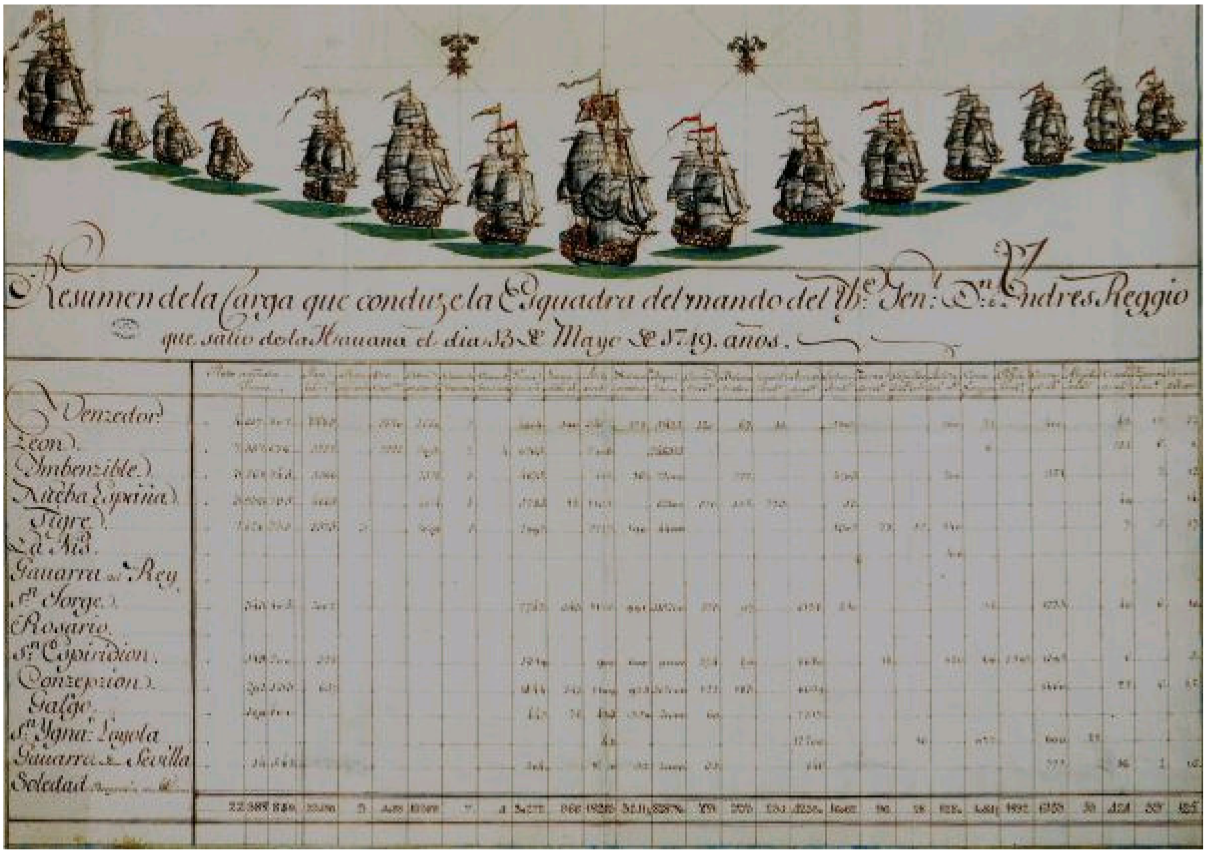
Scientific Report ESF-Exchange Grant



Reference Number: 1241
Activity Title: Mediterranean Climate Variability and Predictability (MedCLIVAR)
Title of the research project: Improved Reconstruction of Atlantic, European and Mediterranean Sea Level Pressure 1750-1850
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1. Purpose of the visit

During the last years several research groups have addressed the important issue of climatic reconstructions over the Atlantic and Europe. In particular, the knowledge about the large-scale atmospheric circulation expressed as Sea Level Pressure (SLP) fields covering the last few centuries, has the capacity of explaining major patterns of precipitation and temperature variability across Europe and the Mediterranean basin.

However, widespread instrumental measurements allowing the construction of gridded datasets of past SLP are only available since the late eighteenth century (Jones et al. 1999; Luterbacher et al. 2002; Casty et al. 2005; Allan and Ansell 2006). Prior to this period, reconstructions have primarily relied on a few long instrumental station pressure series and on proxy information from land-based documentary or natural sources (e.g. tree rings) which do not strictly represent long-term changes in pressure, but rather a combination of atmospheric circulation variability and changes in the influence of the circulation itself (e.g. Jones et al. 2001; Luterbacher et al. 2002; Casty et al. 2007). Based on this multiproxy approach, Luterbacher et al. (2002) statistically reconstructed monthly to seasonal gridded SLP spanning the area of the eastern North Atlantic and European area. Despite the skilful spatial reconstructions (mainly over Central and Northern Europe), this study is inevitably biased by the limited spatial window covered by the predictors used. Most importantly, there is virtually no information from the North African coast, limiting – along with the sparse coverage over the northern North Atlantic Ocean in historical times – the characterization of the prevailing atmospheric circulation conditions over most of southern Europe and the Mediterranean. Therefore the currently available SLP reconstructions are less reliable in those areas, mainly before around 1800, and thus limited in their use for relating the large scale atmospheric circulation to temperature and precipitation variability. This is particularly of importance for regions with dry summer and wet winter, where an accurate representation (in terms of location and strength) of the relevant centres of action (the Azores and western Russian highs and the Icelandic low in winter, as well as the subtropical high and the westward extension of the Russian thermal low in summer) is essential.

The objective to overcome those deficiencies has initiated interdisciplinary projects that aimed at exploiting the meteorological observations taken aboard the sailing ships and preserved in their logbooks as e.g. ICOADS (Woodruff et al. 1987; Worley et al. 2005) or CLIWOC (Gallego et al. 2005; García-Herrera et al. 2005; Jones and Salmon 2005, Wheeler 2005). The wind information over the World's oceans digitised and translated by the project CLIWOC has recently been used in the studies by Gallego et al. (2005) and Jones and Salmon (2005) and has shown its potential to skilfully reconstruct the North Atlantic Oscillation Index (NAOI) and full SLP fields across the northern North Atlantic for the period 1750-1850.

The data sources mentioned above offer a unique opportunity to obtain an improved large scale SLP reconstruction for the Atlantic, European and Mediterranean area based on long instrumental pressure series and the wind information derived from the CLIWOC database covering the period 1750-1850. The inclusion of the CLIWOC data is thereby expected to clearly improve the reconstruction skill over the early decades and in particular over the marine areas, where only a few instrumental series are available. This new blended SLP reconstruction will thereafter allow studying the relationship between the large scale atmospheric circulation over the last 250 years with temperature and precipitation variability, without any circularity (Xoplaki et al. 2007).

2. Description of the work carried out during the visit and first results

2.1 Evaluating the CLIWOC database

A main part of the visit in Seville was used to investigate the CLIWOC database and to determine the criteria upon which the CLIWOC wind information records could be used as predictors in the SLP reconstruction.

The complete, worldwide dataset produced by the CLIWOC project (Version 1.5) contains 280’280 records, which include information on wind speed and wind direction. These records are single point information and cover the period 1750-1854, however not all of them providing complete information on date, location and wind, which is mandatory to use them as potential predictors for the SLP reconstruction. Figure 1 shows the location of these records in the North Atlantic European region along with their temporal availability for winter. It clearly shows that the CLIWOC database is neither spatially nor temporally homogeneous, with a maximum data availability in the 1770s and a minimum in the early nineteenth century.

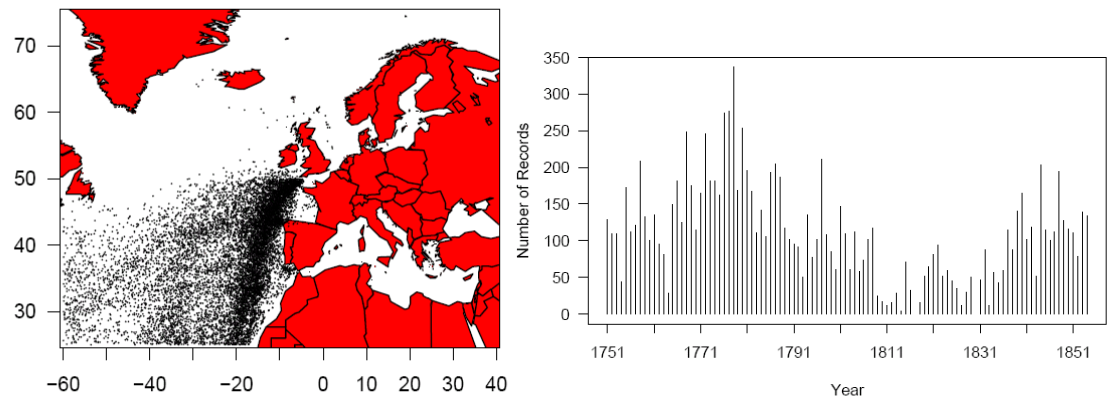

Figure 1: Location of ship log records containing complete information on date, location, wind direction and wind strength for winter (left) and yearly number of winter records available over this region during the CLIWOC period 1750-1854.

The recent studies by Gallego et al. (2005) and Jones and Salmon (2005) reported that the CLIWOC dataset contains only useful density information for SLP reconstructions, when the records are integrated on 8°x8° grids. Gallego et al. (2005) constructed a database, with the u and v wind component (derived from information on wind direction and strength) integrated on a seasonally resolved 8°x8° grid over the globe. Therein, only records containing complete information on date, location, wind direction, wind speed and in addition indicated as being non-coastal (limiting the altering influence from the boundary layer) were included. From this dataset, we have chosen the gridfields used hereafter as predictors. In a first approach, we only focused on winter (average over December, January and February), the season with the most stable atmospheric conditions, i.e. the main pressure centres over the North Atlantic (Azores High and Icelandic Low) exhibit the largest influence on Eurasian climate (e.g. Wanner et al. 2001). Recent SLP reconstructions also yielded the highest reconstruction skill during this season (Luterbacher et al. 2002; Gallego et al. 2005). In this report, we therefore focus on winter only.

The next step was devoted to the investigation of which of these gridfields can be used as predictors. This work is still under progress, however as a first, rather strict criterion, we decided to include only those gridfields (located in the Atlantic north of the equator), which have wind information during at least 50% of the winters during 1750-1850 and whose u and v wind components are in the average based on at least 5 records for each winter. With this criterion we aim at minimizing the noise component due to the too small number of records on which the seasonal gridbox averages are based. This approach returned 13 gridfields (Figure 2), all of them located east of 40°W and south of 56°N, thus primarily resolving the region of the Azores High.

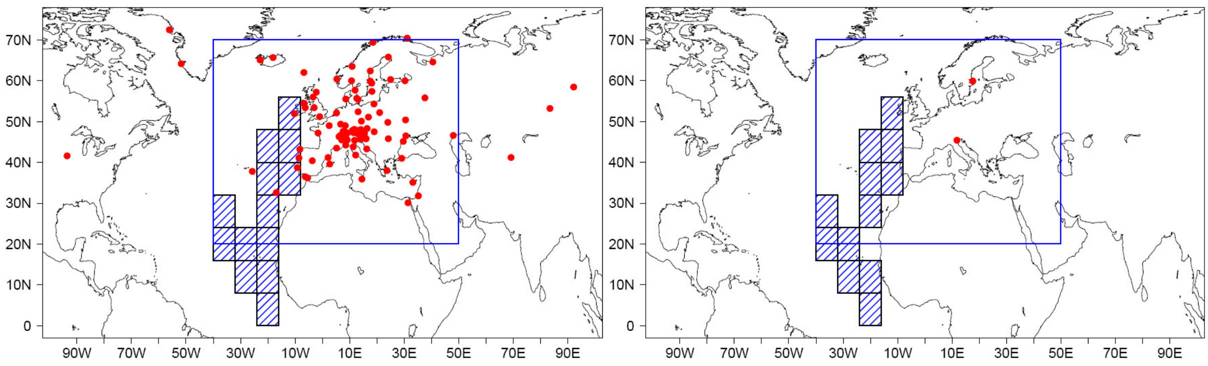

Figure 2: Left: Location of the gridfields (blue dashed boxes) containing wind information obtained from the CLIWOC database and of the instrumental SLP records (red dots) used for the reconstruction of SLP during 1750-1850 over the area indicated by the blue frame. As an example the right panel shows the gridfields and stations containing information for the winter of 1751.

The selection of the gridfields is not yet finalised and other predictor sets will be tested to finally determine the predictor network producing the highest reconstruction skill, also for the remaining seasons. Figure 2 clearly indicates that the inclusion of the CLIWOC data significantly improves the number and spatial distribution of the predictors, exemplary shown for the winter 1751 (right panel). Figure 3 shows the ratio of the number of CLIWOC/ICOADS gridfields to the total number of predictors (including the station pressure series) used in the SLP reconstruction 1750-2004. It is obvious that the CLIWOC data (using this preliminary predictor set) contributes the largest amount of predictors during the pre-1800 period.

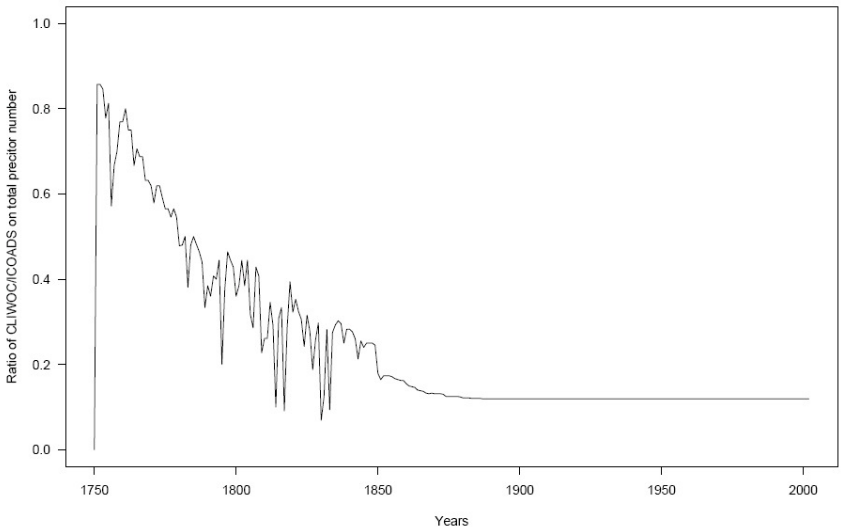

Figure 3: Ratio of the number of CLIWOC/ICOADS gridfields to the total number of predictors used in the SLP reconstruction 1750-2004. For the period 1750-1850 only CLIWOC data is used and afterwards only ICOADS data.

2.2 Generation of gridded SLP fields and preliminary interpretations

With the preliminary predictor set shown in Figure 2, we reconstructed 5°x5° resolved SLP fields over the eastern North Atlantic, Europe and the Mediterranean for the period 1750-2004. We applied an Orthogonal Spatial Regression scheme, following earlier studies (e.g. Jones et al. 1999; Luterbacher et al. 2002; Gallego et al. 2005). For the calibration (1887-2002) the recently published gridded SLP dataset by Allan and Ansell (2006) was used. We produced two separate spatial reconstructions of past SLP once using only the instrumental records (an updated and extended predictor set compared to Luterbacher et al. 2002 and Allan and Ansell 2006) as predictors and once blending those station pressure series with the selected CLIWOC gridfields. This analysis will provide evidence on the quality improvement after adding the CLIWOC gridfields. As examples, the reconstructions for the winters 1752, 1782 and 1810 are presented in Figure 4. The left panels show the reconstruction based solely on the instrumental records and the right panels after the combination with the CLIWOC data.

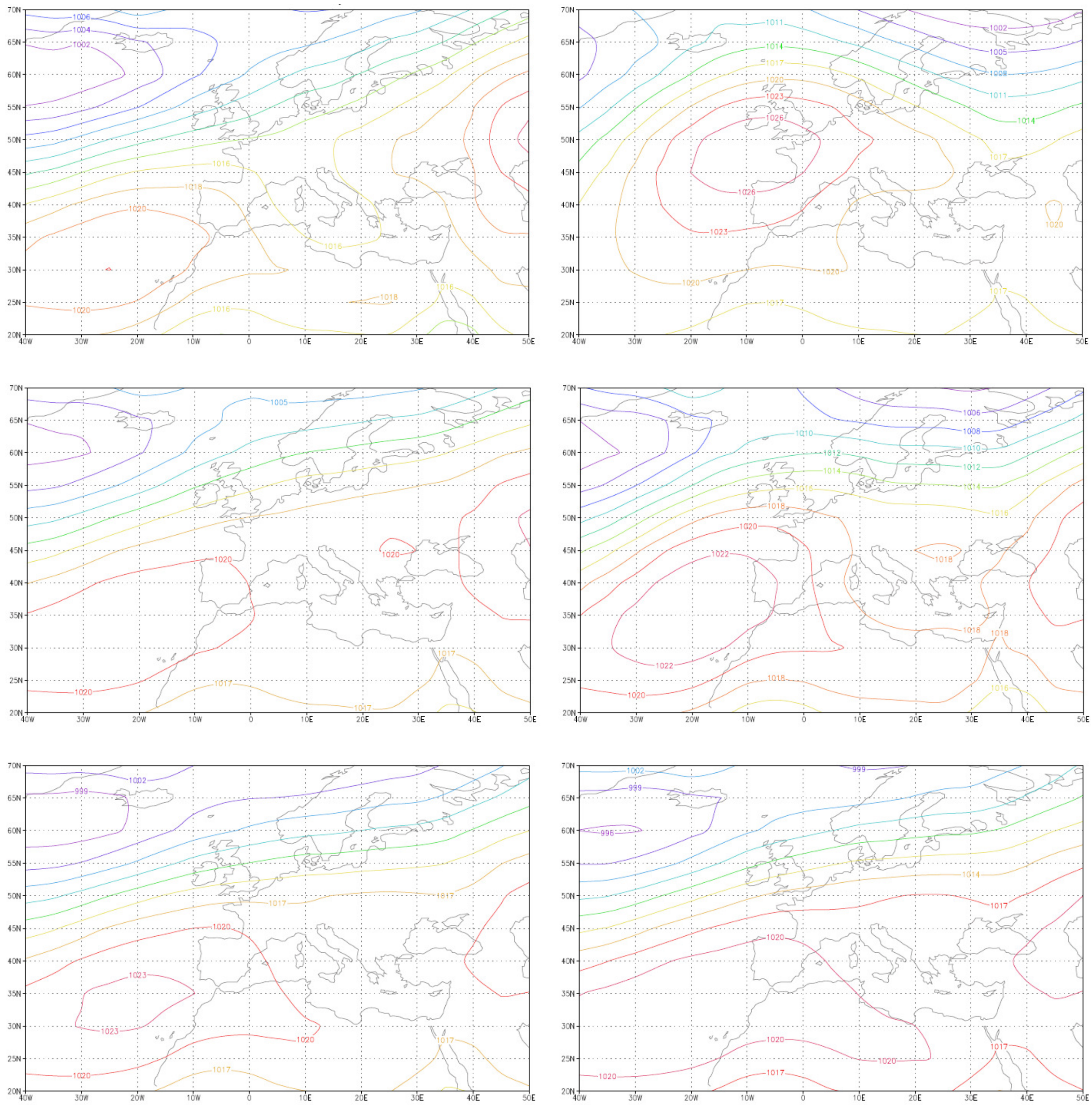

Figure 4: Reconstruction of SLP [hPa] for the winters 1752 (top), 1782 (middle) and 1810 (bottom) based on instrumental data only (left) and their combination with the CLIWOC based gridfield information (right).

As expected, the instrumental records and the CLIWOC data do share common signals. However, major modifications of the reconstructed SLP appear for single years throughout the reconstruction period 1750-1886, when CLIWOC data is included, strongest during the pre-1800 period. This result is not surprising as the majority of predictors in the early decades stem from the CLIWOC database and just very few instrumental records are available (Figures 2 and 3). The largest changes after incorporating CLIWOC data appear over the eastern North Atlantic and the western and central Mediterranean region (Figure 4). The modifications are mainly related to a strengthening of the Azores High mostly connected with a slight shift of the pressure centre towards the north/northeast.

As a measurement for the skill of the reconstructions, Figure 5 shows the values of the Reduction of Error Statistics (RE, Cook et al., 1994) for the reconstructions presented in Figure 4. The higher the RE value, the higher the reconstruction skill.

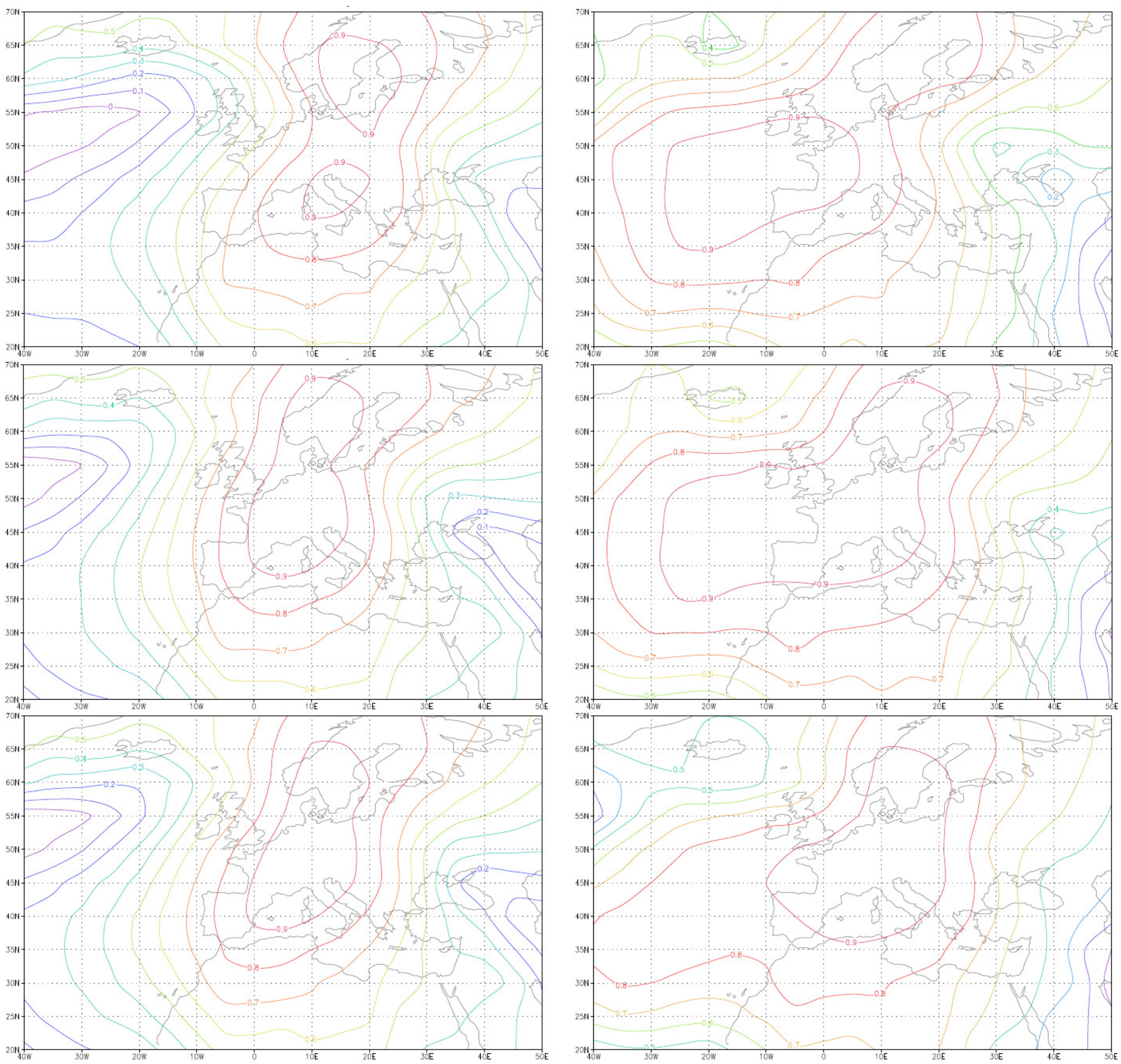

Figure 5: Reduction of Error (RE) statistics for the winters 1752 (top), 1782 (middle) and 1810 (bottom) for the reconstruction based on instrumental data only (left) and their combination with the CLIWOC based gridfield information (right).

It can easily be concluded that a significant increase in reconstruction skill is achieved for all three considered years when CLIWOC data is included, primarily over the eastern North Atlantic and adjacent regions. Figure 5 very clearly indicates that CLIWOC data has a climatological signal and significantly improves the SLP reconstruction over the marine region, more accurately capturing the Azores High and Icelandic Low and thus the strength and direction of the westerlies. We can therefore conclude that the combined use of long terrestrial instrumental SLP records and marine wind information from ship logbooks enables to appropriately represent the large scale pressure field over the North Atlantic, Europe and the Mediterranean region for the period 1750-1850

To highlight the temporal modification of the reconstructed SLP when merging CLIWOC data with station pressure series, Figure 6 shows the mean reconstructed SLP (top) along with the RE statistics (bottom) for two selected gridboxes. The one gridbox (left) presents the highest and the other (right) the lowest correlation between the reconstruction based on instrumental records only (black lines) and the one blended with CLIWOC data (grey lines).

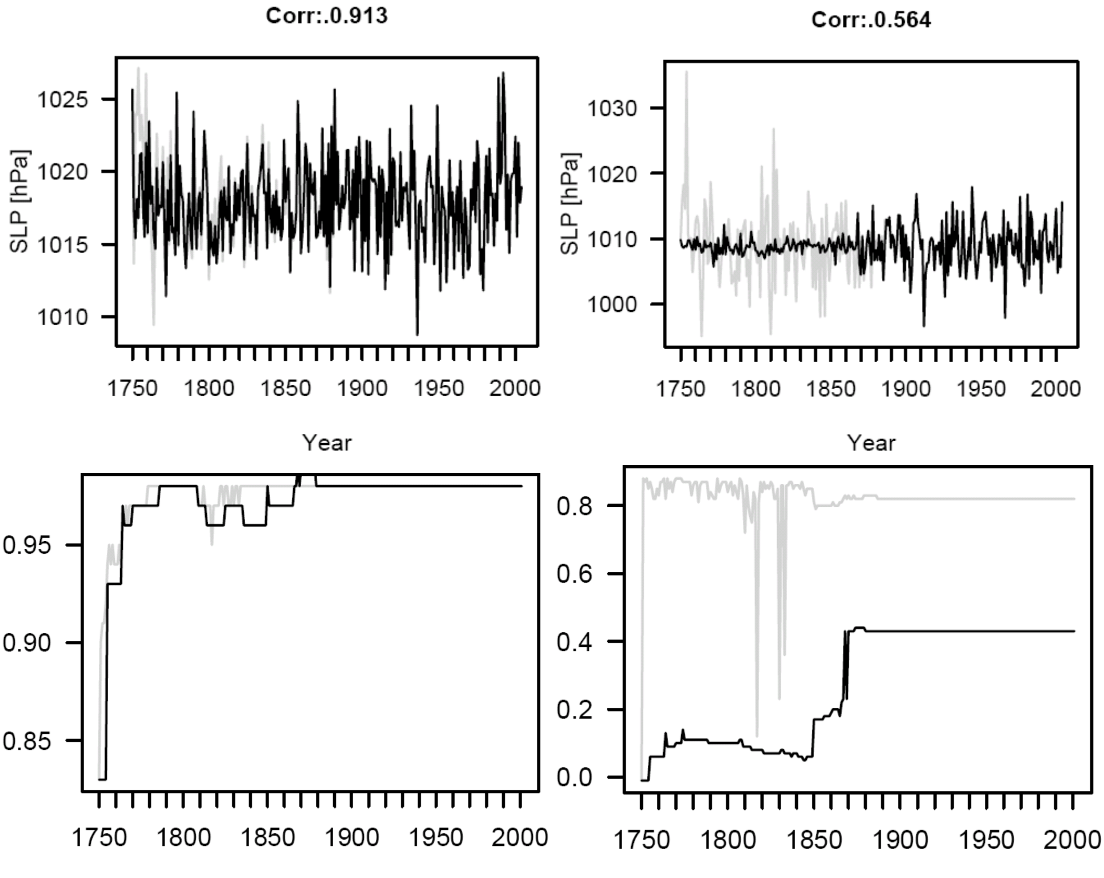

Figure 6: Reconstructed SLP (top) and RE statistics (bottom) for (left) the gridfield presenting the highest correlation between the reconstruction based on instrumental data only (black lines) and the one based on a combination with the CLIWOC data (grey lines) (located over Southern France) and (right) for the gridbox with the lowest correlation (located in the North Atlantic, centred at 50°N and 30°W).

Major changes occur for the gridbox located in the North Atlantic (right panels; the region with generally the largest differences between the two reconstructions), related primarily to a strong increase in amplitude, with SLP values close to the post-1886 instrumental period. It however appears, that the variability might partly be too strong when including the CLIWOC data, as was also found by Gallego et al. (2005). This might be related to the translation of the wind descriptions into numerical values, should however be investigated in more detail. The lower panels of Figure 6 nevertheless clearly demonstrate that the inclusion of CLIWOC data significantly increases the reconstruction skill, particularly over the marine areas. The right panels of Figure 6 also reflect the reduced data availability in the CLIWOC database during the early nineteenth century (see also Figure 1), resulting in a distinct loss of reconstruction skill (bottom) and a too strong SLP variability (top).

3. Future collaboration with host institute

As expected, the three months were a too short time, to finish the entire project. The first results obtained and presented here however clearly indicate, that the combination of long instrumental SLP records and wind information derived from ship logbooks leads to an improved reconstruction of Atlantic, European and Mediterranean SLP over the post-1750 period. CLIWOC data has thus proven to contain valuable information from the marine region, complementing the information from terrestrial sources.

The next steps of this project include a testing of different predictor sets and calibration/verification exercises, aiming at defining a predictor network which is as closely as possible able to capture the past SLP over the area considered here. This will most likely result in different predictor sets for each season. The final SLP reconstruction will thereafter be used to relate past changes in temperature and precipitation over the Mediterranean region to changes in the large scale circulation covering the last around 250 years (Xoplaki et al. 2007).

The collaboration between the University of Bern and the Universidad Pablo de Olavide in Seville will therefore continue, first for finishing this project, and thereafter also for future collaboration within this topic, potentially investigating in more detail some aspects arisen by this study.

4. Projected publications/articles resulting or to result from grant

We plan to submit two papers to major peer-reviewed journals within the next few months. A couple of further joint publications might also result from this exchange grant.

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6. Travel Tickets

6.1 Outward Journey

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6030 EBIKON

Rechnungsdatum **07.02.2007**

Rechnung MasterCard Standard

Saldo letzte Abrechnung	Ihre Zahlungen	Neue Belastungen	**Neuer Saldo zu unseren Gunsten**	Mindestzahlung

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Neue Belastungen

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	Total Karte MARCEL KUETTEL	
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6.2 Return Journey

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Equipaje máximo : 3 bultos; sin superar en conjunto 20kg, ni 250 cm (largo+ancho+alto)
Condiciones Generales del Contrato en www.renfe.es C.I.F. G-84144161

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28MAR07 09.54

Fecha: 01MAY07 Coche: 46 TURISTA
Salida: BCN.FRANCA 20.15 Plaza: 025A NO
Llegada: BERN 08.50 4 PAX CABALL.
Producto: T.HOTEL 273

Fecha: Coche:
Salida: Plaza:
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Informado y conforme el cliente con los datos del billete

Transp.: 1071 1187 1185
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TARJ. CREDITO Gastos gestion: ****4,70
5404902020639405 TOTAL: **138,70
Servicio cubierto por S.O.V. y S.R.C. 07100531294860 IVA 7%: **9,05
Tasa de seguridad, s.o.v., e I.V.A. incluidos

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Llegada: BARN.SANTS 17.42
Producto: ALTARIA 1138

Fecha: Cierre del acceso Coche:
Salida: al tren 2 minutos Plaza:
Llegada: antes de la salida
Producto:

Informado y conforme el cliente con los datos del billete

016 IDA Y VUELTA Precio: ***83,50
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Operacion Tarjeta de Credito
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SEVILL BARN.S 1
BCN.FR BERN 1

TREN	FECHA VIAJE
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Total **225,10