Theor Appl Climatol (2009) 96:85–94
DOI 10.1007/s00704-008-0034-4

ORIGINAL PAPER

Selected instability indices in Europe

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Received: 25 April 2007 / Accepted: 13 February 2008 / Published online: 17 May 2008
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Abstract A climatology of various parameters associated with severe weather and convective storms has been created for Europe that involves using radiosounding data collected at the University of Wyoming for the period from 1991 to 2005. The analysis is based on monthly means, frequency distributions of such parameters as convective available potential energy (CAPE), convective inhibition energy (CIN), KI - index, total totals index (TTI), and the severe weather threat index (SWEAT). Monthly average CAPE values exceeding 300 Jkg^{-1} are observed over the west Mediterranean Sea and the neighboring coastal countries. The similar seasonal cycle and spatial distributions exhibit CIN fields with summer monthly means above 100 Jkg^{-1} observed on the south part of the researched domain. The KI, TTI, and SWEAT indices, which assess both the lapse ratio between 850 and 500 hPa and low level humidity, show the privileged region (the Alpine area and the Carpathian Basin) with the highest instability conditions. Orography clearly plays an important role in this structure. Farther from this area, the monthly average decreases to the east, west, north, and south of the research domain. Ward's procedure was applied to create objective regionalization according to instability conditions. This method tends to produce two regions with relatively different instability conditions and few subregions with similar conditions. The first region, covering the Alpine area, the west Mediterranean Sea, west Turkey and the southern Ukraine, is characterized by the highest instability. The rest of the investigated area is the second region with a more stable atmosphere.

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1 Introduction

When special conditions are met, they can produce severe weather phenomena such as thunderstorms, damaging winds, hail, tornados, strong rain, and flash floods. All of these are associated with convection, defined as motion attributable to the action of a gravitational field upon density variation creating unstable vertical masses of air. To provide a severe weather possibility, various instability indices have been designed that can be calculated from radiosonde observations. A few examples are: convective available potential energy (CAPE), convective inhibition energy (CIN), based on Lifted Parcel Theory, KI-index, total totals index (TTI) and the severe weather threat index (SWEAT) assessing the lapse ratio between 850 and 500 hPa levels and low level humidity. The main aspect of instability index climatology is to support operational severe events forecasting. This problem is resolved by comparison of selected instability index values from radiosounding ascent with numbers and types of convective phenomena. The issues of this research procedure are the threshold values of commonly used parameters with high probability of dangerous weather. For example, CAPE values compared with thunderstorms and tornado occurrence in the USA show that weak short-lived thunderstorms appear when the CAPE is mainly about 500 Jkg^{-1}; but strong, long-lived thunderstorms and tornados are noticed when the CAPE exceeds 1,000 Jkg^{-1} (Rasmussen and Blanchard 1998; Craven et al. 2002; Schultz 1988). In Europe, the same comparison shows lower CAPE values during stormy weather. In northwestern Spain, the mean values of CAPE index with hail observations are 360 Jkg^{-1} while thunderstorm occurrence shows a mean CAPE index of about 260 Jkg^{-1} (López et al. 2001). Over northern Italy, tornado events are observed when KI index exceeds 30,

5. THE ATMOSPHERIC CIRCULATION INFLUENCE ON INSTABILITY CONDITIONS OVER EUROPE

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INTRODUCTION

The atmospheric circulation (together with solar radiations and water vapor circulation) is the main factor that is creating weather conditions. The analysis of relationship between atmospheric circulation and selected weather elements need to identify low-frequency variability pattern.

Two main methods – the teleconnection method and principle component analysis are used in empirical studies to do this for low-frequencies variability pattern. The teleconnection method obtains temporal correlations in a meteorological parameter between one given geographical location and all other in the domain. This procedure is repeated using every possible point as the base point. The locations producing the highest correlation fields accepted as the "centers of actions".

The principle component analysis (PCA) created the eigenvectors of the crosscorrelation matrix are individually scaled according to the amount of total data variance they explain and then linearly transformed under certain constrains to obtain the major circulation pattern. Using this method Barnston and Livezey (1987) computed ten monthly spatial variability modes in a hemispheric 700 hPa dataset, Rogers (1990) in a Northern Hemisphere sea level pressure. Clinet and Martin (1992) described circulation pattern over Europe and North Atlantic. This works relevant few dominant teleconnection patterns referred to as the North Atlantic Oscillation, East Atlantic/Western Russia pattern, Scandinavia pattern.

The European climate conditions are created by a large scale meridional oscillation of atmospheric mass between the subtropical anticyclone near the Azores and the subpolar low pressure system near the Iceland, terms North Atlantic Oscillation (NAO). Numbers of different studies have shown relevance of the NAO to the winter temperature over the Atlantic and European sector (Hurrel 1995, Hurrel i von Loon 1997, Toumenvirth *et al.* 2000, Greatbatch 2000, Huang *et al.* 2006). Additional studies have established links between NAO pattern and precipitations anomalies. Positive anomaly values of precipitations are concerted in the

INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. **31**: 232–243 (2011)
Published online 5 November 2010 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/joc.2247

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Carbon dioxide flux in the centre of Łódź, Poland – analysis of a 2-year eddy covariance measurement data set

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ABSTRACT: Continuous measurements of carbon dioxide turbulent flux F_{CO_2} carried out with the eddy covariance method have been made in Łódź since F_{CO_2} July 2006. The measurement point (Lipowa Station) is located in the west part of the densely built-up city centre, where artificial surfaces clearly prevail over natural terrain. The measurement system includes a Kipp and Zonen's (Delft, Holland) CNR1 net radiometer, RMYoung (Traverse City, Michigamn, USA) 81000 sonic anemometer and Li-cor (Lincoln, Nebraska, USA) 7500 open path H_2O/CO_2 infrared gas analyser. Sensors are installed on the high tower 20 m above the roof of the building and 37 m above the ground, so the measurement height exceeded the urban canopy layer more than twice. The diurnal and annual variability of carbon dioxide flux for the period July 2006 to August 2008 is analysed in the article. The results show the characteristic features in diurnal and annual courses of F_{CO_2}. Independently from the season, positive (upward) fluxes of the order of 0–15 μmol m^{-2} s^{-1} prevail in the data. During the cold season, an increase in turbulent CO_2 exchange is observed (F_{CO_2} quite often exceeded 30 μmol m^{-2} s^{-1}). This can be attributed to anthropogenic CO_2 emissions, which are particularly strong in winter due to, among other things, mineral fuel combustion during domestic heating. The average monthly fluxes are positive in all seasons, which means that emission of CO_2 in the surroundings of the measurement point prevails over its uptake. Apart from the season, the maximum flux occurred during the day and the minimum during the second part of the night. Wintertime monthly averaged fluxes are much higher than summertime ones. The observed increase in CO_2 exchange during weekdays in comparison with weekends can be caused by the weekly rhythm of traffic in the surroundings of Lipowa Station. Copyright © 2010 Royal Meteorological Society

KEY WORDS carbon dioxide; eddy covariance method; turbulent flux of mass; anthropogenic CO_2 emission

Received 16 October 2009; Revised 30 September 2010; Accepted 3 October 2010

1. Introduction

CO_2 is one of the components of the atmosphere which, although it comprises a very small fraction (~0.04% of volume), plays an important role in the energy exchange between biosphere, atmosphere, lithosphere and hydrosphere. First of all, CO_2 participates in the photosynthesis process – oxygen leaves the plants and CO_2 is absorbed, which leads to an increment of biomass, but part of the absorbed CO_2 leaves the plants during nocturnal respiration. Second, it is one of the most important greenhouse gases and its concentration influences the radiation balance of the Earth's surface. According to the IPCC reports (IPCC, 2007), a significant increase in CO_2 concentration has been observed over the last 250 years, from 280 ppm in pre-industrial times to 385 ppm in 2009. Such an increase may be the reason for a mean air temperature rise of $0.6 \pm 0.2\,^{\circ}C$ during the last 100 years (IPCC, 2007). Thus, quantitative determination of net CO_2 emissions is very important from the perspective of the global warming problem. One of the factors determining the intensity of CO_2 exchange between the surface and lower troposphere is the type of surface cover. Above natural or agricultural terrain, the vertical exchange of CO_2 is determined mainly by natural biological processes. During the warm season, a strong daily uptake of CO_2 during photosynthesis and nocturnal release of this gas owing to plant respiration is observed (Baldocchi *et al.*, 2000; Schmid *et al.*, 2000). In the wintertime, when biological processes are very weak, CO_2 exchange is insignificant, especially in the case of snow cover occurrence (Baldocchi *et al.*, 2000; Schmid *et al.*, 2000; Hirata *et al.*, 2007). Above urban terrain, where artificial surfaces dominate over green areas, biological processes proceeding in plants determine CO_2 exchange to a smaller degree. In cities, the most significant source of CO_2 is anthropogenic emission related to mineral fuel combustion, car traffic or heating by the energy industry, which is observed particularly during the cold season (Grimmond *et al.*, 2002; Nemitz *et al.*, 2002; Moriwaki and Kanda, 2004; Gratani and Varone, 2005; Coutts *et al.*, 2007; Vesala *et al.*, 2008; Roth and Velasco, 2010). Only during the warm season is anthropogenic emission mitigated to a certain degree by natural CO_2 absorption during photosynthesis (Grimmond *et al.*, 2002; Moriwaki and Kanda, 2004; Vesala *et al.*, 2008). A qualitative dependence between the degree of urbanization

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WODA-ŚRODOWISKO-OBSZARY WIEJSKIE 2012 (IV–VI): t. 12 z. 2 (38)
WATER-ENVIRONMENT-RURAL AREAS ISSN 1642-8145 s. 185–196
pdf: www.itep.edu.pl/wydawnictwo © Instytut Technologiczno-Przyrodniczy w Falentach, 2012

Wpłynęło 28.10.2011 r.
Zrecenzowano 17.01.2012 r.
Zaakceptowano 17.02.2012 r.
A – koncepcja
B – zestawienie danych
C – analizy statystyczne
D – interpretacja wyników
E – przygotowanie maszynopisu
F – przegląd literatury

TYP POWIERZCHNI MIEJSKIEJ A TURBULENCYJNA WYMIANA DWUTLENKU WĘGLA (NA PRZYKŁADZIE ŁODZI)

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Streszczenie

Celem opracowania jest porównanie intensywności turbulencyjnej wymiany dwutlenku węgla na terenie miejskim o różnym typie zabudowy. Pomiary przeprowadzono w gęsto zabudowanym centrum miasta, w dzielnicy domów jednorodzinnych, na terenie poprzemysłowym oraz podmiejskim. Uzyskane wyniki potwierdzają wyraźną zależność między gęstością i typem zabudowy oraz odsetkiem powierzchni roślinnych a intensywnością i zwrotem wymiany. Najbardziej intensywną dodatnią (do atmosfery) wymianę dwutlenku węgla zaobserwowano w centrum Łodzi oraz, nieco mniejszą, na obszarze poprzemysłowym, podczas gdy w dzielnicy niskiej zabudowy, jedno- i dwupiętrowej, z dużym udziałem terenów zielonych, antropogeniczna emisja CO_2 była w znacznej mierze równoważona przez naturalny pobór tego gazu przez rośliny. Na terenie podmiejskim z kolei wymiana miała charakter zdecydowanie ujemny (do powierzchni czynnej), ze względu na bardzo mały udział antropogenicznej emisji dwutlenku węgla.

Słowa kluczowe: *metoda kowariancji wirów, teren zurbanizowany, turbulencyjny strumień dwutlenku węgla*

WSTĘP

Na podstawie prowadzonych od wielu lat badań stwierdzono, że w przypowierzchniowej warstwie powietrza nad miastami poziom stężenia dwutlenku węgla jest podwyższony [COUTTS i in. 2007; GRIMMOND i in. 2002; HELFER i in. 2010; VESALA i in. 2008]. Miasta, ze względu na gęstość zabudowy, sieci transportowe, zmniejszony udział terenów zielonych oraz ogromne zużycie energii, znacząco modyfikują obieg węgla w środowisku w porównaniu z terenami niezurbanizowa-

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WYDAWNICTWO UNIWERSYTETU ŁÓDZKIEGO • ŁÓDŹ 2011