Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AAS022-01 Room:104 Time:May 25 08:30-08:45

Turbulent analysis of strong wind variability by merging numerical weather prediction and large-eddy simulation models

Tetsuya Takemi[1*], Hiromasa Nakayama[2], Haruyasu Nagai[2]

[1]Kyoto University, [2]Japan Atmic Energy Agency

The variability of wind speed in urban areas is influenced not only by meteorological disturbances and topography but also by buildings and social infrastructures. Particularly in densely built metropolitan areas with high-rise buildings, there is a local-scale wind structure with patches of high/weak wind speeds and high/low wind variability. These characteristic features of local-scale winds are an important factor in dealing with disaster prevention, atmospheric environment, and energy management in urban areas. For understanding the local-scale structure of winds in urban areas, there are two approaches: one is to deploy a surface observation network with densely distributed sites and/or a long-range remote-sensing network; and the other is to use computational simulation techniques by numerical models. It is important to develop numerical simulation models appropriate for applications in order to take a numerical approach. In general, meteorological models are useful in simulating wind variability induced by meteorological disturbances and topography. For example, weather forecasting is based on the numerical simulation techniques by numerical weather prediction (NWP) models; the data produced by NWP models are provided to our community as daily weather information. The resolutions of NWP simulations become higher and higher down to an order of kilometers (an order of 100 meters for research purposes). Wind flows in urban areas with complex surface features, however, are not reproduced by NWP models that cannot incorporate realistic building information. On the other hand, such local-scale wind flows in urban areas are studied in computational fluid dynamics (CFD) communities. The CFD techniques, if coupled with meteorological simulation techniques, should be promising in numerical approaches for representing wind flows in real urban areas under real meteorological conditions. Specifically, large-eddy simulation (LES) techniques are considered to be appropriate for the numerical analyses of wind flows in urban areas with complex surface features. Therefore, the purpose of this study is to propose a numerical approach for quantitative analyses of wind flows in real urban areas. We conduct numerical simulations for strong winds and gusts over the central business district of Tokyo during the passage of Typhoon Melor (2009). The Weather Research and Forecasting (WRF) model is used for the meteorological simulation; Mesoscale Analysis data by Japan Meteorological Agency (JMA) are used as the initial and boundary conditions. The nesting technique is used to resolve the area including central Tokyo at 60-m grid. The high-resolution temporal and spatial data from the WRF model are then used as the initial and boundary conditions for an LES model. The lower boundary of the LES model is determined by a building-height dataset for the analysis area. A turbulent simulation of wind flows in the realistic urban area is conducted with the LES model. The simulation successfully captures the wind variability and peaks observed at a surface site of JMA.

Keywords: Turbulent flow, Urban, Meteorological model, large-eddy simulation, wind gust, environmental fluid dynamics

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AAS022-02 Room:104 Time:May 25 08:45-09:00

Dependence of vertical fluxes on SGS parameterization schemes in a stable boundary layer

Yuji Kitamura[1*]

[1]Meteorological Research Institute

Large-Eddy Simulation (LES) has been widely used in numerical simulations of a planetary boundary layer. However, numerical modeling used LES becomes to be difficult in a stable boundary layer, because of a smaller characteristic scale of turbulent mixing. Kitamura (2010, JMSJ) performed numerical simulations with four types of subgrid-scale (SGS) parameterization schemes in a stable boundary layer and found that the vertical profile of momentum and heat fluxes does not converge on a unique profile, even at a higher model resolution. In the present study, we analyze what bring the spread of these fluxes among the SGS parameterization schemes.

First, we divide the horizontal mean flux into grid-scale (GS) and SGS parts. The dependence of the momentum and heat fluxes on the SGS schemes almost appears in the GS part. Furthermore, the spread of the fluxes is attributed to the GS component in lower horizontal wavenumbers except in the vicinity of the surface. This result suggests that it is important to understand the effects of the SGS schemes on the GS disturbance in the lower wavenumber region.

Dependence on the SGS schemes is observed also in the SGS part of the heat flux. The dependence can be attributed to different formulations of turbulent Prandtl number among the SGS schemes: the spread seen in the SGS heat flux vanishes when a same formulation of turbulent Prandtl number is adopted. This implies that a proper formulation of turbulent Prandtl number is necessary for SGS modeling. However, turbulent Prandtl number in strong stratification is still uncertain despite of many studies in this issue. A further study requires for determining turbulent Prandtl number in strong stratification.

Keywords: Large-Eddy Simulation, Atmospheric boundary layer, Turbulent flux, Parameterization

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AAS022-03 Room:104 Time:May 25 09:00-09:15

Insight into filter-size effect on SGS turbulence structure in the neutral-surface layer with wind-tunnel experiment

Yasuo Hattori[1*], Chin-Hoh Moeng[2], Hitoshi Suto[1], Hiromaru Hirakuchi[1]

[1]CRIEPI, [2]NCAR

A better understanding of structural characteristics of sub-grid scale (SGS) turbulence in the atmospheric surface layer is of practical interest for developing large-eddy simulation (LES) techniques with numerical weather forecasting models. Such LESs have become a powerful tool for studying atmospheric turbulence (e.g. Takemi and Rotunno 2003, Michioka and Chow 2008, Catalano and Moeng 2010, Hattori et al. 2011). However, the surface-layer turbulence is still poorly resolved, especially near the ground, in the simulations, and thus, the improvement of SGS modeling remains a topic of interest (Wyngaard 2004, Chow et al. 2005, Moeng et al. 2007). To tackle this problem, some observation projects were carried out to firmly grasp the characteristics of SGS motion of the surface-layer turbulence (e.g. Sullivan et al. 2003), but the details of spatial, especially vertical, structure of SGS fields have not been clarified yet, because of the difficulty in obtaining multi-point simultaneous velocities in observations.

On the other hand, we have recently developed an experimental approach to mimic the neutral surface-layer turbulence in a test section of wind tunnel (Hattori et al. 2010); by adding large-scale flow disturbances, the scale of which is much large compared with the scale of shear turbulence of the boundary layer, with an active grid technique, we obtained the fully developed logarithmic layer, which consist of a turbulent flow that has similar characteristics to those typically observed in the atmospheric surface layer.

In this study, by using this approach, we have carried out PIV measurement and discussed the SGS motions in the streamwise-vertical plane of the logarithmic layer; the velocity at the centerline of the test section was set to 5 ms-1 and the measuring location was fixed at the distance x = 4180 mm downstream from the active turbulence grid; the logarithmic layer height, hs, was 0.07 m. The velocity vectors were measured with a PIV technique. Particle-containing flow images with a physical size of 88.4x88.4 mm2 were captured by a CCD camera, and then, the velocity vectors were calculated using a cross-correlation method with interrogation windows of a size of 1.4x1.4 mm2. After removing incorrect velocity vectors with a median filter, we decomposed the instantaneous velocity fields into two, grid and sub-grid, scales by the application of a top-hat spatial filter (Sullivan et al. 2003, Inagaki and Kanda 2010) with the filter width, Df. The statistics were calculated from velocity vectors obtained with about 3000 image pairs. Turbulence statistics obtained with the PIV agreed excellently with the hot-wire measurements (Hattori et al, 2010).

Fist, we examined the change in the contribution of the SGS motions to the turbulence intensity with Df, which properly corresponds to observations in the near-neutral atmospheric surface layer (Sullivan et al, 2003); e.g., the contribution of SGS motions increases with Df and becomes dominant for Df/hs$>$0.2. The probability density function distributions (PDF) of SGS velocity also changed with Df. The wider filter width suppresses the low speed fluid motions, implying that SGS motions for Df/hs=0.5 [such filter width is often used in the LES's with numerical weather prediction models (Sullivan et al. 2003)] relate to coherence structures, which include large-scale fluid motions, such as sweep events.

Then, we examined the coherence structure of SGS fluid motions with a proper orthogonal decomposition. The packet like flow patterns (Adrian 2000) appear for Df/hs=0.5, whereas vortex structures become dominant for Df/hs$<<$1, corresponding to discussion about PDF distributions. Also, we checked the correlation between a SGS flux and a grids-scale deformation tensor, which is apparently weak, suggesting that conventional SGS model might have some problems for estimating instantaneous SGS fluxes of the surface-layer turbulence.

Keywords: coherence structure, LES, surface layer, turbulence, wind-tunnel experiment

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AAS022-04 Room:104 Time:May 25 09:15-09:30

LES of flow and plume dispersion in an actual urban area

Hiromasa Nakayama[1*], Nagai Haruyasu[1]

[1]Japan Atomic Energy Agency

There is a potential problem that the intentional release of radioactive materials by terror attacks and the accidental spillage from the transportation or storage of flammable and toxic gas occur within populated urban area. For the assessment of human health hazard or the safety analysis of the hazardous gas, not only mean but also fluctuating concentrations should be estimated. Therefore, we have developed a high resolution atmospheric dispersion model using Large Eddy Simulation (LES) model and perform its simulation on plume dispersion in an actual urban area (Oklahoma city) and investigate the characteristics of mean and fluctuating concentrations.

The basic equations for the LES model are composed of the spatially filtered continuity equation, Navier-Stokes equation and transport equation of concentration. The standard Smagorinsky model (Smagorinsky, 1963) is used and its constant is set to 0.1 for estimating the eddy viscosity. The turbulent Schmidt number is 0.5. In our LES model, two computational regions are set up. One is a driver region for generation of inflow turbulence and the other is a main region for LES of plume dispersion in an actual urban area immersed in the atmosphere boundary layer. First, inflow turbulence is generated by using Kataoka's method (2002) in the driver region and then, its data are imposed at the inlet of the main computational region at each time step.

We can capture the unsteady behaviors of turbulent flow and plume dispersion within and over an actual urban area and show the spatial distribution of mean and fluctuating concentrations.

Keywords: LES, plume dispersion, actual urban area

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AAS022-05 Room:104 Time:May 25 09:30-09:45

Large-eddy simulation of atmospheric boundary layer flow with artificial inflow turbulence

Akihiko Kondo[1*], Satoru Iizuka[1], Kazuya Kinbara[1]

[1]Nagoya University

Due to the rapid growth of computer resources, the boundaries between mesoscale meteorological model (MMM) and engineering large-eddy simulation (eLES) models are overlapping. Recently, there are some examples of very high-resolution MMM and some examples of eLES that deal with very large computational domains. As the next phase of such simulation studies, attempts to merge MMM and eLES are being made. However, the conventional concepts of MMM and eLES are different because an apparent spectral gap has existed between both models. There are various differences associated with 1) turbulence scale, 2) physical processes, 3) variables and parameters, etc., between MMM and eLES; namely, there are many difficulties to merge MMM and eLES seamlessly.

For merging MMM and eLES, the boundaries for eLES are basically given from the output obtained with MMM. However, small-scale fluctuations required for eLES, in particular, small-scale velocity fluctuations at the inflow boundary (inflow turbulence), cannot be obtained from MMM in which the grid resolution is coarser than that of eLES. Thus, to generate inflow turbulence appropriately is one of the most important issues for successful coupling eLES with MMM.

In this study, we conduct LES computations for an atmospheric boundary layer (ABL) flow with artificial inflow turbulence. The inflow turbulence is generated using an artificial method based on a prescribed energy spectrum in the wave number domain proposed by Lee et al. (Phys. Fluids, 1992). A remarkable advantage in their method is that the continuity condition can be easily imposed on the generation procedure. On the other hand, the artificial method of Lee et al. (1992) can generate only homogeneous isotropic turbulence. In order to apply the artificial method to the analysis of ABL (anisotropic turbulence flow), therefore, we divide the inflow boundary into several vertical layers and apply the generation method with different target turbulence intensity and length scale for each layer.

Keywords: Large-Eddy Simulation, Turbulence, Inflow Turbulence, Atmospheric Boundary Layer, Energy Spectrum, Inverse Fourier Transform

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AAS022-06 Room:104 Time:May 25 09:45-10:00

Organized flow structures in the atmospheric boundary layer over the sea detected by a 3D scanning Doppler lidar

Chusei Fujiwara[1*], Yasushi Fujiyoshi[2]

[1]EES, Hokkaido Univ., [2]ILTS, Hokkaido Univ.

Observations of Atmospheric boundary layer (ABL) over the sea started at Ikeshima Island, Nagasaki Prefecture from July 2009 using a 3D scanning coherent Doppler lidar. During this period, small-scale vertical vortices (dust devil-like vortices; DDVs), convective cell circulation and streaks were observed.

DDVs associated with convective cell circulation (fishnet patterns of wind field) were detected not only in the daytime under relatively weak condition (2.4 m s^{-1}) but also in the nighttime under relatively strong wind (9.1 m s^{-1}). The diameter of the vortex core ranged from 45- 104 m, maximum vertical vorticity was 0.18 s^{-1}. The environmental conditions during the DDV events are characterized by a relatively strong wind (2.4-9.1 m s^{-1}), a deep boundary layer height (1-1.2 km) and a large temperature difference between the sea and air (8K). These conditions suggest that DDVs over the sea occur under strong unstable conditions.

Streaks were also observed, over the sea (with fetch several 100 km), under near-neutral conditions with strong wind. This result indicates that streaks did not appear to be generated by any particular surface feature.

Simulation of these flow structures by a Large Eddy Simulation (LES) model and comparison of the simulated structures with those observed by the 3D-CDL will contribute to the understanding of dynamics of flow structure and will be useful LES validation.

Keywords: LES validation, Doppler lidar, Organized flow structure

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AAS022-07 Room:104 Time:May 25 10:00-10:15

Large Eddy Simulation on Dust Devils in Convective Mixed Layers

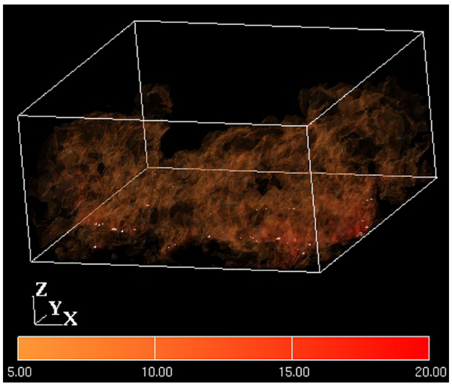
Junshi Ito[1*], Hiroshi Niino[1], Mikio Nakanishi[2]

[1]AORI, The University of Tokyo, [2]National Defense Academy

During daytime in fine weather conditions, convective mixed layers in which turbulent convection dominates due to strong sensible heat flux from the surface heated by insolation. Dust devils, which are small-scale strong vertical vortices, occur in the convective mixed layers. They are visualized by dust particles lifted by their strong winds. Dust devils are considered to be ubiquitous in the convective mixed layers not only on the Earth but also on the Mars. Large Eddy Simulations (LESs) have succeeded to reproduce various characteristics of the convective mixed layers such as the fishnet pattern of convective updrafts and entrainments at the top of the atmospheric boundary layer. Recently, LESs with higher resolution start to succeed in reproducing small-scale vortices similar to dust devils. In fact, we have investigated the formation mechanism of the dust devils reproduced in a LES (Ito et al. 2010, JGU Meeting). In the present paper, we report 1) relationship between the intensity of dust devils and that of the convective updrafts and 2) estimation of dust particle concentration in a convective mixed layer in which there is no general wind and dust particles are lifted by sporadic winds due to the dust devils and convective motions.

To study the first subject, a time-evoluving convective mixed layer is reproduced by a LES with grid size of 50 m, in which a quiescent stably-stratified atmosphere is heated from below at a constant surface heat flux Q. Vertical vorticity of dust devils at the lower level is found to increase linearly with convective velocity scale $w_c=(gQh/T_0)^{1/3}$, where g is the gravitational acceleration, h the height of the convective mixed layer, and T_0 standard potential temperature.

As for the second subject, we have incorporated dust concentration and surface dust flux according to an experimental formula by Loosmore and Hunt (2000) in a LES with a grid size of 20 m, and have calculated the dust concentration of suspended dust particles in diurnally-varying convective mixed layers without general winds. The dust concentration is found to be higher in regions of strong vertical vorticity, which is associated with dust devils (see Figure). Dust concentration of 10^{-5} g/m^3 on average is realized in the convective mixed layer. The horizontally averaged concentration is almost uniform in the vertical direction. If similar weather conditions last continuously, a considerable part of the dust particles lifted on the previous days remain in the atmosphere, and the dust concentration could reach 7 times as much as that of the end of the first day.



Keywords: dust devil, vertical vortices, convective mixed layer, large eddy simulation

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AAS022-08 Room:104 Time:May 25 10:15-10:30

A large eddy simulation on steam devils in a moist convective mixed layer

Haruki Yamaguchi[1], Hiroshi Niino[2*]

[1]Japan Meteorological Agency, [2]The Univeristy of Tokyo

Steam devils which develop in moist convective boundary layers over relatively warm waters during a cold air outbreak are reproduced by a large-eddy simulation model, and their characteristics, formation process and environment are studied. In a non-precipitating case, reproduced steam devils like vortices were similar to dust devils and were found to be phenomena within sub-cloud layer of cell pattern convection, some of their features showing a good agreement with observations. In a precipitating case, cold downdrafts from precipitating cumuli apparently enhanced reproduced vortices by producing local horizontal wind shear and convergence around surface.

Keywords: steam devil, moist convective mixed layer, convection, vortex, atmospheric boundary layer

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Large-eddy simulation of instabilities in and above a hurricane boundary layer

Mikio Nakanishi[1*], Hiroshi Niino[2]

[1]National Defense Academy, [2]AORI, The University of Tokyo

A large-eddy simulation (LES) model is used to explore what instabilities occur and what structures are induced in a hurricane boundary layer (HBL) 100 and 40 km away from the center of the hurricane. The LES results are examined through turbulent statistics and proper orthogonal decomposition (POD) analysis, which is also called empirical orthogonal function analysis. The POD analysis and budgets of turbulent kinetic energy (TKE) demonstrate that an inflection-point instability occurs and horizontal roll vortices with wavelengths of 1.4-3.0 km are induced in the HBL. Also the latter and horizontal distributions of velocity fluctuations show the presence of streaks at intervals of several hundred meters near the ground surface, which are more likely related to small-scale damage often observed after hurricane landfalls. Moreover, in the case of the distance of 40 km from the hurricane center, anticyclonic vortices emerge above the HBL and continue to develop. The horizontal distributions of velocity fluctuations and budgets of TKE suggest the occurrence of a centrifugal instability, although it needs to be confirmed through observations whether such anticyclonic vortices are substantial.

Keywords: large-eddy simulation, horizontal roll vortices, streaks, inflection-point instability, centrifugal instability

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AAS022-10 Room:104 Time:May 25 11:00-11:15

Numerical investigation of instantaneous flow structure within a cubical canopy

Atsushi Inagaki[1*], Manabu Kanda[1]

[1]Tokyo Institute of Technology

Instantaneous flow structure within a cubical canopy was investigated using large eddy simulation (LES). The main interests are (1) large scale coherency of instantaneous flow field within a cubical canopy, (2) how the large scale coherent structures coupled with the turbulent organized structures (TOS) above.

A large numerical domain (i.e., 2560 x 2560 x 1710 m) was used to simulate a whole atmospheric boundary layer for daytime settings with a regular array of cube of 40m height (= H), and a fine spatial resolution (2.5m) to explicitly resolve each cube. The convective mixed layer was sustained by the constant heat supply from all roof and floor surfaces, but the strong mechanical mixing attributed to cubical roughness kept the around the roof level near-neutral.

The numerical result revealed that there are very large coherent structures of both in velocity and temperature fields within the canopy layer. The size of the structures is much larger than that of the cubes. It was also found that the shapes and locations of these structures are closely related with the TOS above.

The upward momentum and heat transport events were clearly related with the TOS developed in the inertial sublayer, which frequently occur below low momentum streaks. Meanwhile, the downward transports are not so correlated with the TOS above but more regulated by the structure of canopy since it frequently occurred within the street axis parallel to the mean wind direction.

Keywords: urban canopy, surface layer, convective mixed layer, turbulent organized structure

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AAS022-11 Room:104 Time:May 25 11:15-11:30

CFD model considering meso-scale disturbance for gas dispersion in an urban district

Takenobu Michioka[1*], Ayumu Sato[1]

[1]CRIEPI

With the increasing availability of powerful supercomputers, numerical simulations have become a very attractive tool for simulating transport and dispersion of airborne materials in an urban district. A normal computational fluid dynamics (CFD) model, however, cannot estimate 1-hour averaged concentration which is usually used in an environmental impact assessment because a large-scale turbulent motion like a meso-scale disturbance cannot be considered in the computational domain. In the present study, a CFD model coupled to a mesoscale model is developed to estimate 1-hour averaged concentration in an urban district. FrontFlow/Red (Unemura et al. 2004) is employed for CFD model, which is based on a finite volume method with an unstructured grid system to resolve a flow structure in a complex geometry. As for a meso-scale model, the Advanced Regional Prediction System, which developed at the Center for Analysis and Prediction of Storms at the University of Oklahoma (Xue et al. 2000, 2001) is applied. Both the CFD and mesoscale models are based on a large-eddy simulation (LES). The detailed method of LES for meso-scale flows is described in Michioka and Chow (2008). The velocities obtained by the mesoscale model are directly given as the boundary conditions for the CFD model without change of velocity variables. To evaluate the performance of the developed CFD model, the model is applied to simulate tracer gas dispersion released from the roof of the building in Komae Research Laboratory at CRIEPI (Central Research Institute of Electric Power Industry) in Japan, where field experiments were conducted in 3 February 2005.

Figure 1 shows the ground concentration which are averaged over 1 hour (15:30 - 16:30). During the period, the wind direction was almost North and the atmospheric stability was nearly-neutral. The concentration $C*$ is noramalized by the reference velocity, Uref, and source strength, Q. It is found that the ground concentration estimated by normal CFD model is larger than that in the field experiment. This is attributed to the fact that normal CFD models do not consider a large-scale turbulent motion like a meso-scale disturbance. It also means that normal CFD models tend to overestimate 1-hour averaged ground concentration. On the other hand, the gas concentration obtained by the developed model is widely distributed compared to that in the normal CFD model owing to large-scale turbulent motion generated in the meso-scale model, and the concentration are nearly equal to that in the field experiment.

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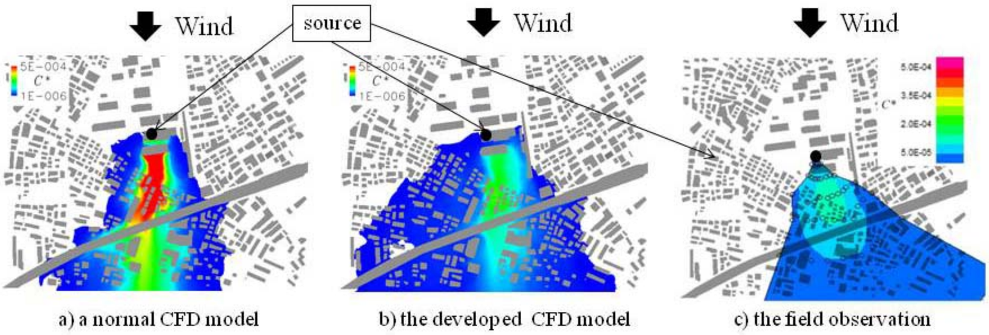

Figure1 1-hour averaged ground concentration

Keywords: Gas dispersion, 1-hour averaged concentration, Meso-scale model, Large-eddy simulation, Urban district

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AAS022-12 Room:104 Time:May 25 11:30-11:45

Mathematical analyisis of the consentrationaof radioactive aerosol from the Chernobyl accident

Kensuke Ota[1]*

[1]University of Tsukuba,graduate school

One of the important case of atmospheric pollution in the modern age, there is a problem of contamination of radioactive aerosol of the Chernobyl nuclear power plant accident.

Examples the accident, former Soviet Union on 26 April 1986, there was a huge explosion at the Chernobyl nuclear power plant reactor 4 of the Republic of Ukraine. Nuclear accident open the air reactor core, so it took several days to cease the accident. And also a large amount of radioactive aerosol fly over wide area. So,this accident become a nuclear the worst in history.

Atmospheric Diffusion Studies in the past have been many studies. However, these studies are intended to safety and temporary refuge, the scope is much more than a few years. In situations that half-life of 30.7 years of Cs, Sr half-life of 28.78 years, we must predict the long-term and wide-area model.

Also, because this radionuclide is highly specific, it can be considered as a tracer in the air, and you can get a basic knowledge of atmospheric dispersion. And, applied to other substances , it can also be considered to obtain long-term and wide-area diffusion about carbon dioxide.

Previous studies have the following equation.

C (t) = Aexp(-LAMBDA phy t) tˆ-BETA

This is a prediction model describes the change in concentration of the fixed point in time, there are two parameters of the model prediction that 2 A and BETA. A is the amount of traces of radioactive aerosol at that point, BETA is a purification of the environment at that point. In addition, LAMBDA phy decay of radioactive elements In addition, LAMBDA phy is disintegration for each elements, Cs, Sr, etc. it's a different value.

In previous studies, we followed the fitting accuracy of Cs. And, applied to other elements,we can followed the fitting accuracy of Sr. So,we think it is possible that we check the safety of the region of fitthing other radioactive aerosol. But there are also disadvantages of this prediction model. Because, this model can predict only time-scale function, so we must also consider space-scale function, otherwise it is not possible to understand the diffusion. I do mathematical analysis to predict the spatial distribution.

To analyze the spatial distribution is the starting advection equation, in order to give an analytical solution of this advection equation, I've a variety of assumptions. First , Using the autocorrelation of turbulent flow by Obukhov proposed. Thereby, changing in time-scale diffusion coefficient was announced.

Second, we focused on environmental purification, it's rivers, plants, and in the purifying of the sea, but near Chernobyl most dominant purification is plant and the uptake rate decreased in inverse proportion to the time. So,we can get the inverse value of power function.

Finally, we do mathematical approximation proposed by Kappor and Gelhar, and if we have a constant spatial distribution, I get the function of previous studies.

However, in the spatial distribution of the derived the analytical solutions were Gaussian function.The Gaussian function only can distribute normal diffusion, we try to fit the real experimental data in Chernobyl accident that was published IAEA. But this function couldn't follow this data.

By this, as what we are studying now, there are two approaches.One is prediction using Probability Density Functions. It is one of the Monte Carlo model, I use Levy Flight model. Levy flight model is applied to Random Walk model, in random walk model , the jump distance is constant, but Levy Flight model the jump distance is not constant, and the jump distance function is inverse value of power function. In this model we can fit space distribution, however we don't know physical meaning, it's advanced research.

Another one is space-scale autocorrelation of turbulent flow by Sreenivasan proposed. This property can introduce the changing in time-scale and space-scale diffusion coefficient, this theory demonstrated the possibility of fitting space distribution.

Keywords: Radioactive aerosol, Atmospheric transport model, Anomalous diffusion, Mathematical analyze, Fractional derivative

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AAS022-13 Room:104 Time:May 25 11:45-12:00

Assessment of turbulence closure models for resonant inertial response in the oceanic mixed layer using LES

Noki Furuichi[1], Toshiyuki Hibiya[2*], Yoshihiro Niwa[3]

[1]Grad. Schl. of Sci., Univ. of Tokyo, [2]Grad. Schl. of Sci., Univ. of Tokyo, [3]Grad. Schl. of Sci., Univ. of Tokyo

Large eddy simulation (LES) of the resonant inertial response of upper ocean to a strong wind forcing is carried out and the results are used to evaluate the performance of each of the two second-order turbulence closure models developed by Mellor and Yamada (1982) (MY) and by Nakanishi and Niino (2009) (NN). We find that the development of the oceanic mixed layer demonstrated by LES such as the strong entrainment at the base of the oceanic mixed layer and accompanying decrease of sea surface temperature is underestimated in MY and overestimated in NN, respectively, whereas the formulation of stability function in NN itself shows a better performance than MY in reproducing the vertical structure of turbulent heat flux obtained from LES. It is also found that the discrepancy is much diminished in the revised NN where the turbulent length scale is formulated so as to be more strongly restricted with the increase of density stratification than in the original NN.

Keywords: near-inertial shear, oceanic mixed layer, turbulence closure model, sea surface temperature, turbulent length scale, entrainment

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AAS022-14 Room:104 Time:May 25 12:00-12:15

Application of LES to blowing snow

Masaki Nemoto[1*], Kouichi Nishimura[2], Takeshi Sato[1]

[1]NIED, [2]Nagoya University

Drifting snow is an important issue in both engineering and climatological fields. On roads, drifting snow causes snowdrifts and reduced visibility. In mountainous regions, nonuniform distribution of snow due to blowing snow, leads to avalanche release. Redistribution of snow by blowing snow is also important for hydrological processes and mass balance in polar regions. Although recent numerical research, based on RANS method, has revealed many basic properties of drifting snow, in reality, spatial and temporal variations is significant in blowing snow. In this study, we applied Large-Eddy Simulation (LES),which is superior in the unsteady calculation of the turbulence phenomenon, to blowing snow. Calculated concentrations fluctuate because of the wind turbulence: the concentrations show similar fluctuating characteristics to the wind. Instantaneous concentrations on a horizontal plane exhibit strong spatial variability. The vertical correlation of the instantaneous concentrations is not significant if the height difference exceeds 1m.

Keywords: Blowing snow, LES

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AAS022-15 Room:104 Time:May 25 12:15-12:30

High resolution general circulation model experiments of the Martian atmosphere: Resolution dependence of disturbances

Yoshiyuki O. Takahashi[1*], Yoshi-Yuki Hayashi[1], Masatsugu Odaka[2]

[1]Kobe University, [2]Hokkaido University

High resolution experiments of Martian atmosphere have been performed by using a general circulation model (GCM). One of purposes of the experiments is to investigate the small and medium scale disturbances whose horizontal scales range from thermal convection to baroclinic waves on Mars. The other purpose of the experiments is to have some insights into dust lifting processes on Mars. Dust suspended in the atmosphere has significant impact on the thermal and circulation structure of Martian atmosphere through radiative processes. In the followings, some features of atmospheric disturbances observed in our model are presented. In this study, the circulation structure and effects of disturbances on dust lifting are investigated by examining its resolution dependence.

The model used in this study consists of the dynamical core of AFES (Ohfuchi et al., 2004), and the physical processes introduced from the Mars GCM which has been developed by our group so far (Takahashi et al., 2003, 2004, 2006). The AFES is a spectral primitive equation model and is based on CCSR/NIES AGCM 5.4.02. The introduced physical processes include the radiative, the turbulent mixing, and the surface processes. In addition, the dust lifting process is implemented to diagnose the dust mass flux in the model. The horizontal variation of surface orographic height, albedo, and thermal inertia are given following the observational results. However, in some experiments, uniform surface properties are used to investigate atmospheric disturbances that are not forced by variations of surface properties. By the use of this GCM, experiments at northern fall condition are performed with horizontal resolutions of T79, T159, T319, and T639, and number of vertical layers of 96. Horizontal resolutions of T79, T159, T319, and T639 are equivalent to about 89, 44, 22, and 11 km grid size, respectively. In these experiments, the dust distribution used for radiative heating rate calculation is assumed to be uniform horizontally with dust optical depth of 0.2.

A lot of atmospheric disturbances are observed in the results of experiments. Some of those are baroclinic waves in northern middle and high latitude, fronts associated with them, vortices in the lees of mountains, several streaks with horizontal scale of tens of kilometers, and a lot of small scale vortices in low latitudes. Comparing the result of T319 resolution experiment with that of T79, many disturbances, such as baroclinic wave, fronts, and lee vortices with several hundred kilometers, are observed in both experiments. Further, the existence of small scale streaks and vortices in low latitude is implied. However, by increasing the model resolution, the structures of streaks become very clear, and the horizontal size of the small scale vortices in low latitude decreases and the strength increases as the increase of horizontal resolution. In addition, the local time when the small scale vortices develop tend to become early by the increase of horizontal resolution. It is considered that these small scale vortices are caused by convective activity represented by the model, and these are the results of the change of model representation of convective motion.

In the presentation, the disturbances observed in experiments with uniform surface properties and the effects of atmospheric disturbances on dust lifting will be shown and discussed.

Keywords: Mars, planetary atmosphere, general circulation model, small and medium scale disturbance, Earth simulator