海洋地球インフォマティックスの可能性
Toward the Marine-Earth Informatics

*高橋 桂子[1]
*Keiko Takahashi[1]

1. 国立研究開発法人海洋研究開発機構
1. Japan Agency for Marine and Earth Science and Technology

海洋地球インフォマティックスとはなにか、どうして必要なのか、その重要性と可能性を提示する。当該テーマを推進するために必要な要素技術や他分野と協力によって加速できる技術、発展が加速されている技術などを紹介し、今後の展望についても提示し、波及効果についても議論する予定である。

キーワード：ビッグデータ、インフォマティックス、学習
Keywords: Big Data, Informatics, Machine Learning

Mission, potential, and prospects of d4PDF

*高薮 出[1]
*Izuru Takayabu[1]

1. 気象庁気象研究所
1. Meteorological Research Institute

When stakeholders make decision how to adapt to the disaster caused by climate change, PDF information of extreme events is needed. The mission of d4PDF is to get such PDF. For this purpose, at least order hundred ensemble experiments have been done. Driving hundred ensembles by using Earth Simulator, we could set the resolution of the model moderately, not so coarse. In this case, we drive AGCM with equivalent grid size of 60km (MRI-AGCM3.2H), and downscale the calculation results by using 20km grid regional climate model (NHRCM20) around the Japanese Archipelago. Here the ensemble number has been increased by adopting many kinds of SST as the lower boundary condition. The perturbation is partly caused by uncertainty comes from the accuracy of observation data. It is clearly shown that hundred ensembles have potential to produce PDF of extreme events. However, the size of the dataset is over 2PB, which makes it difficult to be used in many kinds of adaptation issues.
All the calculation in d4PDF has been done by using the Earth Simulator, under the “strategic project with special support” of the center for earth information science and technology (CEIST) / JAMSTEC. Also, data integration and analysis system (DIAS) helped us archiving the calculated data. Fundamental support has been done with program for risk information on climate change (SOUSEI), sponsored by ministry of education, culture, sports, science and technology –Japan (MEXT).

キーワード：地球シミュレーター、アンサンブル、極端事象、ダウンスケール、気候変動
Keywords: earth simulator, ensembles, extreme event, downscale, climate change

Earthquake and tsunami forecasting procedures using large number of simulation scenarios

*堀 高峰[1]、五十嵐 康彦[2]、岡田 真人[2]
*Takane Hori[1], Yasuhiko Igarashi[2], Masato Okada[2]

1. 独立行政法人海洋研究開発機構・地震津波海域観測研究開発センター、2. 東京大学大学院新領域創成科学研究科
1. R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 2. Graduate school of frontier science, the University of Tokyo

Recent progress in earthquake and tsunami simulations, we can calculate many scenarios for earthquake generation patterns and tsunami propagation patterns. For earthquake forecasting procedure, we propose a method that is based on spatio-temporal variation in slip velocity on the plate interface, which causes interplate earthquakes (Hori et al., 2014). Model outputs are not only information about the occurrence of great earthquakes (time, place, and magnitude) but also information about the physical state evolution that causes earthquakes. To overcome the difficulty in forecasting earthquake generation resulting from uncertainty both in the physical model and in the observation data, we introduce a type of sequential data assimilation. In this method, we compare observed crustal deformation data to simulations of several great interplate earthquake generation cycles. We are currently constructing a prototype, applying this forecasting procedure to the Nankai Trough, Southwest Japan, where great interplate earthquakes have occurred and are anticipated. On the other hand, for tsunami hight forecasting, we constructed a model to forecast the maximum tsunami height by a Gaussian process (GP) that uses pressure gauge data from the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET) in the Nankai trough (Igarashi et al., 2016). We studied the relationship between offshore and coastal tsunami heights with the aim of using DONET1 ocean-bottom pressure gauges for tsunami prediction. We assumed various tsunami models, including fault models and tsunami sources, and created a large number of simulations (more than 1,500) to reveal the relationship between DONET1 ocean bottom pressure gauge measurements and coastal tsunami heights. We found a greatly improved generalization error of the maximum tsunami height by our prediction model. The error is about one third of that by a previous method, which tends to make larger predictions, especially for large tsunami heights (>10 m). These results indicate that GP enables us to get a more accurate prediction of tsunami height by using pressure gauge data. We will further develop both earthquake and tsunami forecasting procedure using data driven science and high performance computing technology.

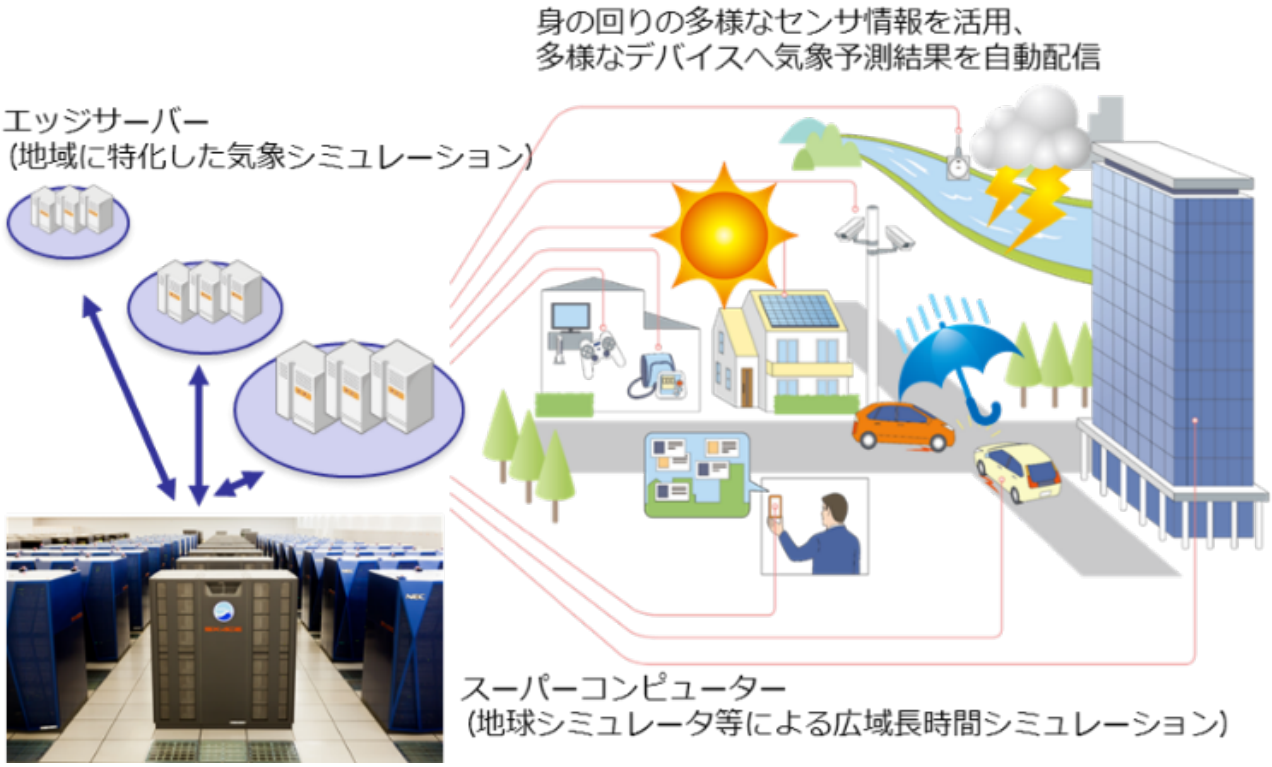
Smart weather forecasting by computing network comprising the Earth Simulator and edge servers

*Ryo ONISHI[1], Koya Mori[2], Fumiaki Araki[1], Ken'ichi Itakura[1], Shintaro Kawahara[1], Ryota Nakada[2], Noriyuki Takahashi[2], Keiko Takahashi[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. NTT Network Innovation Laboratories

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and NTT Network Innovation Laboratories (NTT) have started a new collaborative research on the development of smart weather forecasting system that can bring new information infrastructure for future smart society. As illustrated in Fig.1, the system relies on a computing network, including the Earth Simulator at JAMSTEC and edge servers consisting the edge computing platform lead by NTT. The big data obtained from huge number of various IoT sensors are utilized to improve the forecasting in an efficient way in terms of both computation and network communication. The edge servers, in the vicinity of the users and devices, can provide detailed local weather information that can be of use for many local services. We will present the possible social applications as well as the new system itself.

Keywords: weather forecasting simulation, Earth Simulator , Edge Computing



Quasi-realtime forecast using global nonhydrostatic icosahedral atmospheric model for the observation plan on the Earth Simulator.

*池田 美紀子[1]、那須野 智江[1]、大倉 悟[1]、上原 均[1]
*Mikiko Ikeda[1], Tomoe Nasuno[1], Satoru Okura[1], Hitoshi Uehara[1]

1. 国立研究開発法人海洋研究開発機構
1. Japan Agency Marine-Earth Science and Technology

The Earth Simulator was once top ranked in "TOP500" supercomputers between 2002 and 2004. Its third generation introduced in 2015 performs 32 times more FLOPS than the original one, and provides irreplaceable amount of computing resources to the earth science as well as many other fields. JAMSTEC manages and operates the Earth Simulator and supports its users with technical assistance. We run near real-time forecasts using global nonhydrostatic icosahedral atmospheric model (NICAM) on the Earth Simulator during field campaigns led by JAMSTEC. The close collaboration between in-situ observation and numerical simulation is one of major tasks of Marine Earth Informatics. In Pre-YMC (November - December 2015) campaign, we conducted real-time forecasts and provided the simulation results to the observational sites, including Research Vessel “Mirai”, via internet. Now we are working on the field campaign “the Years of the Maritime Continent (YMC)” (July 2017 - July 2019). We make improvement in the simulation setups, execution procedures, and the job scheduling method to efficiently run the forecast system on the Earth Simulator under a close collaboration between the research division and the operational division. We aim for better performances of forecasts both in physical accuracy and in computational performance.

キーワード：スーパーコンピュータ、気象予測、全球大気モデル
Keywords: supercomputer, weather forecast, global atmospheric model

Large Scale Simulations of Dynamic Rupture Propagation to Investigate the Fault Behavior of Mega-Thrust Earthquakes

*津田 健一[1]、宮腰 淳一[1]、Ampuero Jean Paul[2]、今任 嘉幸[3]、杉山 大祐[3]、坪井 誠司[3]
*Kenichi Tsuda[1], Jun'ichi Miyakoshi[1], Jean Paul Ampuero[2], Yoshiyuki Imato[3], Daisuke Sugiyama[3], Seiji Tsuboi[3]

1. 清水建設 株式会社 技術研究所、2. カリフォルニア工科大　地震学教室、3. 海洋研究開発機構
1. Institute of Technology, Shimizu Corporation, 2. Seimo Lab, California Institute of Technology, 3. Japan Agency for Marine-Earth Science and Technology

The investigation of dynamic rupture propagation is very important to understand the seismic behavior of mega-thrust earthquakes such as the 2011 Tohoku earthquake. The shallow parts of the fault (near the trench) hosted large slip and long period seismic wave radiation, whereas the deep parts of the rupture (near the coast) hosted smaller slip and strong radiation of short period seismic waves. Understanding such depth-dependent feature of the rupture process of the Tohoku earthquake is necessary as it may occur during future mega-thrust earthquakes in this and other regions, such as the Nankai Trough. In order to achieve such understanding, dynamic rupture modeling is an important tool (e.g., Galvez *et al.,* 2014).
In this study, we have simulated the dynamic rupture propagation for models of the Tohoku earthquake. Our large-scale simulations used the 3D spectral element method on unstructured grids (Galvez *et al.,* 2014) with performance tuning for the Earth Simulator at JAMSTEC. The number of elements in the mesh is 4,300,000 with 2 km size and polynomial order 4. The simulation takes around 10 hours of wall-clock time on 512 cores. The effective period for the simulation is longer than 1.2 sec.
Our model reproduced the depth-dependency of the rupture process of the Tohoku earthquake. We also examine the sensitivity of the results to model parameters and assumptions, for instance to the value of the slip weakening distance (Dc). We find that the value of Dc does not affect the final slip distribution, as long as it is small enough to allow the rupture to develop and propagate to the trench. A long Dc (order of 10 m) is reasonable in terms of fracture energy and promotes the generation of long period seismic waves on the shallow part of the fault.

キーワード：動的断層破壊、スペクトル要素法、地球シミュレータ、すべり弱化距離
Keywords: Dynamic Rupture Propagation, Spectral Element, Earth Simulator, Slip Weakening Distance

The Big Data Repository at the IRIS Data Management Center: Developing Standards for Services and Federated Access for Globally Distributed Data Centers

*Timothy Keith Ahern[1], Chad Trabant[1], Mick Van Fossen[1], Rob Casey[1]

1. Incorporated Research Institutions for Seismology

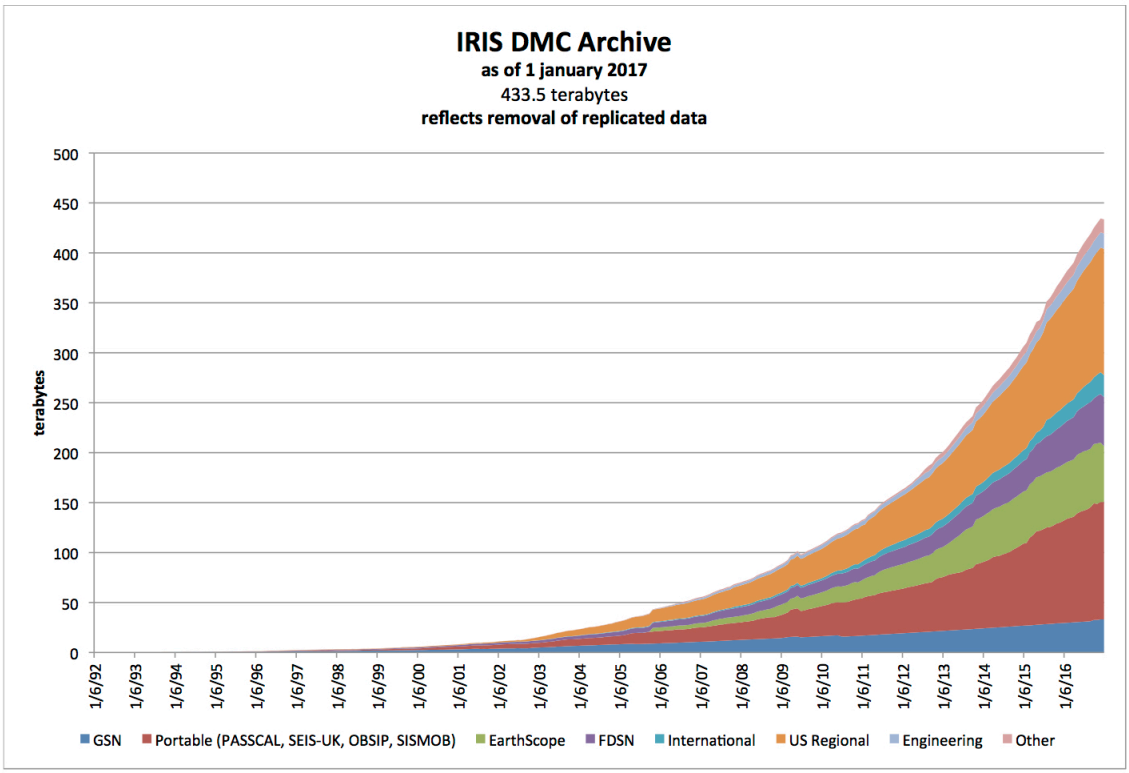
The IRIS DMC is the largest repository of seismological data from permanent observatories in the world. The archive at IRIS is nearly 1/2 petabyte in size and distributes nearly 1 petabyte per year to the scientific and monitoring communities. IRIS works closely with the International Federation of Digital Seismograph Networks (FDSN) in coordinating standards for data exchange formats, metadata descriptions, standardized web services, standardization of request parameters and federated concepts for data centers.

IRIS currently operates a large analytics engine that automatically assesses quality of data from seismic observatories. This "Big Data" problem has resulted in a powerful system that will enable researchers to receive data that have been filtered by their quality in addition to the specification of space-time constraints. As the volume of data increases in the expanding federated system of seismological data centers, IRIS is also developing a system called Research Ready Data Sets (RRDS) that will allow a users data request to be filtered by their quality as measured by the quality assurance system at the DMC that is now fully operational.

IRIS is currently testing the concept of operating its data center infrastructure in both High Performance Computing (HPC) as well as Cloud Computing environments with the ultimate goal of this project to identify an appropriate environment in which to run a data center.

This presentation will describe several aspects of current IRIS DMC systems, how web services have totally changed our ability to service huge numbers of user requests, how have adopted new access mechanisms, and how quality assurance systems are now being used to improve seismic network performance as well new tools being developed that will make scientific researchers more efficient in conducting their research.

Keywords: Seismology, Web Services, Federation, Quality Assurance



Science Metadata Management, Interoperability and Data Citation of the National Institute of Polar Research, Japan

*金尾 政紀[1]
*Masaki Kanao[1]

1. 国立極地研究所
1. National Institute of Polar Research

The Polar Data Centre (PDC) of the National Institute of Polar Research (NIPR) has a responsibility to manage the polar science data as one of the National Antarctic Data Centre (NADC) under the Science Committee on Antarctic Research (SCAR). During the International Polar Year (IPY 2007–2008), a remarkable number of data/metadata involving multi-disciplinary science activities had been compiled. Although a long-term stewardship of those accumulation of metadata falls to the data centre of NIPR, the efforts have been in great collaboration with the Global Change Master Directory (GCMD), the Polar Information Commons (PIC), the World Data System (WDS) and other data science bodies / communities under the International Council for Science (ICSU). In addition, linkages of metadata interoperability with other data centers, such as the Data Integration and Analysis System Program (DIAS) of the Global Earth Observation System of Systems (GEOSS) , the Polar Data Catalogue of Canada have been initiated in 2014 by using the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). The compiled metadata by the PDC of NIPR, moreover, are recently equipped an automatically attributing system of the Digital Object Identifier (DOI) by requesting to the DataCite through the Japan Link Center (JaLC).

キーワード：Metadata management、Interoperability、Data citation
Keywords: Metadata management, Interoperability, Data citation

海洋生物情報統合情報システムBISMaLの現在と今後
BISMaL as an integrated information system for marine organism: a current achievement and the next step

*細野 隆史[1]、齋藤 秀亮[1]、藤倉 克則[1]、園田 朗[1]、坪井 誠司[1]
*Takashi Hosono[1], Hideaki Saito[1], Katsunori FUJIKURA[1], Akira Sonoda[1], Seiji Tsuboi[1]

1. 国立研究開発法人　海洋研究開発機構
1. Japan Agency for Marine-Earth Science and Technology

環境意識の高まりから、海洋生物の情報を網羅的に把握する事ができる情報システムへの期待が高まっている。これを受け2009年、海洋生物の情報をOne stopで提供できる情報システムBISMaL (Biological Information System for Marine Life; http://www.godac.jamstec.go.jp/bismal/j/) の開発が開始された (田中ら、2010)。2016年時点において、BISMaLは海洋生物の出現記録の地図化、海洋生物の分類情報、画像、映像の提供、そしてデータ提供者自身によるデータ管理解析機能を提供するなど、ほぼone stopに近い情報システムとして完成している。個々の機能を取り上げた場合、出現記録のデータベースとしては世界規模でのデータを扱うOBIS、生物分類情報のデータベースとしてはWoRMSといったように代替のかつより巨大なサービスはいくつかある。しかしBISMaLはそれらと異なり一つのシステムの中で各機能を強固に連結させて完結できている点できわめてユニークなシステムとなっている (だからこそ、one stopサービス)。日本において海洋生物情報を取り扱うオンラインサービスとしては比較的有名なシステムの一つといえるが、今後どのようなサービスを展開していくかについては模索が続いている。たとえば、生物情報を単独で扱うのではなくBISMaLと他の海洋環境情報システムとを連結すれば、誰でも容易に生物の出現パターンと環境要因との因果関係を推定または予測できるサービスが可能になるだろう。あるいは、実観測データではなく、大規模場再解析データを用いることにより生物情報に対して任意の時空間の環境情報を付与することも可能になるだろう。本発表においては、BISMaLが有する現在の機能およびサービスをレビューしたうえで、どのようなサービスを付加することで今後の科学および社会的ニーズに寄与できるのかを議論したい。

キーワード：BISMaL、Integrated information system
Keywords: BISMaL, Integrated information system

大容量化する海洋観測データの長期安定的なアーカイブ基盤の構築
Construction of long-term stability archive System for Ocean observation data of large capacity

*北山 智暁[1]、岸良 武文[2]、松田 尚子[2]、宮城 伸[2]、石黒 駿[1]、伊禮 一宏[1]、豊村 鉄男[1]、齋藤 秀亮[1]
*Tomoaki Kitayama[1], Takehumi Kishira[2], Shoko Matsuda[2], Shin Miyagi[2], Shun Ishiguro[1], Kazuhiro Irei[1], Tetsuo Toyomura[1], Hideaki Saito[1]

1. 国立研究開発法人海洋研究開発機構、2. 株式会社マリン・ワーク・ジャパン
1. Japan Agency for Marine-Earth Science and Technology, 2. Marine Works Japan LTD.

国立研究開発法人海洋研究開発機構（JAMSTEC）の航海・潜航調査で取得される海洋観測データは、新たな観測手法の開発や観測装置の性能向上による多様化・大容量の一途を辿っている。例えば、海底地形を計測することができるマルチビーム測深機（Multi-Beam Echo Sounder, MBES）では、測深間隔を短縮し、直下方向の音響ビームを集約させるなどで、これまで以上に高分解能な海底地形を計測することができ、取得される観測データも大容量化している。JAMSTECが有する海洋観測データは、時空間的に二度と取得できないものであるだけでなく、深海など容易にアクセスできない極めて特殊な環境下で取得された学術的価値の高いものであり、研究・教育などをはじめ社会で広く活用されるためには、将来にわたって損失無く保管する必要がある。そのためには、長期的に安定して海洋観測データを保管するとともに、必要なときに必要なデータを抽出できる大容量ストレージやネットワークなどを総合したアーカイブ基盤が必要である。

JAMSTEC地球情報基盤センター（JAMSTEC/CEIST）は、海洋観測データを保管するストレージの大容量化・多様化と、遠隔の２拠点間でのデータバックアップを行うための拠点間ネットワークの広帯域・高速化を行い、ディザスタリカバリも想定した長期安定的なアーカイブを実現している。ストレージは海洋観測データの大容量化に対応するとともにアクセス性を維持するため、ハードディスクドライブと磁気テープメディアへの格納の両方を用いた運用を可能にしている。さらに磁気テープ格納型のストレージでは、階層型ストレージ管理（Hierarchical storage management, HSM）とLTFS（Linear Tape File System）で多層アーカイブを行うことで、消費電力等の運用コストを削減しながら、データの大容量化・多様化に対応するための運用の柔軟性も確保している。さらに、国立情報学研究所の学術情報ネットワークSINETの更新に合わせ、拠点間接続回線の広帯域化を行うとともに、UDPベースのデータ転送システムを併用することで、大容量のデータを高速に転送できる環境を整備した。

本発表では、海洋地球インフォマティクスを支える海洋観測データのアーカイブ基盤についてその取り組みを紹介する。

キーワード：海洋観測データ、大容量ストレージ、ディザスタリカバリ、高速データ転送、アーカイブ基盤
Keywords: Ocean Observation Data, Large Capacity Storage, Disaster Recovery, High-speed data transfer, Data Archive System

Classification and visualization of simulated clouds using machine learning

*松岡 大祐[1]
*Daisuke Matsuoka[1]

1. 国立研究開発法人海洋研究開発機構
1. Japan Agency for Marine-Earth Science and Technology

High-resolution atmospheric general circulation models reproduce realistic behavior of atmosphere in global scale. The data set generated by such simulation contains a large amount of information. One of the most important variable of the simulation results is a cloud. In order to understand such simulation results, it is necessary to visualize individual clouds and their physical properties. In the present study, we propose a new visualization method which enables scientists to classify and visualize them based on ten type cloud classification proposed by World Meteorological Organization (WMO). The proposed method is divided into two steps. In the first step, individual clouds are classified into six types (low clouds, middle clouds, high-clouds, low-middle clouds, cumulus, cumulonimbus) based on their vertical flow and altitude of top and bottom of them. In the final step, their clouds are further classified more finely into ten types (cirrus, cirrostratus, cirrocumulus, altocumulus, altostratus, nimbostratus, stratocumulus, stratus, cumulus, cumulonibmus) by their appearance using deep learning which is one of machine learning techniques. Here, we used photographs of these clouds, which we can easily download on the web, as training data. As a result, we succeeded in effectively visualizing three-dimensional cloud and their temporal behavior during complex atmospheric phenomena such as development of cumulonimbus and generation of tropical cyclone. The proposed method is beneficial to intuitive understand information-rich simulation data.

キーワード：可視化、大気シミュレーション、機械学習
Keywords: Visualization, atmospheric simulation, machine learning

シミュレーションと微気象観測によるみなとみらい２１地区の熱風環境解析
Co-analysis of observations and LESs in MM21 district

*杉山 徹[1]、佐土原 聡[2]
*Tooru Sugiyama[1], Sadohara Satoru[2]

1. 国立研究開発法人海洋研究開発機構 地球情報基盤センター、2. 横浜国立大学 都市イノベーション研究院
1. Japan Agency for Marine-Earth Science and Technology Center for Earth Information Science and Technology, 2. Yokohama National University Institute of Urban Innovation

We have performed thermal and wind environment LESs in MM21 district in Yokohama. The used simulation model is MSSG (Multi-Scale Simulator for the Geo-environment). The spatial resolution is about 5m in horizontal and vertical axis. We have also made observations at the Grand moll park located center of MM21 district. At the center of the park, there observed some characteristic wind which blows to anti-direction of the area averaged wind. Here we will report the collaboration of these numerical and observational analysis in the micro-meteorology in the urban area, especially in the point of view that the number of data are highly un-balancing.

キーワード：熱環境、微気象、みなとみらい２１地区
Keywords: thermal environment, micro-meteorology, Minato Mirai 21

