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SELECTED CHARACTERISTICS OF THE ATMOSPHERIC TURBULENCE OVER A CENTRAL EUROPEAN CITY CENTRE – INTEGRAL STATISTICS

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Abstract

The contribution presents selected characteristics of turbulence calculated on the base of long term measurements in Łódź, central Poland (population ca 750,000). Turbulent characteristics were measured with the aid of fast respond sensors (sonic anemometers) at two points in the city centre. At the first point data were collected in years 2000-2003 and at the second point measurements are continued since 2005. At both stations sensors were mounted at thin masts at the level (37m and 42m above ground), significantly taller than mean building height (11m and 17m respectively). The study presents integral characteristics of turbulence at both stations. Typical integral characteristics (a drag coefficient and normalized standard deviations of wind component and temperature) are calculated as a function of stability parameter. Results show good agreement with functions predicted by Monin-Obukhov similarity theory.

Keywords: turbulence, drag coefficient, normalized standard deviation

1. INTRODUCTION

Knowledge of the structure of turbulence is essential for many practical applications including atmospheric dispersion. The spectral and integral properties of turbulence over homogenous surface are well established. In accordance of Monin-Obukhov (M-O) similarity theory, both spectra and normalized velocity standard deviations, σ_i/u_*, should depend on z/L where L is Obukhov length. In the urban atmosphere roughness sublayer where the flow is three-dimensional due to the influence of individual roughness elements can be relatively extended. As a consequence upper part of surface layer, the inertial sublayer where the Monin-Obukhov similarity is supposed to work, shrinks. It raises a question on the applicability of the M-O theory on the urban areas. Because of the absence of generally accepted alternative theory results of measurements on urban areas are analyzed with the M-O similarity framework. Review of turbulence over urban areas was done by Roth (2000). The objective of this study is to investigate integral turbulence statistics (drag coefficient and normalized standard deviations of wind component and temperature) at two urban measurement points located in Łódź, central Poland. Turbulence statistics are expressed as a function of local values of z/L to get functional relations.

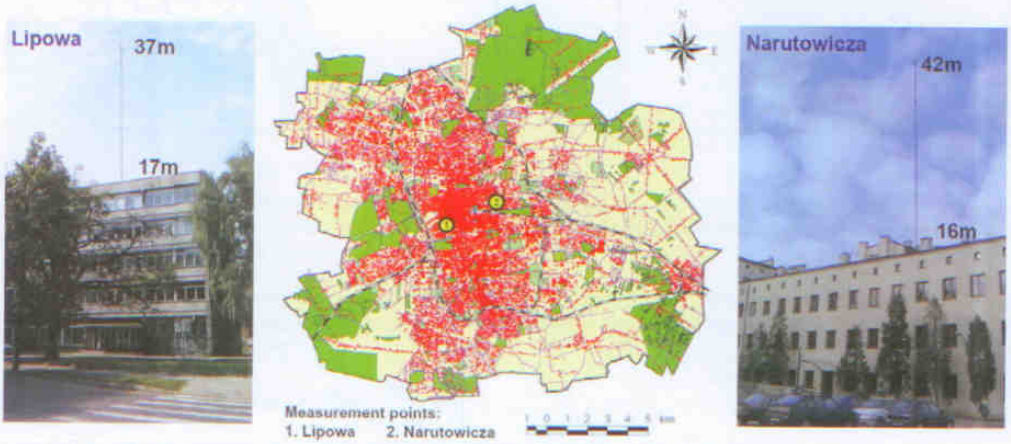

Fig. 1 Location of the measurement points in Łódź, central Poland.

2. MEASUREMENT SITE AND DATA USED

Łódź (51°47'N, 19°28'E) is the one of the largest Polish city with population ~750 000. It is placed in the centre of Poland on relatively flat area with lack of big rivers, lakes or other water reservoirs. The city center is

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The International Urban Energy Balance Models Comparison Project: First Results from Phase 1

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ABSTRACT

A large number of urban surface energy balance models now exist with different assumptions about the important features of the surface and exchange processes that need to be incorporated. To date, no comparison of these models has been conducted; in contrast, models for natural surfaces have been compared extensively as part of the Project for Intercomparison of Land-surface Parameterization Schemes. Here, the methods and first results from an extensive international comparison of 33 models are presented. The aim of the comparison overall is to understand the complexity required to model energy and water exchanges in urban areas. The degree of complexity included in the models is outlined and impacts on model performance are discussed. During the comparison there have been significant developments in the models with resulting improvements in performance (root-mean-square error falling by up to two-thirds). Evaluation is based on a dataset containing net all-wave radiation, sensible heat, and latent heat flux observations for an industrial area in Vancouver, British Columbia, Canada. The aim of the comparison is twofold: to identify those modeling approaches that minimize the errors in the simulated fluxes of the urban energy balance and to determine the degree of model complexity required for accurate simulations. There is evidence that some classes of models perform better for individual fluxes but no model performs best or worst for all fluxes. In general, the simpler models perform as well as the more complex models based on all statistical measures. Generally the schemes have best overall capability to model net all-wave radiation and least capability to model latent heat flux.

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Coreless winters in the European sector of the Arctic and their synoptic conditions

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Abstract: The coreless winters (*i.e.* not having a cold core) were distinguished in four stations within the European sector of the Arctic. Anomalies of the frequency of the Niedźwiedź's (2011) circulation types were calculated separately for the mid-winter warm months and for cold months preceding and following the warm-spells. Furthermore, composite and anomaly maps of the sea level pressure as s well as anomaly maps of the air temperature at 850 gpm (geopotential meters) were constructed separately for the mid-winter warm events and for the cold months before and after warming. Different pressure patterns were recognized among the days of mid-winter warm spells, using the clustering method. The occurrence of coreless winters in the study area seems to be highly controlled by the position, extension and intensity of large scale atmospheric systems, mainly the Icelandic Low. When the Low spreads to the east and its centre locates over the Barents Sea the inflow of air masses from the northern quadrant is observed over the North Atlantic. This brings cold air of Arctic origin to the islands and causes an essential drop in the air temperature. Such situation takes place during the cold months preceding and following the warm mid-winter events. During the warm spells the Icelandic Low gets deeper-than-usual and it is pushed to the northeast, which contributes to the air inflow from the southern quadrant.

Key words: Arctic, North Atlantic, Svalbard, winter air temperature, circulation, polar climate.

Introduction

The weather and climate at higher latitudes are strongly controlled by the air circulation, particularly in winter, when the inflow of solar irradiation vanishes. During the polar night, atmospheric circulation accounts for 95% of the warmth advection to the Arctic, while the other 5% is due to oceanic circulation (Alekseev *et al.* 1991, cited in Przybylak 2000). The intense cyclonic activity in the European sector of the

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FUNKCJA ŚLADU I OBSZAR ŹRÓDŁOWY STRUMIENI TURBULENCYJNYCH – PODSTAWY TEORETYCZNE I PORÓWNANIE WYBRANYCH ALGORYTMÓW NA PRZYKŁADZIE ŁODZI

Zarys treści: W pracy omówiono podstawy koncepcji funkcji śladu (ang. *footprint function*) i obszaru źródłowego (ang. *source area*) turbulencyjnych strumieni ciepła jawnego i ciepła utajonego mierzonych metodą kowariancji wirów. Porównano trzy analityczne algorytmy wyznaczania funkcji śladu. Stwierdzono, że dla równowagi chwiejnej wszystkie trzy algorytmy prowadzą do bardzo zbliżonych rezultatów. Większe różnice pojawiają się przy stałej stratyfikacji atmosfery. Przeanalizowano przykładowe obszary źródłowe dla dwóch łódzkich punktów pomiarowych, na których turbulencyjne strumienie ciepła mierzone są metodą kowariancji wirów. Wykazano, że umieszczenie czujników wysoko ponad poziomem dachów (w tym wypadku około 25 m) zapewnia reprezentatywność wyników dla obszarów urbanistycznych o podobnej strukturze zabudowy. W indywidualnych przypadkach obszary źródłowe tworzą, na ustalonych poziomach P=50%, 75% i 90%, strukturę przypominającą „pawie oko" położoną od strony nawietrznej, natomiast dla średnich z dłuższego przedziału czasu obszary źródłowe przyjmują postać mniej lub bardziej regularnych kręgów o promieniach od kilkuset metrów (P=50%) do prawie kilometra (P=90%) otaczających punkt pomiarowy.

Słowa kluczowe: metoda kowariancji wirów, obszar źródłowy, klimat miast, bilans cieplny

Key words: eddy covariance method, source area, urban climate, heat balance

Wstęp

Wymiana ciepła i pędu pomiędzy powierzchnią ziemi a atmosferą ma kluczowe znaczenie zarówno w kształtowaniu klimatu lokalnego, jak i w problematyce globalnych zmian klimatycznych. Wprowadzenie w ostatnich latach komercyjnych anemometrów akustycznych i analizatorów gazowych pozwalających na pomiary ruchu powietrza i zawartości gazów z dużą częstotliwością (10 Hz i większą) umożliwiło rozpowszechnienie

Chapter 11
Urban Surface Energy Balance Models: Model Characteristics and Methodology for a Comparison Study

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Abstract Many urban surface energy balance models now exist. These vary in complexity from simple schemes that represent the city as a concrete slab, to those which incorporate detailed representations of momentum and energy fluxes distributed within the atmospheric boundary layer. While many of these schemes have been evaluated against observations, with some models even compared with the same data sets, such evaluations have not been undertaken in a controlled manner to enable direct comparison. For other types of climate model, for instance the Project for Intercomparison of Land-Surface Parameterization Schemes (PILPS) experiments (Henderson-Sellers et al., 1993), such controlled comparisons have been shown to provide important insights into both the mechanics of the models and the physics of the real world. This paper describes the progress that has been made to date on a systematic and controlled comparison of urban surface schemes. The models to be considered, and their key attributes, are described, along with the methodology to be used for the evaluation.

11.1 Introduction

The world's population is becoming increasingly urbanised. The fraction of the global population living in cities now exceeds 50% and urban dwellers are expected to reach 6 billion people, or two-thirds of the global population, by the year 2050 (UN, 2004). On the same timescale, climate change predictions estimate an increase in global mean temperature of 0.5–1.5 °C (IPCC, 2001). Whilst predicting human induced climate change on a regional scale is still uncertain, one climate

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RESEARCH ARTICLE

The occurrence of coreless winters in central Spitsbergen and their synoptic conditions

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Keywords
Spitsbergen; coreless winters; air temperature; circulation; polar climate.

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Abstract

Ten warm-core winters were distinguished in the period 1975/76–2007/08, drawing on data from the Svalbard Airport weather station in central Spitsbergen and using the conditions $t_{m-1} < t_m$ and $t_m > t_{m+1}$ (t is the monthly mean temperature while $_{m-1}$, $_m$ and $_{m+1}$ denote subsequent winter months) and the parameter of a coreless rate, c_r (the ratio of the second, a_2, to the first, a_1, harmonic of the annual temperature wave). Composite maps of sea-level pressure (SLP) and z 500-hPa means, and anomaly maps, were constructed separately for the mid-winter warm events and for the cold months before and after warming. Using the clustering method, different pressure patterns were recognized among the days of mid-winter warm spells. The occurrence of coreless winters in central Spitsbergen seems to be largely controlled by the position, extent and intensity of large-scale atmospheric systems, mainly the Icelandic Low. When the low spreads to the east and its centre is over the Barents Sea the inflow of air masses from the northern quadrant is observed over central Spitsbergen. This inflow of cold air of Arctic origin to the island takes place during the months preceding and following warm mid-winter events. Different circulation conditions appear when the Icelandic Low gets deeper than usual and shifts northwards, which coincides with warm spells. Sometimes a secondary cyclonic centre is located over Fram Strait and its warm sector encompasses Svalbard.

From year to year mean monthly surface air temperatures at high latitudes vary considerably, as does the annual temperature pattern, particularly for the winter season. A characteristic of the annual pattern of surface air temperature in the polar regions is a mid-winter warm spell. This phenomenon of a semi-annual temperature cycle was first recognized in the Antarctic and was called "kernlose", or coreless, winter (Wexler 1958), that is, a winter lacking a cold core (see Van Loon 1967). The long warm spells observed during the polar winter are also known as "warm-core events" (Umemoto 1998). The occurrence of coreless winters in the Antarctic has been well recognized and widely described (e.g., Van Loon 1967; Dolgin 1976; Wendler & Kodama 1993; Kejna 2002; Lipowska 2004; Styszyńska 2004; Chen et al. 2010). Fewer works deal with the occurrence of coreless winters in the Arctic (Rubinshteyn 1962; Umemoto 1998).

Two principal mechanisms to account for coreless winter phenomenon have been discussed. One is the influence of air circulation factors that contribute to warm advection from lower latitudes during the polar winter (Wexler 1958; Rubinshteyn 1962; Dolgin 1976; Dolganov 1986; Wendler & Kodama 1993; King & Turner 1997; Styszyńska 2004). The second is a characteristic of the radiation balance during polar nights: a strong inversion reaching the level of 2 km (and amounting to 25°C) in the Antarctic (Connolley 1996) and about 1 km over the Arctic Basin (Serreze et al. 1992). With this inversion, the upper and middle layers of the troposphere

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THE INTERNATIONAL URBAN ENERGY BALANCE COMPARISON PROJECT: INITIAL RESULTS FROM PHASE 2

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ABSTRACT

Many urban land surface schemes have been developed, incorporating different assumptions about the features of, and processes occurring at, the surface. Here, the first results from Phase 2 of an international comparison are presented. Evaluation is based on analysis of the last 12 months of a 15 month dataset. In general, the schemes have best overall capability to model net all-wave radiation. The models that perform well for one flux do not necessarily perform well for other fluxes. Generally there is better performance for net all wave radiation than sensible heat flux. The degree of complexity included in the models is outlined, and impacts on model performance are discussed in terms of the data made available to modellers at four successive stages.

Key words: Energy balance; fluxes; model complexity

1. INTRODUCTION

The increasingly urbanised global population, predicted to be nearly 70% by 2050, combined with enhanced computer resources, which allow greater spatial resolution to be resolved, have created greater demand for weather and climate information in cities. The surface morphology (existence of buildings, urban canyons), presence of impervious building materials, sparseness of vegetation, anthropogenic heat contributions, and bluff body nature of the buildings, combine to change energy partitioning in urban areas. Land surface schemes, used within numerical models, need to account for the urban influences on the surface-atmosphere exchanges. However, the complexity of these schemes has to be balanced with computational and data demands for particular objectives (e.g. global climate modelling, operational weather forecasting).

Here, first results from Phase 2 of an international comparison of 25 urban land surface schemes (Grimmond et al. 2009a,b) are presented. The fundamental requirement for the models to be included is that they model the urban energy balance fluxes:

$$Q^* + Q_F = Q_H + Q_E + \Delta Q_S$$

The models are forced with the incoming short- ($K\downarrow$) and long-wave fluxes ($L\downarrow$), air-temperature, pressure, specific humidity and wind components. From these the outgoing radiative fluxes ($K\uparrow$, $L\uparrow$) and net all wave radiation (Q^*), turbulent sensible heat (Q_H), turbulent latent heat (Q_E), storage heat flux (ΔQ_S) and the anthropogenic heat (Q_F) may be determined.

Whilst many urban models have been evaluated against observational datasets, these comparisons have not been conducted in a controlled manner that allows robust model inter-comparison. The objective here is to do just that; to undertake a staged and controlled comparison of urban energy balance models and their performance. This will assist in determining those modelling approaches which result in the best model performance.

2. METHODOLOGY

The methodology used here follows PILPS (Project for Intercomparison of Land-Surface Parameterization Schemes) (*Henderson-Sellers et al. 1993*). This allows the relative importance of key parameters to be determined and provides for an assessment of the level of model complexity required for optimal performance. Individual groups run their model(s) 'offline' using forcing data provided to allow the performance of the land surface schemes to be examined while the atmospheric conditions are fixed and not a function of the performance of a larger scale model.

Results presented here are for the first four stages of Phase 2. Phase 1 results are provided in Grimmond et al. (2009). In Phase 2/Stage 1, participants were provided with 15 months of forcing data from an urban site (here termed "alpha") (Table 1). At subsequent stages, additional site information was provided (Table 1): Stage 2 - pervious/impervious fraction, Stage 3 - urban morphology, and Stage 4 -urban materials. From the information provided, further parameters potentially could be derived if needed by individual modelling groups

The models are classified using eight characteristics (Table 2) (see Grimmond et al. 2009b for more details). Each model was assigned a random identifier number so that model performance is anonymous but class performance can be seen. Here the last 12 months of the data set are analysed to allow an initialisation or 'spin-up' period for the models. This includes 8520 30-min periods when all fluxes are observed. Statistics used to compare the models include the root mean square error (RMSE), systematic RMSE ($RMSE_s$) and unsystematic RMSE ($RMSE_u$).

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Before citing this paper please contact so we can provide the most up-to-date results, references and conclusions.

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Multi-indices analysis of southern Scandinavian storminess 1780–2005 and links to interdecadal variations in the NW Europe–North Sea region

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ABSTRACT: Extra-tropical cyclone frequency and intensity are currently under intense scrutiny because of the destruction recent windstorms have brought to Europe, and because they are a major meridional heat transport mechanism that may respond to differential latitudinal warming trends. Several studies using reanalysis data covering the second half of the 20th century suggest increasing storm intensity in the northeastern Atlantic and European sector. Fewer analyses cover a longer time period but show different trends or point towards the dominance of interdecadal variability instead of any clear trends. Hence, it is relevant to analyse cyclone variability over as long a period as possible. In this study, we analyse interdecadal variability in cyclone activity over northwestern Europe back to AD 1780 by combining information from eight storminess indices applied in an Eulerian framework. These indices, including four new approaches towards gauging cyclone activity, use the series of thrice-daily sea level pressure observations at Lund and Stockholm. We find pronounced interdecadal variability in cyclonic activity but no significant overall consistent long-term trend. The major interdecadal-scale variability common to all indices is in good agreement with geostrophic wind reconstructions for NE Atlantic and NW Europe, and with variations in the North Atlantic oscillation (NAO). Our results show that the reanalysis studies cover a time period chiefly coinciding with a marked, but not exceptional in our 225-year perspective, positive variation in the regional cyclone activity that has more recently reversed. Because of the interdecadal variations, a near-centennial time perspective is needed when analysing variations in extra-tropical cyclone activity and the associated weather conditions over northwestern Europe. Copyright © 2009 Royal Meteorological Society

KEY WORDS cyclone activity; windstorms; Eulerian statistics; storm frequency; climate variability; sea level pressure; multi-decadal variation

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1. Introduction

Long-term variability in extra-tropical cyclone frequency and strength is at the centre of international attention, both because of scientific theoretical analysis of climate change and because of socio-economic consequences of potential changes in storminess activity. Extra-tropical cyclone activity is one of the major meridional heat transport mechanisms; thus, it could be an important indicator of global climate change, particularly when considering changes to the meridional temperature gradient. Windstorms related to the deep cyclones often result in severe damage to property and forests. Storm surges and wind waves are also an obvious consequence of high wind speed associated with the deep lows. The question is whether changes to such storminess characteristics are a result of changes in frequency and intensity of deep cyclones in exposed regions. The essential problem is thus if any changes to cyclone activity are within natural variability or not, that is, the classical problem of climate change detection. As intense cyclones and severe windstorms and comparatively rare events, long-term records are required to capture the natural variability. But the existing long-term records of wind measurements are notorious for their inhomogeneity (Carretero *et al.*, 1998; Achberger *et al.*, 2006). Thus, alternative approaches for assessing the wind climate and storms back into the pre-industrial era are of particular interest.

In general, intensity of extra-tropical cyclone activity is a result of temperature differences between Equator and Pole. Decrease in the Northern Hemisphere (NH) surface meridional temperature gradient (Gitelman *et al.*, 1997), being mainly a consequence of warming in polar regions, should result in decrease in mid-latitude cyclone activity (Held, 1993; Lambert, 1995). The reverse effect in upper atmosphere can amplify eddy activity in mid-latitudes. As these two effects counteract each other, the outcome is the balance between them (Raible, 2006). In addition, the increased moisture content of a warmer atmosphere can either decrease cyclone activity due to more effective latitudinal heat transport or lead to greater

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