PRESENT CLIMATE, GCM-BIASES AND EXPECTED CHANGES ALONG ONE ZONAL AND ONE MERIDIONAL BELT, CROSSING IN EAST-CENTRAL EUROPE

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ABSTRACT. Present climate, GCM-Biases and expected changes along one zonal and one meridional belt, crossing in East-Central Europe. Geographical zonality and continentality are presented. The global climate models (GCM) and the ERA-40 adjusted observations are called to answer three questions: (i.) How do these peculiarities appear in the observed climate of single meridional and zonal belts around the Globe? (ii.) Can the models properly simulate the present zonal and continental order in seasonal and annual means of temperature, precipitation and sea-level pressure? (iii.) Can these features also be recognised in patterns of CO_2-forced climate changes? The questions are answered by using the MAGICC/SCENGEN 5.3v2 diagnostic model (Wigley, 2008). The third answer is based on the A1B emission scenario with no changes in the aerosol content. The simulated present climate patterns are compared to those from the ERA-40 reanalyses. The future time horizon is 2030-2049 compared to 1980-1999 for baseline climate. Zonality and continentality are presented in two narrow belts around the Globe. The pair of zonally oriented belts with 2.5 degree width, taken along both sides of the 47,5 N latitude, is selected to demonstrate the effects of continentality. These two neighbouring belts spread from the Pacific Ocean along North-America, the Atlantic Ocean, Europe and Asia. The other 2.5 degree wide belt starts at the North Pole, spreads along the 18.75th eastern longitude in its centre towards the South Pole, continuing along the 161.25th western longitude towards the North Pole, again. The first 180 degree long part of this belt crosses parts of Europe, Africa and Antarctica, whereas the rest spreads along the Pacific Ocean, is slightly disturbed in its purely oceanic character by Alaska. This belt is chosen to demonstrate zonality. The results indicate that various aspects of zonaliy and continentality occur in the simulation biases and projected changes, as well.

Keywords**:** climate change, MAGICC/SCENGEN, temperature, precipitation, air pressure

1. INTRODUCTION

Terms zonality and continentality are used in geography to characterise spatial features of the present climate. Since we have global climate models, one can judge objectively whether these features are direct consequences of those physical differences, which are often used when these concepts are introduced. This is the aim of our paper, as well. Narrow zonal and meridional belts are defined and the recent GCM outputs, adjusted by the MAGICC SCENGEN software

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(Wigley, 2008) will be analysed, besides the present climate, which is applied by the same software from the ERA-40 (Uppala et al., 2005).

The model simulations are based on the A1B SRES scenario (IPCC, 2007). The MAGICC/SCENGEN diagnostic tool (see below) provides individual results and averages from selected models. In Section 6 we use the means from all the 20 recommended GCMs. In some cases, similar models are used with differences in the resolution, or in parameterization of one single process. Horizontal resolution of the model-atmospheres varies between 4° x 5° to 1.1° x 1.1°, with 20-47 vertical levels. The oceanic models exhibit finer horizontal resolution due to smaller scales of equilibrium vortices in this domain. This characteristic grid-point distance varies between is 0.2° and 2.5 ° with often latitude and direction-dependent resolution. The full list of the 20 OAGCMs can be found in the IPCC Report (IPCC 2007 WG-I, Ch. 8, 597-599).

2. THE MAGIC/SCENGEN DIAGNOSTIC TOOL

In order to generate climate scenario on local and regional scales, a relatively simple tool, namely, the MAGICC/SCENGEN 5.3 software package (Wigley et al., 2008) was applied. All these newest GCMs were evaluated by the AR4 (IPCC, 2007). The global section of the package, the MAGICC, is based on an up-welling diffusion energy balance model calibrated by global sensitivity of the GCMs outputs. For a selected region, the large number of GCM output fields may reduce the existing uncertainty of climate prediction. In this section 20 GCMs treated by the package are considered.

Local climate change is strongly influenced by local features such as mountains, which are not well represented in global climate models. Yet, despite these deficiencies, GCMs play an important role in regional climate research. In the followings the above model outputs are averaged and synchronised by the MAGICC/SCENGEN 5.3 diagnostic software tool. Temperature, precipitation and sea-level pressure data are analysed. The SCENGEN applies linear scaling from the output fields from each model. One should note that the present diagnostic tool has already been used to assess the projected changes in Europe with special emphasis to the Danube watershed (Mika et al., 2010).

3. THE SELECTED BELTS

The investigated zonal belt is set between the 45-50°N latitudes. It has been chosen, as it contains the homeland of the authors and a wide variety of lowlands and mountains, warm and cold sectors of oceans, what makes the comparative research more conducive. In favour of better comparability and transparency, 10 sample area has been defined within this temperate belt. Every entitled area (Figure 1) contains 10-10 rectangles of the 2.5^{o} long x 2.5^{o} lat fields, in which data data, the errors and the changes are given. The meridional belt is just

2.5 deg wide and spreads from the North Pole to the South Pole along the 18.75E meridian, and continues along the 161.75W meridian.

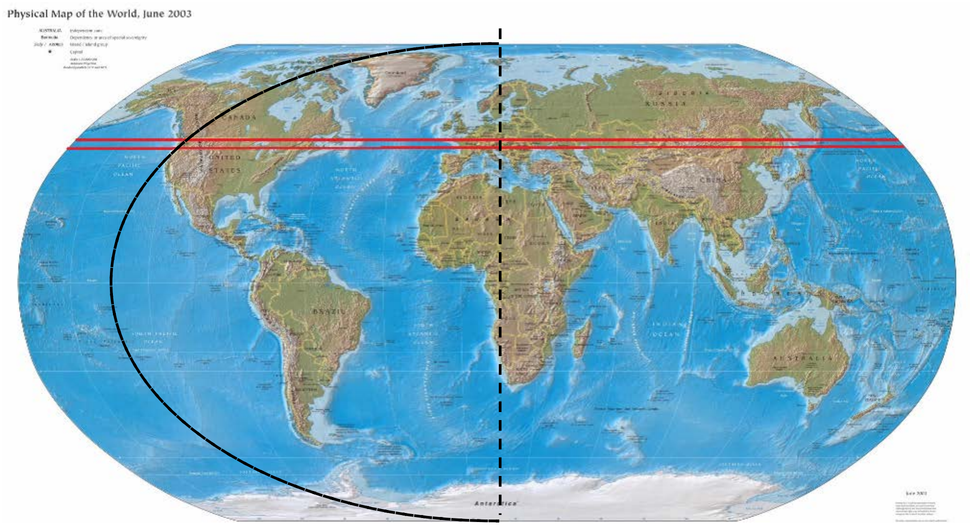


Fig 1. Map of the investigated zonal and meridional belts. *In the zonal belt, between 45th and 50th latitudes, the abbreviations are as follows. Pa1 – Pa2: the Pacific, cold resp. warm current; Am1 – Am2: North-America: mountains resp. plains and lakes; At1 – At2: the Atlantic: cold resp. warm current; Eu1 – Eu2: Europe: mountains (Alps and Carpathians) resp. plains; As1 – As2: Asia: table-land, mountains resp. mountains.*

4. ZONALITY AND CONTINENTALITY IN PRESENT CLIMATE

Three aspects of temperature, precipitation and sea-level pressure fields are investigated concerning zonality and continentality. All of them are reduced to the above specified zonal and meridional belts. These aspects are (i) the present observed fields and (ii) the bias error of the simulated fields derived from the 20 GCMs and adjusted by the MAGICC/SCENGEN software tool, and finally, the changes in the elements between the foreseen 2030-2049 period compared to the 1980-1999 reference period. The first two aspects are seen in Figs. 2-4. in respect to zonality, and Figs 5-7 to continentality.

For the temperature (Fig. 2), besides the obvious zonality of temperature in both extreme seasons, one can establish slight overestimation at the tropical and temperate latitudes with strong underestimation in the Polar regions. This underestimation is stronger in the belt crossing mainly continental regions (along 18.75 E) than in the other one, spreading over the oceans (along 161.75 W).

For precipitation, even the observed mean values are interesting along the two different belts (Fig 3.). Not only the oceanic belt is characterised by much higher values in both seasons in many latitudes, but shapes of the zonal profiles are different in both seasons.

The errors are mainly overestimations except the tropical latitudes with a few critical relative overestimations at some latitudes where the observed values are generally low. The dependence of the bias on the latitudes is rather different in the mainly oceanic vs. the mainly continental belts, spreading between the Poles.

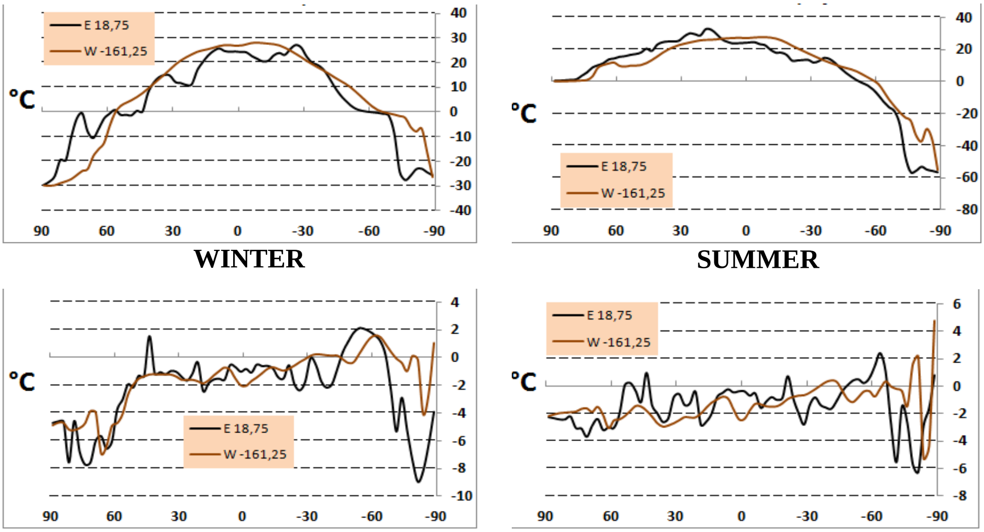


Fig. 2. ***Observed mean values (upper graphs) and simulation bias (lower) of temperature (^{o}C) in winter (left) and in summer (right) in the meridional belt representing zonality.***

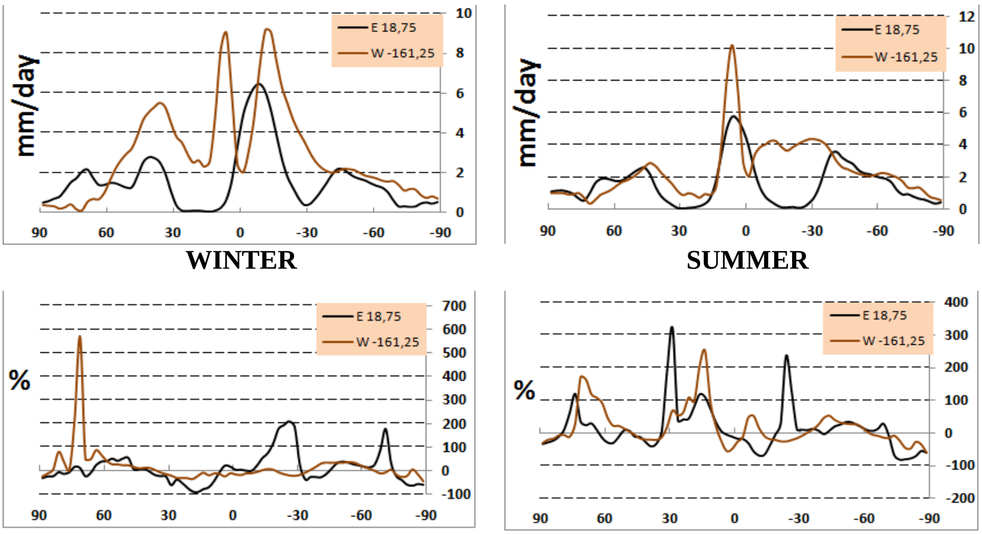


Fig. 3. ***Observed values (mm/d: upper) and simulation bias (%: lower) of precipitation in winter (left) and in summer (right) in the meridional belt representing zonality.***

For the observed values of sea-level pressure one can see a considerable phase shifts between the two meridians indicating big differences between continental and oceanic areas of both hemispheres. The latitudinal dependence of the sea-level pressure is also clearly seen in the upper graphs of Fig. 4. For the zonal sections (Fig, 5) one may see clear differences indicating the higher pressure over continents in winter and over the oceans in summer.

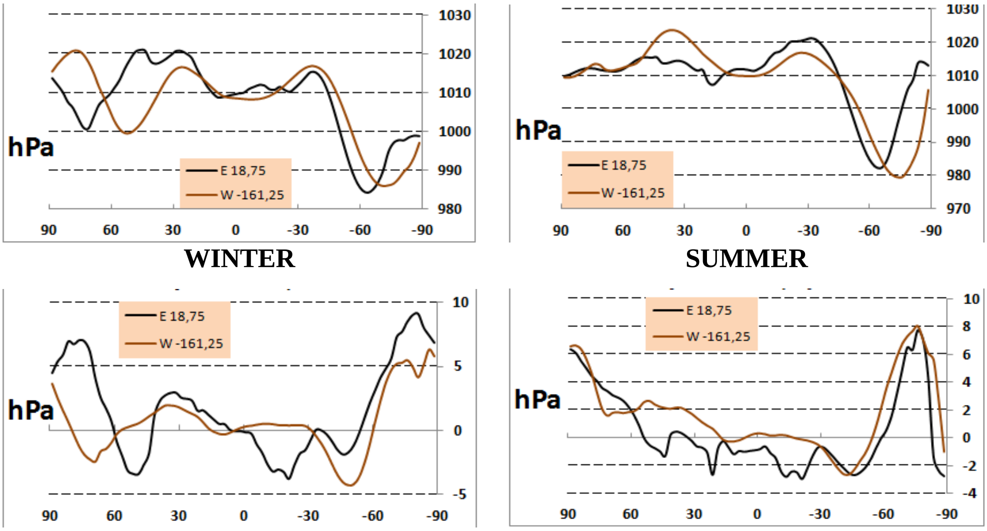


Fig. 4. ***Observed values (upper graphs) and simulation bias (lower) of sea-level pressure (hPa) in winter (left) and in summer (right) in the meridional belt representing zonality.***

The bias errors along the meridional section are high again in the Polar regions where the models mainly overestimate the seasonal mean pressure of these regions. For the zonal belts, in winter the Eurasian continent is under-estimated with overestimations of some oceans. In summer the bias errors are much smaller.

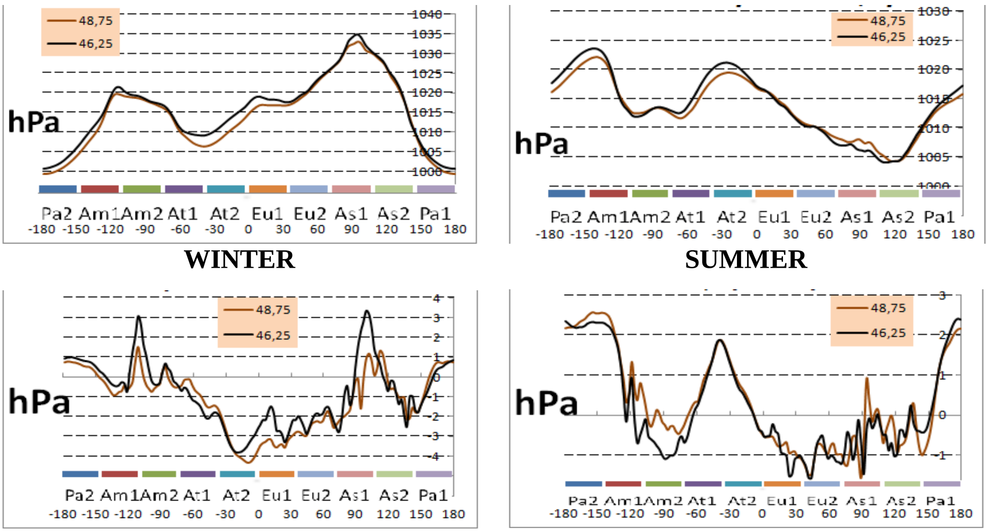


Fig. 5. ***Observed values (upper graphs) and simulation bias (lower) of sea-level pressure (hPa) in winter (left) and in summer (right) in the zonal belt representing continentality.***

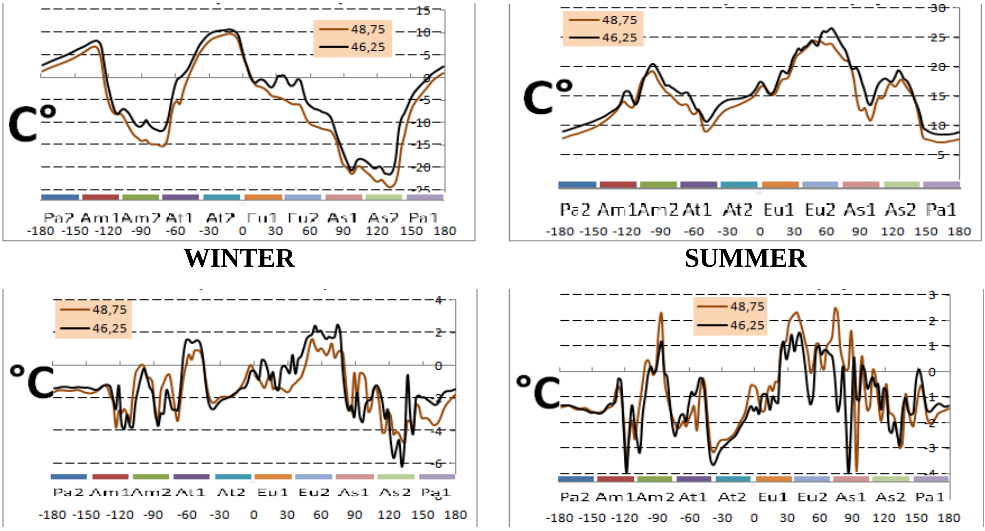


Fig. 6. ***Observed values (upper graphs) and simulation bias (lower) of temperature (^oC) in winter (left) and in summer (right) in the zonal belt representing continentality.***

The continentality is clearly seen in the latitudinal belts (Fig. 6). High temperature is seen in eastern borders of oceans between the continents in winter, but in summer the eastern parts of continents have relative maxima. Precipitation indicates strong differences between the continental and oceanic areas of the given belt. The models mainly underestimate the temperature with deviations also related to nature of the surface. In winter the models strongly overestimate precipitation in some dry regions. In summer the biases are smaller and not domain- dependent.

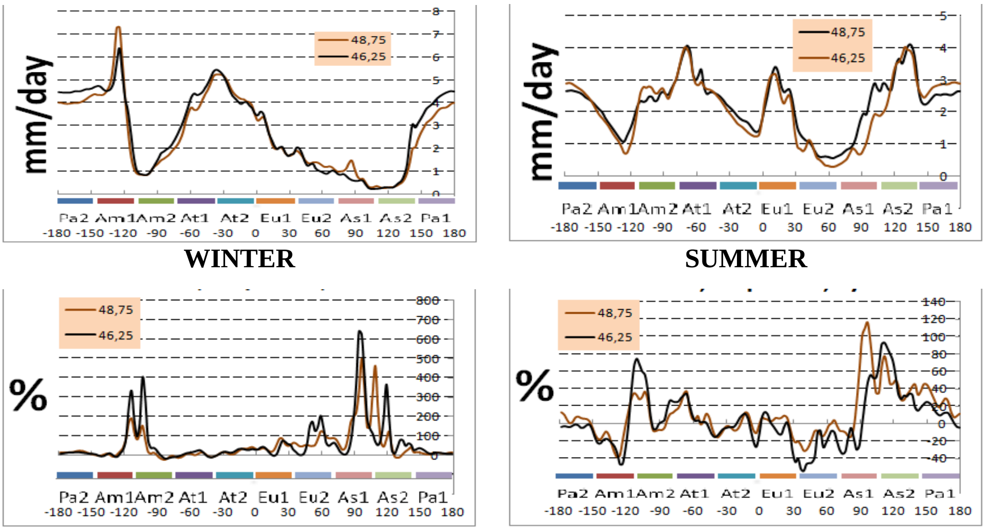
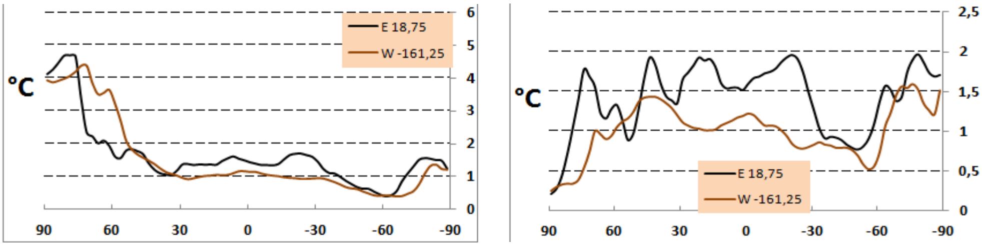


Fig. 7. ***Observed values (mm/d: upper) and simulation bias (%: lower) of precipitation in winter (left) and in summer (right) in the zonal belt representing continentality.***

5. ZONALITY AND CONTINENTALITY IN THE PROJECTED CHANGES

Changes of climate variables are derived by (large-scale) physics of the climate models. Hence, one may expect occurrence of zonality and continentality in the changes, as well. The stronger changes of temperature in winter indicate no unequivocal differences in winter but much weaker changes in summer over the ocean-based section Along the latitudinal belts the warming is generally stronger over the continents (Fig. 8).



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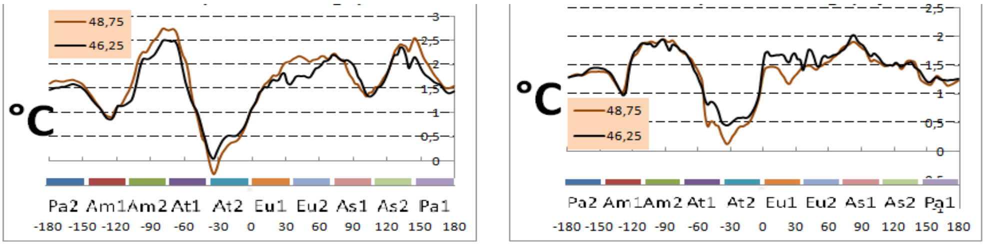
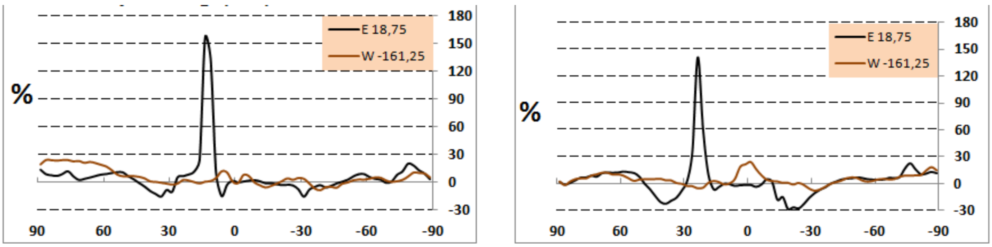


Fig. 8. ***Projected changes of temperature (^oC) in the meridional and zonal belt, representing opposite tendencies between 2030-2049 and 1980-1999 according to GHG, A1B scenario.***



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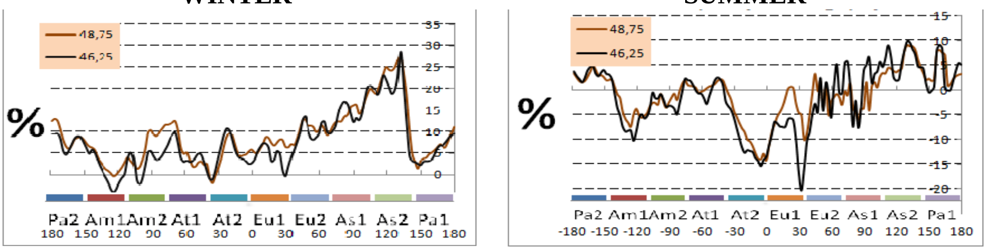

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Fig. 9. ***Projected changes of precipitation (%) in meridional and zonal belts, representing opposite tendencies between 2030-2049 and 1980-1999 according to GHG, A1B scenario.***

For precipitation (Fig. 9) the changes are mainly positive along the oceanic meridional belt in winter. Along the continental one, the changes are different. In summer the situation is similar with rather hectic differences along the continental meridional belt. Along the zonal belt, there are positive changes of precipitation almost everywhere with one peak towards Asia. In summer the changes are negative in most of the circle with no unequivocal continent vs. ocean differences.

Sea-level pressure changes are in anti-phase along the oceanic vs. continental meridian in winter with compensation of the slight decrease along the continent by the oceanic meridian in summer. In the zonal belt, longitudinal dependence of pressure changes is seen in both seasons, with no simple statements on continentality (Fig 10).

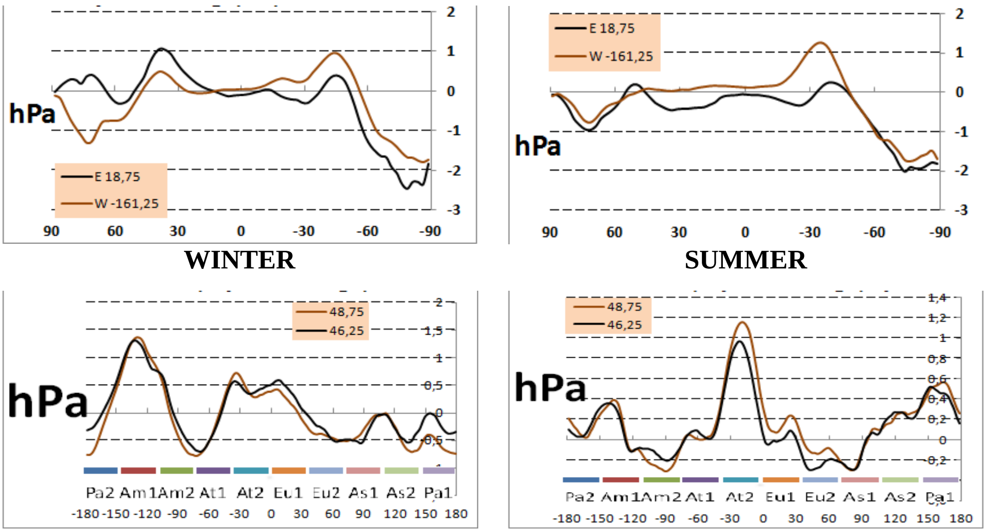

Fig. 10. ***Projected changes of sea-level pressure (hPa) in meridional and zonal belts representing opposite tendencies between 2030-2049 and 1980-1999 according to GHG, A1B scenario.***

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