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Supplement of

Large-scale climate signals of a European oxygen isotope network from tree rings

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Location	*Country*	*Species*	*Altitude*	*Lat.*	*Lon.*	*First year*	*Last year*
Carzola	Spain	*Pinus nigra*	1820 m	37.53°	-2.57°	1600	2002
Cavergno	Switzerland	*Quercus petraea*	900 m	46.21°	8.36°	1637	2002
Col Du Zad	Morocco	*Cedrus atlantica*	2200 m	32.59°	-5.14°	1600	2000
Dransfeld	Germany	*Quercus petraea*	320 m	51.50°	9.78°	1776	2002
Fontainebleau	France	*Quercus petraea*	100 m	48.38°	2.67°	1600	2000
Gutuli	Norway	*Pinus sylvestirs*	800 m	62.00°	12.18°	1600	2003
Inari	Finland	*Pinus sylvestris*	150 m	68.93°	28.42°	1600	2002
Isibeli	Turkey	*Juniper excelsa*	1800 m	37.06°	30.45°	1850	2005
Laizer	Austria	*Quercus petraea*	300 m	48.18°	16.20°	1600	2003
Lochwood	United Kingdom	*Quercus petraea*	175 m	55.27°	-3.43°	1749	2003
Monte Pollino	Italy	*Pinus leucodermis*	1900 m	39.58°	16.16°	1604	2003
Mount Vichren	Bulgaria	*Pinus heldreichii*	1900 m	41.46°	23.24°	1800	2005
Naklo	Slovenia	*Larix decidua*	440 m	46.30°	14.30°	1600	2005
Niepolomice	Poland	*Quercus robur & Pinus sylvestris*	190 m	50.12°	20.38°	1627	2003
Panemunes	Lithuania	*Pinus sylvestris*	45 m	54.88°	23.97°	1816	2002
Pedraforca	Spain	*Pinus uncinata*	2120 m	42.13°	1.42°	1600	2003
Pinar de Lillo	Spain	*Pinus sylvestris*	1600 m	42.57°	-5.34°	1600	2002
Plieningen	Germany	*Quercus petraea*	340 m	48.42°	9.13°	1822	1999
Poellau	Austria	*Pinus nigra*	500 m	47.95°	16.06°	1600	2002
Rennes	France	*Quercus robur*	100 m	48.25°	-1.7°	1751	1998
Sivakkovaara	Finland	*Pinus sylvestris*	200 m	62.98°	30.98°	1600	2002
Suwalki	Poland	*Pinus sylvestris*	160 m	54.10°	22.93°	1600	2004
Vigera	Switzerland	*Pinus sylvestris*	1400 m	46.50°	8.77°	1675	2003
Vinuesa	Spain	*Pinus uncinata*	720 m	42.00°	2.45°	1850	2002
Woburn	United Kingdom	*Pinus sylvestris*	10 m	51.98°	-0.59°	1604	2003

Table S1: The characteristics of each sample site which is used within our study. 22 of the 26 $\delta^{18}O_{cel}$ records were created within the EU project ISONET (Treydte et al., 2007a, b) and four additional sites from Bulgaria, Turkey, Southwest Germany and Slovenia were added (Hafner et al., 2014; Heinrich et al., 2013).

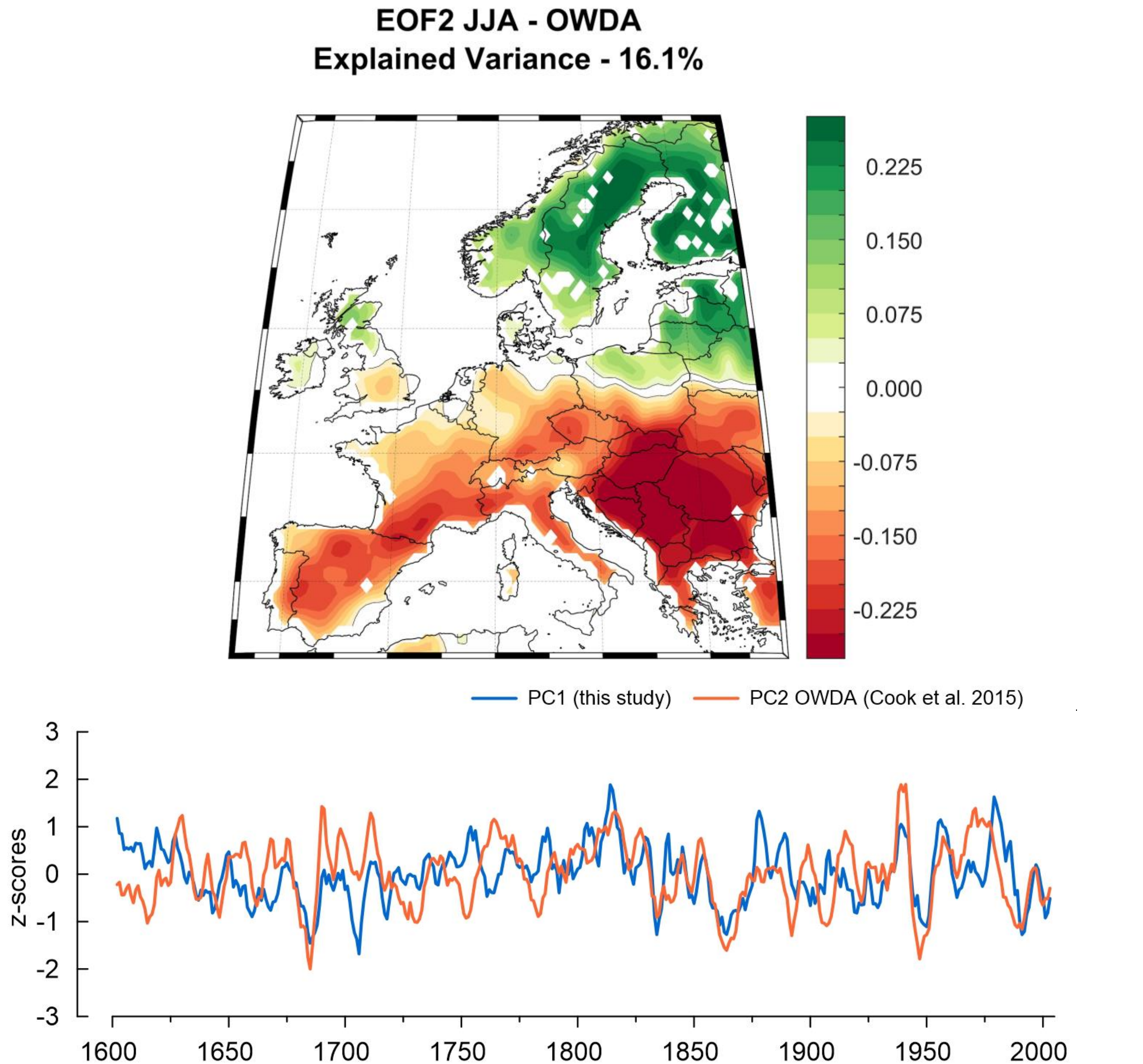

Figure S1: Upper panel: The second EOF of the OWDA (Cook et al., 2015) for JJA (explaining 16.1% of the variance). Lower panel: The associated PC2 of the OWDA for JJA and PC1 of our study. The correlation between the two time series is R=0.39 (p-value=4.2e^{-16}).

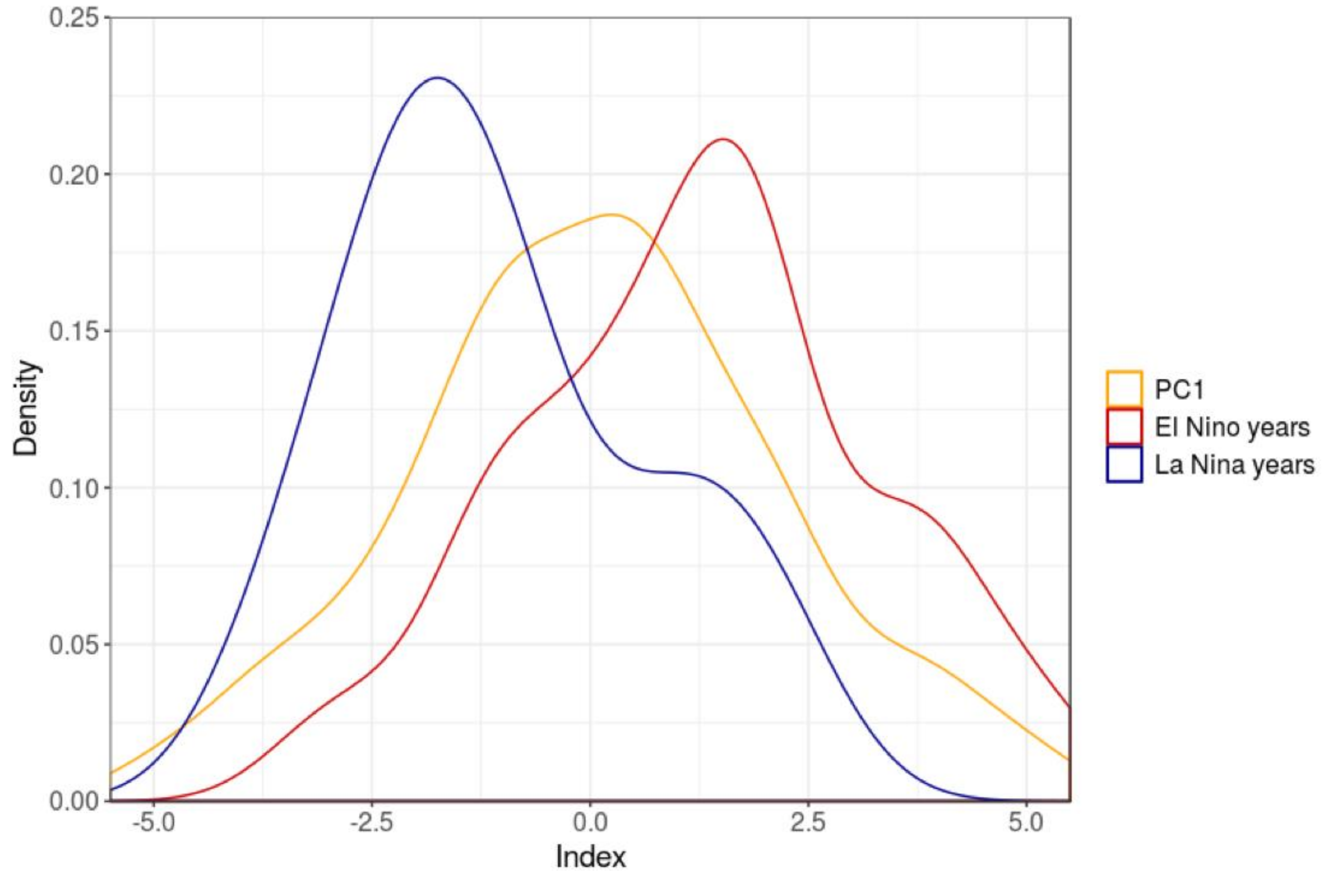

Figure S2: The probability density function of PC1 with two additional functions for El Niño and La Niña years. The El Niño and La Niña years have been extracted out of a Nino 3.4 DJF index (HadISST1; Rayner et al. 2003) for the period from 1870 to 2000.

	LI ET AL. 2011	LI ET AL. 2013	DÄTWYLER ET AL. 2019
1750-1849	r=0.121 p-value=0.231	r=-0.008 p-value=0.936	r=-0.078 p-value=0.442
1850-1949	r=0.223 p-value=0.026	r=0.303 p-value=0.002	r=0.296 p-value=0.003

Table S2: Correlation between the first component of the $\delta^{18}O_{cel}$ network with three different ENSO reconstructions for two different time periods.

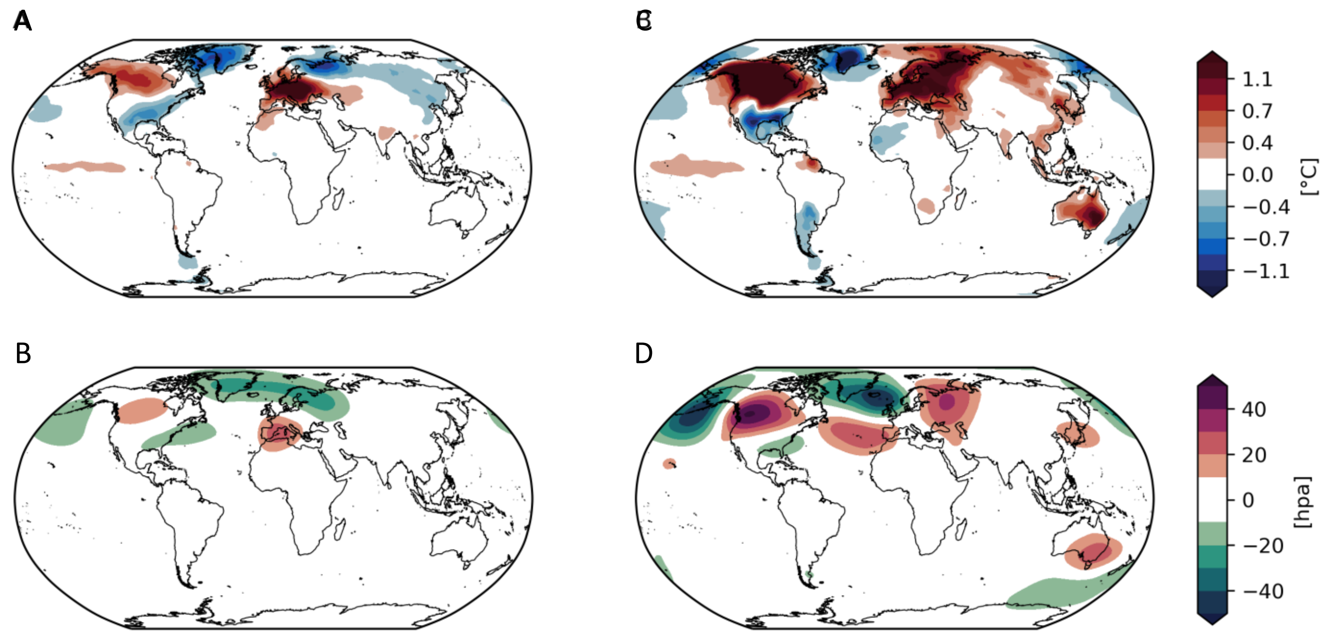

Figure S3: Composite maps (high-low) for air temperature and Z500 from the Ensemble Kalman Fitting Paleo-Reanalysis Version 2.0 (Franke et al., 2020) for winter related to the NDJ Niño3.4 index by Li et al. (2013). The first column shows the characteristics of air temperature (**A**, **C**) and the second Z500 (**B**, **D**) whereas the first row shows the results for the period 1750 to 1849 and the second for the period 1850 to 1949. The Z500 pattern over the North Atlantic shows similarities to the NAO (**D**) which can't be identified in the period before (**B**). The differences are also shown in the pattern of air temperature. The comparison of the two different periods suggests that the influence of ENSO variability on the European climate could change over time which is shown by different air temperature and Z500 patterns.

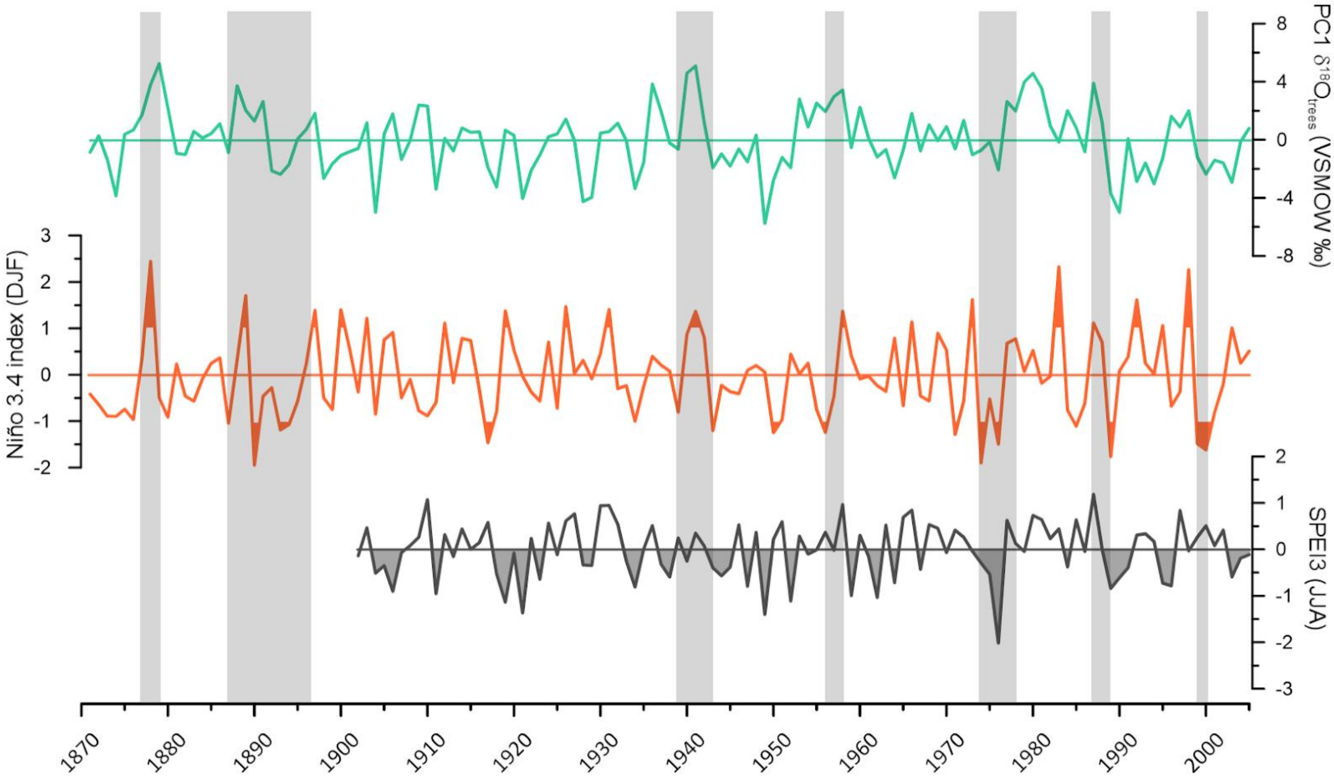

Figure S4: The time series of the first component of the stable oxygen isotope network in comparison to other time series of climate patterns. For a better comparison, a Nino 3.4 index for DJF (HadISST1; Rayner et al. 2003) and a SPEI3 drought index (SPEIbase v.2.5 [SPEI3]; Longitude -5° to 10°/Latitude 46° to 52°) are shown. Selected El Niño and La Niña events are highlighted via a grey background.

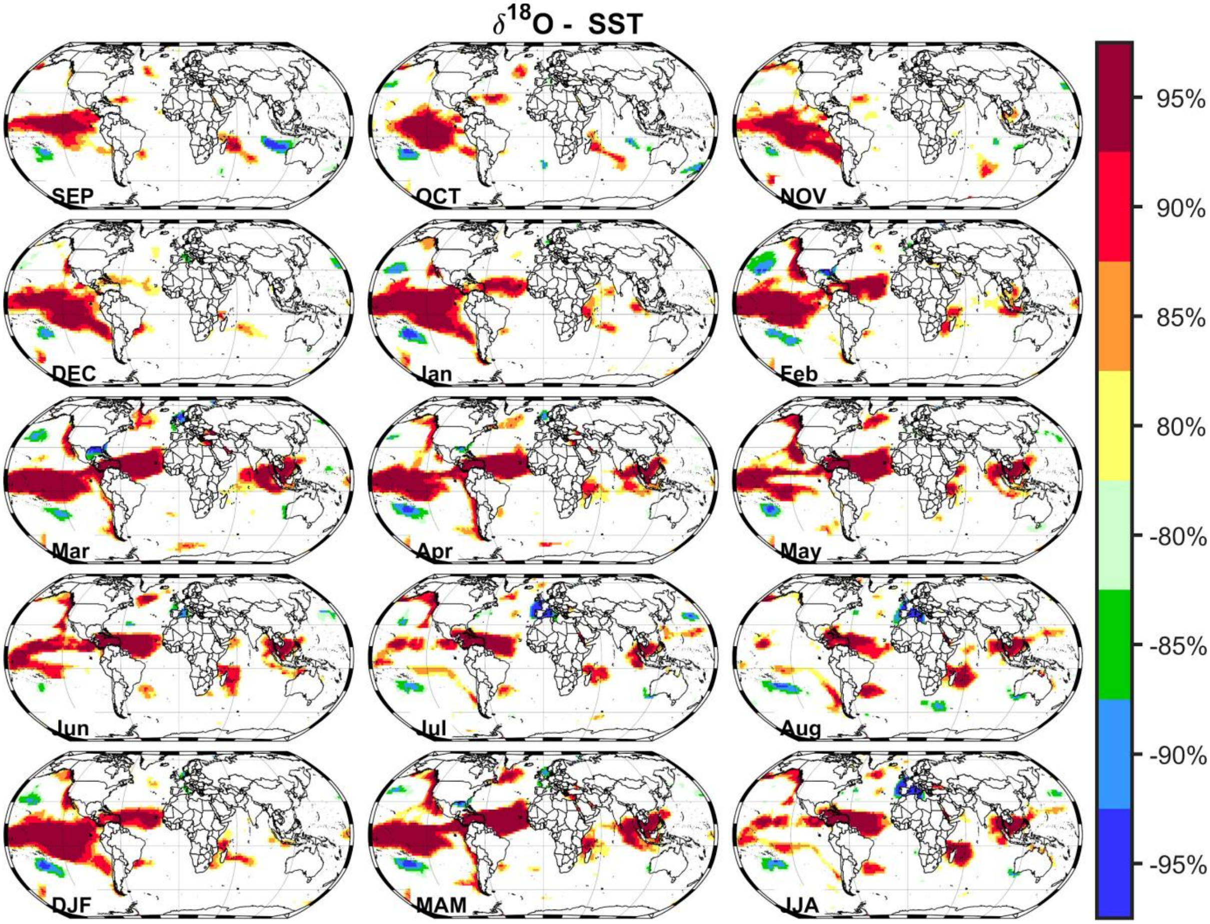

Figure S5: Stability maps for the correlation between SST anomalies (Huang et al., 2017) and the first mode of $\delta^{18}O_{cel}$. In order to show how stable the connection between the sea surface temperature (SST) of the tropics and the first mode of $\delta^{18}O_{cel}$ is, we have computed the stability maps of the correlation between these two quantities. The stability map is a tool which is primarily used for streamflow predictions to identify stable teleconnection (for more details see Rimbu et al. 2005 or Ionita and Nagavciuc (2020)). SST anomalies from the ERSST have been correlated with the first mode of $\delta^{18}O_{cel}$ in a moving window of 31 years. The correlation is considered to be stable for those grid points where anomalies are significantly correlated at the 90% level for more than 80% of the 31-year windows, covering the period 1854–2005. The color bar indicates how many years are characterized by a significant correlation (at the 90% level) in a 21-yr window, covering the period 1854–2005. Positive correlations are shown from yellowish to reddish and negative correlations from greenish to blueish. As it can be inferred from Supp. 6, one of the largest locations with stable correlations is located in the tropical Pacific. Stable correlations are shown from September (last year) to June which also supports our result that $\delta^{18}O_{cel}$ is able to capture a multi-seasonal signal and that the first mode of $\delta^{18}O_{cel}$ is sensitive for ENSO variability. Based on these results, we suggest that the relation between the first mode of $\delta^{18}O_{cel}$ and the SST in the tropical Pacific/Atlantic in winter and spring is stable in the period from 1854 to 2005.