golfin@inia.es

Behavior of the wood outside the contact with the ground in Spain. Project BIA 2013-42434R

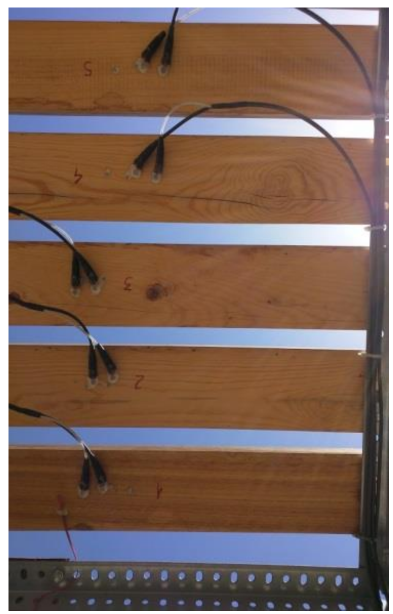
Galván, J., Acuña, L., Conde, M., Conde, M., Fernández-Golfín, J

INIA
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria

National Institute for Agrifood Research and Technology

objetives

- M.C. monitoring under different climatic regimes (Spain)
- Effect of species and climatic events (rain, dew, hoarfrost)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variables

7 species and types of wood

Dimensions: Boards of 20 x 100 x 750 mm^3

Eucalypt (EU),
Laricio P. (PL),
Spruce (PC),
Scots P. (PS),
Radiata P. (PR),
Chestnut (CS),
Thermotreated Radiata P.(PRMMT)

7 sites

In Madrid also a 150x150x750 mm^3 Scots pine sample (PSMEG) was included to assess the massivity effect.

Asturias-Llanes,
Vitoria
Palencia
Valencia
Madrid
Córdoba
Huelva

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sites

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Four interior sites with continental climate (Madrid, Palencia, Cordoba, Vitoria)

- Very cold in winter with strong dew effect, summer hot and dry (Vitoria). Scheffer index 76
- Very cold in winter occasionally dew, summer very hot and dry (Palencia). Scheffer index 74
- Mild in winter and very hot in summer with mild dew effect in winter (Cordoba). Scheffer index 35
- Cold in winter and hot and dry in summer with mild dew effect in winter (Madrid). Scheffer index 4

Three sites with sea effect (Asturias-Llames, Valencia, Huelva)

- High frequency of rain events (130), high RH (79%), (Llames), Scheffer I. 126
- Medium frequency of rain events (102), high RH (70%), (Valencia), Scheffer I. 62
- Low frequency of rain events (50), medium levels of RH (65%), (Huelva), Scheffer index 62

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methodology

Improving MC measurement. To improve MC accuracy measurement, we derived MC vs R models for Spanish species:

Eucalyptus: MC=(LOG10(LOG10(R)+1)-1,20197)/(-0,05422) (R^2= 99,7%) [unpublished]

Laricio Pine: MC=(LOG10(LOG10(R)+1)-1,06875)/(-0,037175) (R^2= 99,7%) [1]

Spruce: MC=(LOG10(LOG10(R)+1)-1,014)/(-0,034) (R^2= 92,2) [3]

Scots pine: MC=(LOG10(LOG10(R)+1)-1,10078)/(-0,039267) (R^2= 99,3%) [1]

Radiata pine: MC=(LOG10(LOG10(R)+1)-1,11945)/(-0,0414) (R^2= 99,4%) [1]

Sweet chestnut: MC=(LOG10(LOG10(R)+1)-1,03248)/(-0,041097) (R^2= 99,3%) [1]

Thermotreated radiata: MC=(LOG10(LOG10(R)+1)-1,08884)/(-0,046215) (R^2= 99,7%) [2]

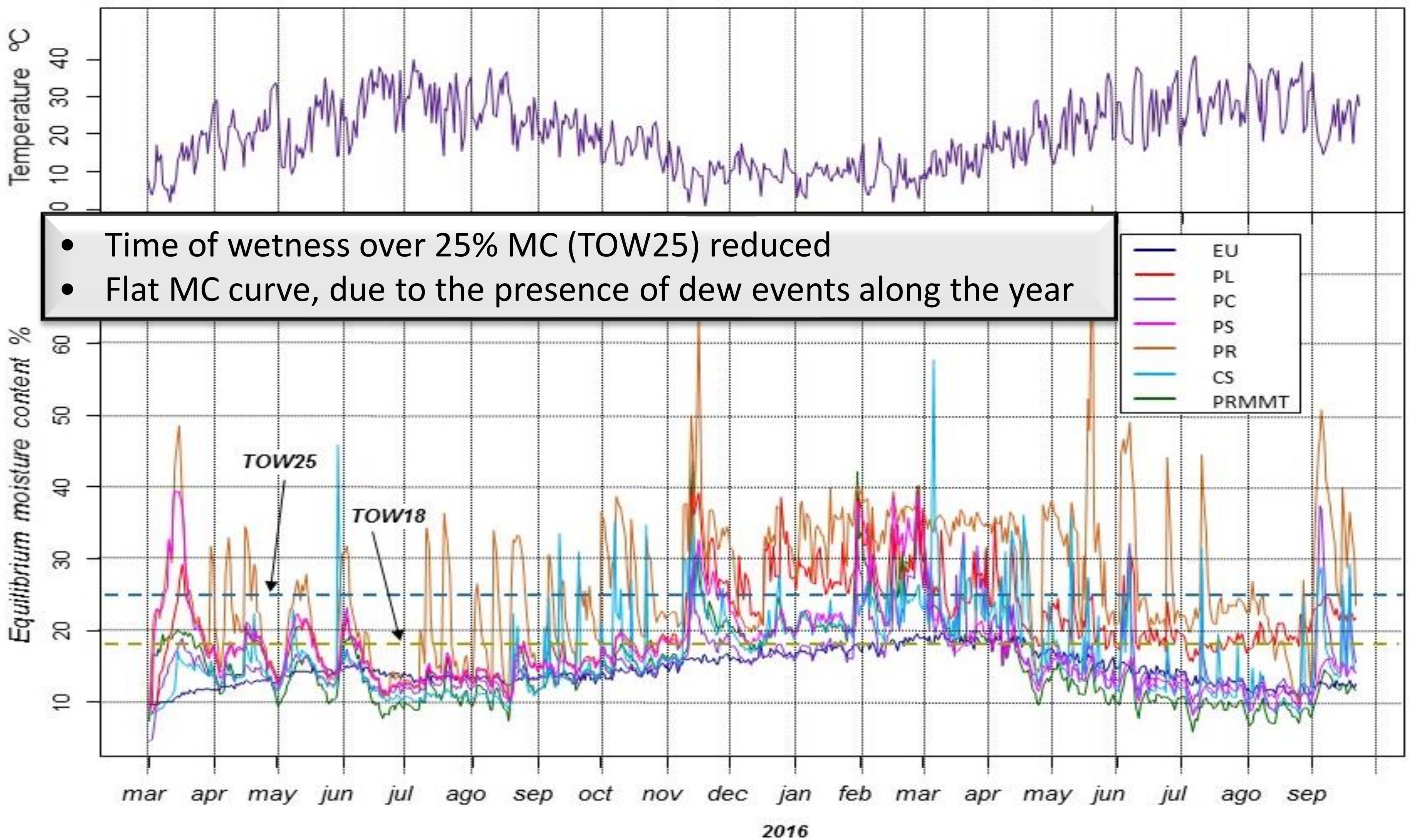
Maritime pine: MC=(LOG10(LOG10(R)+1)-1,08497)/(-0,040351) (R^2= 99,5%) [3]

[1] Fernandez-Golfin, J.I.; Conde Garcia, M.; Conde Garcia, M.; Fernandez-Golfin, J.J.; Calvo Haro, R.; Baonza Merino, M.V. de Palacios, P. (2012). Curves for the estimation of the moisture content of ten hardwoods by means of electrical resistance measurements. Forest Systems (2012) 21(1):121-127. DOI: 10.5424/fs/2112211-11429.

[2] Fernández-Golfín, J.I., Conde García, M.; Fernández-Golfín, J.J.; Conde García, M., Hermoso, E.; Cabrero, J.C. (2014). Effect of temperature of thermotreatment on electrical conductivity of radiata pine timber. Maderas Ciencia y Tecnología (2014) 16(1): 25-36. DOI: 10.4067/S0718-221X2014005000003.

[3] Forsén H, Tarvainen V. (2000) Accuracy and functionality of hand held wood moisture content meters. VTT publications num 420. 95 pp. ISBN 951-38-5581-3.

results (effect of species)



- Time of wetness over 25% MC (TOW25) reduced
- Flat MC curve, due to the presence of dew events along the year

Vitoria

Continental, Cfb, temperate with dry and temperate summer, strong dew effect

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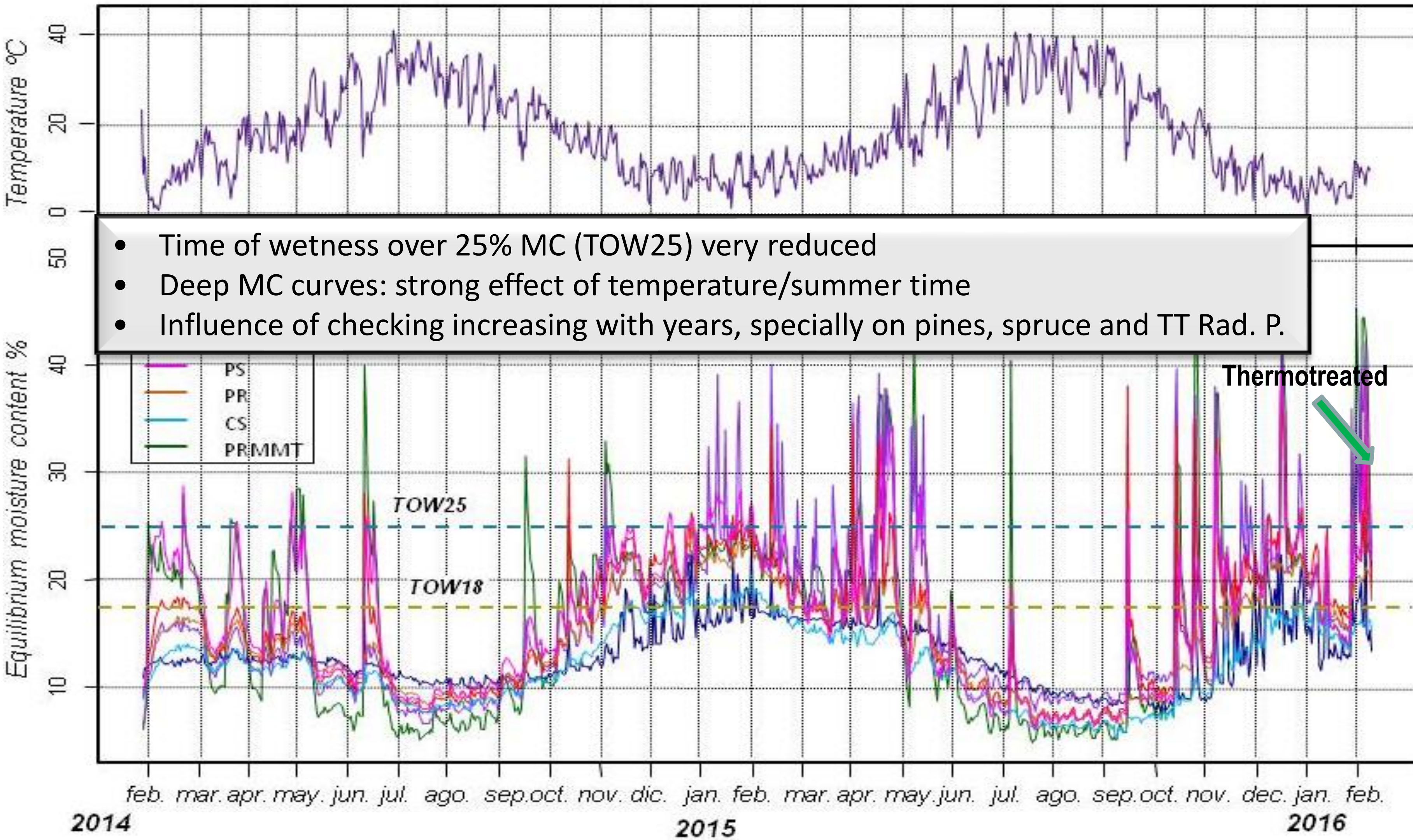
results (effect of species)

- Time of wetness over 25% MC (TOW25) very reduced
- Deep MC curves: strong effect of temperature/summer time
- Influence of checking increasing with years, specially on pines, spruce and TT Rad. P.



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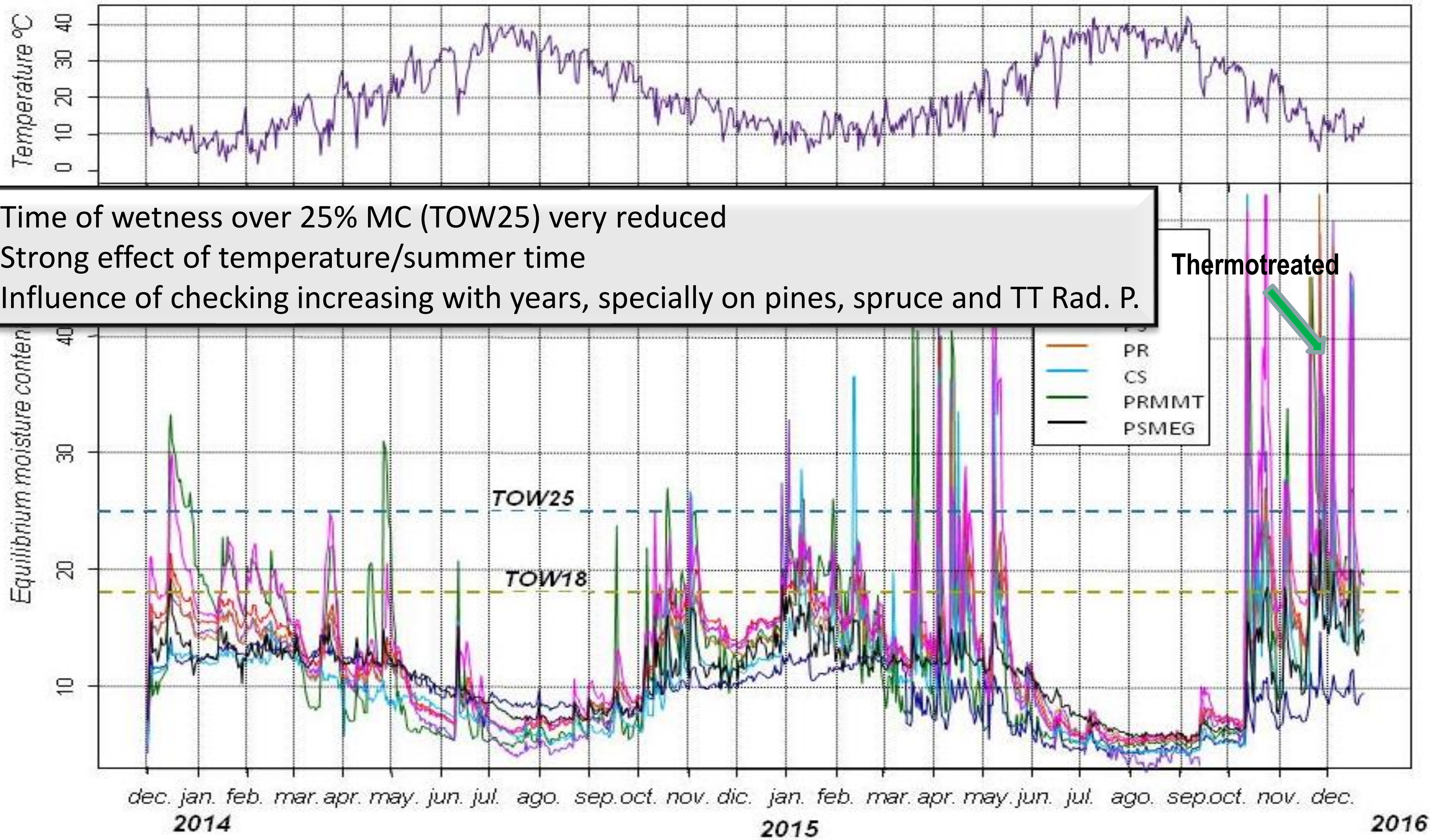
Palencia

Continental, Cfb/Csb, temperate with dry and temperate summer

results (effect of species)



- Time of wetness over 25% MC (TOW25) very reduced
- Strong effect of temperature/summer time
- Influence of checking increasing with years, specially on pines, spruce and TT Rad. P.

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Madrid

Continental, transition BSk/Csa, temperate with dry and hot summer

results (effect of species)

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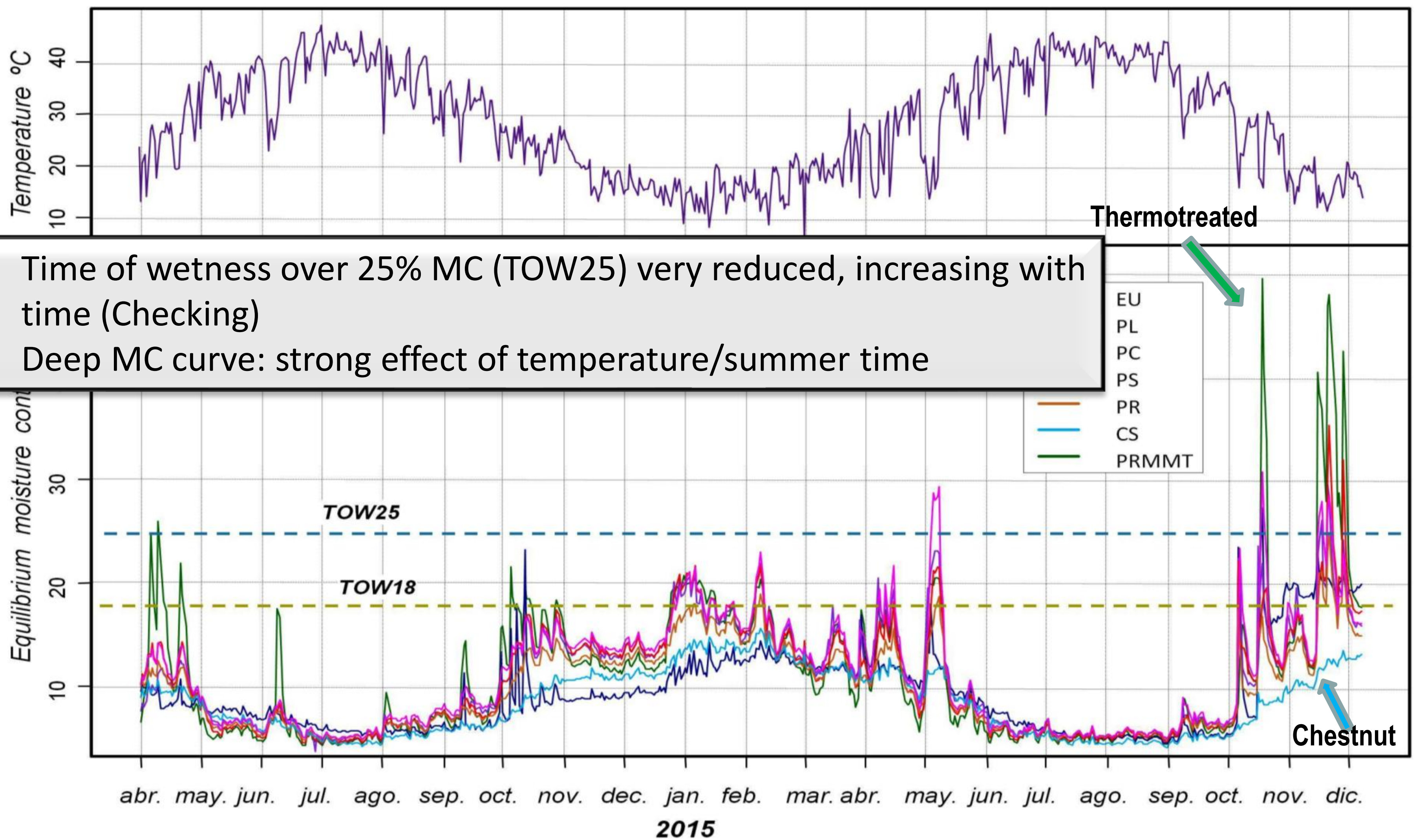

- Time of wetness over 25% MC (TOW25) very reduced, increasing with time (Checking)
- Deep MC curve: strong effect of temperature/summer time

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Cordoba

Continental, Csa, temperate with dry and hot summer, mild winter

results (effect of species)

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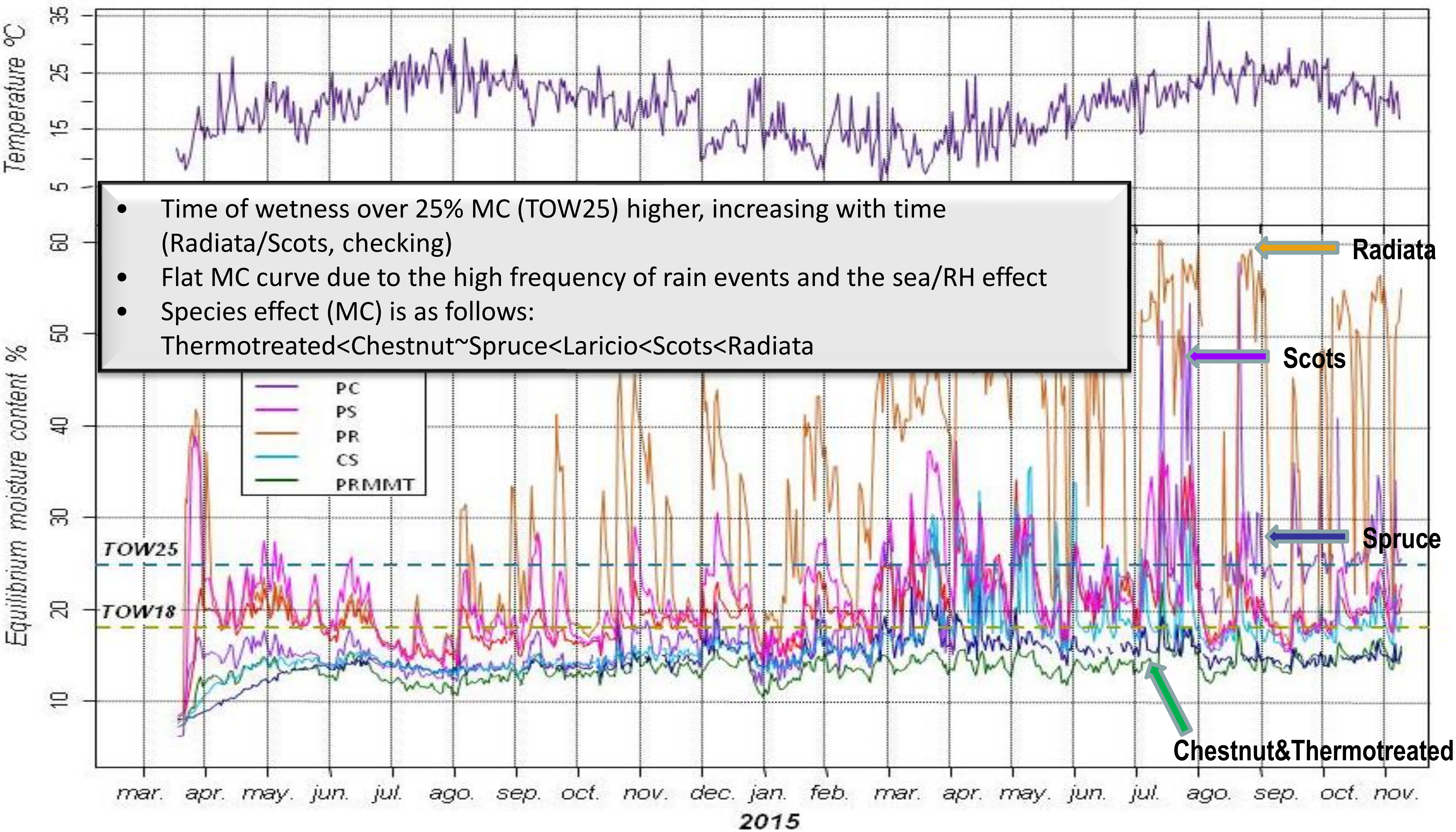
- Time of wetness over 25% MC (TOW25) higher, increasing with time (Radiata/Scots, checking)
- Flat MC curve due to the high frequency of rain events and the sea/RH effect
- Species effect (MC) is as follows: Thermotreated<Chestnut~Spruce<Laricio<Scots<Radiata



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Asturias-Llames

Oceanic, Cfb, temperate with dry and temperate Summer, sea effect on the site

results (effect of species)

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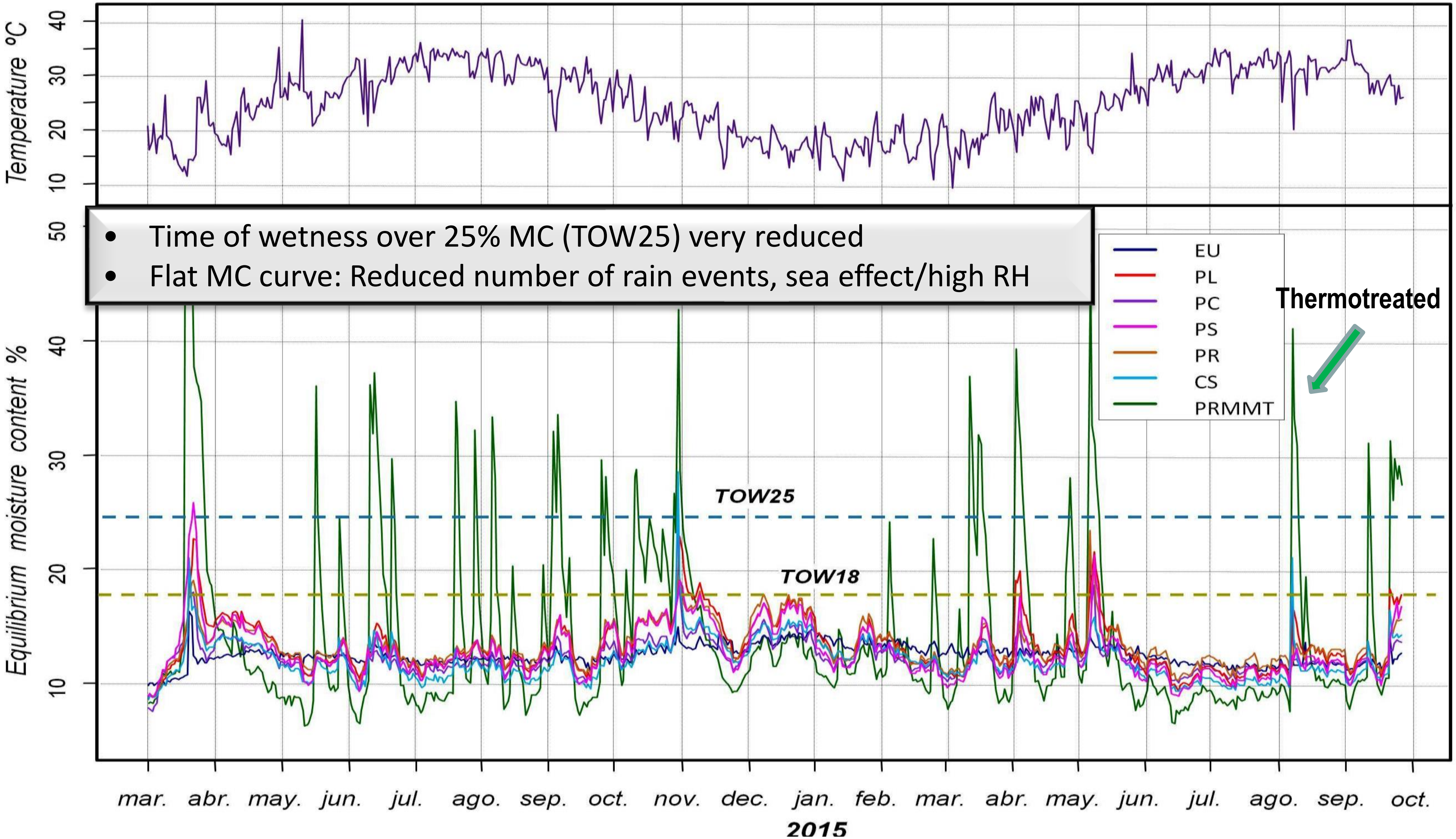
- Time of wetness over 25% MC (TOW25) very reduced
- Flat MC curve: Reduced number of rain events, sea effect/high RH



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Valencia

Mediterranean coast, Csa, temperate with dry and hot summer, sea effect

results (effect of species)

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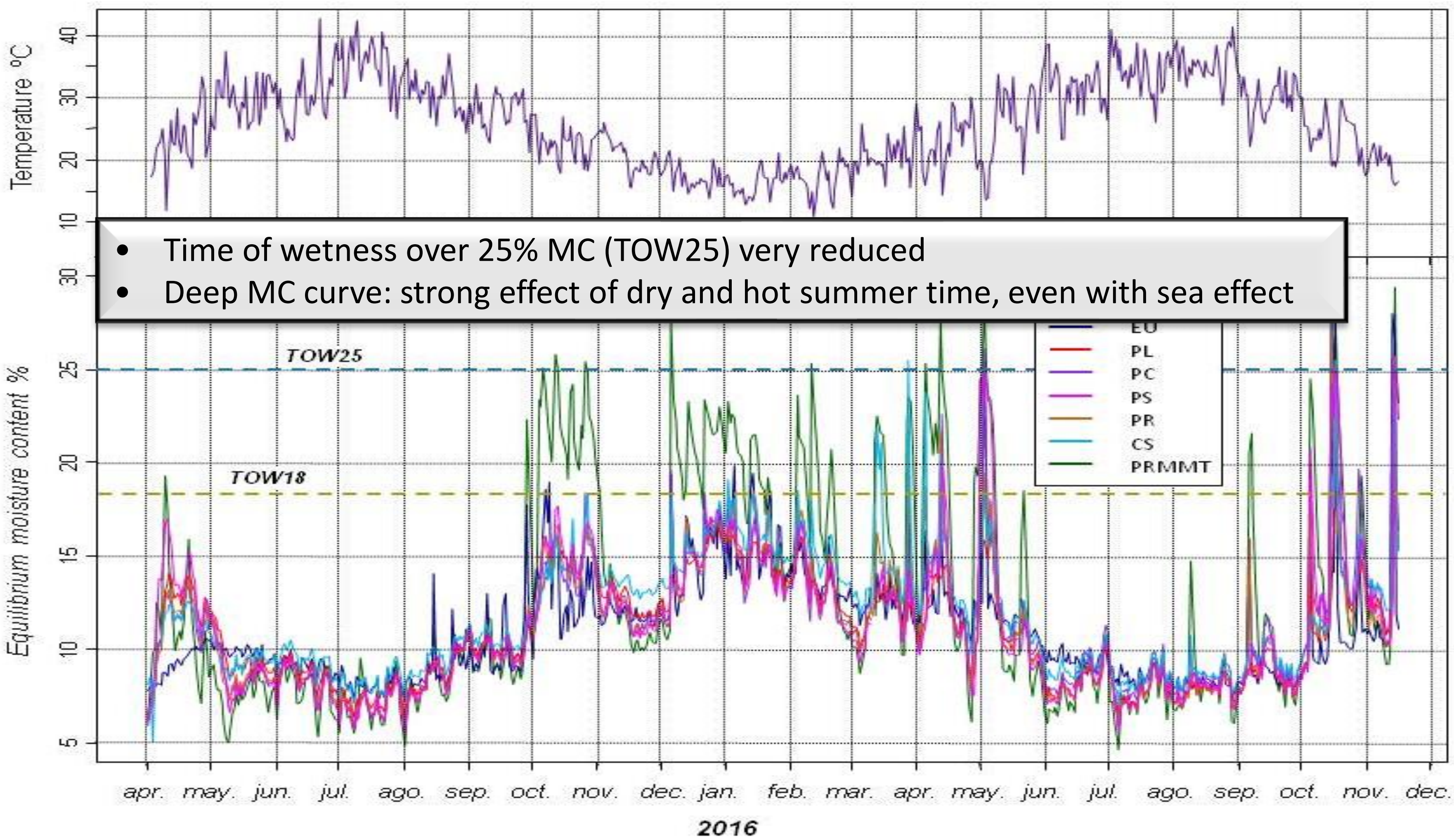

- Time of wetness over 25% MC (TOW25) very reduced
- Deep MC curve: strong effect of dry and hot summer time, even with sea effect

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Huelva

South Atlantic coast, Csa, temperate with dry and hot summer, sea effect

results (effect of massivity)

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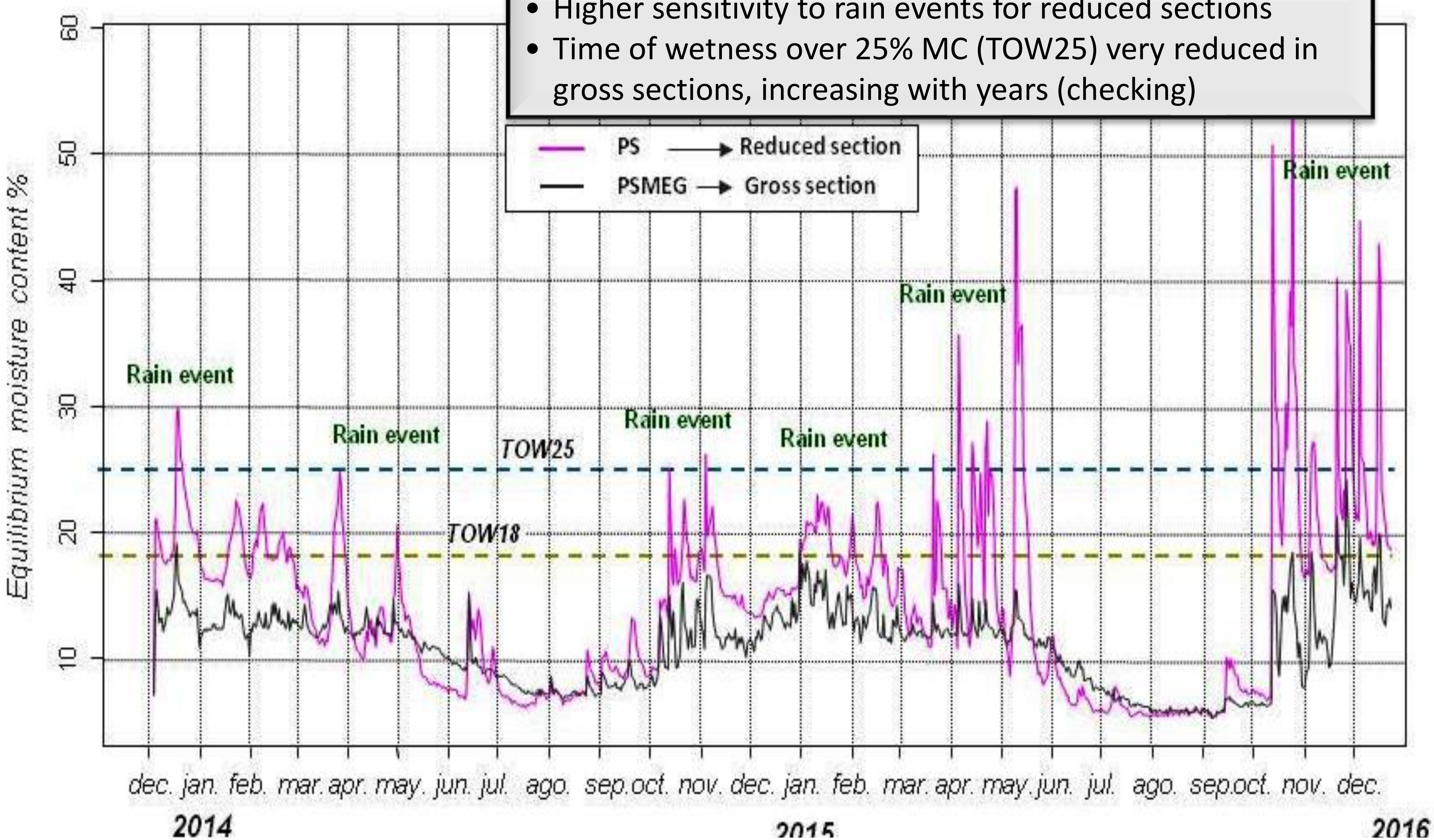
- Higher sensitivity to rain events for reduced sections
- Time of wetness over 25% MC (TOW25) very reduced in gross sections, increasing with years (checking)



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(Scots pine) Madrid

Interior, Continental climate

20x100x750 mm^3 vs. 150x150x750 mm^3

	Station	Temp	EU	PL	PC	PS	PR	CS	PRMMT
Max	Madrid	45,4	27,5	55,8	55,8	60,4	60,0	55,9	68,3
Min	Madrid	-8,4	5,5	5,5	5,5	5,5	5,5	5,5	5,5
Median	Madrid	13,6	9,5	12,3	13,0	14,5	12,4	10,2	10,1
Average	Madrid	15,0	9,5	12,8	12,7	15,2	12,7	10,9	12,7
TOW18 (2016) h	Madrid		0,0	1558	1472	3064	1498	918	2392
TOW18 (2016) %	Madrid		**0,0**	**17,8**	**16,8**	**35,0**	**17,1**	**10,5**	**27,3**
TOW25 (2016) h	Madrid		0,0	520	622	828	384	574	566
TOW25 (2016) %	Madrid		**0,0**	**5,9**	**7,1**	**9,5**	**4,4**	**6,6**	**6,5**
Max	Palencia	45,9	26,0	46,2	51,4	40,3	26,2	20,5	73,1
Min	Palencia	-8,5	7,7	5,5	5,5	5,5	6,1	5,5	5,5
Median	Palencia	12,1	12,8	14,9	14,1	15,0	13,9	11,8	15,1
Average	Palencia	13,8	13,2	15,4	15,5	15,8	14,2	11,9	15,6
TOW18 (2016) h	Palencia		894	3802	3932	3834	2804	724	4496
TOW18 (2016) %	Palencia		**10,2**	**43,4**	**44,9**	**43,8**	**32,0**	**8,3**	**51,3**
TOW25 (2016) h	Palencia		0	544	1404	1038	6	0	758
TOW25 (2016) %	Palencia		**0,0**	**6,2**	**16,0**	**11,8**	**0,1**	**0,0**	**8,7**
Max	Cordoba	52,5	31,3	37,3	35,3	32,6	32,2	22,6	52,4
Min	Cordoba	-5,3	5,5	5,5	5,5	5,5	5,5	5,5	5,5
Median	Cordoba	19,5	9,4	10,9	10,8	11,1	10,1	9,2	10,1
Average	Cordoba	21,1	10,8	11,6	11,4	11,8	10,7	9,4	11,9
TOW18 (2016) h	Cordoba		1624	1700	1522	1780	606	0	1926
TOW18 (2016) %	Cordoba		**18,5**	**19,4**	**17,4**	**20,3**	**6,9**	**0,0**	**22,0**
TOW25 (2016) h	Cordoba		16	136	102	280	12	0	494
TOW25 (2016) %	Cordoba		**0,2**	**1,6**	**1,2**	**3,2**	**0,1**	**0,0**	**5,6**
Max	Valencia	40,3	16,2	22,8	25,8	25,8	23,4	28,5	71,4
Min	Valencia	9,1	9,7	8,5	7,4	8,7	8,6	8,5	6,2
Median	Valencia	25,6	12,4	12,6	11,8	12,1	12,8	11,5	10,8
Average	Valencia	24,9	12,4	13,2	12,2	12,7	13,2	11,9	14,1
TOW18 (2016) h	Valencia		14	768	78	318	536	58	1806
TOW18 (2016) %	Valencia		**0,2**	**8,8**	**0,9**	**3,6**	**6,1**	**0,7**	**20,6**
TOW25 (2016) h	Valencia		0	2	0	2	6	2	550
TOW25 (2016) %	Valencia		**0,0**	**0,0**	**0,0**	**0,0**	**0,1**	**0,0**	**6,3**
Max	Huelva	44,4	28,0	32,9	44,6	68,4	41,0	45,2	76,8
Min	Huelva	0,5	6,9	6,0	5,6	5,3	5,7	5,0	4,4
Median	Huelva	19,4	11,7	12,0	12,0	11,9	11,7	12,0	11,2
Average	Huelva	19,7	11,9	12,6	12,5	13,1	12,3	12,6	13,9
TOW18 (2016) h	Huelva		362	778	738	1258	840	714	2892
TOW18 (2016) %	Huelva		**4,1**	**8,9**	**8,4**	**14,4**	**9,6**	**8,2**	**33,0**
TOW25 (2016) h	Huelva		90	186	234	392	100	66	584
TOW25 (2016) %	Huelva		**1,0**	**2,1**	**2,7**	**4,5**	**1,1**	**0,8**	**6,7**

results

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	Station	Temp	EU	PL	PC	PS	PR	CS	PRMMT
Max	Vitoria	42,6	22,6	55,2	44,4	60,8	63,5	50,6	47,3
Min	Vitoria	-11,3	9,4	8,0	5,5	7,5	8,4	5,5	5,5
Median	Vitoria	11,4	15,2	21,8	16,2	18,5	29,9	16,2	15,2
Average	Vitoria	12,5	15,6	22,5	18,1	19,2	28,8	17,8	16,5
TOW18 (2016) h	Vitoria		2604	8598	4512	4182	8424	5046	4112
TOW18 (2016) %	Vitoria		**29,7**	**98,2**	**51,5**	**47,7**	**96,2**	**57,6**	**46,9**
TOW25 (2016) h	Vitoria		0	4314	1830	754	6470	1448	1194
TOW25 (2016) %	Vitoria		**0,0**	**49,2**	**20,9**	**8,6**	**73,9**	**16,5**	**13,6**
Max	Asturias	34,0	187,0	176,0	57,8	174,0	72,7	37,8	40,8
Min	Asturias	-1,0	7,9	4,2	4,3	8,3	6,2	4,0	7,0
Median	Asturias	14,7	15,8	20,6	21,3	22,8	38,25	17,1	14,5
Average	Asturias	14,8	15,7	20,9	22,1	23,6	36,8	17,5	15,3
TOW18 (2016) h	Asturias		1526	8390	8388	8376	8562	5418	2096
TOW18 (2016) %	Asturias		**17,4**	**95,8**	**95,8**	**95,6**	**97,7**	**61,8**	**23,9**
TOW25 (2016) h	Asturias		0	1724	4208	3772	7394	756	126
TOW25 (2016) %	Asturias		**0**	**19,7**	**48,0**	**43,1***	**84,4***	**8,6**	**1,4**

EU: Eucalypt; PL: Laricio pine; PS: Scot pine; PC; spruce; PR: Radiata pine; CS: Sweet chestnut; PRMMT: Thermotreated radiata pine (210ºC)
(*) Decay rate 1 in July 2017

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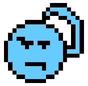
conclusions

1. The main factor affecting MC evolution above 18% (and decay risk) is the presence of rainfall and or condensations rather than relative humidity (sea effect).

2. Considering a critical threshold for decay onset of 25% in MC, the time of wetness for this threshold (TOW25) in Spain is very short in all sites. According to TOW25, in Spain wood would never decay!!!.



Instead of TOW25 we are considering TOW18

3. According to the data, the permeability to rain water during the first year (no large checking) for the different species is as follows: Thermotreated radiata pine (PRMMT)<Sweet chestnut (CS)<Eucalypt (EU)<Spruce (PC)<Laricio pine (PL)<Scots pine (PS) ≈ Radiata pine (PR) .

4. Checking changes the performance of wood in outdoor exposure, increasing the MCmax and TOW values and reducing the differences between species and sizes. In order to characterize the decay risk in laboratory we suggest first to induce checking and then evaluate the permeability under artificial rain/drying cycles (not only immersion or RH conditioning).

5. The cutting pattern seems to modify wood permeability to rain water. Scots pine and radiata pine in Asturias-Llames and Vitoria sites (mixed cutting pattern) present an opposite behavior than in the other five sites (tangential cutting pattern). This is at present under further studies.

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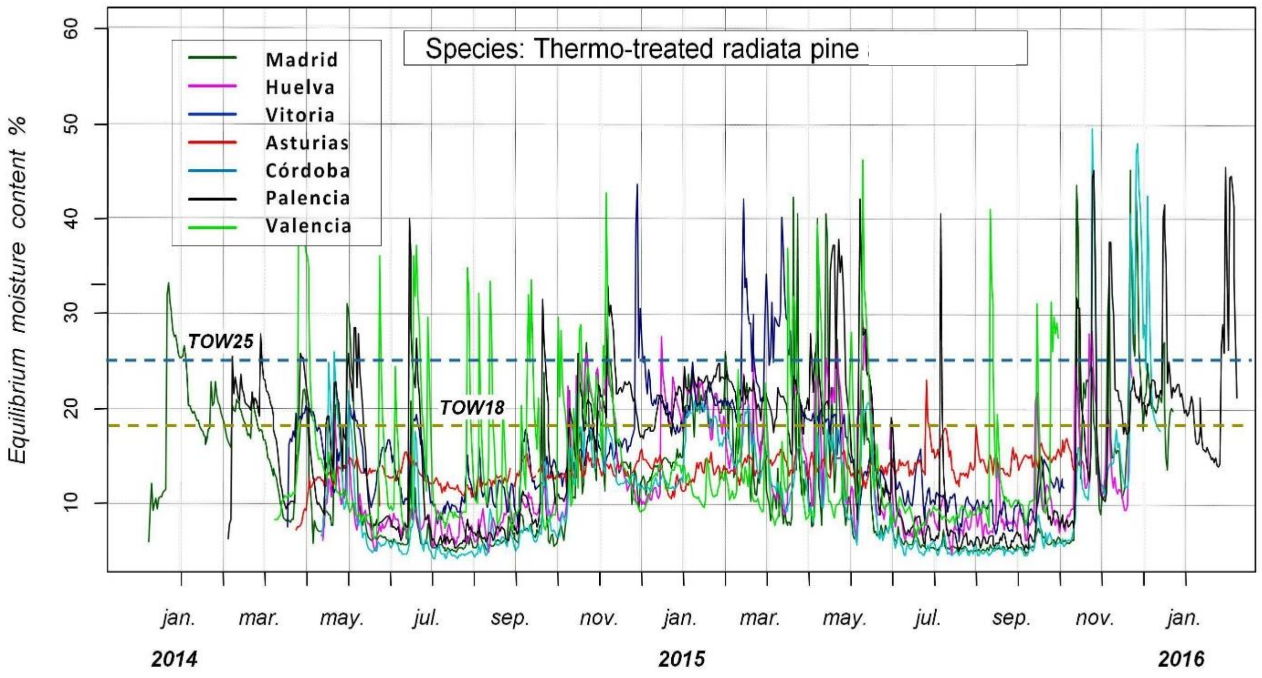
conclusions

6. Thermotreated wood suffers severe checking in continental climate sites, being not recommended in those locations.



Thanks to the contributors of the project

golfin@inia.es

JI Fernández-Golfín (INIA)
M. Conde (INIA)
R. Diez (INIA)
R. Sánchez (UCO)
E. Perea (private individual)
M. Conde (UCO)
R. Capuz (private individual)
L. Torres (UHU)
L. Acuña (UVA-Palencia)
J. Galván (IETcc-CSIC/INIA)
F. Peraza (AITIM)
E. Martínez (UE)
E. Nuere (Taujel)
A. Ortiz (Neiker)
E. Larrumbide (IETcc-CSIC)
MT. Troya (INIA)
JL García Ceca (INIA)
B. Abad (INDITECMA)

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