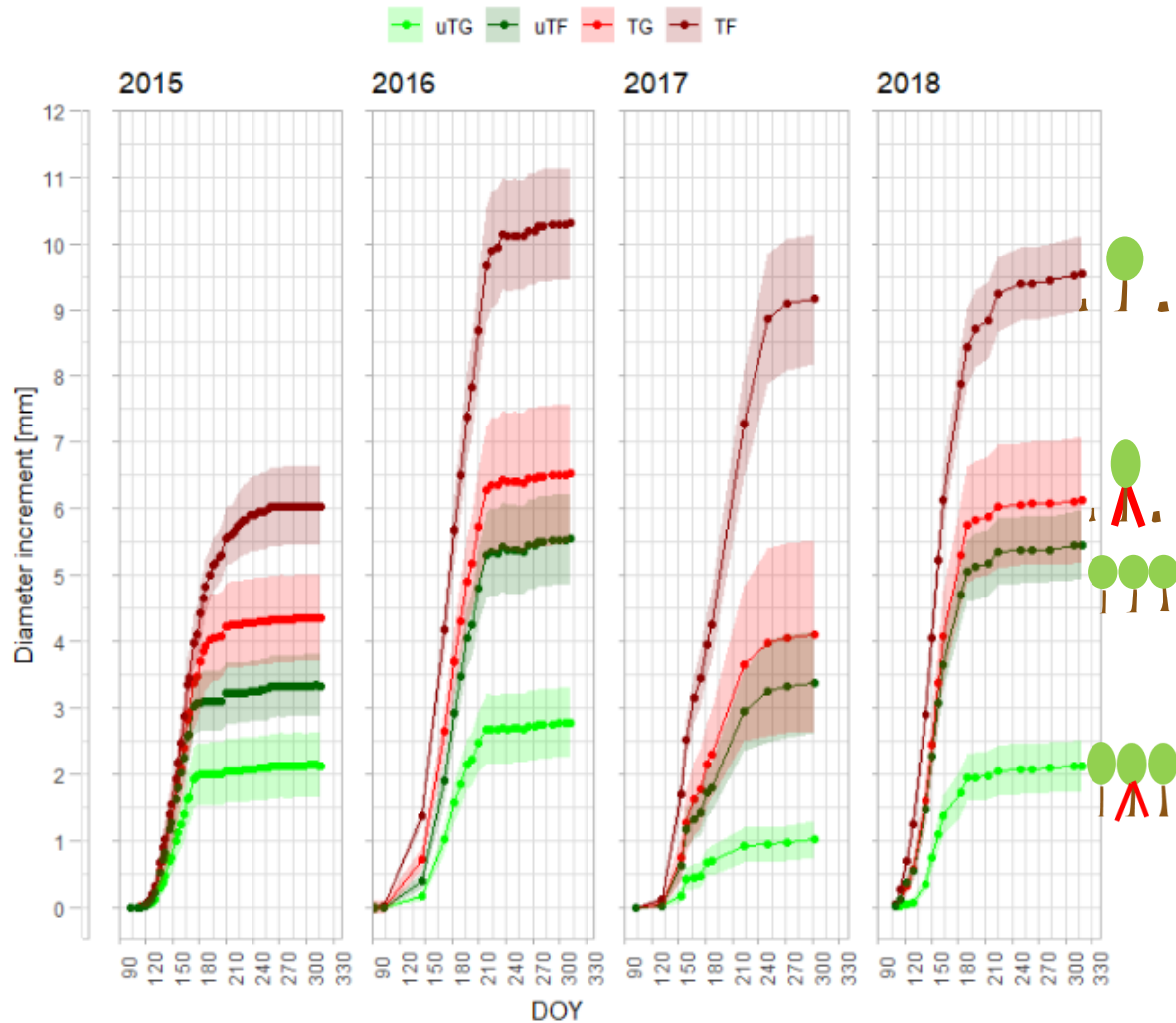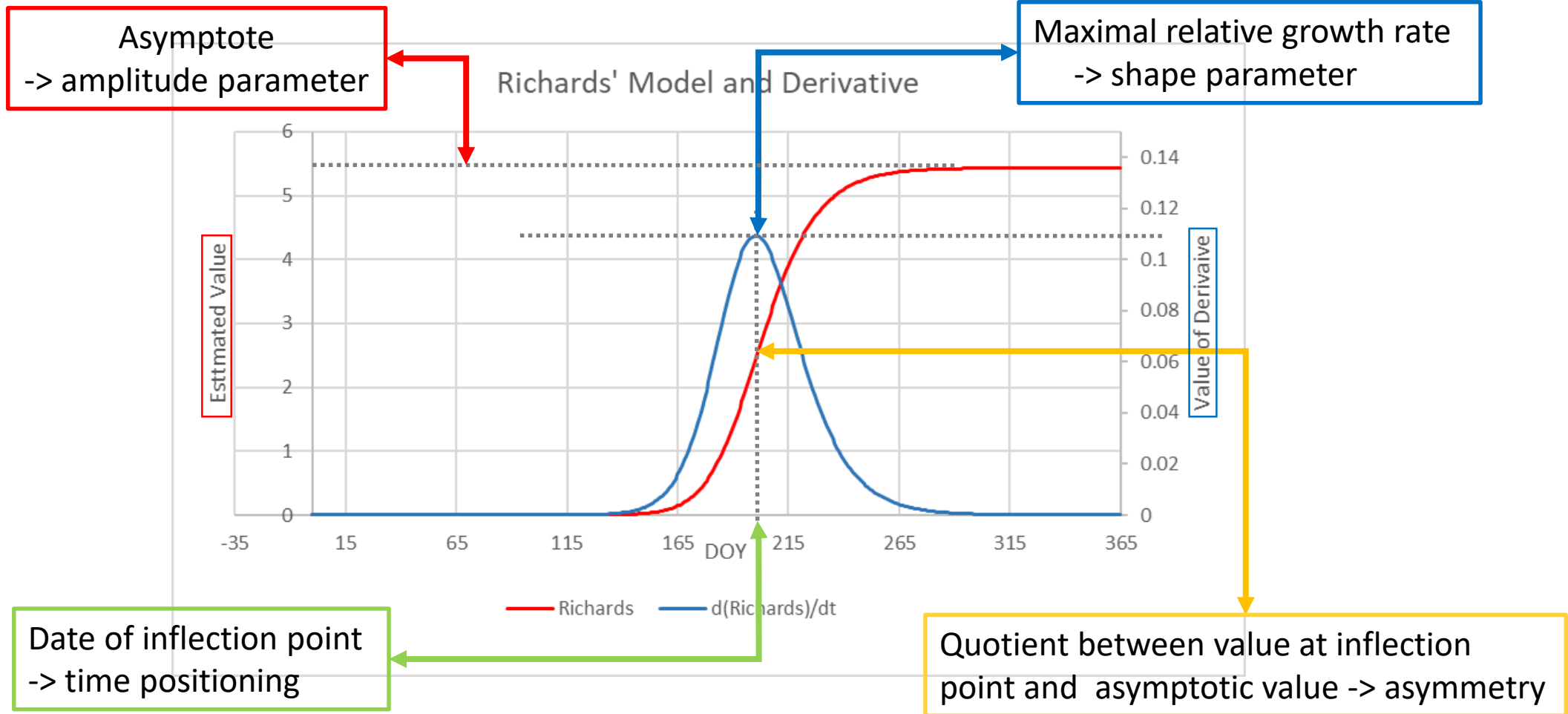

Beyond the ON-OFF effect due to guying :

➢ What is the importance of swaying under wind during the growth season?

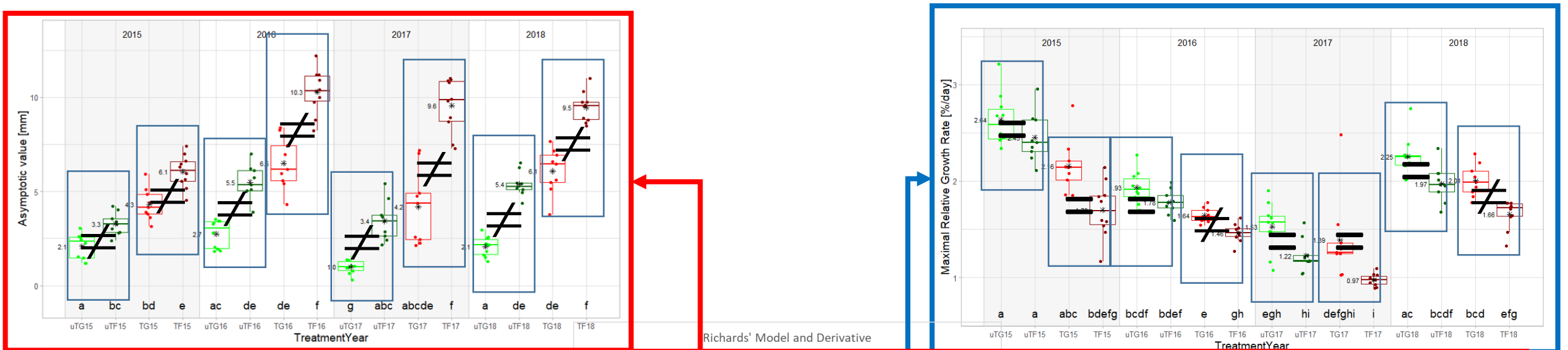➢ Does it contribute to the inter-annual differences ?

How to answer ?

Constant et al. en préparation

Where to look for the wind effect ?

4 meaningfull parameters defining Richards 's model of a growth curve

Asymptote
-> amplitude parameter

Maximal relative growth rate
-> shape parameter

Richards' Model and Derivative

Date of inflection point
-> time positioning

Quotient between value at inflection
point and asymptotic value -> asymmetry

Esttmated Value

Value of Derivaive

DOY

Richards   d(Richards)/dt

Richards' Model and Derivative

Despite contrasted years, for both stand structures, almost no significant differences of parameters between guyed and free trees except for the asymptotes.

Assumption : The mechanosensing effect is concentrated on the final growth magnitude, so its effect on radial growth for shorter periods must be connected to windy days during this period

Richards   d(Richards)/dt

5
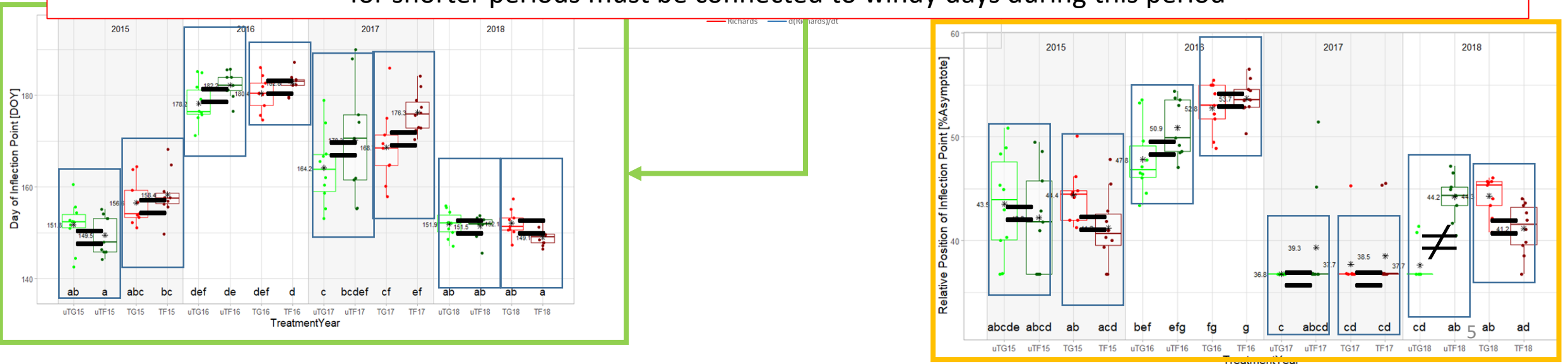
Which variables for modelling the successive radial increments along a year?

Diametral Increment during X days

Availability: Difference of growth between both dates simulated from individual growth models

1st Need :
to reflect the general trend of seasonal growth variation (photoperiod, summer droughter than spring...)

Variable :
Order of the X days period since the beginning of growth

Availability:
- Beginning of growth identified by modelling

2d Need :
To synthesize the water stress during the period

Variable :
Number of days without water stress during the period

Availability:
- From Biljou (Water Balance Model) :
Daily REW >=0.4

3rd Need :
- To introduce a proportionality between the ability to grow and the doping effect due to wind over a windspeed threshold
(cf. Bonnesoeur et al. 2016)

Variable :
Number of days without water stress AND with strong wind during the period

Availability:
- By crossing daily REW and maximal daily Windspeed

First Case : Thinned trees, Free to sway under wind:
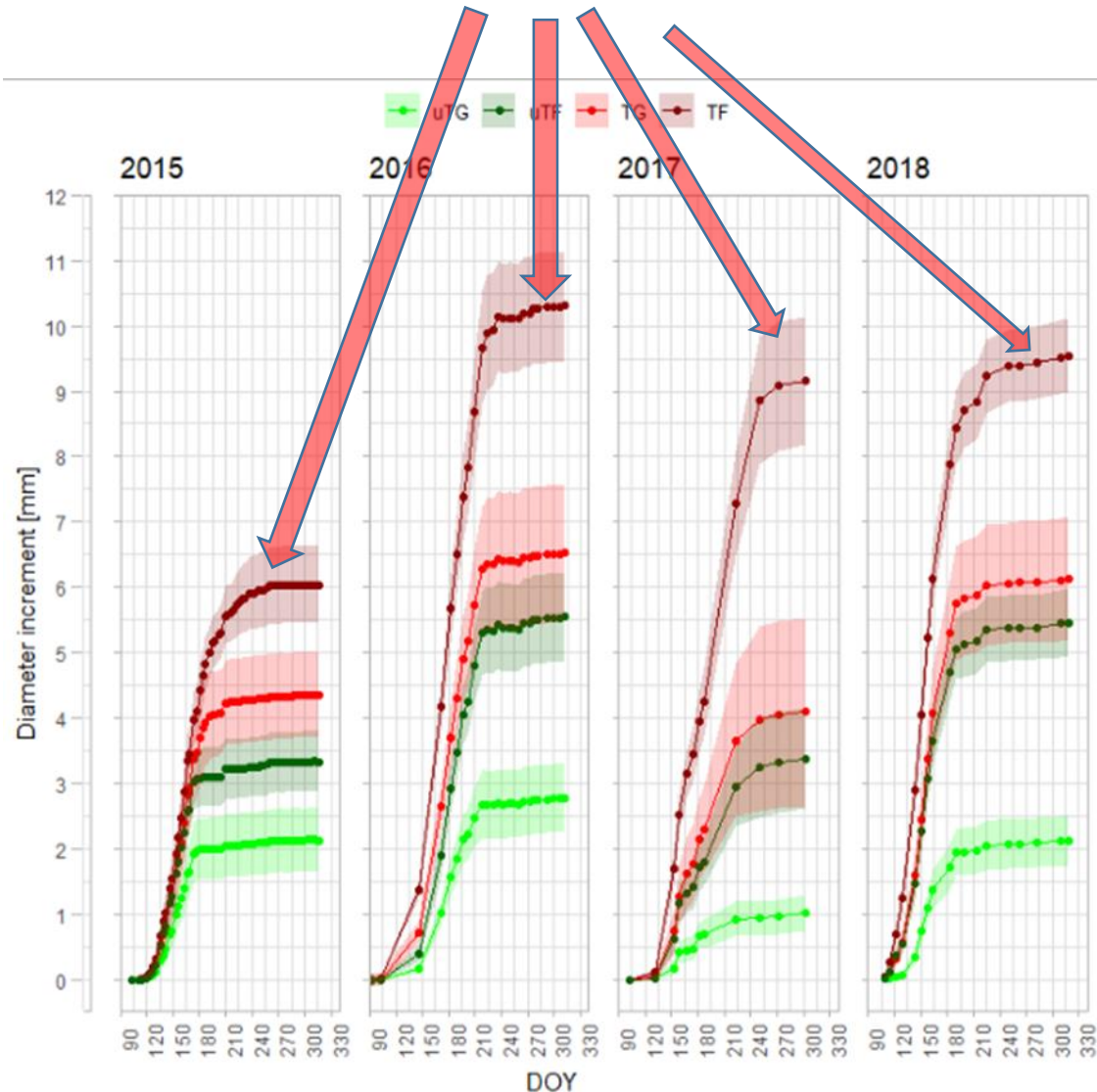
2 preliminary choices (rediscussed afterwards)
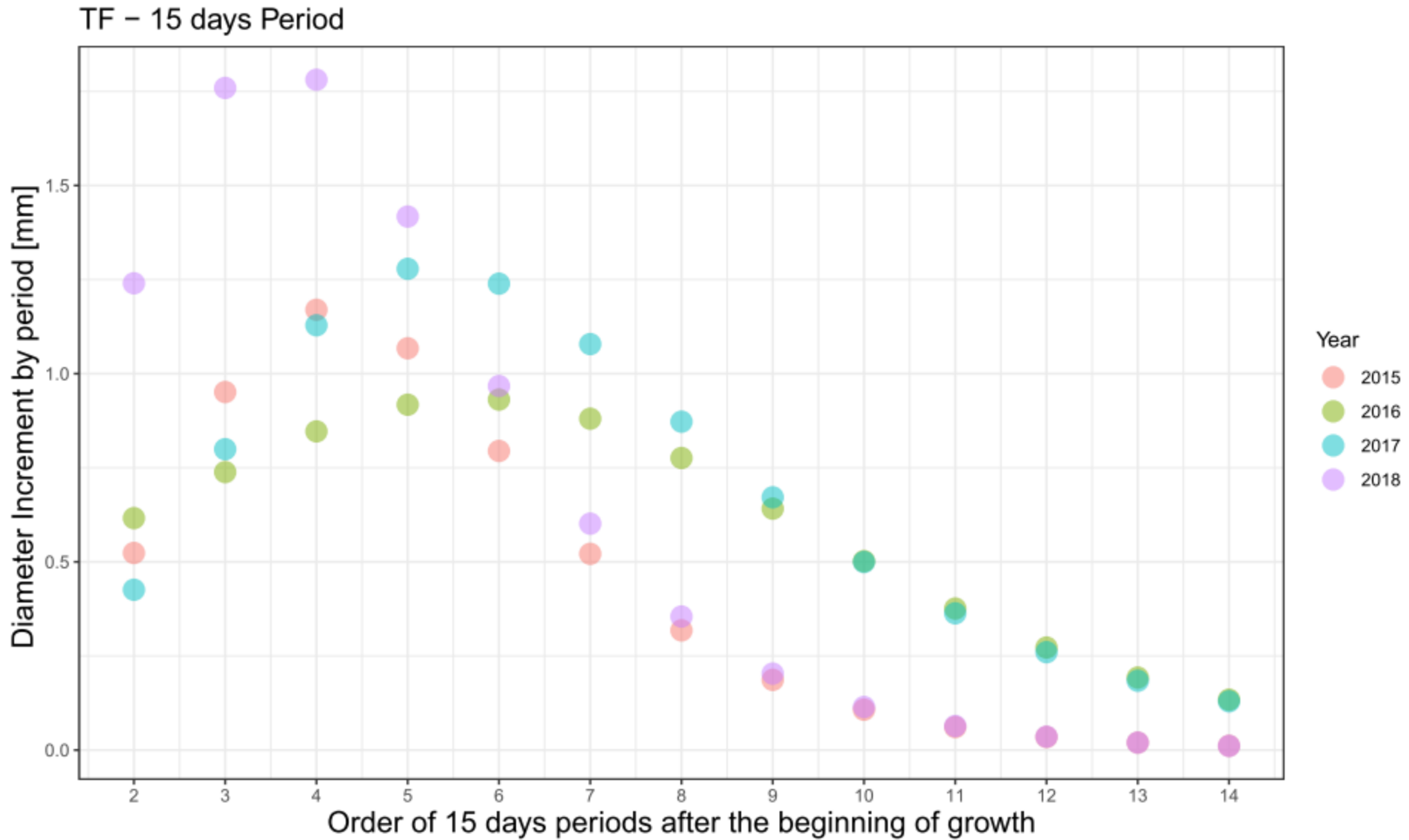
- Which duration for the period?
    - Not too short because of the smoothing effect of Richard's models
    - Not too long because the maximal variation of radial growth in four months
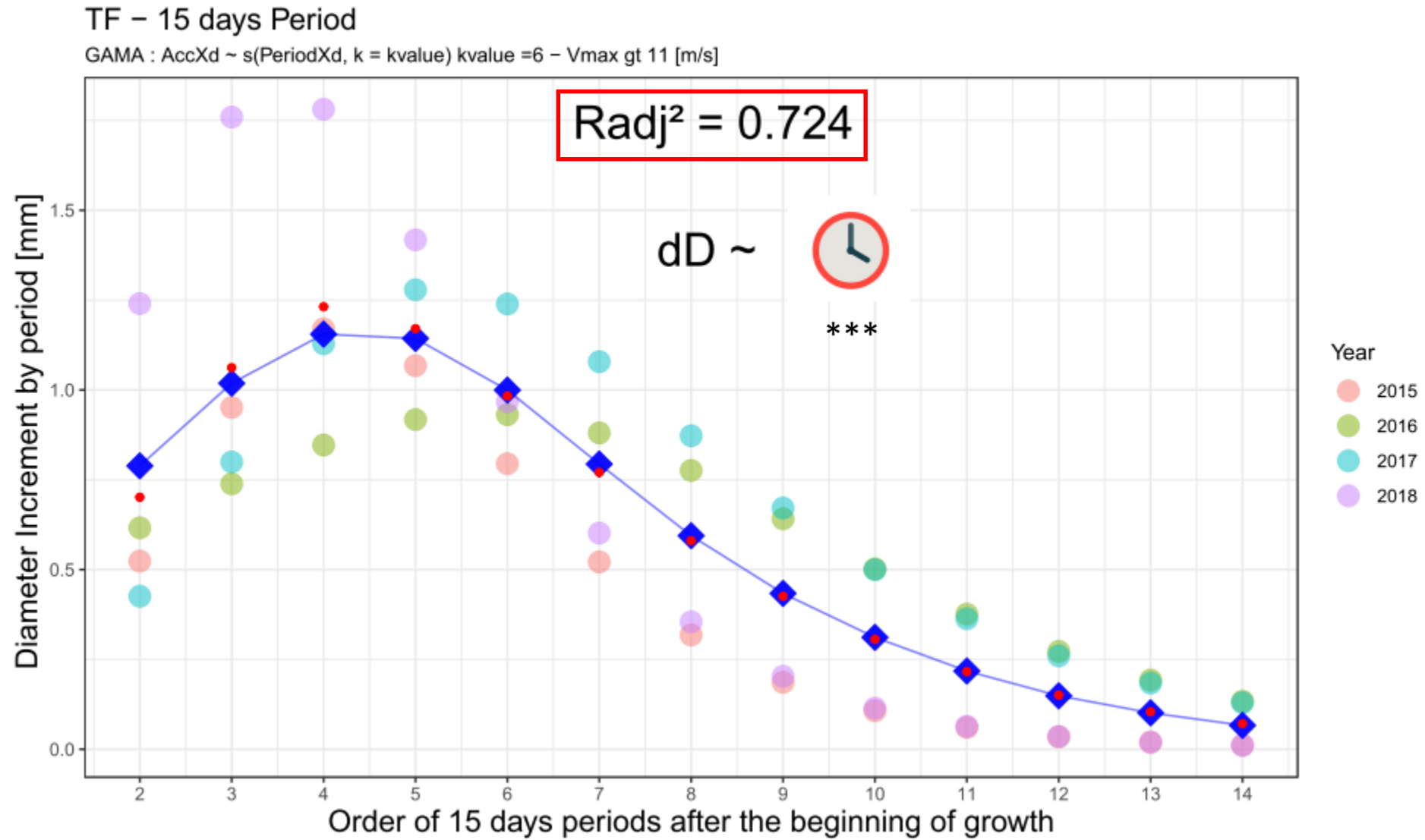
    ↳ 7 days < 15 days < 30 days ?

- Which windspeed threshold for a strong wind day?
    - Trees don't react to frequent stimulations of low intensities
    - In our data : 6 m/s < Daily Vmax < 16 m/s
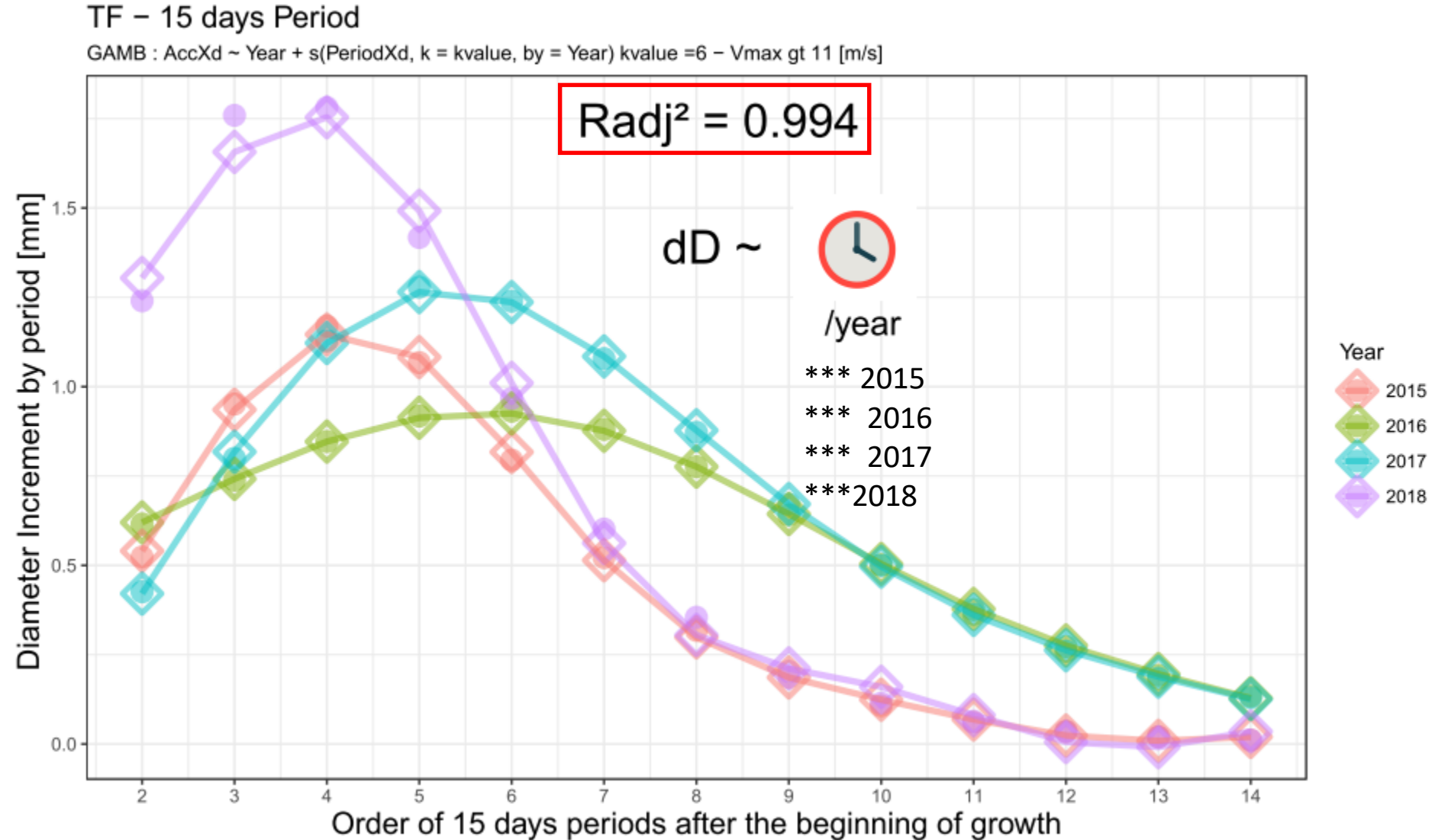   - Meteorological strong winds : Vmax > 10 m/s

    ↳ V max > 11 m/s

Diameter Increments vs. Order of 15 days Periods by years

TF – 15 days Period

1st GAM : Diameter Increments vs. period order

TF − 15 days Period

GAMA : AccXd ~ s(PeriodXd, k = kvalue) kvalue =6 − Vmax gt 11 [m/s]

Radj² = 0.724

dD ~

***

Year
- 2015
- 2016
- 2017
- 2018

Diameter Increment by period [mm]

Order of 15 days periods after the beginning of growth

Reference GAM : Diameter Increments vs. period order for each year

TF − 15 days Period

GAMB : AccXd ~ Year + s(PeriodXd, k = kvalue, by = Year) kvalue =6 − Vmax gt 11 [m/s]

$R_{adj}^2 = 0.994$

$dD \sim$ /year

*** 2015
*** 2016
*** 2017
***2018

Diameter Increment by period [mm]

Order of 15 days periods after the beginning of growth
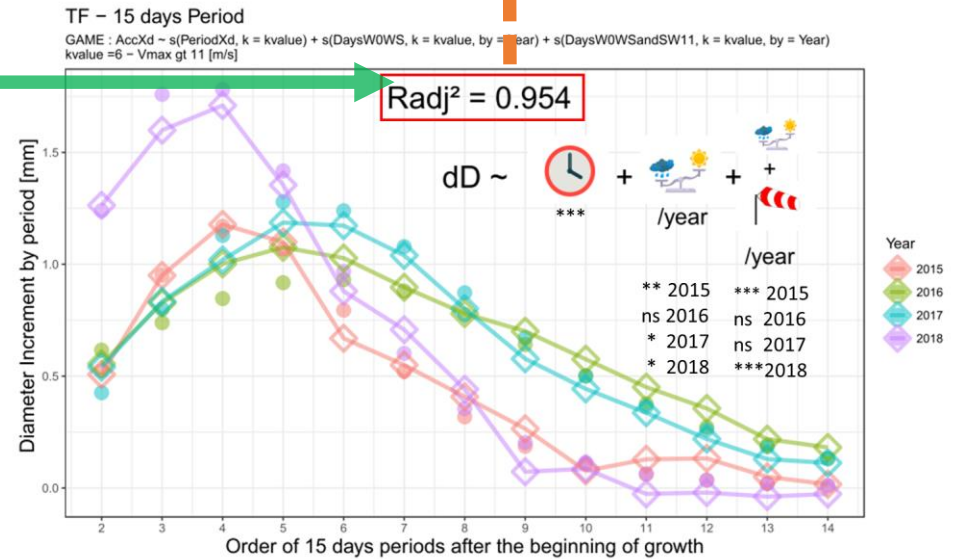
Year
2015
2016
2017
2018

GAM : Diameter Increments vs. period order and Days With No Water Stress during each period

TF – 15 days Period

GAMC : AccXd ~ s(PeriodXd, k = kvalue) + s(DaysW0WS, k = kvalue, by = Year) kvalue =6 – Vmax gt 11 [m/s]

Radj² = 0.794

dD ~ 🕐 + 🌧️
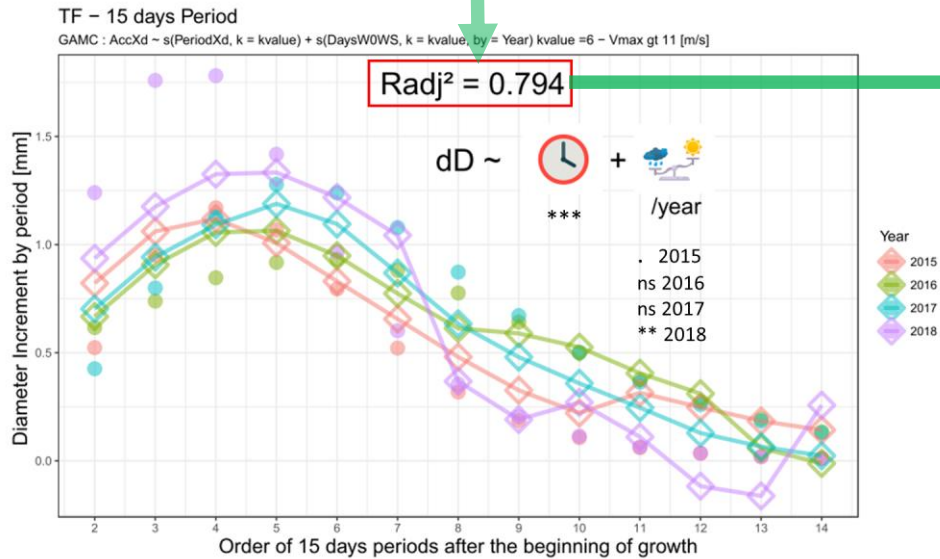
*** /year
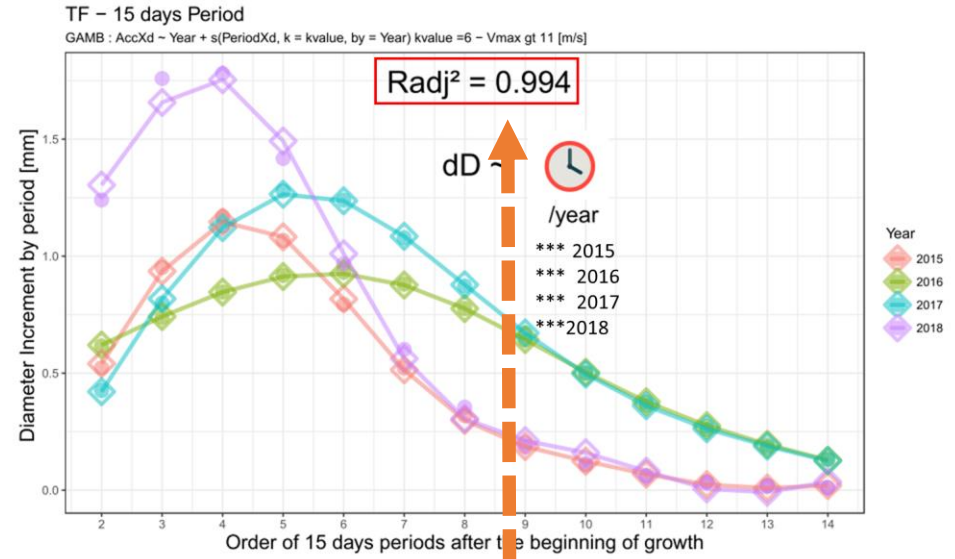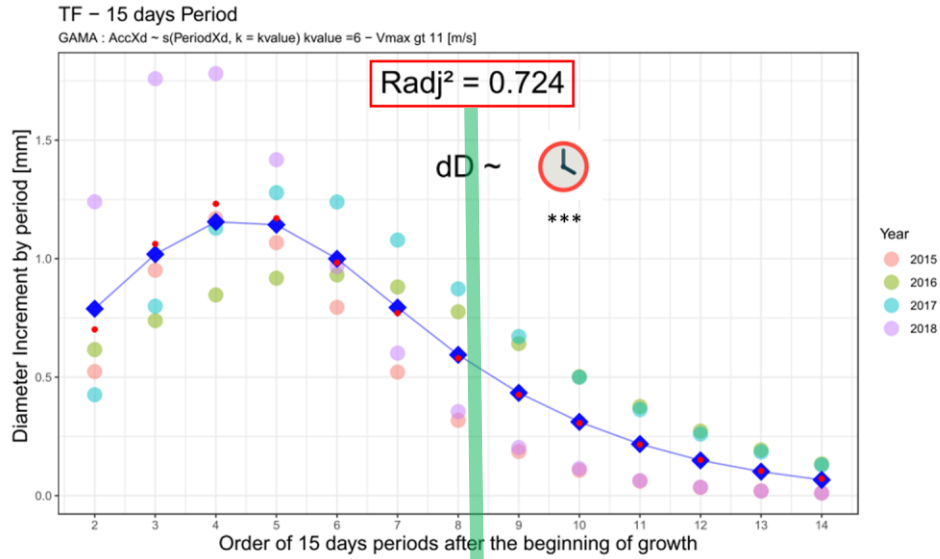
. 2015
ns 2016
ns 2017
** 2018
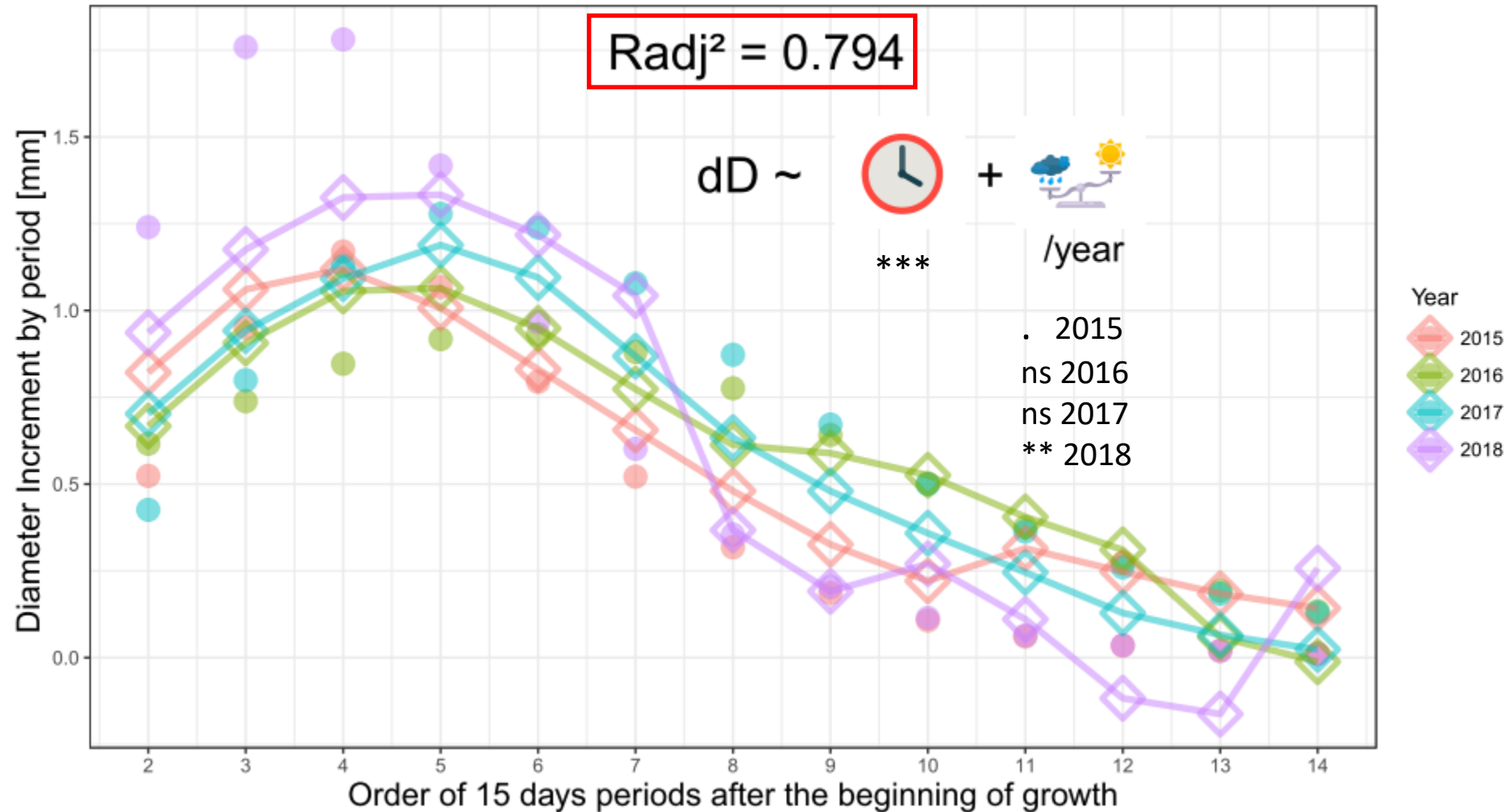
GAM : Diameter Increments vs. period order
and Days With No Water Stress
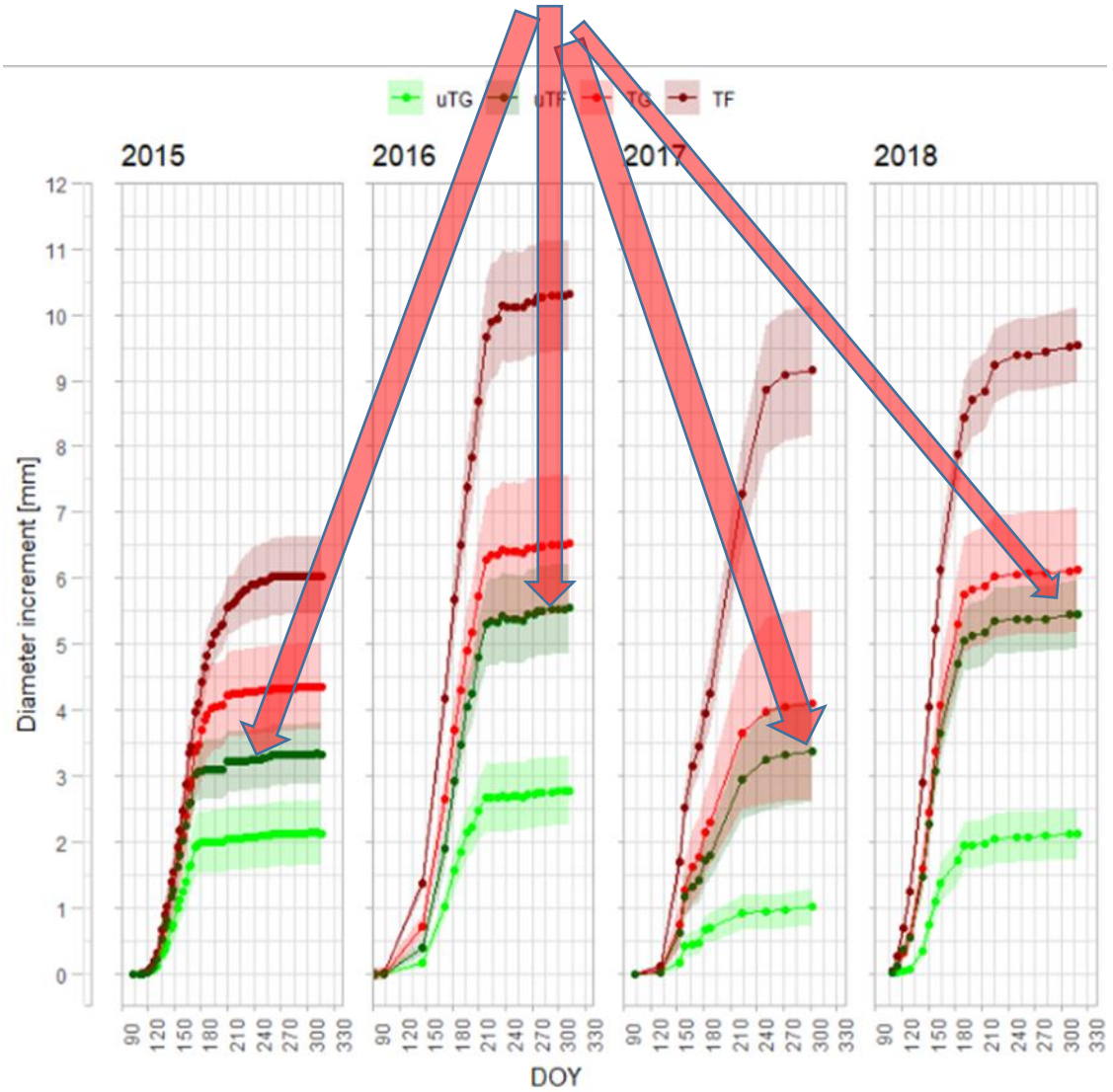## and (Days With Strong Wind and No Water Stress) during each period

TF − 15 days Period

GAME : AccXd ~ s(PeriodXd, k = kvalue) + s(DaysW0WS, k = kvalue, by = Year) + s(DaysW0WSandSW11, k = kvalue, by = Year)
kvalue =6 − Vmax gt 11 [m/s]

Radj² = 0.954

$dD \sim$ ⏰ + ☔ + 🌬

***

/year

/year

** 2015   *** 2015
ns 2016   ns 2016
* 2017   ns 2017
* 2018   ***2018

Year
2015
2016
2017
2018

Diameter Increment by period [mm]

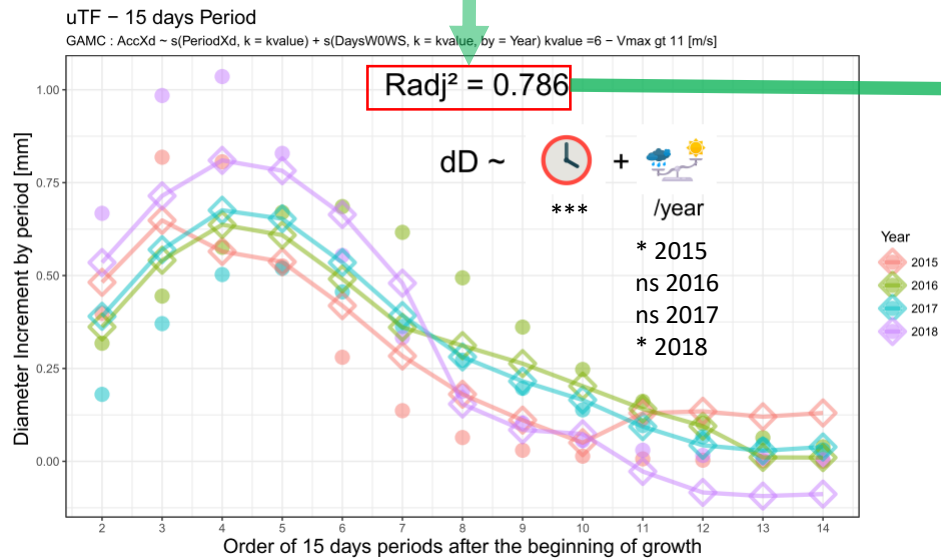Order of 15 days periods after the beginning of growth
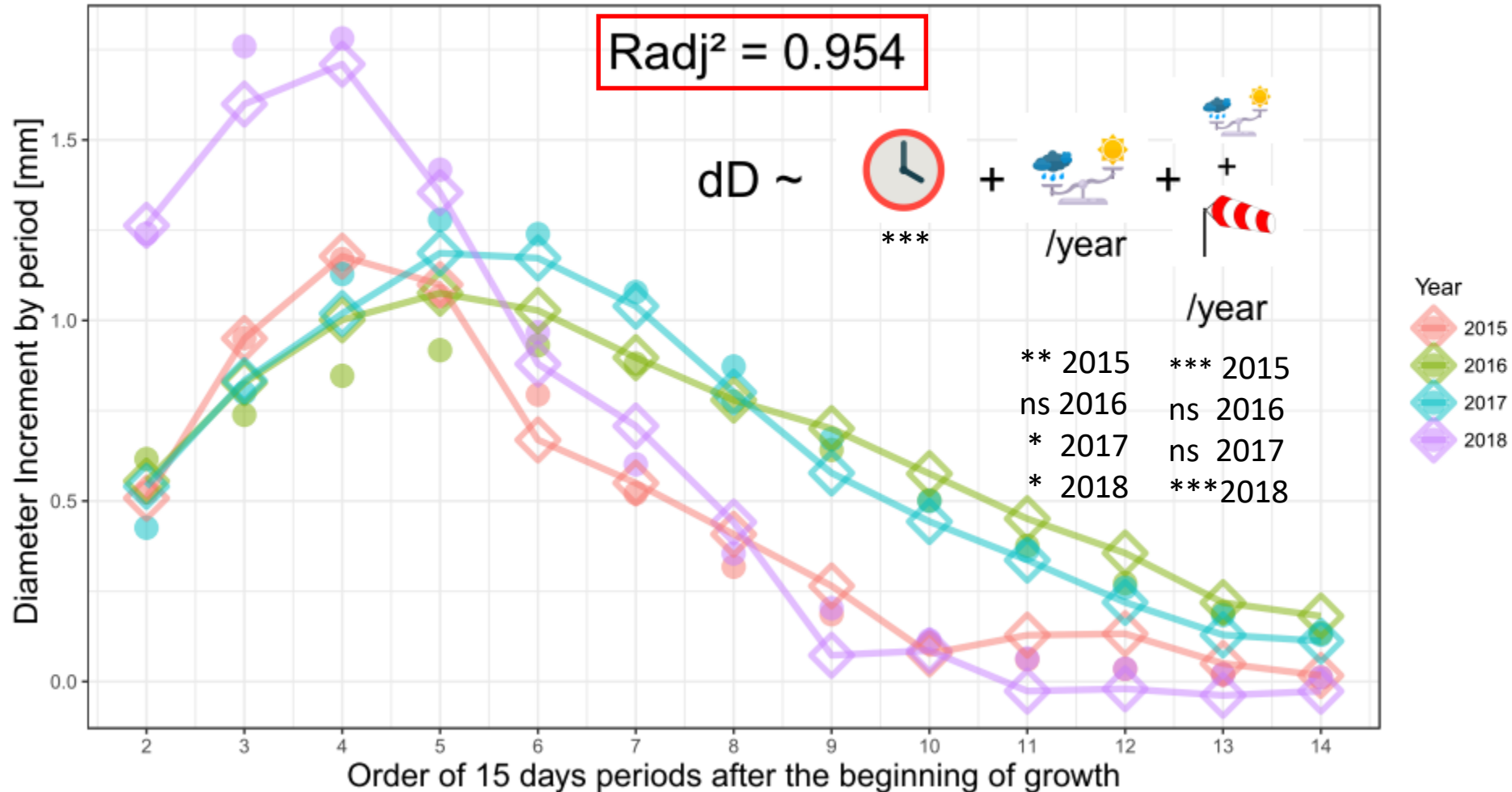
Thinned trees: Summary

Second Case : Control trees, Free to sway under wind:

Control trees: Summary

uTF − 15 days Period
GAMA : AccXd ~ s(PeriodXd, k = kvalue) kvalue =6 − Vmax gt 11 [m/s]

Radj² = 0.719

dD ~ 🕐 ***

uTF − 15 days Period
GAMB : AccXd ~ Year + s(PeriodXd, k = kvalue, by = Year) kvalue =6 − Vmax gt 11 [m/s]

Radj² = 0.981

dD ~ 🕐 /year
*** 2015
*** 2016
*** 2017
*** 2018

uTF − 15 days Period
GAMC : AccXd ~ s(PeriodXd, k = kvalue) + s(DaysW0WS, k = kvalue, by = Year) kvalue =6 − Vmax gt 11 [m/s]

Radj² = 0.786

dD ~ 🕐 + 🌧️☀️
*** /year
* 2015
ns 2016
ns 2017
* 2018

uTF − 15 days Period
GAME : AccXd ~ s(PeriodXd, k = kvalue) + s(DaysW0WS, k = kvalue, by = Year) + s(DaysW0WSandSW11, k = kvalue, by = Year) kvalue =6 − Vmax gt 11 [m/s]

Radj² = 0.824

dD ~ 🕐 + 🌧️☀️ + 🚩
*** /year /year
ns 2015   ns 2015
ns 2016   ns 2016
ns 2017   ns 2017
ns 2018   ** 2018

15

Back to the windspeed threshold : is 11m/s relevant?
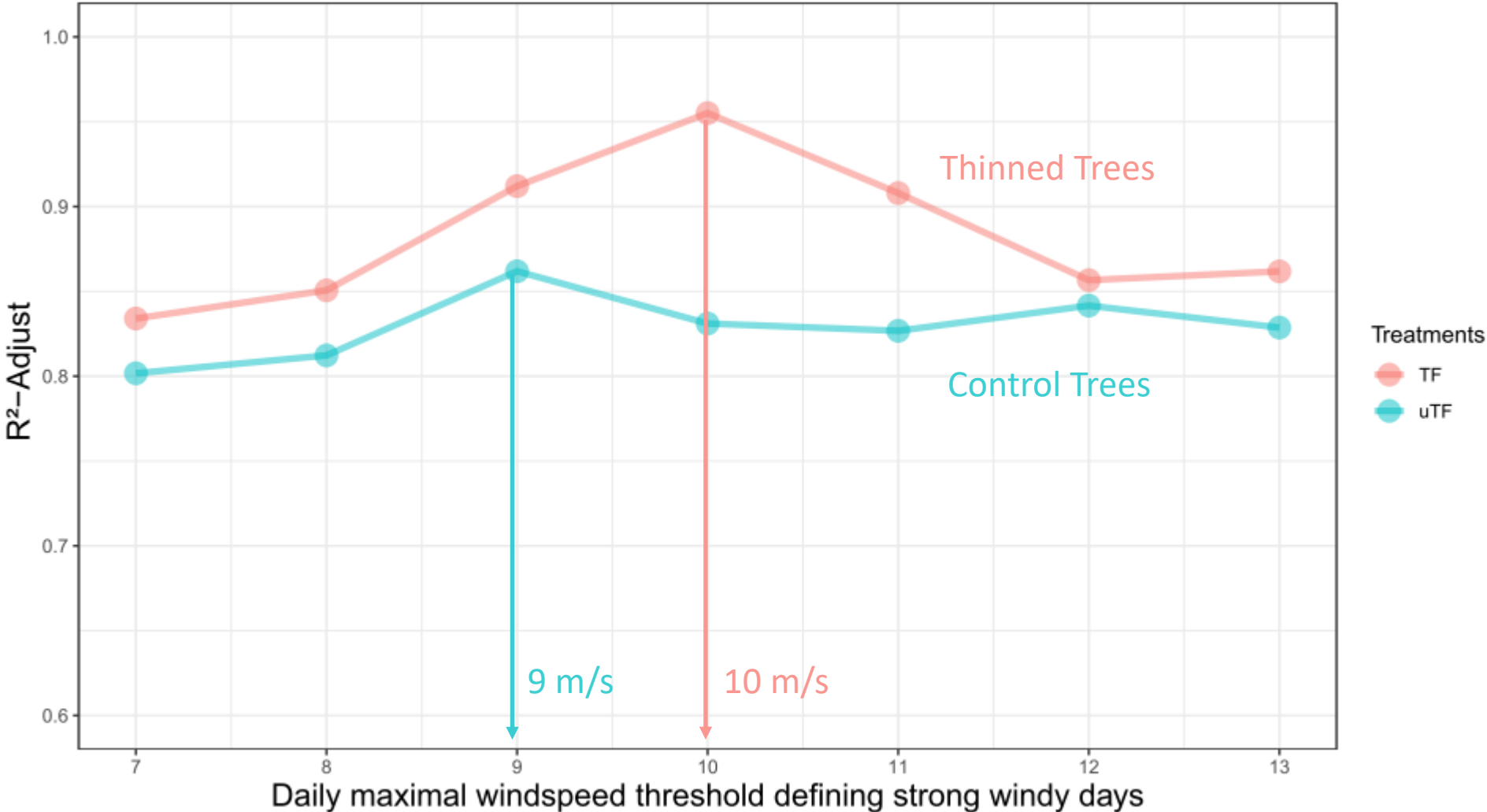
Back to the duration of the period : is 15 days relevant?

7 days

Limits for coupling increments computed from Richard's model to climatic events during such a short duration. Especially for max wind speed over 11 m/s
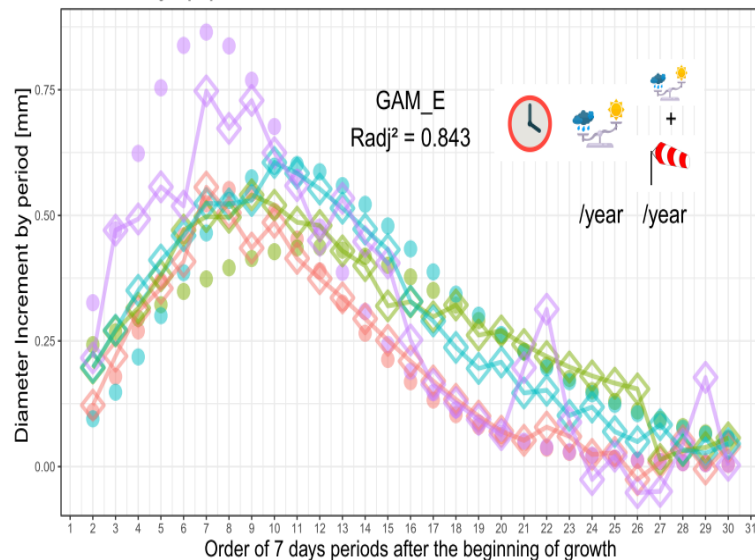
15 days

Good performance

30 days

Model performance close to 15 days ones, but the number of periods is small, and enhancing the effect of missing data at the beginning of growth
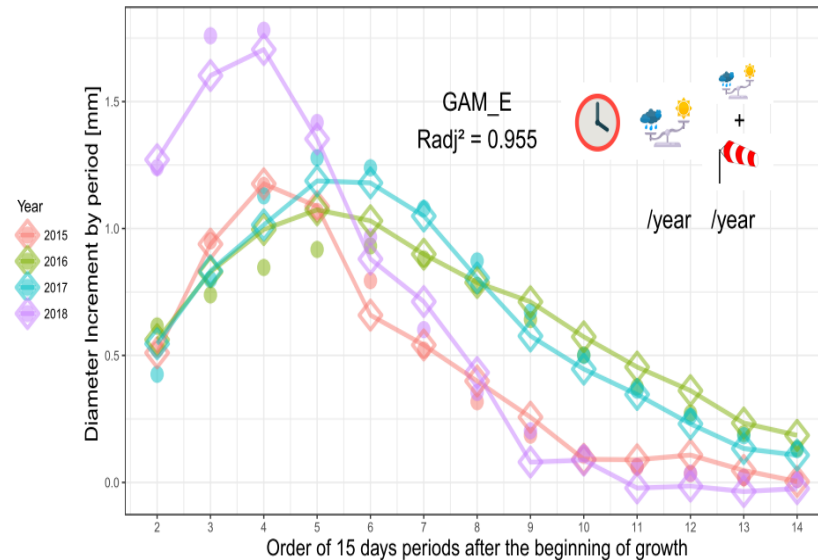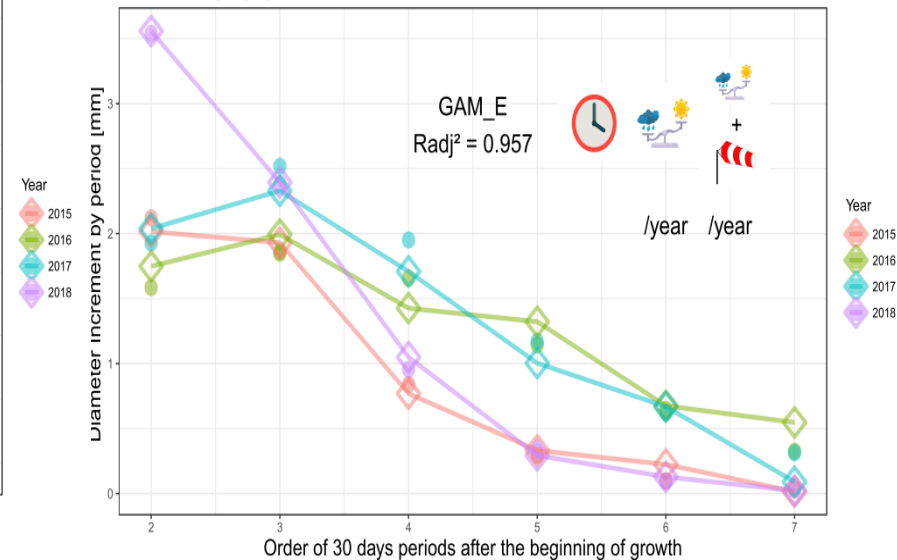
Conclusions and Perspectives :

- Daily Maximal Windspeed over a given threshold is very relevant to catch the interrannual variation of radial growth in addition to water stress information on X days periods.

- With our imperfect data, 15 days periods is the best compromise,
    - But this must be confirmed by using growth data recorded at a daily frequency, added to similar information on daily windspeed and water balance.
    - Can we integrate this effect at the annual time step ?

- Windspeed threshold is a keypoint : in our experiment Vmax ~ 10 m/s seems relevant,
    - But trees are rather similar : Does it vary a lot with the structure of the stand, species,.. ?
    - This work proposed a methodology to determine it in a specific context.
    - Biologically, this threshold is linked to a mechanical strain threshold resulting from the tree answer to the corresponding drag force.
    - Is it possible to simplify the physical problem by a transfer function linking windspeed and strain based on stand structure information?

Merci de votre attention

uTF − 15 days Period

GAMD : AccXd ~ s(PeriodXd, k = kvalue) + s(DaysW0WSandSW11, k = kvalue, by = Year) kvalue =6 − Vmax gt 11 [m/s]

$R_{adj}^2 = 0.825$

dD ~ 🕐 + + /year

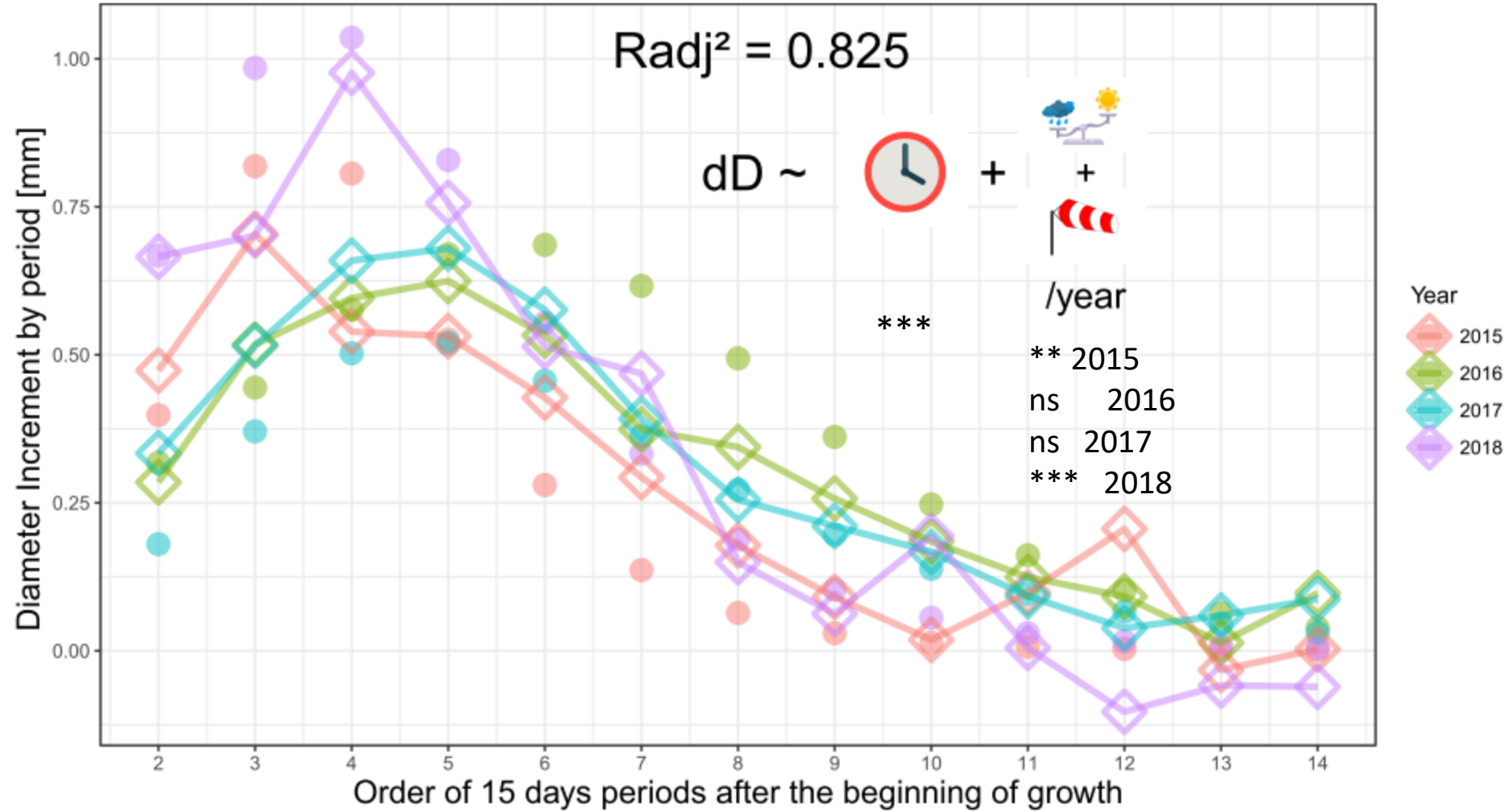***

** 2015
ns   2016
ns 2017
*** 2018

Year
2015
2016
2017
2018

23

Which variable are supposed to influence these periodic increments?

For a given year the number of days without water stress during each period was computed with Biljou

from the resulting daily variation of Relative Extractable Water (REW)

Relative Extractable Water along year 2017

REW < 0.4
→ Water Stress