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DROUGHTS AND LOW WATER LEVELS IN LATE MEDIEVAL HUNGARY II: 1361, 1439, 1443-4, 1455, 1473, 1480, 1482(?), 1502-3, 1506: DOCUMENTARY VERSUS TREE-RING (OWDA) EVIDENCE

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Abstract

As a continuation of the first paper from the late medieval drought series related to medieval Hungary, we present, analyse and compare further late medieval drought data, based on contemporary direct and indirect written sources. The evidence derived from documentary sources referring to the droughts and dry spells in 1361, 1439, 1473, 1480, 1482(?), 1502-1503 and 1506 are further compared to the recent tree-ring based hydroclimate reconstruction of the OWDA (Old World Drought Atlas), and similarities, differences and complementary information are discussed in more detail. Additionally, documentary evidence related to Danube low water-levels of 1443, 1444, 1455 and 1502 are as well presented in a broader context: these cases provide evidence on the hydrological conditions of the Upper-Danube catchment, and not on the Carpathian Basin. The OWDA evidence in most cases shows good agreement with the discussed documentary-based drought reports, some differences in the spatial extension and intensity of the drought were only exceptionally detected (e.g. 1455, 1507). Most of the written documentation refer to droughts that covered more than one calendar years.

Keywords: droughts, late Middle Ages, low water level, Danube, documentary evidence, OWDA

INTRODUCTION

In the present paper eleven confirmed or presumed drought years, occurred in the Carpathian Basin, are discussed based on direct and indirect documentary evidence, also taking into consideration the tree-ring based annual summer precipitation and spring-summer PDSI reconstructions of the Old World Drought Atlas (see Cook et al., 2015). As Kiss and Nikolić (2015) suggested in the first paper of the current series on medieval droughts, when reported, the memorable drought events are often one year after the Western and West-Central European ones in contemporary Hungarian sources. Nevertheless, indirect information in contemporary domestic sources or foreign documentation may also suggest that, in case of 1362, 1474 and 1507 already the year before, namely in 1361, 1473 and 1506, while in case of 1479 also in 1480, larger areas of the Carpathian Basin might have also suffered from the lack of sufficient precipitation. Moreover, in some additional cases documentary evidence is available concerning drought years or very dry summers in 1439, 1482 and 1503, and in four additional cases, in autumn 1443, spring 1444, summer 1455 and probably also in autumn 1502 low or very low Danube water levels were reported.

Combining and complementing the information presented by Kiss and Nikolić (2015) with the currently discussed evidence, on the one hand, in the present paper some "more complicated" and indirect source evidence is also analysed in a Central European context. On the other hand, the information derived from documentary evidence is compared to the recently published, tree-ring based, annually resolved hydroclimate reconstruction available in the Old World Drought Atlas (hereafter OWDA).

Additionally, in the present paper some auxiliary information on weather background (e.g. winter snow, heat, rainfall and flood reports) is also included. As large part of the annual precipitation in the most populated, major agricultural areas of the country fell in late spring and early summer time, and the cereal and hay harvests strongly depended especially on the May-June, and partly on winter(-early spring) precipitation, potentially there is a significant connection between reported droughts, usually mentioned in relation with harvest problems, and the evidence presented by the OWDA. Furthermore, in case of the tree-ring based hydroclimate reconstruction, the precipitation conditions of the preceding autumn can as well influence tree growth (Prokop et al., 2016).

APPLIED DOCUMENTARY SOURCES AND THE OWDA DATABASE: STRENGTH AND WEAKNESSES

Documentary evidence

As demonstrated by Kiss and Nikolić (2015), mainly individual reports on droughts are available in an increasing number towards the second half of the 15th

century. These cases were usually recorded due to the impacts of droughts, and therefore the beginning of the drought period is rarely known, while some of the major consequences – either affecting transportation or harvest results – were mentioned in more detail. Although it is clear that not all the late medieval droughts can be detected in this way, by the 15th century, especially concerning its second half, written documentation enables us to determine greater drought events that affected larger regions of the country.

The presently discussed cases are mainly known from town and diocese accounts (1443-3, 1455, 1502-3, 1506), but narrative sources such as Hungarian and German chronicles (years 1439, 1473, 1480) and charter evidence (1361, 1482) as well play an almost equal role in the available documentation. At present two account series are known that contain weather- and water-level related data in larger quantity: the Pressburg/Pozsony (Bratislava-Sk) accounts and the account books of the bishop of Eger, Ippolito d'Este. Both in source type and content, the short reports available in the accounts of the Eger bishop (E. Kovács, 1992), form a separate group: in these cases only very indirect information is available that generally suggest unfavourable conditions: through one-one bad year for bees with shortage of honey and wax, damaging thunder reports or significant loss of sheep we may presume previous unfavourable conditions that might have been partly (or mainly) related to droughts. As for the narratives, the Thuringian chronicle of Johann Rothe refers to a drought in Hungary under the year 1439, while the Hungarian chronicle of Antonio Bonfini reports on droughts in 1473 and 1479. Similar is true for the known charter evidence related to the drought in 1361-2, and the very dry summer of 1482 or 1483.

Concerning the calendar dating applied, in the present work the original dates in Julian Calendar are provided. Nevertheless, in those cases when the difference between the Julian and Gregorian Calendars affects the interpretation, also the Gregorian Calendar dates (hereafter GC) are provided in brackets.

Application possibilities of the OWDA evidence in drought severity detection of single years

The recently published OWDA maps present natural hydroclimate variability based on tree-ring data in annual resolution: the maps provide June-August scPDSI (Palmer Drought Severity Index) information, and reflect on spring and summer soil moisture conditions year by year concerning the period between 0 AD to 2000 (Cook et al., 2015). Thus, it describes a key period from the viewpoint of, for example, agriculture, but does not offer an evidence on the precipitation or soil moisture conditions of the entire year. In generating the annually-resolved maps, regression-based climate field reconstruction method has been applied which also means that in an area where no tree-ring based hydroclimate reconstruction is available, the closest available series will have the most influence and mainly this/these (and lesser extent the further-located series) will form the basis of extrapolation.

In the OWDA database (Cook et al., 2015), concerning the Carpathian Basin including the Carpathian Mountains, four series area available. The closest data series, and the only one that extends back in time to our late medieval study period with a sufficient amount of sample, is the recent millennial hydroclimate reconstruction of Prokop et al. (2016). In this reconstruction the oak tree samples were derived from different parts of Slovakia, from the northern parts of the Carpathian Basin, in the Western Carpathians. The reconstruction usually explains around or less than 50% of the variables, but correlation also varies over time. Furthermore, whereas until the end of the 14th century the number of annual samples is rather low that determines applicability (see Prokop et al., 2016: Fig. 2A), from the early 15th century onwards the reconstruction is already based on a more sufficient, representative number of samples (exceeds ca. 30-50, and then 100).

Another important point of the reconstruction is spatial correlations: whereas the Slovakian series shows the strongest correlations to the Czech and Western Ukrainian series, this correlation is somewhat weaker, though still significant, with Western, North-western and North-eastern Hungarian series from hilly areas. As no tree-ring based hydroclimate series are known from, for example, the Great Hungarian (or Pannonian) Plain or Central Transylvania, it is not clear in what extent the Prokop et al. (2016) series can describe the hydroclimate variability of these areas. We also have to account with other potential uncertainties. For example, it is generally also possible that after a significant drought year or years the tree 'overreacts' in the following year, and even if the year is not extraordinary humid, the tree produces the signs of very wet conditions. While, according to recent observations, this is clearly true on the seedling level (see e.g. Turcsán et al., 2016), it is also a realistic possibility in case of the adult tree population that forms the basis of hydroclimate reconstruction (see Dobrovolný et al., 2017).

Despite the fact that the reconstruction only covers the spring-summer period, and also the potential uncertainties that make tree-ring based hydroclimate reconstruction a safer tool for multiannual than annual comparison, the aforementioned OWDA maps and the database behind provide an exceptionally valuable, indirect source of information. Its importance gets particularly high when, for example, in documentary evidence only indirect or non-contemporary sources, often with uncertainties in dating, reflect on one-one drought period. In these cases the tree-ring based hydroclimate reconstruction can support or weaken the validity of the information derived from documentary evidence.

RESULTS

The drought year of 1361

In the previous paper of the series (Kiss and Nikolić, 2015), spring 1362 drought information from Dalmatia was presented, together with the presumed early grapevine harvest data, probably suggesting altogether

rather warm late spring-summer conditions in the Budapest area in spring-summer 1362. As we could already see, in Middle-Dalmatia the drought started earlier, so that latest the winter could be notably drier than usual.

From further, contemporary Austrian charter evidence it is known that in 1361 there was very bad grain harvest in Austria, in the Czech Lands and also in Hungary (see e.g. Csendes and Oppl, 2001; Rohr, 2007; Kiss et al., 2016), but in Austria already 1360 was a drought year (Rohr, 2007). The fact that already in mid-spring 1362 the Hungarian king prohibited grain export in Dalmatia (in Raguza/Dubrovnik-Hr) from his territories in general (Gelcich and Thallóczy, 1887), further supports the idea that bad-harvest problems affected large parts of the areas of the Hungarian crown. In the meantime, most parts of Western and Central Europe, including such neighbouring countries as Poland, the Czech Lands and Austria, faced with a serious drought in 1361, while in Austria already 1360 was a drought year. Furthermore, apart from the bad grain harvest in 1361, in Austria vine harvest was reportedly bad as well (Alexandre, 1987; Brázdil and Kotyza, 1995; Rohr, 2007).

In Hungary bad or very bad grain harvests were often related to lack of sufficient amount and type of precipitation in the late spring-early summer period, and often already winter was (cold and) dry, then crops could not develop properly. In the Middle Ages such cases were reported, for example, related to the drought year of 1507 (see e.g. Kiss and Nikolić, 2015, Kiss, 2017), but already the mid-14th-century biographer of King Louis I, János Küküllei (Florianus, 1884), listed drought among the most important factors being responsible for famines in Hungary.

As demonstrated by the OWDA maps (see Fig. 1), based on tree rings, 1361 was particularly dry in summer, but soil moisture, very necessary to the development of crops, was perhaps at a loss in spring and summer. In case of such a very strong negative PDSI values, we cannot exclude the possibility that low soil moisture was already a problem before spring 1361. It is, however, and interesting fact that the winter or early spring of 1361 was not dry at least in some parts of the Carpathian Basin: for example, in early spring (possibly in March) along the ford between Lake Fertő/Neusiedlersee and the Hanság/Wasen wetlands cold weather and much snow, while in mid-April the great mud obstructed perambulations (Dreska, 2001). In the meantime, in the hilly north, in Turóc county (today N-/NW-Slovakia) the great snow similarly obstructed a perambulation in mid-March (HNA DL 90540; see Kiss, 2016). This is in slight contradiction with, for example, reports from Austria and Germany where this winter had a cold, but mainly dry character (see e.g. Alexandre, 1987; Brázdil and Kotyza, 1995).

Combining the aforementioned indirect evidence, it seems rather probable that 1361, and spring-(early-)summer in specific, was extraordinary dry, and to some extent this dry tendency also continued in (early) 1362. However, unlike in large parts of Central Europe, the winter of (1360-)1361 was not necessarily dry in Hungary.

1439: very dry (spring-)summer in South-Hungary?

A rather interesting report was preserved in the German *Düringische Chronik* of Johann Rothe (Liliencron, 1859), under the title "*801. Wie die Torcken yn das lant zu Ungirn quomen*". According to the description, the summer of 1439 was dry in Hungary, and the water called "*Mossir*" also dried up ("*Nu was der sommer etzwas dorre unde trocken, alsso das yn den landin das wassir gnant die Mossir gar vertruckent was,...*"). Afterwards, the author

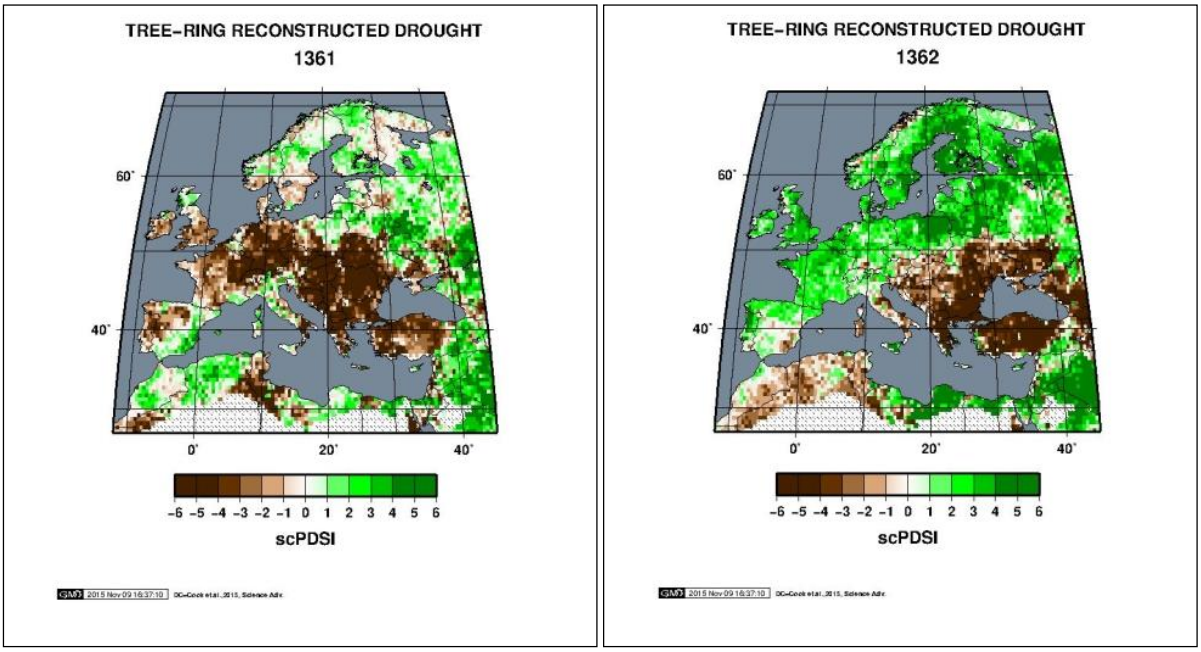

Fig. 1 Tree-ring based hydroclimate reconstructions of the OWDA: 1361 and 1362 (Cook et al., 2015)

shortly described the Turkish campaign and the Hungarian military response, especially in the Banat area that is today North-eastern Serbia and South-western Romania.

The description of the military operations fits the author's dating: in 1439 summer a significant Turkish army first invaded Serbia, and then indeed entered Hungary, attacked the the Banates of Temes and Szörény (centre: Szörényvár/Turnu Severin-Ro), the areas in South Hungary most easily reachable both from Serbia and Valachia. The Hungarian king, Albert, sent an army (with János Hunyadi in lead) to defend especially Szörény against the Turkish attack (see e.g. Bánlaky, 1931).

There is no any known, significant water body in this area that holds the "*Mossir*" name. However, it is possible that the word in the present case does not cover a proper noun, but it is a somewhat distorted form of the Hungarian word of "mocsár" in the meaning of swamp or wetland. If the lowland marshes/swamps/wetlands "quite much" dried up, for example, in medieval Southern Hungary, this circumstance naturally provided more favourable environmental conditions for travel or military campaigns with increasing the possibilities of a quick march and swift attack.

The original author of this volume, Johann Rothe (1360-1434), was the clerk or notary of the town Eisenach in Thuringia. Nevertheless, he died in 1434, and the name of the author who continued his chronicle and also wrote the 1439 Hungarian report, is unknown. Even if it is rather possible that the author who continued Rothe's chronicle was contemporary, missing the author's name, this statement cannot be proved with certainty. Furthermore, the author's description most probably relied on the observation of other people, even if based on the potential interpretation of the word "*Mossir*" we can raise the possibility that the person from whom the unknown author heard the 'story' could be from Hungary. With regards to the dating of the event, as described above, there was indeed a siege of Szörényvár (Turnu Severin-Ro) and a military campaign of the Hungarian army to Serbia in summer-autumn of 1439 (see e.g. Bánlaky, 1931).

According to the tree-ring based hydroclimate reconstruction of the OWDA, around the turn of the 1430-1440s two summers were particularly dry in the Carpathian Basin: 1439 and 1440 (see Fig. 2). The quite dry marshes(?), in accordance with the OWDA scPDSI values, may also suggest that this dry spell started earlier, and probably already spring was drier than usual and, as mentioned before, the political circumstances also support the author's dating of the event to 1439. Furthermore, the fact that the Turkish emperor, Murad II started his military campaign against Serbia in late May (see e.g. Bánlaky, 1932), and was already in the borderline area with his army in June, suggest a quick military campaign that is rather unlikely to happen, for example, in wet weather conditions.

Danube low water levels in autumn 1443 and spring 1444

Although in the Pressburg/Pozsony (Bratislava-Sk) accounts references on floods appear much more often (see e.g. Kiss, 2018), occasionally Danube low water levels are also mentioned. In the first case, on 13 September (GC: 22 September) in 1443, the Danube was noted for being very small (AMB, K6/77: *Item am phinztag noch Nativitate Marie virginis hab wir land in daß wasser geczogen haben als di Tuna gar klain waß*…). Furthermore, in next spring, on 11 April (GC: 20 April) 1444 a reference on small Danube was again included in the accounts (AMB, K7/171: *Item am*

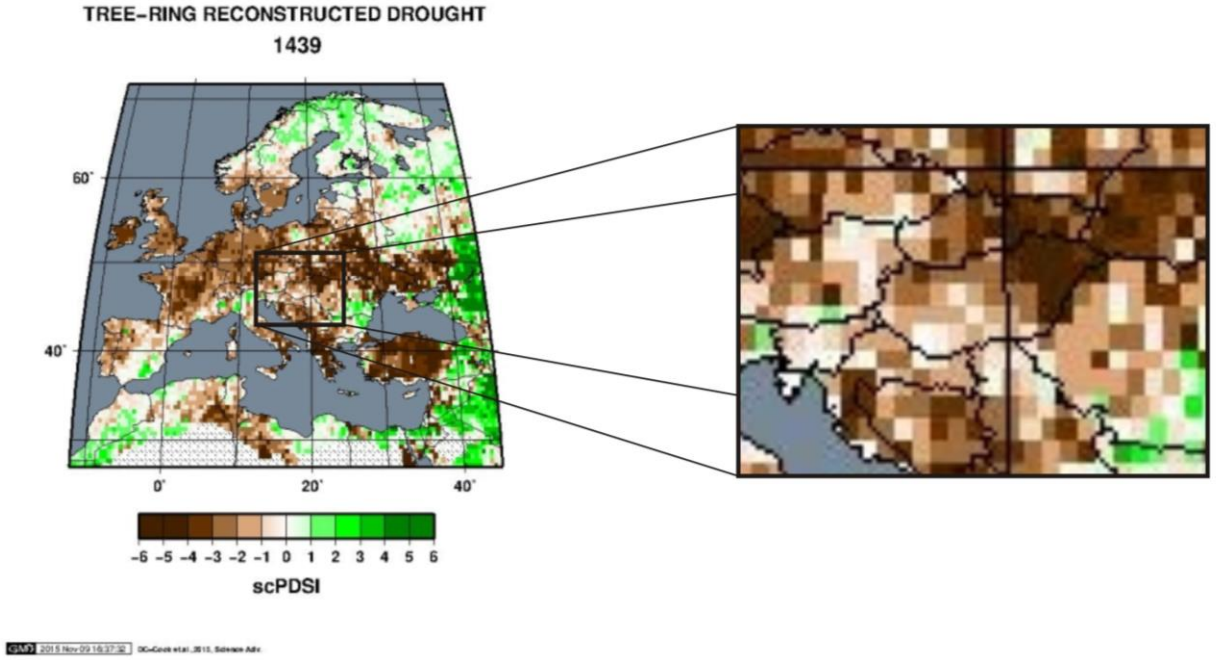

Fig. 2 Tree-ring based hydroclimate reconstruction of the OWDA from 1439, and the reconstruction detail of the Carpathian Basin and its immediate neighbourhood (see Cook et al., 2015)

Sambstag am heiligen Oster obund hab wir gehat xiiij aribater dy Sannd uber dy Tuna uber gepracht haben, in ainer Zullen als dye Tuna klain waß,…).

As the Danube low-water reports come in both cases from the area near the Austrian borderline, the information holds a precious hydroclimate signal concerning the precipitation conditions of the preceding months, primarily referring to the Upper-Danube catchment basin. Thus, these data do not directly reflect on dry periods in the Carpathian Basin, but they primarily correspond to the weather conditions of more westerly areas.

It is interesting to further note that no flood was reported in the accounts between early August 1443 and mid-July 1444 (see Kiss, 2018). Nevertheless, while in July a Danube flood was mentioned (AMB K6/75), in mid-September the water level, reported by the same source in the same volume written by the same hand only three pages later, was already very low. In relation with the three low water-level mentions, concerning 1443 we can find a 'perfect fit' with the relevant OWDA map: based on tree-ring evidence in the (spring-)summer period, great drought prevailed in West-Central Europe in this year.

The Central European documentary evidence provides rather interesting though somewhat biased further information concerning the years 1443 and 1444: whereas the wine harvest was good at Lake Constance in 1443, which suggests overall warmer and drier summer-early autumn conditions, Lower-Austrian and Czech sources speak about rains and windy conditions from mid-July, presumably also in autumn (see e.g. Brázdil and Kotyza, 1995). Nonetheless, in fact the summer and autumn of the previous year, 1442, was memorably dry, followed by a cold and snowy winter that lasted until late April; in some areas snow even fell after that, in early May. The winter of 1444 started early and was memorably hard not only in Central Europe (Brázdil and Kotyza, 1995; Rohr, 2007; Glaser, 2013), but also in the Balkan Peninsula (e.g. Telelis, 2008). In late autumn-early winter time a major military campaign, probably also supported by low waters and overall dry late autumn conditions on roads, was led by the Hungarian king through the Northern Balkan as far as Bulgaria and the Black Sea (see e.g. Bánlaky, 1931). Whereas the winter was dry in Silesia, it was reported with abundant snow in Bavaria, Salzburg and Klosterneuburg. Furthermore, the winter in the Czech Land released only after 17 March (Brázdil and Kotyza, 1995; Glaser, 2013).

Consequently, merely based on the information from Central Europe, the Danube low water-level evidence dated to autumn 1443 and spring 1444 should be better dated to 1442 and 1443. The 'problem' in this case is that the Pressburg accounts are very clearly dated: all previous and following entries could refer only to 1443 and not 1442 in the autumn case, while to 1444 and not 1443 in the spring case. Furthermore, it is also highly unlikely that for works, carried out in 1442 the town would have paid with a year or even several months of delay (without even mentioning that). It is also an interesting fact that, while the dates in the relevant section of the accounts clearly and unambiguously refer to 1443 in volume (AMB) K6 and to 1444 in volume K7, no information on low-water level conditions remained in the previous, 1442 (AMB K4) and 1442-1443 (AMB K5) volumes. It is, nevertheless, somewhat thought-provoking that long-lasting and large-scale works took place in 1442 in the Old Tabor (riverbank, harbour) area, and this would have been rather difficult to carry out during the high water level or flooding of the Danube.

In the present case, the OWDA reconstruction plays a rather important role in sorting out the potential discrepancy in dating the (very) low Danube water level

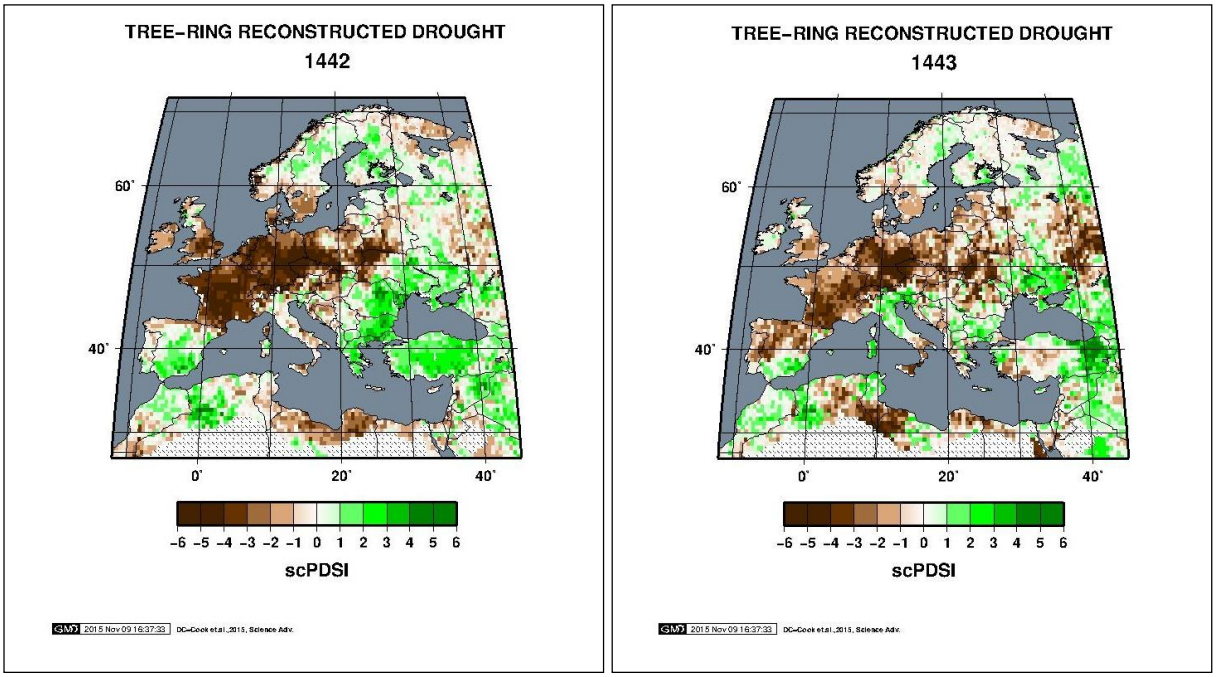

Fig. 3 Tree-ring based hydroclimate reconstructions of the OWDA: 1442 and 1443 (Cook et al., 2015)

reports: according to the tree-ring based hydroclimate reconstruction both in 1442 and 1443 the (spring-) summer period was very dry in the Upper-Danube catchment area (see Fig. 3). On the basis of this and the above-mentioned documentary evidence, it is possible that - although dry conditions and low water levels already prevailed in 1442, due to particular works where related water-level conditions were mentioned, the source only mentioned the low water level of the Danube when because of the payment conditions such an explanation was necessary in particular account entries, namely in autumn 1443 and spring 1444.

Low Danube water level or not? The small-water reference in summer 1455

More than a decade later, the little extension of water was again mentioned in the Pressburg accounts, at this time in summer: on 23 June (GC: 2 July) 1455 the small size of the river was noted (AMB K22a/47: *Item und haben auch gehabt besundere ij aribater pei dem hanns stewber pinter die pewsch gelegt haben als die Tuna klain waß die dass wasser zu dem wasser Rad gelait haben* …). The text clearly refers to low water-level conditions of the Danube river, in the Pressburg/Pozsony (today Bratislava-Sk) area, and also the late June 1455 dating is accurately provided (previous and following dates all belong to the year of 1455) in the account book.

With regards to the potential, documentary-based weather-related parallels in the neighbouring countries, in 1455 the winter was hard and lasted until the end of March in Bohemia, but the spring and particularly the summer could be warm. In summer, heat and great drought was recorded in Silesia (Brázdil and Kotyza, 1995). No information is available concerning the spring, but according to Glaser (2013), the summer was wet and infertile in the German areas. Except for the Eastern Alpine area where mainly dry weather conditions prevailed, the relevant map of the OWDA also shows slightly wet conditions in the Upper-Danube catchment basin, especially in Bavaria, even if dry conditions prevailed in large parts of Austria (Fig. 4).

In conclusion, although the Czech and Silesian sources rather refer to a warm and dry summer, the German reference, partly in accordance with the OWDA evidence, clearly mentions it to be wet. At the moment we cannot solve this apparent contradiction, but it is clear that the Pressburg accounts item is accurately dated, and clear about the Danube low water level. However, as the information comes from early summer, it is probable that more significant precipitation occurred after this date, and it might be also possible that the Eastern Alpine catchment basin of the Danube was predominantly dry in (spring-)early summer, and this circumstance influenced the water level conditions of the Danube in Eastern Austria and Hungary.

Drought in 1473, and 1474 revisited

In relation with the "perennial" drought report of the contemporary chronicle writer, Antonio Bonfini, who dated the event to 1474, three other, non-contemporary sources were listed by Kiss and Nikolić (2015) considering a great drought, referred under the year 1473. While one of the non-contemporary sources, the compilation of the Swiss Lycosthenes, was written in the mid-16th century, two other, 17th-century chronicles, the chronicle of Leibic/Leibitz (L'ubica-Sk) town and the chronicle of Caspar Hain from Lőcse/Leutscha (Levoča-Sk) both from the Szepesseg/Spiš region (today in NE-Slovakia), reported on a great drought that happened in 1473 (for references, see: Kiss and Nikolić, 2015).

Thus, on the one hand, a contemporary report is available on a great drought written by Bonfini, a contemporary author of Italian origin, who later lived

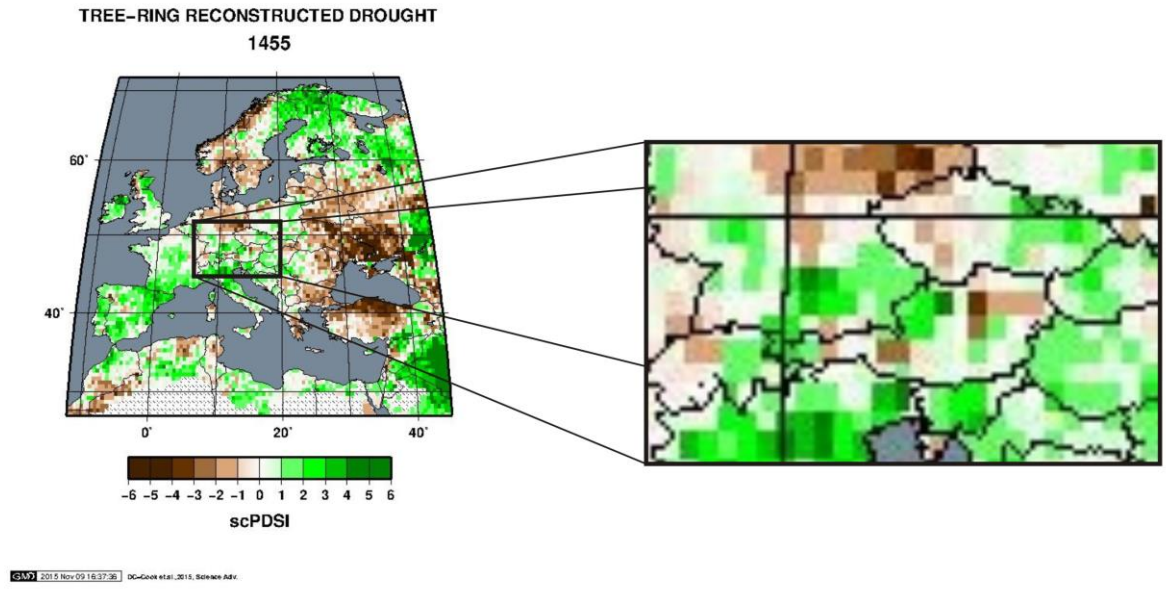

Fig. 4 Tree-ring based hydroclimate reconstruction of the OWDA from 1455, and the reconstruction detail of the Upper-Danube catchment basin (see Cook et al., 2015)

in Hungary, wrote the most detailed and accurate history of Hungary of his time, clearly gained his information from eye-witnesses in Hungary, applied thorough source critics, and accounted for being a most reliable author of the reign of King Matthias (1458-1490; see e.g. Klaniczay, 1974). Bonfini's report provides 1474 dating, with suggesting a long-term drought that allows an interpretation of an event that lasted longer than a year and thus, does not exclude a 1473-1474 dating either, especially, because the author also refers to parallel Turkish attacks that happened both in 1473 and 1474 (see e.g. Bánlaky, 1932).

On the other hand, three non-contemporary chronicles, two of them from Hungary and another one from Switzerland suggested 1473 as the great drought year in Hungary, and none of the three mentioned 1474 in connection with drought. And while, according to the contemporary documentation, 1473 was a great drought year in Central Europe, including the Czech Lands, Poland, the German areas, Switzerland as well as Austria (see e.g. Brázdil and Kotyza, 1995; Glaser, 2013), the sources were mostly silent about the character if 1474 in the same areas. Thus, in this case we have a rather unique situation as the only contemporary narrative that reported on the drought provides a somewhat different (even if no fully contradicting) dating than the non-contemporary chronicles, and the evidence from the neighbouring countries more supports the dating of the non-contemporary sources and not that of the contemporary one.

The relevant OWDA maps, however, show that in the Carpathian Basin there were considerable (spring-) summer dry spells both in 1473 and 1474, even if 1473 seems to be generally more extreme, especially in the northern half of the Basin (see Fig. 5). Nonetheless, in the southern part of medieval Hungary, including the southern borderlines of the kingdom, the drought of 1473 does not appear to be considerably more severe on the OWDA maps than in 1474.

Further documentary-based (even if indirect) information may provide some additional help to solve potential contradictions. As for Bonfini, in his work on the Hungarian history, the drought was only a background information that helped him in the description of military processes (see Kulcsár and Kulcsár, 1974). Thus, he probably mentioned drought only when he felt it necessary in his explanations, while only briefly referred it without specification on date or location (as a circumstance that made Turkish attack easier) when his text did not need this kind of auxiliary information. Moreover, he gained large part of his information about these years from eye-witnesses in or related to the royal court: these eye-witnesses were likely to be the soldiers, or even leaders of military operations, who participated in the military campaigns leading to the south, towards the territories occupied by the Ottoman Empire. These military campaigns, however, mainly took place in 1474 (see e.g. Bánlaky, 1932; Klaniczay, 1974) and not in 1473, and therefore the potential Hungarian eye-witnesses could have personal experience, at least through large part of the country including the southern borderlines, mainly in this year. The extensive wetlands of the lowland areas usually needed longer period of time to dry up: if there was a severe drought in 1473, and 1474 was also dry, the really visible consequences, for example, in the extension of stagnant water bodies or the height of groundwater table could be perhaps even more apparent in 1474 than in 1473.

Additionally, a Silesian source may shed more light on the character of 1474 in the close neighbourhood of the Carpathian Basin. The contemporary Silesian chronicler, Peter Eschenloer (Roth, 2003; Gyalókay, 1940), while describing the successful military campaign of King Matthias against the Polish king in Silesia, noted that the water level of the Oder/Odra was low in early October 1474 at Krappitz (Krapkowice-Pl), when the Polish army crossed it. This fact suggests overall dry preceding conditions in the Southern Silesian catchment

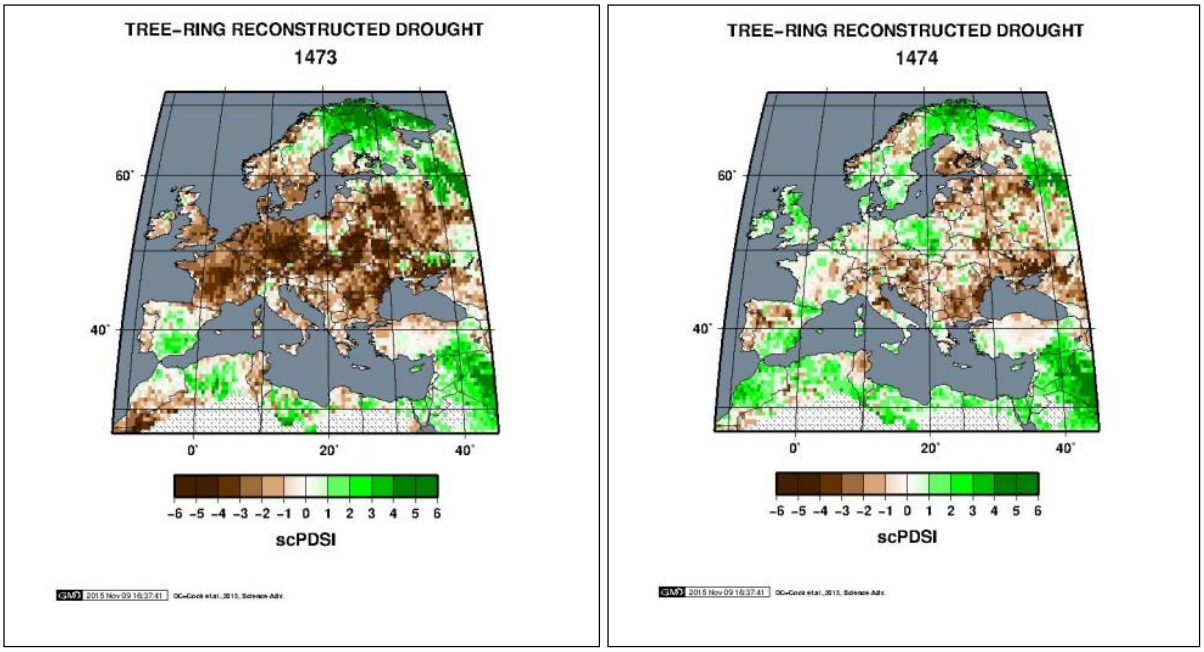

Fig. 5 Tree-ring based hydroclimate reconstructions of the OWDA: 1473 and 1474 (Cook et al., 2015)

basin of the river prior to early October, while the Polish chronicle writer, Jan Długosz, in November mentioned heat and drought (length not defined), and then a flood of the Oder/Odra that had been caused by rain (Bazkowski et al., 2005).

Consequently, in accordance with the aforementioned documentary and tree-ring based evidence, and also with reference to the part-conclusions of Kiss and Nikolić (2015), we suggest that both 1473 and 1474 could be years with more significant water deficit in Hungary and the Carpathian Basin, even if the intensity of this dry spell and drought may have had spatial and temporal differences within the Carpathian Basin.

Religious procession praying for rain: great spring (and summer?) drought in 1480

Briefly referred by Kiss and Nikolić (2015), following the inquiry of king Matthias I, the Pauliners of Budaszentlőrinc made a religious procession in (late?) spring, from Budaszentlőrinc to the Castle of Buda, carrying the relics of the saint (Paul) with them, and praying for rain in the "great drought". However, it started raining before the procession could have turned back to the monastery, and the vegetation recovered (Gyöngyösy, 1988). This information is particularly interesting as the only available report, Antonio Bonfini's extensive chronicle, suggests 1479 as a memorable drought year, and does not mention dry conditions for 1480 (Kiss and Nikolić, 2015). Nonetheless, in, for example, the Czech Lands 1480 was marked by its characteristic dry nature and not 1479.

Another additional, indirect evidence, similarly dated to 1480, might be worth to be mentioned here: the judge of (Buda)Felhévíz warned the tax-collectors to the royal charter that stated their tax-free status on their own cargo ships carrying food (Bártfai Szabó, 1938). Although such a case could happen any time, there is somewhat more chance for food-related conflicts, for example, in times with food shortage problems. It has to be further noted that, documented in the Pressburg accounts, in early summer 1480 there was a Danube flood of moderate intensity in the Bratislava area (see Kiss, 2018).

As presented on the related OWDA maps (Fig. 6), 1479 was a significant drought year concerning at least the (spring-) summer period practically all over Europe, while 1480 was more concentrated to the southern, south-eastern parts of the continent, including the Carpathian Basin. Nevertheless, on the tree-ring based hydroclimate reconstruction map the Carpathian Basin seems to be strongly affected by drought in both years, and therefore in this case – in agreement with the direct and indirect documentary evidence – we have to account with a double drought-year in Hungary.

"In aestate ultra arida"- very dry summer in Transylvania: 1482?

In a charter dated to 19 February 1496 (Iványi, 1928), the nobles of Pókafalva (Păuca-Ro) in South-eastern Transylvania, preserved an earlier complaint against the people of the Pauline friary: in 1482 there was very dry summer, and the serfs ("*layci nostri*") of these nobles drove their draught animals to a fishpond, constructed in 1475, to drink. They went there three times, and finally armed men of the friary came, and gravely injured with their swords two serfs of the nobles ("*In anno quidem domini millesimo quadringentesimo octuagesimo secundo in aestate ultra arida cum layci nostri ad adaquandas iumenta ipsorum ad piscinam dictorum fratrum depulissent, tunc prior praefatorum tertiusmet sibi similibus, armatis manibus de claustro irruentes, duos ex laicis nostris cum gladio letaliter vulnerarunt....*"). The most important, weather-related information of this story is that in 1482 the summer was memorably dry, but there was enough water in the local fishpond to serve as a water supply for large domestic animals.

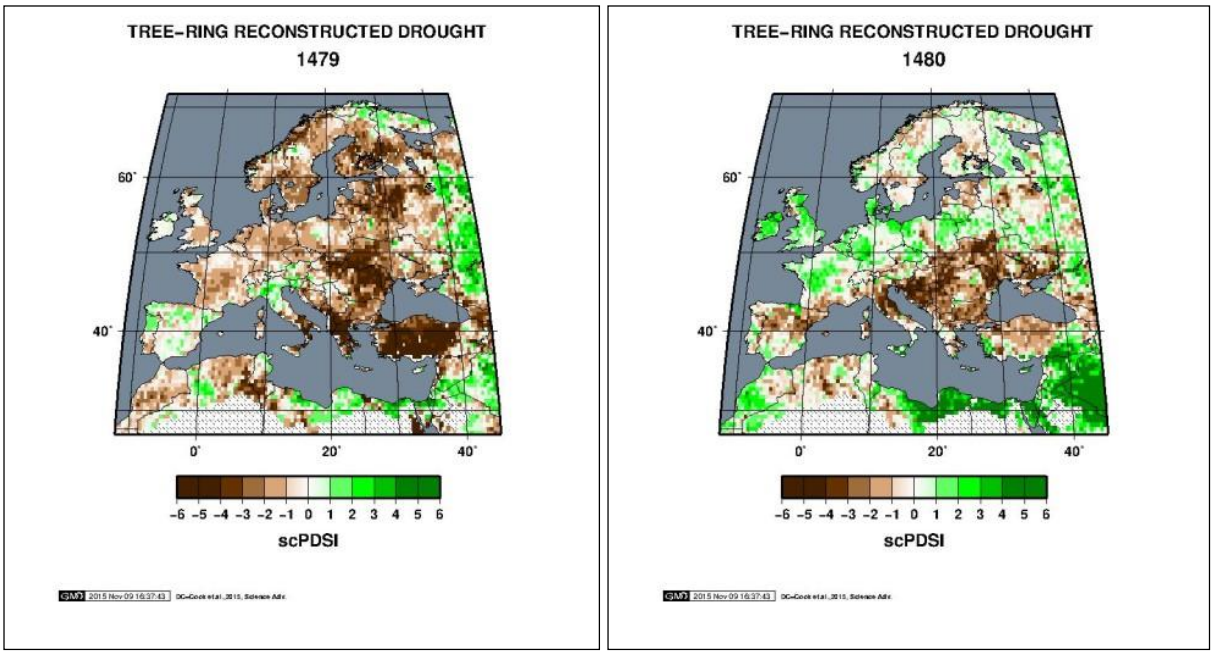

Fig. 6 Tree-ring based hydroclimate reconstructions of the OWDA: 1479 and 1480 (Cook et al., 2015)

The charter was written almost 14 years after the event. Although legal documents, and charters in particular, form a most accurately dated source group, in the present legal procedure the fact that the event happened particularly in 1482 did not play a central role in the legal case and thus, we cannot completely rule out the possibility that the event occurred one year earlier or later. Nevertheless, as the charter itself referred back to 1482 specifically as a (memorable) summer of great drought, it is probable that the event was not misdated, and potentially many eye-witnesses still could confirm the dating.

Taking into consideration the OWDA reconstruction (Fig. 7), however, we can see that 1483 (or even 1484) would be a more likely option for a particularly dry summer in Transylvania. According to the OWDA, 1482 was although dry, it did not represent a particularly dry period in Transylvania. Nonetheless, since the OWDA provides information mainly on (spring-)summer patterns, this might be also in connection with spring (or even earlier) precipitation. North, north-east to Transylvania, the areas what is today the Ukraine show extreme dry patterns for the (spring-)summer of 1482, which may indirectly support the theory of a very dry summer in large parts of Transylvania, too. Therefore, although we cannot exclude the possibility that the year 1482 was mentioned in the charter by mistake instead of, for example, 1483, it is also possible that the charter evidence provide in this case a more accurate information than the OWDA data.

Loss of bee, grain and vine harvest, high prices and low water level: indicators of a dry spell in 1502 and 1503?

In Hungary, no contemporary source is known that directly refers to any dry spell or drought in the years 1502 and 1503. Nevertheless, some indirect evidence suggests that considerably dry conditions. On 29 November (GC: 9 December) in 1502 the small water is mentioned in the Pressburg accounts (AMB, K58/34: *Item Kamerer hat hingeben ain alte pletten ausß dem urfar denn Ungern in das klain wasser zw dem Thaman sthoff*…). The phrasing of the sentence less obviously refers to general low water levels than the ones in 1443, 1444 and 1455. Still, in the text clearly a Danube trajectory and a ship are mentioned, and the sentence is regarding to the actual conditions of a Danube branch. However, as the text refers to an old ship, the most possible option is that the small extension of the water was emphasised because this important circumstance influenced, either positively or negatively, the conditions of removal. Although the reference is dated to late autumn-early winter times, it is worth noting that the OWDA map for (spring-)summer 1502 shows rather dry conditions in Western and West-Central Europe including the majority of the Upper-Danube catchment basin, and the dry character of the autumn could have further supported the development of a dry spell that resulted the 1503 extreme low tree ring values (see Fig. 8).

Documented in a number of contemporary sources and presented by the relevant OWDA map (Fig. 8), 1503 is a well-known severe drought year in Western and Central Europe, also including, for example, the Czech Lands, Poland, Austria or the German areas (see e.g. Brázdil et al. 2014; Rohr, 2007; Glaser, 2013). Thus, both 1502 and 1503 were drought years in Western and North-western Europe, but in (spring-)summer 1503 the drought was considerably more severe. According to the above maps (Fig. 8), however, the Carpathian Basin would have been less affected in 1502, and even in 1503 the drought could have appeared in a significantly milder form than in the West. However, it is interesting that while on the OWDA map the central and eastern parts of Austria,

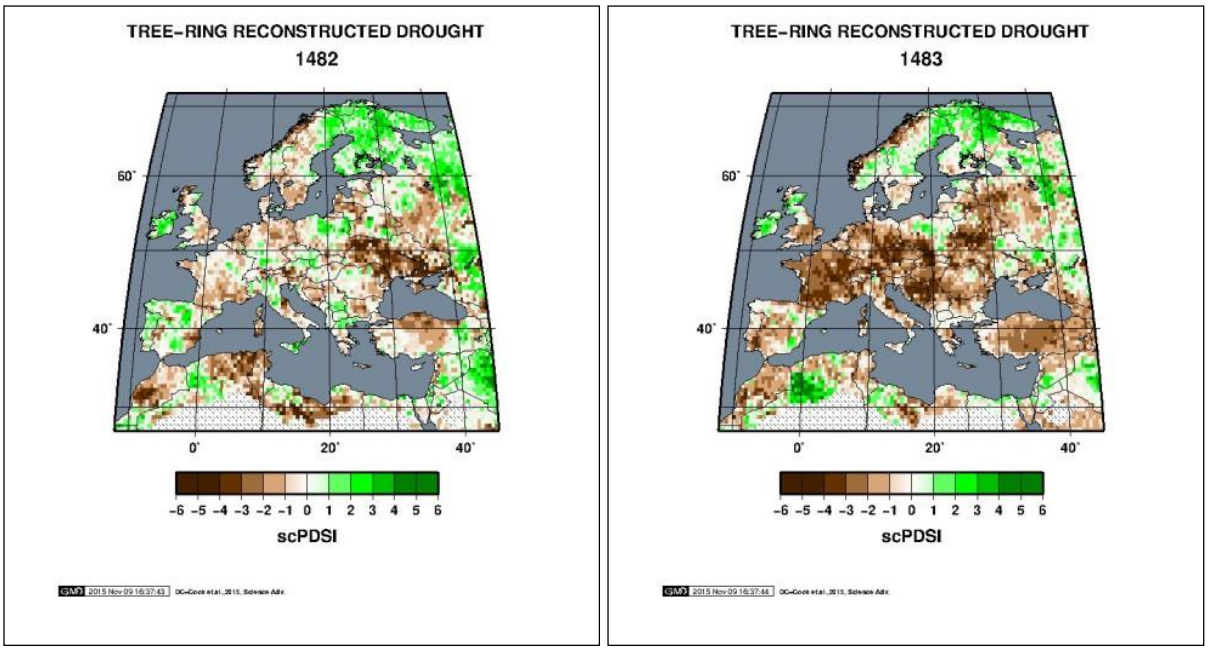

Fig. 7 Tree-ring based hydroclimate reconstructions of the OWDA: 1482-3 (Cook et al. 2015)

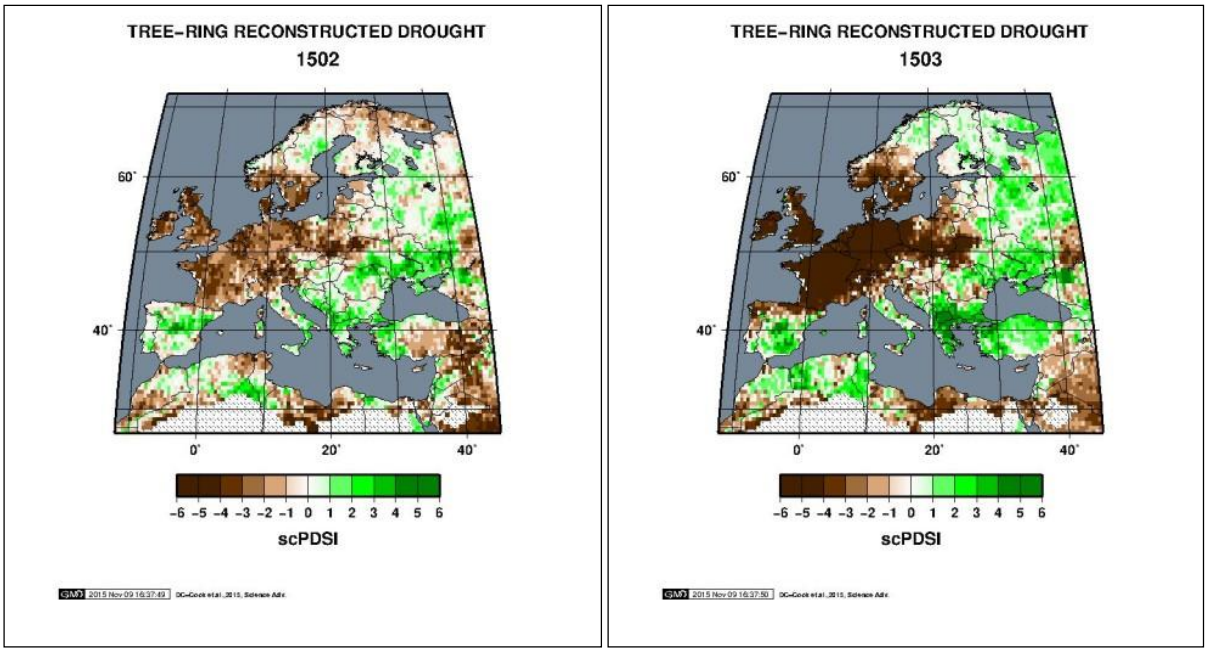

Fig. 8 Tree-ring based hydroclimate reconstructions of the OWDA: 1502 and 1503 (Cook et al. 2015)

similar to most of the Carpathian Basin, do not belong to the areas notably affected by severe drought, the chronicle of Lorenz Mittenauer in Wels (Upper-Austria) clearly emphasised the extreme drought of 1503 and its unfavourable consequences (including devastating hails) on cereal and hay harvest as well as on fish supply (see Rohr, 2007). It is also interesting that, based on documentary evidence, in the Czech Lands there were droughts in 1501, 1503 and 1504, too.

In 1502 or 1503 no direct source refers to a drought in Hungary. Nevertheless, in the rather detailed accounts of the bishop of Eger (source: E. Kovács, 1992) many entries are related to certain problems that later, in 1507, again appear in the accounts when drought and related damages are listed (see Kiss and Nikolić, 2015; Kiss, 2017). Even if the full account book is not available for 1502, rather interesting information is known from the 1503 accounts both concerning 1502 and 1503. No drought was directly mentioned, but much more is known concerning the damaging hails. Mentioned on 14 February 1503, vineyards were previously damaged by hails in Borsod county (e.g. Boldva, Varbó; NE-Hungary): this evidence most probably refers to hails that still occurred in 1502. Furthermore, the high prices of "all things" were mentioned in Eger on 1 March 1503: this information may suggests harvest problems already for 1502.

Damages due to hails, bad weather, or simply the great damages in vineyards without mentioning the cause, occurred in 1503, were reported in the bishop's accounts concerning Kaza in Zemplén county (also heavily affected area in 1507: see Kiss, 2017), Sajószentpéter in Borsod county, (Olasz)Liszka, Gálszécs (Sečovce-Sk) and Nádasd (Tornanádaska) in Újvár county. Except for Gálszécs/Sečovce in South-eastern Slovakia, all settlements are located today in North-eastern Hungary, in Borsod-Abaúj-Zemplén county. In the vine region of the Eger diocese (i.e. Gyöngyös, Gyöngyöspüspöki, Solymos) part of the wine went bad ("rotten") in this year. Damages by hail or simply bad harvest were also reported in Szabolcs county (Nádudvar, Hegyeg) where spring cereals and the oats were destroyed. As presented by Kiss and Nikolić (2015) and Kiss (2017), similar problems were typical during the 1507 drought event. Another negative circumstance was mentioned concerning Eperjes (Prešov-Sk): due to fire, the town received tax release in this year.

A further problem, again rather similar to those described in 1507, was the low income or complete failure in bee products. Even if in 1503 this was mentioned in less cases than in 1507, it could be still a significant general problem in the area of the diocese, especially because larger areas, entire districts, for example the Szántói district in Szabolcs, the Homonnai (Humenné-Sk), Varannói (Vranov nad Topľou-Sk), Sztropkói (Stropkov-Sk), Nagymihályi (Mihalovce-Sk) districts in Zemplén, the Kazai district in Borsod county and the entire Újvár county had no beehives to send to the castle (Eger) in this year. As bees usually react rather sensitively on weather extremes, and this is particularly true in case of drought (or very wet conditions), similar to 1507 (Kiss, 2017), they may act as indicators of weather-, and probably (spring-summer, or earlier) drought-related problems in 1503.

Thus, although currently no contemporary documentary evidence mentions drought related 1502 or 1503, it is clear that both years were problematic in some (e.g. the north-eastern) parts of the country, and based on the parallels of the neighbouring countries as well as the relevant OWDA maps, we may raise the possibility that dry conditions prevailed in some parts of Hungary in 1503, and probably also in 1502. It has to be further added that, despite drought problems, probably not the entire year or years of 1502 and 1503 were dry, and even water surplus might have caused problems in this period. For example, on 6 May 1503 a letter written by the king to the royal town of

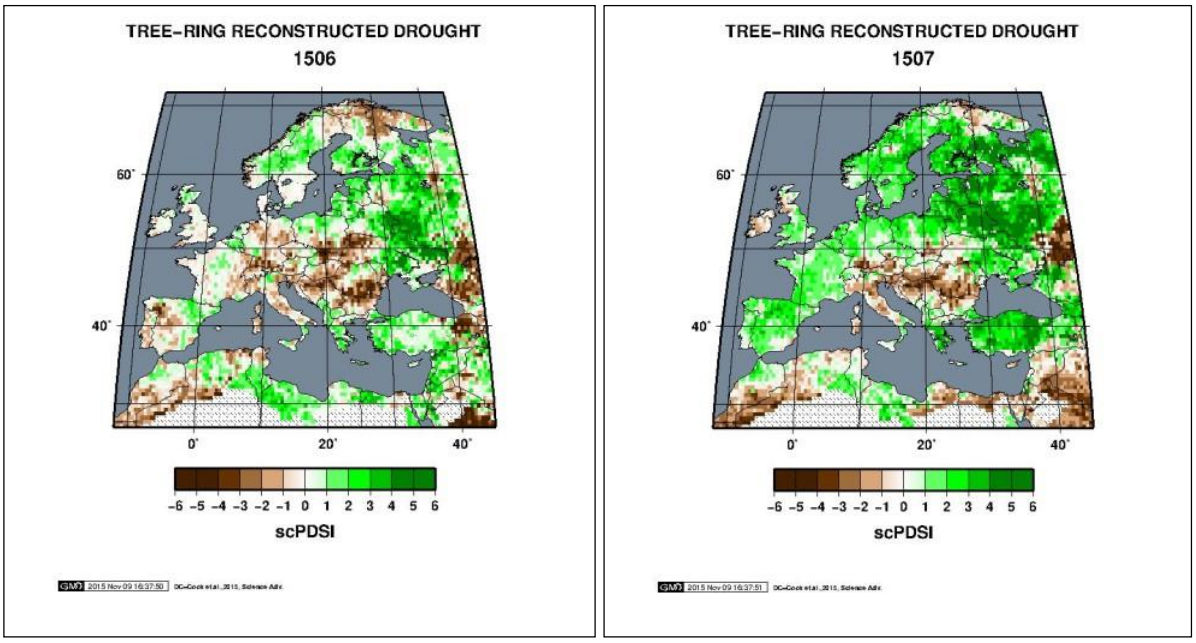

Fig. 9 Tree-ring based hydroclimate reconstructions of the OWDA: 1506 and 1507 (Cook et al. 2015)

Pozsony (Bratislava-Sk) informs us about the severe problems caused by the frequent great floods ("*ex frequenti illuvie aquarum*") in the area of the town (HNA DF 240970; see Kiss and Laszlovszky, 2013), while according to Rohr (2007) there was a great flood with significant damages on the River Traun in September 1503 at Wels in the catchment basin of the Upper-Danube. This flood, together with the potential flood of other rivers in the Eastern Alpine area, might have also influenced the water-level conditions of the Danube in Hungary.

Loss of sheep, high prices and convective events: indirect indicators of a drought in 1506?

As presented by Kiss and Nikolić (2015), 1507 was mentioned by different sources as a memorable drought year in north-eastern part of the kingdom, that is today North-east Hungary, Eastern Slovakia and South-western Ukraine. The other contemporary source, János Kakas in Buda, however, mentioned this drought related to the entire kingdom. Nonetheless, in most parts of Central Europe rather 1506 was reported in contemporary sources as a year with great drought.

The relevant OWDA maps (see Fig. 9) concerning the years 1506 and 1507 show conditions considerably drier than usual, but according to these maps, a notable (spring-)summer drought anomaly could be detected especially in the southern and the north-eastern part of the Carpathian Basin in 1506, and only in the southern parts we see a greater drought anomaly in 1507. In general, based on the OWDA maps, both years were rather dry especially in the south, but drier conditions would have prevailed in large part of the Carpathian Basin in 1506 than in 1507.

Both the information coming from documentary evidence of the neighbouring areas (where detectable) and the tree-ring based hydroclimate reconstruction suggest dry conditions or drought in 1506 in Central Europe, even if the data based on the tree-ring reconstruction suggest a less significant drought event than what is known from documentary evidence. In Hungary no contemporary report is known that directly mentions 1506 as a year of drought. Nevertheless, some indirect evidence suggests that weather/environmental conditions were unfavourable not only in 1507 but already in 1506.

As presented in Table 1, the church of Saint John burnt down in summer 1506 due to thunder in Eger (see Table 1), which means that a significant convective event occurred. Other convective events had resulted the damaging hails that caused particularly great damages, most probably in 1506, in Tolcsva that belongs to the Tokaj-Hegyalja wine region. The lamb tithe problems in Sáros county (Table 1; today N-NE-Slovakia) probably refer to feeding/nutrition problems and/or disease in the 1506, but no details are known. However, according to the relevant OWDA map this was one of the areas affected the most by drought in 1506 (see Fig. 9). In March 1507 there were only a few sturgeon and other fish in Tisza: this fact most probably refers to preceding low water levels, and reflects on the precipitation patterns of a period that covered at least several months prior to the date of mention and thus, most probably already in 1506 the prevailing water levels were lower than usual. As the catchment basin of the Upper-Tisza covers the north-eastern part of the Carpathian Basin (NE-Slovakia, SW-Ukraine) as well as Northern Transylvania (N-Romania), in these areas at least the second part of 1506 had to be drier than usual.

Unlike in 1507 when it seemed to be a significant problem, based on the bishop's accounts, there were no bee-related problems or lack of bee-products mentioned in 1506. However, the full accounts concerning 1506 are missing, and only the references remained in the 1507 accounts are known. Thus, the lack of reference on the problem may not automatically refer to the lack of problems.

Table 1 Problems mentioned in the accounts of the Eger diocese (Source: E. Kovács, 1992; see also: Kiss, 2017)

Date of Account	Location /county	Bad harvest or other damage	Tax release, postponing	Weather-related Evidence
24.07.1506 GC: 03.08	Eger	St. John church burnt		Struck by thunder
after 15.12.1506 GC: 25.12	Buda, Pest	Flood		Very great Danube ice and coldness before
02.02.1507 GC: 12.02	Szabolcs county	Losses (from 1506?): lamb tithe	Paid together with the 1506 lamb tithe	
02.02.1507	Sáros county	Lamb tithe: low income		
14.03.1507 GC: 24.03	Tolcsva (Zemplén county)	Wine tithe: very great damages in vineyards	12 Ft tax release due to previous damages, and for public works	Hails (probably in 1506)
25.03.1507 GC: 04.04	Kürt (at the Tisza river)	Few fish (sturgeon, other fishes)		
24.04.1507 GC: 04.05	Felnémet (Heves county)	Poverty of serfs	Full release of remaining tax due to much public work	

Comparing the OWDA map with the available indirect documentary evidence, it is thought-provoking that in 18 April 1507 the king in a dramatic letter asked the citizens of Sopron royal town to send a 1000 Golden Forint as a special military tax, because he urgently had to pay the soldiers at the southern borderline, due to their extreme great need ("*extreme inopie magnitudo*"; Házi, 1928). This dramatic tone and the grave problems along the southern defence line can be, of course, always explained by the ever-uncertain military situation, as Turkish troops could attack the area any time. The long-term expenses of the mere maintenance of this long defence line in itself meant a significant burden on the annual royal budget. Nevertheless, taking into consideration the relevant OWDA map which shows that in 1506 the southern part of the country was the most affected by drought, it is also possible that in spring 1507 the very high price of food was an even more striking problem in the south than usual. Given the fact that the king was late with the soldiers' payment, they most probably had severe food supply problems that threatened the southern fortresses with desertion. Thus, apart from the general political and socio-economic problems of the south, we might also have to count with the negative effects of actual weather conditions.

CONCLUSIONS AND OUTLOOK

In the present paper, based on direct and indirect, mainly contemporary source evidence and also on the basis of the OWDA maps eleven years with dry spells were discussed. Seven of the discussed cases were suggested as drought events occurred in some parts of the Carpathian Basin, while in further four cases low water-level reports were discussed in more detail. The known low water-level reports in 1443, 1444, 1455 and 1502, were all documented in the Pressburg accounts, and refer to the Danube in the Bratislava area, and therefore primarily reflect not on the precipitation deficit of the Carpathian Basin, but rather that of the catchment basin of the Upper-Danube, including Bavaria and the Eastern Alpine area (Austria).

As presented throughout the paper in a number of case studies, when documentary evidence is available, usually there were not only one but two years affected by drought. In this way, although directly the next (or previous) year was more emphasised in 'local' documentation, some of the great European drought years (e.g. 1473, 1480, 1506) could be also detected regarding late medieval Hungary. Moreover, in some cases it is probable that among the coupled drought years not necessarily the drought year, most severe in Western or West-Central Europe, was the more severe in the Carpathian Basin.

Due to the characteristics of source types applied, it is also a possible option that while one drought year was (occasionally) mentioned in a contemporary domestic source due to related consequences, the other, similarly important (preceding or following) drought year remained unreported or can be detected only in the indirect evidence. This is true not only for the direct drought references, but also to the other important source group that concerns Danube low water levels. For example, the 1443 or 1444 low waters were recorded in relation with particular activities, and therefore even if the previous year would have meant a similar or even greater anomaly, could easily remained unreported.

Furthermore, in some of the cases it is also possible that while in the first year one part of the country was more affected, in the other year the drought was more severe in other parts (e.g. 1473-4, 1506-7). The OWDA maps also show that, even if there were anomalous drought years that affected majority of Central and Western Europe, similar to modern droughts, in most

cases we have to account with considerable spatial differences not only between the different parts of Europe, but also compared to the neighbouring countries, and even within the Carpathian Basin itself.

Although occasionally, especially concerning intensity and spatial extension of one-one significant drought events, some differences occur (e.g. in 1507), in most cases we found fairly good agreement between the (spring-)summer hydroclimate reconstruction of the OWDA and the documentary-based drought information. Moreover, in some cases the OWDA map provided a good support to the identification of drought years, documented only in one contemporary source in Hungary, but with scarce or no parallel information in the neighbouring countries. This might be particularly important in case of two or more drought years in series (e.g. 1442-1444). We also have to add that, rather clearly, many of the dry spells, captured in tree-ring evidence, still could not be detected in the domestic written documentation. However, rather indirectly other sources (e.g. food shortage problems and the OWDA-based long drought periods), not (yet) discussed in this and the previous paper, may provide further data that helps to capture more signs of severe droughts in late medieval Hungary.

The 15th-century dry spells, detected in written sources, are to some extent clustered around two periods: the first such period is the late 1430s-early 1440s: here 1439, 1443 and 1444 addressed in documentary evidence. Nevertheless, the OWDA as well as the information from the neighbouring areas suggest that also years in between (i.e. 1440, 1442) were considerably dry in Central Europe and probably also in Hungary, in the (spring-)summer period. Taking into consideration also the evidence presented by Kiss and Nikolić (2015), the other such period is concentrated around the 1470s-early 1480s.

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