Field:
Earth Science/Geosciences/Environment

Session Topic:
Aerosols: sources, depositions and impacts

Introductory Speaker:
Atsushi MATSUKI, Kanazawa University

Title : Minute particles have major impact on climate

Minute particles, Major impact

Atmospheric aerosols are believed to have significant impacts on the climate via number of direct and indirect ways. The process by which particles themselves scatter and absorb sunlight is termed the 'direct effect'. White smoke essentially scatters light and partially sends sunlight back to space, while black smoke absorbs light and warms up the surrounding atmosphere. Gray smoke does both (extinction). In general, the aerosol direct effect acts to reduce the total sunlight reaching the earth surface, the fundamental driver of the climate system.

Aerosols not only interact directly with sunlight, but indirectly by modifying the microphysical structure of clouds. Hygroscopic (e.g. water soluble) particles act as Cloud Condensation Nuclei (CCN) upon which water vapor condenses on to, and create liquid clouds. Certain insoluble solid particles act as Ice Nuclei (IN) that initiate the formation of ice crystals within clouds in relatively warm temperatures (> -35°C). Clouds of course, are by far the most important component controlling the earth's albedo, but clouds cannot even exist without the help of the aerosols! Therefore, aerosols impose substantial 'indirect effect' on the climate system through their ability to control formation and lifetime of clouds.

Challenges ahead

One of the difficulties in tracking the evolution of the aerosol properties stems from the fact that they can easily change sizes, shapes, and chemical composition by collision or reaction with ambient gases to form mixed particles (hence affects the way they interact with light and cloud). For example, windblown dust particles have long been regarded as insoluble particles that serve mainly as IN but recent field measurements suggested that their chemical processing and reaction with pollutants turn them into extremely soluble particles that potentially act as efficient CCN. Certain organic materials are surfactant that can reduce surface tension of water and promote cloud droplet growth, while others like wax or oil slows down the growth through their essentially hydrophobic nature. How these organic materials are mixed within the CCN relevant inorganic particles (i.e. sulfate) is also important for the prediction of the aerosol indirect effects.

Coordinated efforts of laboratory experiment, field observation, remote sensing, and numerical model development are needed in order to reduce the uncertainties as to how the climate and future weather-forecasting models handle these highly complex particles.

Field:
Earth Science/Geosciences/Environment

Session Topic:
Aerosols: sources, depositions and impacts

Speaker:
Andreas HELD, University of Bayreuth

Title : Natural sources of climate-relevant atmospheric aerosols

Atmospheric aerosols have a large impact on climate. Scattering and absorption of light exhibits a direct effect on the radiation budget while the contribution of aerosol particles to cloud formation and the modification of cloud properties indirectly affects climate. Therefore, it is important to identify and quantify sources of aerosols and their spatial distribution. Known natural sources such as sea salt from the ocean or mineral dust from deserts or degraded soils contribute globally to the atmospheric aerosol burden.

Here, two regional aerosol sources and their potential impact on climate will be discussed: aerosol formation above coniferous forests and aerosol emission from the Arctic Ocean.

Trees and other plants emit large amounts of organic gases into the atmosphere and atmospheric oxidation reactions can produce compounds which partition into the particle phase. These gas-to-particle conversion processes can be important sources of new aerosols in areas such as boreal forests with a large impact on regional climate. In general, an increase in temperature leads to higher emissions of organic gases and more aerosol formation. More aerosols above forests tend to cool regional climate, thus leading to a potentially negative feedback mechanism.

In the central Arctic Ocean, a local natural source of aerosol particles from bursting bubbles at the ocean-atmosphere interface links marine biological activity, clouds and climate through the ejection of organic microcolloids from open leads into the atmosphere. Once airborne, some of these particles may contribute to cloud formation, typically warming the central Arctic. Further warming of the Arctic leads to melting of the sea ice, more open leads, and more local aerosol emission. Therefore, these ocean-ice-aerosol-cloud interactions may constitute a positive climate feedback mechanism in the Arctic Ocean.

The presented case studies show the potentially large effect of aerosols on climate, our limited understanding of the underlying processes, and thus, the urgent need to identify and quantify natural sources of atmospheric aerosols.

Further reading:

Mauritsen, T., Sedlar, J., Tjernström, M., Leck, C., Martin, M., Shupe, M., Sjogren, S., Sierau, B., Persson, P. O. G., Brooks, I. M., and Swietlicki, E. (2011) An Arctic CCN-limited cloud-aerosol regime. Atmos. Chem. Phys., 11, 165-173, doi:10.5194/acp-11-165-2011.

Paasonen, P. *et al.* (2013) Warming-induced increase in aerosol number concentration likely to moderate climate change. Nature Geoscience, 6, 438–442, doi:10.1038/ngeo1800.

Field:
Earth Science/Geosciences/Environment

Session Topic:
Aerosols: sources, depositions and impacts

Speaker:
Mizuo KAJINO, Meteorological Research Institute

1. Introduction

In the presentation, I would like to focus on the importance of size and hygroscopicity of atmospheric aerosols on environmental impacts. There are two deposition processes, dry deposition (contacting on earth surfaces) and wet deposition processes (involving cloud processes). There are two distinct mechanisms in the wet deposition process: collision and coalescence with rain and snow droplets mostly occurring below cloud (washout or below-cloud scavenging) and activated as cloud condensation nuclei (CCN) to form cloud droplet (rainout or in-cloud scavenging). Although size and hygroscopicity of aerosols are essentially important for all the above deposition processes[1], the model performances are not very good because some processes are poorly understood. Also, the activated aerosols affect the cloud property (cloud albedo, lifetime, and precipitation intensity)[2], and thus accurate prediction of aerosol size and hygroscopicity is needed for accurate prediction of cloud processes, and vice versa (this is so-called aerosol-cloud interaction).

2. Toward a cost effective modeling of aerosol-cloud interactions and the limitations

Aerosol-cloud interaction (aerosol effects on cloud property) is not negligible. For example, the global mean cooling effect of aerosol-cloud interaction could counteract the warming effect of major greenhouse gases (CO_2, CH_4, and N_2O)[3]. On the other hand, none of the numerical models for short-term (less than a week) and long-term (several months) weather prediction does not consider aerosol processes, because the weather prediction is time-critical and also because the high uncertainty in the simulated aerosol field might even aggravate the predictability of cloud and precipitation. Importance of aerosol-cloud interaction is a consensus of our atmospheric science community, but nobody is brave enough to include the detailed and computationally expensive aerosol processes in their weather prediction models for the purpose of predicting cloud and precipitation.

We need to efficiently distribute the limited computer resources to spatial and temporal resolution and scales. Therefore, optimization is indispensable toward a cost-effective modeling of aerosol-cloud interaction indicated by the following equation:

$$E_{sum} = \sum C_i \times E_i(C) + E_{boundary};\ C_{total} = \sum C_i = \text{given}, \quad (1)$$

where E_i(C) is an error as a function of computational cost (relative error from the numerical solution) of process module *i*. The limited total computational cost C_{total} is distributed to each process module so that E_{sum} becomes a minimum. For atmospheric models involving aerosol-cloud interactions, process modules are fluid dynamics, land-surface interaction, atmospheric radiation, cloud convection, cloud microphysics, aerosol microphysics, aerosol chemistry, gas chemistry, liquid-phase chemistry, and etc. $E_{boundary}$ is an error of boundary conditions (e.g. emission amount, size and hygroscopicity when emitted, and etc.).

E_i(C) is obtained only when the simulation result of module *i* approaches the true value as the resolution is finer (time, space, size, chemical species, and etc.). However, most of the aerosol and cloud modules implemented in the three dimensional models are computationally efficient but accuracy is not necessarily increasing as the resolution is finer (accuracy is rather case dependent than resolution dependent). The uncertainty bars of radiative forcing of aerosol-cloud interaction[3] do not indicate the uncertainty from the numerical solution or observation values, but the differences of different models. However, even though the models are different, the implemented aerosol and cloud modules are similar with each other, and so are the simulated results of radiative forcing. In this context, nobody could succeed in deriving the plausible values of the radiative forcing of the aerosol-cloud interaction.

3. My contribution to the aerosol-cloud modeling community

In the presentation, I would like to present my small contribution to the aerosol-cloud modeling community that E_i(C) is reduced by four-fold for an aerosol microphysics module by introducing a new concept, the triple moment sectional approach[4].

Conclusion

The accurate prediction of size and hygroscopicity of atmospheric aerosols are essentially important for the accurate prediction of their depositions as well as cloud property and hydrological cycles through aerosol-cloud interaction processes. However, due to the limited computer resources and limited knowledge of the complexity of processes and properties of atmospheric aerosols, accurate prediction of the aerosol-cloud interacting systems is still far from feasible. An innovative and cost-effective strategy is needed for the advance in the aerosol-cloud interactive modeling.

References

1. Adachi K., Kajino M. et al. Emission of spherical cesium-bearing particles from early stage of the Fukushima Daiichi nuclear power plant accident in Japan, in review.
2. Rosenfeld D. et al. (2008) Flood or drought: How do aerosols affect precipitation, Science 321, 1309.
3. Isaksen I. S. A. et al. (2009) Atmospheric composition change: Climate-Chemistry interactions, Atmospheric Environment 43, 5138-5192.
4. Kajino, M. et al. (2013) Modal Bin Hybrid Model: a surface area consistent, triple moment sectional method for use in process-oriented modeling of atmospheric aerosols, J. Geophys. Res., doi:10.1002/jgrd.50685, in press.

《Aerosols: sources, depositions and impacts》Glossary

Aerosol【エアロゾル】Atmospheric aerosols are tiny particles of liquid or solids that are suspended in the air. These invisible particles have sizes ranging from few nanometers (1 x 10^{-9} m) to several tens of micrometers (1 x 10^{-6} m). Windblown dust over deserts, sea spray from breaking waves, and ash from volcanoes are the representative natural sources of primary particles. Biomass and fossil fuel burning can generate significant amount of elementary carbon 'soot' that are primary in origin and we can sometimes visually recognize them as black smoke.

Aerosol microphysics【エアロゾル微物理】= **aerosol dynamics**【エアロゾル動力学】Condensation and evaporation of condensable (non- or semi- volatile) gases, coagulation of aerosols.

Below-cloud scavenging【雲底下洗浄，除去】= **washout**【ウォッシュアウト】removal of aerosols due to collision and coalescence with rain and snow droplets mostly occurring below cloud.

Coagulation【凝集】collision and coalescence, usually used for aerosol dynamical process due mainly to Brownian motion (Brownian coagulation)

Coalescence【併合】merging of collided multiple particles into one

Cloud albedo【雲アルベド】Ratio of reflection of solar radiation by clouds. The rest is the ratio of radiation transmitted through clouds.

Cloud condensation nuclei (CCN)【雲凝結核】Aerosols, which can be activated at certain super-saturation and forming cloud droplets to grow

Cloud convection【雲対流】= **cloud dynamics**【雲のダイナミクス】Air flow associated with a cloud or a system of clouds usually used for sub-grid scale motions (smaller scale of motions than the grid resolution of the model).

Cloud microphysics【雲微物理】Condensation, evaporation, and sublimation of water molecules, collision and coalescence of hydrometeors, freezing and melting of hydrometeors.

Collision【衝突】A moving particle contacts another particle, no matter if they marge into one (coalescence) or they bounce.

Computer resources/ computational cost【計算機資源，計算コスト】Memory, CPU, Allocated time, and so on.

Dry deposition【乾性沈着】Transfer of gases or particles in the atmosphere to the surface without precipitation (e.g., by gravity or turbulent motion)

Fluid dynamics【流体力学】Transport phenomena of momentum, heat, and water vapor.

Gas chemistry【気相化学反応過程】Chemical reactions between atmospheric trace gases, such as NO, NO_2, SO_2, O_3, OH, H_2O_2, and volatile organic gases.

Gas-to-particle conversion【気体からの粒子生成】Pathway by which new particles form in the atmosphere by the condensation of oxidized precursor gases such as volatile organic compounds (VOCs) and sulfur dioxide (SO_2). Also known as "secondary particles" since they are not emitted primarily as particles at the point of emission.

GLOSSARY

Hydrological cycle【水循環】Circulation of water molecules in the ocean, water vapor, and hydrometeors in the atmosphere, river, lake, pond, and ground water in the land area.

Hydrometeors【適切な和訳無し；大気中水（氷）粒子】Any water or ice particles that have formed in the atmosphere (i.e., cloud, rain, ice, snow, graupel, and hail particles or droplets)

Hygroscopicity【吸湿性】Absorbability of moisture from the atmosphere under sub-saturated conditions (i.e. relative humidity < 100%)

In-cloud scavenging【雲内洗浄，除去】Removal of aerosols due to activation as cloud condensation nuclei to form cloud droplet.

Land-surface interaction【大気表面相互作用】Land-ocean, land-ground surface, and land-vegetation interactions.

Liquid phase chemistry【液相化学反応過程】= aqueous phase chemistry occurring in aerosol water, cloud water, and rain water.

Precipitation intensity【降雨強度】Rain or snow droplet reached to ground per unit time.

Radiative forcing【放射強制力】Difference in radiation budget with and without the climate forcing agents, such as greenhouse gases, aerosols, and solar irradiation, usually defined at the top of the atmosphere (TOA). Positive forcing warms the system,while negative forcing cools it.

Rainout【レインアウト】See in-cloud scavenging

Resolution【解像度】Time resolution, spatial resolution, and size resolution.

Supersaturation【過飽和】Relative humidity larger than 100%

Washout【ウォッシュアウト】See below-cloud scavenging

Wet deposition【湿性沈着】The removal of gases or particles from the atmosphere to the surface by precipitation

Field:

Mathematics/Informatics/Engineering

Session Topic:

Energy meets informatics: Smart electric-power management

Introductory Speaker:

Sebastian LEHNHOFF, OFFIS-Institute for Information Technology, Oldenburg

Today's power systems are operated in a completely centralized fashion. Electric energy is produced by a few large power plants at very high voltages. It is distributed over long distances and transformed step-wise down onto lower voltage levels before it reaches the millions of consumers, e.g. single households, offices or factories. Operation of such power plants is scheduled based on long-term forecasts of power demand due to the mechanical inertia with which such plants are only able to increase or decrease their output.

This top-down control of the grid comes at a high price: in large-scale international grids electric power may be distributed across several countries before reaching a consumer and thus result in enormous power losses. Unpredictable and typically short-term deviations from demand forecasts have to be balanced by fast (and thus often times highly inefficient) power plants. These plants provide so-called balancing power at peak prices due to the fact that most of the time they are running without actually feeding into the grid in order to provide the power gradients needed to balance short-term demand fluctuations.

The ongoing trend of expanding distributed and especially renewable power generation results in a rapid increase of such short-term fluctuations in supply situations due to the unpredictability of renewable energy sources, e.g. wind power or photovoltaic. Renewable power generation is usually installed in the form of widely dispersed small-scale plants with relatively low power output. Peaks in power consumption could theoretically be balanced with a corresponding increase in distributed power generation or vice versa (in the same geographic region with minimal power losses). The latter often being referred to as "Demand Side Management", presenting a conceptual change in operating power systems through the flexibilization of small scale household devices and thus following the volatile generation side instead of the other way around.

However, traditional centralized power management is capable neither of identifying such situations nor of taking appropriate individual actions with millions of consumers and distributed renewable power plants connected to the grid. Modern power grids are blind to the precise supply and demand configurations on the lower voltage levels. Hence, the need for inefficient short-term balancing power increases even further.

Monitoring and efficiently operating power networks with a high density of distributed renewable generation and consumption is not possible with centralized management. In order to achieve the necessary resolution and level of control, prospective smart energy networks (so called "Smart

Grids") need to be controlled by autonomous yet coordinated software agents acting on behalf of consumers and producers of electric energy. Such a distributed control system adequately matches and coordinates the complex ownership and organizational/social structures as well as the individual goals and objectives of every single electrical actor through local collaboration: individual needs will be negotiated, local or regional imbalances will be smoothened out and the resulting load flows will be evenly distributed across the different layers of the power network, from local distribution networks up to national/international transmission grids. The local optimal operating configurations will be coordinated and interconnected step-wise up forming ever-larger networks in order to achieve an efficient operating of the power grid on a global level. This bottom-up approach closely resembles an organic system as it solves the complex problem at hand through self-organization under distributed control.

In this session the authors will present specific problems in the context of increased complexity in the operation of electric power systems with a broader focus on local distribution networks (Hiroaki Kawashima, Kyoto University) as well as international transmission grids (Ulf Haeger, Technical University of Dortmund). Yet, both scientists present solutions and mechanism to tackle the issues at hand through local coordinated control in the fashion of organic self-organizing systems.

Further Reading:

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• Horst F. Wedde, Sebastian Lehnhoff, Christian Rehtanz and Olav Krause (2008) Bottom-Up Self-Organization of Unpredictable Demand and Supply under Decentralized Power Management. Proceedings of the SASO '08 the 2008 Second IEEE International Conference on Self-Adaptive and Self-Organizing Systems, Pages 74-83, IEEE Computer Society Washington, DC, USA ©2008. http://dl.acm.org/citation.cfm?id=1475944

• http://standards.ieee.org/news/2013/smartgrid_research.html

Field:
Mathematics/Informatics/Engineering

Session Topic:
Energy meets informatics: Smart electric-power management

Speaker:
Ulf HAEGER, TU Dortmund

Title : Distributed autonomous control of electric power transmission systems

Energy market activities together with integration of renewable energies are currently causing an increase of the average distance between generation and load as well as an increase of volatility of power flows (as introduced in the previous presentation by Sebastian Lehnhoff). As the generation by Renewable Energy Sources (RES) is correlated to the changing weather conditions, the pattern of power flowing through the transmission network is changing significantly over time as well. For the electric power transmission system this leads to an increasing demand of new grid capacities. The conventional way of extending grid capacity is by installing new overhead transmission lines. However, it is more and more challenging to find new routes for overhead lines due to acceptance problems from the population. Furthermore, new overhead transmission lines involve very high costs. The goal of our current research is to develop new algorithms and methods for monitoring and controlling the grid, which allow for a better utilization of the existing transmission grid and thereby to reduce the demand for new transmission lines.

The future increase of transmission capacity will be achieved by several interlinked operational measures. The main focus of this presentation will be on new operational control measures. Two very relevant examples of such control measures are introduced in the following:

- Coordination of Power Flow Controllers (PFC):
  Usually the pattern of power flows derives directly from physical laws (Ohm and Kirchhoff) and the transmission grid operators cannot influence the level of flows. By using new PFC devices, the level of power flows on certain lines can be influenced directly which also influences the power flow on surrounding lines. To assure an optimal use of the PFC-devices a coordination system is necessary to determine optimally the PFC set-points of devices in the same area.
- Curtailment of fluctuating generation:
  The option of reducing the generation by RES in certain situations can help to reduce the required grid capacities. The main idea is to curtail generation which is located far away from loads in situations of very high generation, causing very large power flows on the transmission lines. The analysis of measured data about wind speed and solar irradiation show that situations with a very large amount of power by RES only occur very rarely. That means that the impact of curtailment in peak situations on the amount of total energy fed in by renewables over one year is very low.

For the realization of such operational measures we use a distributed multi-agent approach, in which each agent is a small software entity communicating with other agents and being capable of acting in its environment. This is justified by a good scalability of the approach, providing a manageable interface to large amounts of distributed generators. Furthermore, the control measures have a wide-range impact on several control areas operated by different grid companies. This leads to the situation that the control measures have to be executed based on incomplete system information and only local data. Multi-agent systems provide an advantage compared to central control systems in getting along with only local information.

In this multi-agent system each PFC is associated with a controlling agent and each non-controllable power system device (such as a transmission line) is equipped with a non-controlling agent. Controlling agents continuously receive StateInformMessages which are originated from the non-controlling agents and contain information about state and loading of the power system devices. Based on these messages the controlling agent performs a topology analysis, followed by a sensitivity analysis to estimate the influence of PFC control actions on each power system device. A weighting function, which uses the loading and the sensitivity information, sorts the power system devices according to their control needs. Based hereon control actions are executed, if necessary, with the PFC-device corresponding to the controlling agent. Thus, power flows on overloaded lines in the system are reduced by coordinated control actions of PFC devices.

Further Reading:

- U. Häger, S. Lehnhoff, C. Rehtanz, and H. F. Wedde, “Multi-agent system for coordinated control of FACTS devices”, in IEEE PES Intelligent System Applications to Power Systems (ISAP ’09), Curitiba, Brasil, 2009.
- U. Häger, C. Rehtanz, and S. Lehnhoff, “Analysis of the robustness of a distributed coordination system for power flow controllers”, in 17th international IEEE Power Systems Computation Conference (PSCC), Stockholm, Sweden, 2011.
- U. Häger, “Integration of advanced technologies for future transmission grids”, in, G. Migliavacca, Ed. Springer, 2012, ch. 6: Coordination Methods for Power Flow Controlling Devices.

Field:
Mathematics/Informatics/Engineering

Session Topic:
Energy meets informatics: Smart electric-power management

Speaker:
Hiroaki KAWASHIMA, Kyoto University

1. Introduction

To balance supply and demand of electricity, utility companies need to be equipped with electrical power generators with enough capacities to meet the peak demand. While renewable energy, such as solar photovoltaics (PV) and wind power, increases the total energy of electricity generation, they also increase the volatility of power grids since their power output strongly depends on the dynamic change of weather and other conditions. Besides, newly introduced devices in households will push this trend further; for example, plug-in hybrid electric vehicles (PHEV) will account for a large portion of the power consumption in a household during their charging period. As a result, suppliers are required to have much more operating reserves by preparing additional power plants, which eventually increase electricity prices. Thus, "how to absorb the volatility in the grid" is a critical issue for reliable and efficient future power systems.

Several approaches are being pursued to address this problem, e.g., coordination of different areas with long distances and installation of large batteries. Since renewable energy generators installed in different locations are affected by weather change in different timing, the first approach may cancel out short-term fluctuation, known as the smoothing effect. The second approach directly introduces capacitance into the grid and decreases high peaks via low-pass filtering. While these approaches are promising to reduce power fluctuations, both require large investment for infrastructure. For example, as the current grid in Japan is not designed to coordinate different areas but rather to achieve reliability in each area, the interconnection capacity between different areas is limited. As such, another approach should be pursued in parallel.

2. Coordinated Demand-side Energy Management

In contrast to the aforementioned utility-side approaches, we focus on energy management inside each household, and introduce *the coordination of demand side (end users)*. In this approach, we consider that an autonomous home energy management system (HEMS) is installed in each household and connected via a communication network. Given such situations, we can bring a variety of information technologies into the grid, from sensing of power consumptions to automated coordination of multiple households.

In particular, we introduce an architecture in which end users (households) participate in a certain incentive-based program and constitute a community. The users are connected through a provider, which is often referred to as an "aggregator" (Fig. 1). Here, the aggregator coordinates the end users and tries to achieve a group-level objective (e.g., power balancing, CO_2 reduction) in total. The community size depends on the type of objectives; for example, a town-size community (micro grid) is often appropriate for power balancing. The proposed approach is one of demand response (DR) frameworks, in which end users change the electric usage from their normal consumption patterns in response to incentives or prices. In a classical DR program, utility companies remotely control (or request to control) participants' devices to reduce peak loads during critical periods. Although this classical strategy satisfies utility-side demands, it cannot fully take into account user-side demands, i.e., quality of life (QoL), preference, or flexibility of changing power profiles. In the proposed method, we balance these two-sided demands/requests by introducing machine learning and distributed optimization techniques [1]:

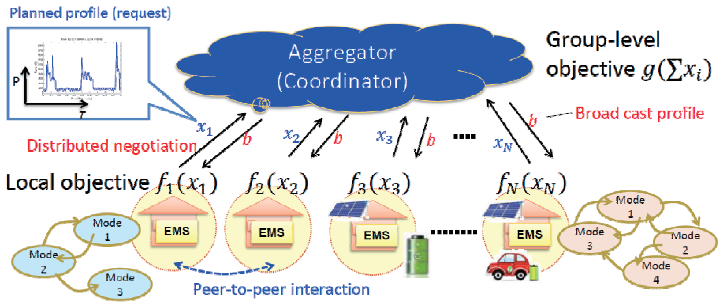


Figure1. Coordination of demand-side management

1. First, the normal consumption patterns in each household are modeled by using a probabilistic generative model, which enables us to represent the preference or flexibility of changing power usages with a probabilistic distribution of sequences.

2. The distributed optimization algorithm finds an agreement point of both the end-users' objectives (e.g., QoL) and the aggregator's objective. Here, the end-users' objectives can be derived directly from the probabilistic models introduced in 1.

The key aspects are that (1) the probabilistic model in 1 can be learned from real data captured via smart taps (outlets) in each household and that (2) the distributed algorithm in 2 only requires the exchange of planned demand/supply profiles, i.e., it encapsulates actual device controls in each residence. In this talk we will show some numerical results to demonstrate how the method achieves the flattening of total power consumption.

Conclusion This is a joint work with the *energy informationization (i-energy)* project [2], which aims to integrate physical power grids and information networks through four phases from demand side: sensing and monitoring, power control in a house, priority control of multiple power sources/batteries, and the coordination of households. The present approach is in the fourth phase, and we are now planning to investigate a variety of coordination schemes including peer-to-peer and hierarchical architectures.

References [1] H. Kawashima, T. Kato, and T. Matsuyama, Distributed Mode Scheduling for Coordinated Power Balancing, *IEEE SmartGridComm*, Vancouver, Canada, Oct. 2013.

[2] T. Matsuyama, Creating Safe, Secure, and Environment-Friendly Lifestyles through i-Energy, *New Breeze*, Vol. 21, No. 2, pp.1-8, 2009.

《Energy meets informatics: Smart electric-power management》Glossary

Aggregator【アグリゲータ】is a provider or a business operator who contracts with end users, coordinates their demand, and sells the aggregated demand response to utilities, etc.
複数の需要家（消費者）と契約を結び，それら複数の需要家の需要調整量をまとめて電力会社などに売る事業者.（発送電が分離されている国・地域では，電力会社ではなく独立系統運用機関などとやりとりすることもある.）

Demand Response (DR)【需要応答】is defined as “changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.” (Source: Assessment of Demand response and Advanced Metering, FERC, 2012.)
電力料金の時間的変化や,（電気卸市場価格の高騰時や系統の信頼性低下時に電気の使用量を低下させるよう設計された）インセンティブの支払に応じて，需要家（消費者）側が通常の電力消費パターンに対して電気の使用を変化させること.

Demand-side energy management【需要家側エネルギー管理】modifies end users’ demand for energy through, for example, financial incentives. Typically the modification of demand is achieved by shifting the time of electric usage and/or altering the load level of devices/appliances.
需要家（電力消費者）側における需要を，たとえば経済的なインセンティブなどを通じて変化させるエネルギー管理方法．電気機器の使用タイミングや消費電力レベルを変化させることで実現することが多い.

Distributed optimization【分散最適化】refers a method that solves an optimization problem in parallelized or decentralized fashion by decomposing the original problem into subproblems and coordinating their computation.
ある最適化問題を，部分的な最適化問題に分解したうえで，それらの計算を連携させることで，元の最適化問題を並列的・分散的に解く手法.

Electricity balancing【同時同量制御】is an act to balance the supply (generation) of electricity equals demand in real time.
電気の供給（発電）が常に需要と同量になるように調整すること.

Grid (electrical/power grid)【電力網】is a network to deliver electricity from suppliers to consumers. Microgrid is a smaller-scale grid designed to locally consume power supplies from, for example, renewable energy in order to reduce delivery losses, to increase reliability, etc.
電力供給元から消費者まで電気を送るためのネットワーク.「マイクログリッド」は小規模の電力網であり，再生エネルギーなどの供給を局所的に消費（地産地消）することで，送電ロスの削減や，信頼性の向上を実現する.

Home energy management system (HEMS)【家庭内エネルギー管理システム】 is an energy management system (EMS) installed in a household that has functionalities of monitoring and control of appliances/generators (e.g., solar panel). If an EMS is installed in a building, factory, and wider community, it is called BEMS, FEMS, and CEMS, respectively.
家庭に設置されたエネルギー管理システム (EMS) であり，家電や発電機（太陽光パネルなど）の監視や制御機能を持つ．ビル，工場，より広域のコミュニティに設置された EMS は，
それぞれ BEMS，FEMS，CEMS と呼ばれる.

GLOSSARY

Probabilistic generative model【確率生成モデル】is a mathematical model of observation (e.g., sensing data), where observation is assumed to be randomly drawn from a certain probability distribution or a combination of conditional probability distributions with Bayes rule.
観測（計測データなど）の数理モデルであり，観測は，ある確率分布もしくは条件付き分布の（ベイズルールによる）結合からランダムに生成されると仮定する．

Renewable energy【再生可能エネルギー】is energy derived from natural process (e.g., solar, wind, and hydro) that are continually replenished at faster rate than they are consumed.
太陽，風力，水力など，自然界に由来し，消費する以上の速度で補充されるエネルギー．

Smart tap/outlet【スマートタップ】is a sensor to measure electrical current, voltage, and power consumption of devices connected to it. Usually, it has a capability of transmitting measured data to a host device via wireless communication. In contrast, a smart meter measures the total power consumption of a household with slower sampling rate.
接続された機器の，電流，電圧，電力消費を計測するためのセンサー．通常，計測データをホスト機器に無線で送信することができる．一方で，「スマートメーター」は，家庭全体の電力消費を，より遅いサンプリングレートで計測する．

Field:
Chemistry/Material Science

Session Topic:
Imaging molecular motion

Introductory Speaker:
Ryota IINO, the University of Tokyo

Title: You can observe a lot just by watching motions of individual molecules

Yogi Berra, a famous baseball player in US once said "You can observe a lot just by watching." Now this mouthful dedicated to baseball can be applied to molecular science. Recent advances in optical and scanning probe microscopes have made it possible to watch individual molecules in action. Just by watching and making the movies of single molecules, we can learn a lot about the detail of their dynamic properties.

So, why do we have to image molecular motion? For example, Figure 1 shows the 3D structure of a rotary molecular motor made of protein. Red part of this molecule likely rotates in a ring made of green and yellow parts. However, structure itself cannot prove if it really rotates, and cannot predict many properties such as rotational direction and speed. This kind of information on dynamics can be only directly obtained from the molecular imaging. Because motions of rotary and linear molecular motors are directly connected to their functions, they have been intensively studied with this approach.

I'm always fascinated by protein molecular motors evolutionally created by nature, because they move fast, precisely and efficiently by using the energy of chemical bond. Biologists (or biophysicists) have observed the steps, pauses and structural changes of moving molecular motors. In addition, not only from the imaging but also manipulation of individual molecules, insights on the mechanisms of energy conversion and force generation have been gained. These efforts have helped much to understand the operation principles supporting sophisticated behaviors of the molecular motors.

Furthermore, by utilizing insights obtained from the biological molecular motors, chemists have started to create artificial molecular motors. The materials used are biological or non-biological molecules, or hybrid of both. This approach is still in an early stage, but some already have succeeded in creation and observed the motion of individual molecules to verify their design principle.

I believe that imaging molecular motion is a powerful approach and will lead to an exciting future of biology and chemistry. Above all things, watching moving molecules is fun! I'm really happy if you also enjoy the molecular movies in this session.

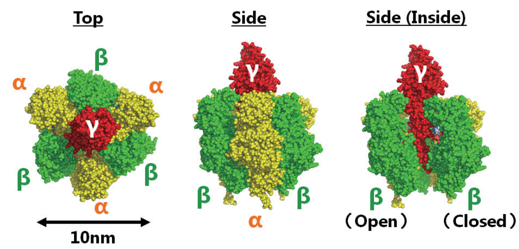


Figure 1. Structure of a molecular motor made of protein. Red part likely rotates in a ring made of green and yellow parts, but rotation can be proved only by direct imaging of molecular motion.

Field:
Chemistry/Material Science

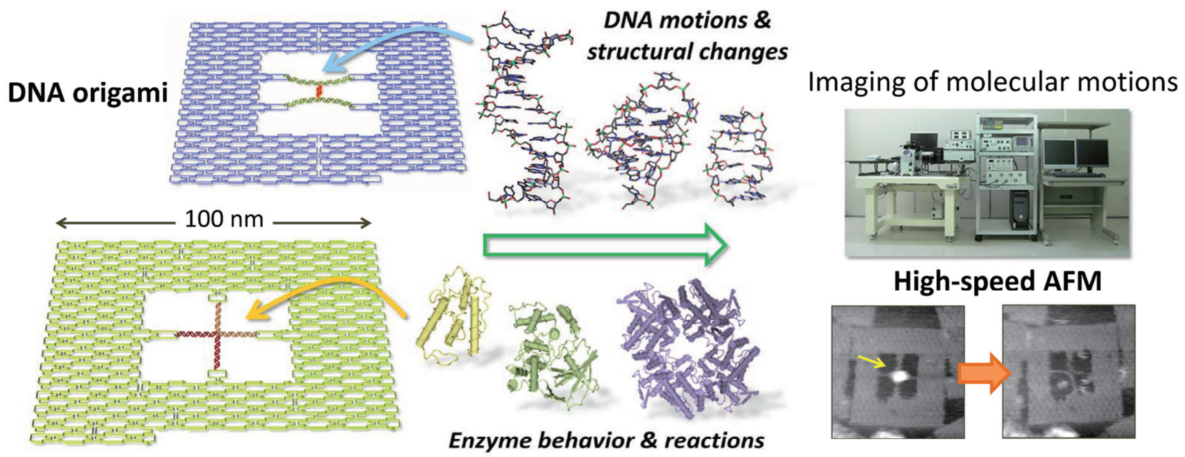
Session Topic:
Imaging molecular motion

Speaker:
Masayuki ENDO, Kyoto University

Tittle: Visualization of molecular motions on the DNA origami

Live imaging of an interesting biomolecule is one of the goals for scientists wishing to study various phenomena involved in living systems and to obtain information on the physical properties of the molecules. For observation of the molecules in physiological conditions, atomic force microscopy (AFM) is one of the best choices for studying the motions of biomolecules. Especially, biological reactions occur in a subsecond timescale, so that high-speed AFM, which realized the analysis of dynamic motions of biomolecules in subsecond time-resolution, can be a powerful tool for their visualization.

DNA origami, a new DNA self-assembly system based on DNA nanotechnology, has recently been developed for the preparation of 100 nm-sized two- and three-dimensional structures.[1] These can be used as a pegboard for placement of various molecules at desired positions.



We employed the DNA origami system to expand single-molecule observation of target molecules and analysis for the detailed dynamics of the individual molecules.[2] We expected the exact placement of the target object on the DNA origami structure during the AFM scanning. The behaviors of the enzymes and DNA structural changes were observed in the DNA origami structures using high-speed AFM.

We designed various DNA origami for the preparation of the observation stages, and watched their behaviors and reactions of various enzymes including DNA modification, repair, recombination, and transcription on the DNA origami structures. In addition, we directly observed the DNA structural changes including four DNA strand assembly (G-quadruplex formation), double-helix formation (Figure 1A),[3] and helical rotation (B-Z DNA conformational changes). Also, we developed the molecular transporter system on the DNA origami structure, and controlled the movement of a synthetic DNA walker on the designed pathways like a nanoscale railroad (Figure 1B).[4]

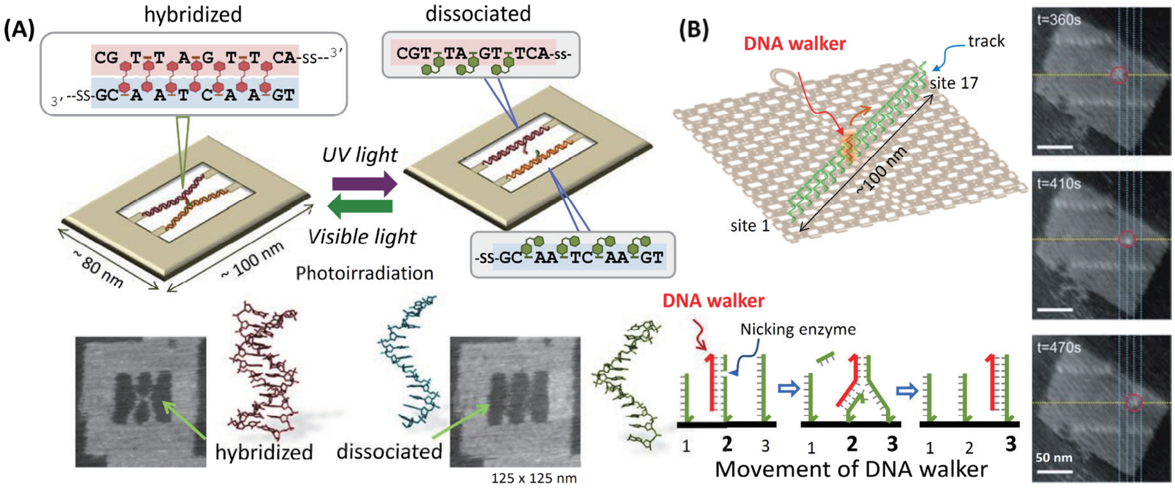


Figure 1. Visualization of the motions of DNA molecules in the DNA origami structure. (A) Photo-responsive DNAs are introduced to the DNA nanostructure, and dissociation and hybridization of photo-responsive DNAs are manipulated by irradiation of light. (B) Stepwise motion of DNA walker along the DNA track on the DNA origami. Working principle of DNA transporter along single-stranded DNAs.

DNA origami system allows the design of desired nanostructures, the precise placement of the target molecules, and their manipulation. In the current studies, direct visualization of the mobile molecules on the DNA origami structures worked effectively.

For the further understanding of biological phenomena, we are now working on more sophisticated design of DNA origami system as a nanoscale tool and developing new imaging technique for real-time observation.

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Field:
Chemistry/Material Science

Session Topic:
Imaging molecular motion

Speaker:
Berenike MAIER, University of Cologne

Tittle: How genes move: the biophysics of horizontal gene transfer

Bacteria reproduce by cell division. Therefore, the daughter cells are genetically identical with their mother cells. Horizontal gene transfer enables bacteria to exchange genetic information. One consequence of gene transfer is that multi-resistant bacteria evolve very fast. Through mutations of specific genes bacteria can become resistant against an antibiotic and this process often happens within few days [1]. Through gene transfer, bacteria can rapidly acquire resistance genes from other bacteria and thus become multi-resistant within hours. Therefore, it is very important to understand the mechanism of horizontal gene transfer at the molecular level.

In the simplest case, bacteria acquire DNA directly from their environment in a process termed transformation. Transformation is the import and inheritable integration of DNA acquired from the environment. For importing DNA, bacteria have evolved nanomachines that support the transport through into the cell [2]. We are trying to elucidate how the DNA import machine works.

For deciphering the molecular mechanism of the bacterial import machine, we are using tools from nanotechnology. Laser tweezers enable us to manipulate small objects [3]. The accuracy of the technique is in the range of nanometers (10-9m) and piconewtons (10-12N). In particular, we can watch the import of single DNA molecules in living bacteria in real time and quantify the speed and the force generated by the DNA import machine. We found that the speed of DNA import is high enough for some bacterial species to import their entire gene content within ~ 20 min [4].

The next challenge will be to combine laser tweezers with super-resolution microscopy and with methods from molecular biology to understand the mechanism of DNA import. Production and running of the DNA import machine is are associated with a cost. Therefore another long term question will be under which conditions the benefit of gene transfer outweighs its cost.

Horizontal gene transfer has a major impact on bacterial adaptation and fitness. Deciphering its mechanism and control will hopefully improve our understanding of bacterial evolution.

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《Imaging molecular motion》 Glossary

Adenosine triphosphate【アデノシン 3 リン酸】: Adenosine triphosphate (ATP) is often called the "molecular unit of currency" and transports chemical energy within cells for metabolism. It is one of the end products of photophosphorylation, cellular respiration, and fermentation and used by enzymes and structural proteins in many cellular processes, including biosynthetic reactions, motility, and cell division.

Atomic force microscopy【原子間力顕微鏡】: Atomic force microscopy (AFM) is a very high-resolution type of scanning probe microscopy, with the resolution smaller than 1 nanometer in height. High-speed AFM has made it possible to image molecular motions in real time.

Brownian motion【ブラウン運動】: Brownian motion is the random movement of particles suspended in a fluid (a liquid or a gas) resulting from their bombardment by the fast-moving atoms or molecules in the gas or liquid. Brownian motion is one of the major driving energies of molecular motion.

DNA origami【DNA オリガミ】: Method for constructing 100 nm-sized 2D and 3D structures by assembling a long single-stranded DNA and short complementary DNA strands.

DNA nanotechnology【DNA ナノテクノロジー】: One of the names of nanotechnology field. Based on programmed DNA self-assembly, desired nanoscale structures can be designed and constructed.

Inertia【慣性】: Inertia is the resistance of any physical object to a change in its state of motion or rest, or the tendency of an object to resist any change in its motion (including a change in direction). At the molecular scale, inertia is negligible because the mass of the molecule is very small.

Photo-responsive DNA【光応答性 DNA】: Synthetic DNA which has a molecule that can change the structure with irradiation of light.

Single-stranded DNA【1 本鎖 DNA】: One of the chains of double-helix DNA. Short single-stranded DNA (<100-mer) is chemically synthesized and commercially available.

Viscosity【粘性】: Viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. At the molecular scale, viscosity is a dominant factor controlling the molecular motion.

Visualization & imaging【可視化とイメージング】: In this session, we are using “visualization” as a direct observation of the shape of the target molecules such as using AFM. “Imaging” meaning here is seeing some clue to track the target molecule, for example observing fluorescence label by fluorescence microscope.

Field:
Social Sciences

Session Topic:
Management of uncertainty – dynamics of change and problems of control

Introductory Speaker:
Sabine PFEIFFER, University of Applied Science Munich and
Institute for Social Research (ISF Munich)

Title : Unavoidable Uncertainty – uncertainty production by solving uncertainty problems.

For ages humanity saw uncertainty as an unavoidable constant in human life. Uncertainty was seen as a mere normality of being, while immanently bearing the potential of dreadful and unheralded fate. Uncertainty as fate is something to be feared or to be accepted, something one could pray to be spared and bargain over with god. Uncertainty as fate is only fought by faith. Individual and societal coping strategies in real life therefore aimed not on the occurrence or nature of uncertainty but on its effects and consequences.

In contrast, the idea of uncertainty as something that could be mastered and tamed is modern to the core. To diminish if not annihilate uncertainty by science and rationality was the express promise of modernity. Enlightenment sparked the idea of humanity mastering its fate based on reason, industrialisation spread the logic of scientific methods into the production process and its organisations, and democratisation provided institutions following the idea of rational bureaucracy. The faith in god was replaced by the belief that uncertainty could be mastered by applying modern logic: the more scientific rationality, elaborate technology and reasonable planning, the better.

While first modernity as Beck calls this period never really fulfilled its promise, today global society faces not only more, but more substantial uncertainties than ever. It seems to get increasingly evident that modernity comes with side-effects not only underestimated, but misunderstood. Uncertainties tend not to persist and even increase although applied modern methods, but partly because of them. Current scientific methods of planning and management promise not to master uncertainties but to make them calculable and manageable. One could interpret that as a shift from controlling uncertainty to coping with its immanent logic, or as a step from neglecting to acknowledging the fuzzy quality of uncertain dynamics. We find this kind of approach especially in fields where uncertainties are acknowledged as immanent phenomenons: the management of risk, of disaster and of innovation, topics and fields that will be addressed by the contributors in the session „Management of Uncertainty“ on different levels. While Mark Mölder‘s presentation focusses on the role of investigative journalism as an institutional actor producing and fostering uncertainty, Shuhei Kimura provides an insight into intercultural differences in coping with the outcomes of disaster management after earthquakes in Japan and Turkey. The introductory speech will concentrate on the management of risk and of innovation inside of economic organisations, where new forms of organisational standards try to make the risks and uncertainties of innovation manageable. This empirical insight provides the stepping stone for some conceptional reflexions on whether the side-effects typical for first modernity described above are addressed by these new approaches of innovation management that claim to overcome the weaknesses of simplistic ideas of mastering and controlling uncertainties. It will be discussed whether old paradoxes dissolve or if and why new ones may occur.

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Field:
Social Sciences

Session Topic:
Management of uncertainty – dynamics of change and problems of control

Speaker:
Shuhei KIMURA, University of Tsukuba

Title : Handling disaster risk and uncertainties: A comparative approach

1. Introduction

In this presentation I will examine the ways to manage uncertain events by comparing the trajectory of the forecasted major earthquakes in two countries, Turkey and Japan, where I have conducted field research for years.

Normally, the concept of risk is defined as a probability of damage caused by an undesirable event in the future, and the probability is quantified based on the statistical analysis of past events. Hence risk is associated with decision making: you can decide to take or avoid the risk, and you have to take responsibility of your choice. In this perspective, the concept of uncertainty represents the events which probability is immeasurable and damage is unpredictable because of the scarcity of information. In this sense, natural disaster like earthquake or hurricane tended to be seen as an "act of God" because of its low probability and difficulty of prediction. It is only recently that earthquake has slipped into the category of "risk", with the progress of earth science and the development of technologies which lead to the improvement of hazard maps, disaster insurance, building standards, and so on. Focusing on the two earthquakes referred to by their unique names in their local context, I will follow the process of how an earthquake becomes a risk in the above definition.

2. Earthquakes

The first case is the earthquake in Istanbul. Its "discovery" reflects the historical interplay between the progress of Turkish earth sciences and actual earthquakes which hit Turkey. The 1999 Marmara Earthquake "verified" empirically the hypothesis of "the migration of earthquakes," which claims that the pattern of earthquakes in the North Anatolian Fault line is successive, that is, from east to west or from west to east. It was then that the Istanbul earthquake, with about sixty percent probability, began to be the object of pre-emptive action: Istanbul municipality conducted a seismic risk assessment, and then launched an anti-seismic urban reform project. However, the lack of the citizen's participation in the project became the obstacle to its implementation since the municipality did not disclose pertinent information: for local people, the consequence of the project itself was uncertain.

The other is the earthquake in the Pacific Ocean off the coast of Japan. In 1976 a young seismologist claimed that a large scale earthquake was expected in the near future in the central part of Japan. In response to this, the government agencies started contributing capital to scientific research on earthquake prediction. A coalition between government and academia has promoted the research, and even after large, "unexpected" earthquakes, the basic orientation of the research was not questioned. After the March 11 disaster, despite the criticisms, the government recalculated the disaster risk and published new seismic hazard maps, which are used as a basis of public and citizen's disaster planning.

3. Discussion

Both earthquakes each underwent a process of becoming a risk rather than an uncertainty: they were discovered, assessed, and then became objects of pre-emptive reactions. Although the contingent interaction between local geologic structure, the accumulation of seismological knowledge, and political actions makes the processes and their consequences look different in each country, it may be an oversimplification to say that the difference is attributed to the difference of culture between Turkey and Japan. Rather, I will argue that it is worth exploring the similarity – the path-dependency and the production and alienation of uncertainties as by-product – as a culture of risk.

Field:
Social Sciences

Session Topic:
Management of uncertainty – dynamics of change and problems of control

Speaker:
Marc MOELDERS, Bielefeld University

Title : Investigating the Investigators – On the Role of Investigative Journalisms in the Management of Uncertainty

Why is sociology interested in how different societal groups deal with uncertainty? It is not only the existence of different meanings attached to uncertainty, but rather to observe these contexts colliding. This happens whenever, for instance, there are decisions regarding science and technology at stake, recent cases being nanotechnology, synthetic biology or hydraulic fracturing. Here, for some uncertainty may mean to foster further research because uncertainty regarding opportunities and risks will otherwise never be convertible to certainty. Others would argue that further research is already too risky just because of uncertainty: If risks, of which we might not even now at present, cannot be excluded, it would be careless to go ahead.

Moreover, uncertainty means something entirely different within political, scientific, legal, or economic contexts. Very little attention, though, has been drawn to the role investigative journalism (IJ) plays in societal debates concerning contested issues - although the recent success of the "Offshore-Leaks Team" proved its capabilities. Their strategy was the publication of an enormous amount of data which gave rise to public outrage and thus exerted pressure on decision-makers.

From a sociological point of view this move towards transparency has a "downside": There is hardly any chance for the (general) public to form an opinion as these data - and their mere quantity - cannot be comprehensible to outsiders. Yet, other parts of IJ already seem to be aware of this problem. ProPublica, an independent IJ agency based in New York, not only gathers and publishes data to interfere with decision-makers, but also tries to awaken public interest in complex issues. To achieve this, it works with formats such as songs, videos, or comic strips. These are thought to facilitate an easy access to difficult issues and the opportunity to build up an opinion in the long run.

This obviously is an interesting and inventive attempt to public education, but it remains a risky endeavor. Not so much because videos and the like may lead to an "underexposed picture". The risk is rather to treat uncertain things as if they were certain in order to take sides – and be it "in the public interest", as ProPublica puts it in its motto. Such a "policy of transparency" may lead to adverse effects with regard to the management of uncertainty, because it obscures that uncertainty and the need to deal with it will remain.

For sociology, I want to argue, this means not to take sides, but to observe others taking side and see what might be learned – for example by investigating the investigators.

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《Management of uncertainty – dynamics of change and problems of control》Glossary

Certainty【確実性】Here it is used in the sense of constructing evidence for political or juridical decision-making, because such decisions are necessarily based on knowledge; and their legitimacy depends highly on the ascribed certainty of the knowledge used.

Coping strategies【対処方法】Experiential methods used by (collective) actors to deal with uncertain situations and probable devastating events.

Culture【文化】Patterned ways to behave and think shared by a certain group of people.

Disaster Management【災害管理】A system to reduce the damage from disaster including structural measures (e.g. earthquake-resistant buildings, seawalls) and non-structural measures (e.g. disaster prevention plan, disaster drill and education, local knowledge of past disasters).

Governance【管理】An analytical concept to describe the change of the state's role in political processes of decision-making. Governance (unlike "government") emphasizes the meaning of originally non-political stakeholders (civil society, economic actors, scientific experts, lays etc.) and their relations to the state when a political decision and its legitimation are at stake.

Innovation management【革新管理】All sorts of strategies and tools to organize technological innovation processes that intend to put enterprises in a position to create new products and/or processes.

Investigative journalism【調査報道】 A kind of journalism in which reporters investigate a topic for a comparatively long time and publish the results of their research in order to reveal otherwise hidden grievances.

Modern society【近代社会】 In contrast to traditional societies, modern societies are based on the assumption that social evolution is neither steered by fate nor pre-structured by a divine order but is depending on decisions and the logic of functional differentiation of social spheres (such as politics, law, science, or economy). This constellation, characterized by the hope to solve any problem through growing rationalization with the tools of science, technology and bureaucracy, was described as first-modern constellation (Ulrich Beck). Beck argued, that since the 1970s, the side-effects of this constellation are undermining their own productivity and are inducing structural changes in society. Therefore, a second modernity is formed.

Path-dependency【経路依存】like QWERTY (the key arrangement of computer keyboard), either rational or not, the range of choices at present is conditioned by past decisions cumulatively.

Rationalization【合理化】One of the main processes in the evolution of modern societies which is connected to the idea that subsumes any social practice dealing with a systematic calculation of means for chosen purposes.

Risk【リスク】a probability of damage caused by an undesirable event in the future, and the probability is quantified based on the statistical analysis of past events.

Social contexts【社会的文脈】One and the same information may mean something entirely different, may have very different consequences, depending on the social context in which it is interpreted. Context might refer cultural (==> culture) differences, to functional differences (e.g.: political, legal, scientific points of view), to the differences between groups, milieus, classes and the like.

GLOSSARY

Transparency【透明性】A central value to enable the creation and formation of democratic publics. It especially means to grant access to publicly relevant data, documents, and information that were kept secret or remained unpublished formerly and the right to know who is the actor behind the information.

Uncertainty【不確実性】Events of which probability is immeasurable and damage is unpredictable because of the scarcity of information.

Field:

Physics/Astrophysics

Session Topic:

Physics of the Sun

Introductory Speaker:

Robert IZZARD, University of Bonn

The light and heat of the Sun drive the cycle of life on Earth and without it we could not exist. Throughout recorded history the Sun has been revered and worshipped, either as a deity or personified as a symbol of life and power. Until the 19th century, it was thought that the Sun's light came from chemical or gravitational energy sources, but in the 20th century it was understood that only new physics could explain the four-billion-year lifetime of the Earth and the solar system. We now know that nuclear fusion powers the Sun and all other stars, and that the same process of converting light elements to heavy elements drives the chemical evolution of the Universe. Because of its proximity to the Earth, the Sun is the perfect test subject for many branches of physics, from astronomy to quantum theory. For example, studies of the oscillation of the Sun allow us to probe the interior structure of a star with unprecedented accuracy. The solar neutrino problem, and its solution, confirmed that neutrinos -- a basic component of the standard model of particle physics -- are massive particles. Magnetic fields and the solar wind drive the heliosphere, in which the Earth resides, and offer a natural test of theories of magnetohydrodynamics and plasma physics. Finally, the origin and final fate of the Sun and its solar system are closely related to the physics of stellar evolution and star and planet formation. Our Sun is a vast physics experiment which will continue to fascinate and amaze us long into the 21st century.

Field:
Physics/Astrophysics

Session Topic:
Physics of the Sun

Speaker:
Laurent GIZON, Max Planck Institute for Solar System Research, Katlenburg-Lindau and Georg August University of Goettingen

Title : Helioseismology

The origin of the Sun's magnetic field is not yet understood. What are the processes that lead to the formation of sunspots? Why does the number of sunspots change with a period of eleven years? In order to answer such questions, one must understand the motions that maintain the magnetic field in the solar interior. Hopefully, sunquakes can tell us about the internal structure and dynamics of the Sun, just like earthquakes can tell us about the interior of the Earth. Solar acoustic oscillations are continuously excited by convection: they cause sunlight fluctuations, which can be measured using dedicated observatories from space or from the ground. The science of helioseismology consists of interpreting the frequencies, amplitudes and phases of the oscillations seen at the surface to make images of the solar interior. Important results include, for example, maps of internal rotation (as a function of radius and latitude) and flow patterns associated with convection and magnetic activity, which play a crucial role in models of the solar dynamo.

Field:
Physics/Astrophysics

Session Topic:
Physics of the Sun

Speaker:
Yukio KATSUKAWA, National Astronomical Observatory of Japan

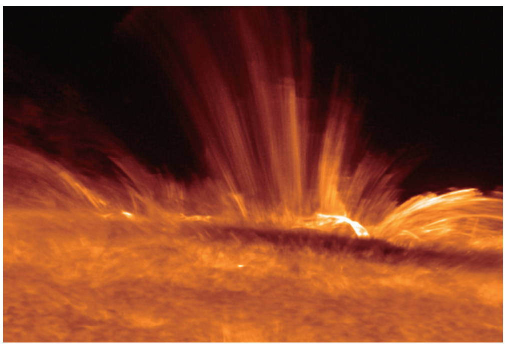
1. Introduction

Studying the Sun has long history since 400 years ago, from the observation by Galileo Galilei using his telescope. His careful observations of sunspots led to the finding that sunspots are a phenomenon on the solar surface and changes their shape in a couple of days. Modern observations of the Sun were opened by the finding by Hale in the early 20th century that strong magnetic fields exist in a sunspot. The presence of magnetic fields in the Sun led to the studies on how magnetic fields are maintained and created inside the Sun and how they drive various dynamic activities taking place in the solar atmosphere.

The Sun is not only emitting electromagnetic waves but also a source of solar winds consisting of hot ionized particles, i.e. plasma, coming from outer atmosphere of the Sun, solar corona, whose temperature is more than one million Kelvin. Plasma ejections and high-energy particles are also generated when strong eruptions, so-called solar flares, happen in the corona around a sunspot. These activities are primarily driven by magnetic fields. Other stars also exhibit active phenomena driven by magnetic fields, such as starspots, stellar flares and winds. The uniqueness of the Sun is that we can directly observe them with spatial resolution, which is essential to study what physical processes work behind the activities. Another uniqueness is that the Sun’s active phenomena are directly linked with the near-earth environment. Strong solar winds disturb the earth magnetic field, and high-energy particles from the Sun sometimes damage satellites revolving the earth. Strong coupling between the Sun and the earth gives rise to the concept “space weather”, leading to importance to understand and “predict” the solar activity as a source of the space weather. This is why we have been extensively studying the Sun for long years via observational, theoretical, and numerical approaches.

2. Heating of the Solar Corona

One of the major mysteries is why the solar corona is so hot (more than one million Kelvin) compared with the solar surface, photosphere (6 thousand Kelvin). The HINODE satellite, which was launched in 2006, has provided lots of new finding for us to know elemental processes to heat the solar corona. The most surprising outcome was that HINODE revealed super-sonic jets ubiquitously occurring in the chromosphere that is the atmospheric layer between the photosphere and the corona. The small-scale jets can be candidates of the “nanoflares” which have been speculated to be a tiny flare to heat the corona[1][2]. Another finding was that threading

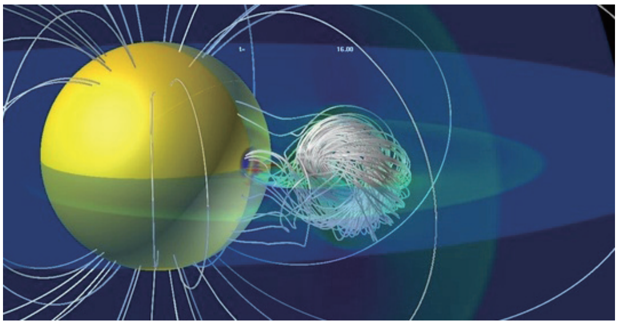


Active chromosphere seen with HINODE

structures seen in the chromosphere are revealed to exhibit lateral oscillations, which probably carries magnetic energy required to heat the corona[3]. These discoveries were realized by significant improvement in the spatial resolution of HINODE. In 2013, a new spacecraft “Interface Region Imaging Spectrograph” (IRIS) is to be launched, and is anticipated to provide quantitative information of the dynamic chromosphere for complete understanding of the energy transfer and dissipation among different atmospheric layers.

3. Space Weather and Climate

Solar flares are the most energetic event in the solar system. To understand and predict their influence on the earth environment, it is quite important to measure magnetic configuration around a sunspot producing a flare, and to know how the build-up of magnetic energy happens and what process triggers sudden release of the stored energy through magnetic reconnection. Recent advances of the observation instruments, such as HINODE and Solar Dynamics Observatory (SDO), allow us to measure magnetic fields on the surface and to simulate the 3D magnetic structure around a sunspot with help from numerical modeling. These study make it increasingly clear what magnetic configuration is necessary to cause an eruptive flare[4] though it is difficult yet to predict their onset in advance. The secular change of the solar magnetic activity is also of particular interest these days because the number of sunspots in the current cycle is clearly fewer than in the last 100 years. The sunspot number periodically changes with 11-years cycle, but it sometime exhibits irregular variation. The most famous period is the Maunder minimum in the 17th century when the number of sunspots was extremely few for longer than 50 years. The recent irregular activity in the Sun possibly provides a good opportunity to study the “space climate” on how the long-term change in the Sun influence the earth environment with modern techniques including the advanced observations and numerical simulations.



Solar eruption reproduced with numerical modeling based on an observation with HINODE.

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《Physics of the Sun》Glossary

Chromosphere:【彩層】 The atmospheric layer outer than the photosphere, which is 2000-5000 km thick and is about 10^4 K temperature slightly hotter than the photosphere. The chromosphere contains spikes of gas called spicules.

Helioseismology : 【日震学】 The study of wave propagation in the Sun, analogous to seismology – the study of earthquakes – on earth. Turbulent motion in the solar surface convection zone excites pressure waves which cause the Sun to "ring" like a bell. By observing these oscillations, solar physicists can determine the internal structure of the Sun.

HINODE：【ひので衛星】ISAS/JAXA mission dedicated to observations of the Sun, and started its observations since 2006. The Solar Optical Telescope (SOT) on-board HINODE is the largest solar telescope ever launched into space, which achieves 0.2 arcseconds (corresponding to 150 km on the solar surface) angular resolution.

Hydrogen burning:【水素燃焼】 See *nuclear fusion.*

IRIS (Interface Region Imaging Spectrograph)：【アイリス衛星】 NASA Small Explorer mission (SMEX) dedicated to spectroscopic observations of the solar chromosphere and corona. It was launched in June 2013.

MHD wave：【磁気流体波】Waves seen in the magnetohydrodynamic (MHD) plasma. There are three kinds of wave modes, but the Alfvén mode of the three is thought to be important in transferring energies among different atmospheric layers.

Magnetic reconnection：【磁気リコネクション】 Magnetohydrodynamic (MHD) process converting magnetic energy into kinetic and thermal energy. The energy conversion happens when anti-parallel field lines are reconfigured at the interface.

Nanoflare:【ナノフレア】Small-scale flare contributing to coronal heating, which was originally proposed by Parker (1972). Estimated energy released by each event is an order of 10^{17} J, which is 10^{-9} of the largest solar flare. Quest for the nanoflare has been one of the key targets in the observations of the Sun.

Neutrino :【ニュートリノ】 A subatomic particle released during hydrogen burning in the centre of the Sun (see *nuclear fusion* and *solar neutrino problem*).

Nuclear fusion : 【核融合】The joining of two or more atomic nuclei to form a new nucleus. In the Sun, hydrogen nuclei (each one proton) combine to form helium (two protons and two neutrons), a process called *hydrogen burning* (although it has nothing to do with the more familiar *chemical burning*). The mass of a helium nucleus is slightly less than the mass of four protons and this "missing mass", m, is released as energy, E, according to Einstein's formula, $E = mc^2$, where c is the speed of light.

Photosphere:【光球】 Atmospheric layer where most of the visible light comes from, which is 300-500 km thick and is about 6000 K temperature. Strong thermal convection in the photosphere makes cell-like structures called granules.

GLOSSARY

Plasma: 【プラズマ】Plasma is a state where atoms are ionized into positive ions and negative electrons when a gas is heated. Because plasma is highly electrically conductive, it strongly interacts with electric and magnetic fields. In the solar atmosphere, most of the gasses are in the plasma state.

Solar Convection Zone :【太陽対流層】The surface layers of the Sun are mixed by convection, as in most stars with mass less than about $1.2M_{\odot}$. In most of the solar interior, radiation is sufficient to transport energy from the interior, where energy is generated by nuclear fusion, to the surface, where energy is radiated into space. Near the surface, the opacity increases because of partial ionization of hydrogen and helium, thus radiation transport is inefficient and convection sets in.

Solar Corona :【太陽コロナ】 Hot and extended atmosphere surrounding the Sun whose temperature is more than one million K. We can see the solar corona at the visible light when the strong radiation of the solar disk is blocked in a total solar eclipse. We can observe the solar corona in X-rays and UVs from the satellite.

Solar Flare :【太陽フレア】Violent event accompanied with sudden release of magnetic energies in the solar corona. The energy released by the largest flare is $\sim 10^{26}$ J. Plasma hotter than 10^{7} K is created and emits strong UV and X-ray radiation.

Solar neutrino problem : 【太陽ニュートリノ問題】 For many years the number of neutrinos measured to come from the Sun was lower than expected from the nuclear burning at its core. The resolution to this problem was a modification of the standard model of particle physics, i.e. the introduction of *neutrino oscillation*. See also *neutrino*.

Solar units : 【太陽単位】Astrophysics often uses solar units including: the solar mass, $1M_{\odot} = 1.9855 \times 10^{30}$ kg; solar radius $1R_{\odot} = 6.955 \times 10^{8}$m and solar luminosity $1L_{\odot} = 3.839 \times 10^{26}$W = 3.839×10^{33} ergs^{-1}

Solar wind : 【太陽風】Flow of plasma released from the outer atmosphere of the Sun and filling interplanetary space. There are two components depending on their speeds: The “slow" solar wind has a velocity of ~ 400 km/s and the “fast” solar wind has a velocity of 600 – 1000 km/s.

Space climate : 【宇宙気候】 Long-term changes of the earth’s and near-earth’s climate induced by long-term changes of the solar magnetic activity. The solar magnetic activity has ~11 year periodic variation, which is observed as variation of the number of sunspots. Variation much longer than the 11-year periodicity is also seen, and its influence to the earth’s climate is of strong interests.

Space weather : 【宇宙天気】 Influence of solar activities, such as solar flares and solar winds, onto the near-earth’s environment. Especially the earth’s upper atmosphere and magnetosphere are highly disturbed by energetic particles and magnetic fields carried by the solar winds as well as the Sun’s UV and X-ray radiation.

Sunspot : 【黒点】 Dark spot created by concentration of strong magnetic fields in the photosphere. The temperature inside a sunspot is about 2000 K lower than the surrounding photosphere because heat transfer by the thermal convection is suppressed due to presence of the strong magnetic field.

Field:
Biology / Life Science

Session Topic:
The Pandemic

Introductory Speaker:
Kimihito ITO, Hokkaido University

Influenza A viruses are typical zoonotic pathogens that infect a wide variety of animals, including humans, pigs, chickens, and ducks. Influenza A viruses are divided into 16 HA subtypes (H1–H16) and 9 NA subtypes (N1–N9). Migratory ducks are known to be the natural reservoir of the viruses, and all the influenza viruses in other animal species originate from the duck viruses. Influenza viruses are harmless to the wild ducks, but once they transmit and effectively replicate in other host animals, they cause severe infectious disease.

Influenza pandemic, a global outbreak of influenza, occurs when a strain of an animal virus transmits and effectively replicates among human population. In the last one century we had five influenza pandemics. The most devastating one was Spanish flu occurred in 1918, which was caused by a strain of H1N1 viruses. We also had pandemics of Asian flu in 1957, Hong Kong flu in 1968, and Russian flu in 1977, which were caused by H2N2, H3N2, and H1N1 viruses respectively. The most recent pandemic was caused by a strain of H1N1 viruses in 2009. It should be noted that at least two out of five, i.e. Hong Kong flu viruses and the 2009 H1N1 pandemic viruses were transmitted from pigs to human population.

Pandemics cause substantial mortality and morbidity, posing many questions and challenges to us. In Asian countries H5N1 virus strains have been circulating in chickens since 1997 and this avian virus are yet to be controlled. Recently a strain of H7N9 viruses has widely spread in birds in China and occasionally infected humans. We must be well prepared for the next influenza pandemic by designing and implementing preemptive measures. We need to elucidate the ecology of influenza viruses in the wild animals, livestock, and humans. We also need to clarify the molecular basis of the pathogenesis and host range of the viruses. The establishment of mathematical models of infections is necessary to predict outbreaks, epidemics, and pandemics of influenza. To accomplish the prevention and control of influenza, combined efforts from a large variety of scientific disciplines should be prerequisite.

Field:
Biology / Life Science

Session Topic:
The Pandemic

Speaker:
Guelsah GABRIEL, Heinrich-Pette-Institute, Leibniz Institute for Experimental Virology, Hamburg

Title: Influenza: a continuous pandemic threat

Influenza epidemics occur yearly during autumn and winter in temperate regions. Illnesses result in hospitalizations and deaths mainly among high-risk groups (the very young, elderly, chronically ill and pregnant women). According to the estimations of the WHO, these annual epidemics result in about three to five million cases of severe illness, and about 250 000 to 500 000 deaths worldwide.

In addition to the annual epidemics, influenza A viruses possess the potential to cause pandemics. The Spanish influenza caused by an H1N1 influenza virus subtype is the first recorded pandemic where approximately thirty to fifty million people died worldwide. The second and third pandemic was caused by an H2N2 and H3N2 influenza virus subtype, respectively, resulting in about one million deaths worldwide. We all experienced the H1N1 pandemic in 2009 with estimated 300 000 to 500 000 fatal cases. In contrast to the second and third pandemic, both H1N1 pandemics mostly affected young healthy people without underlying medical conditions.

Besides the annual epidemics and the occasional pandemics, avian influenza viruses are able to transmit repeatedly from their animal reservoir to humans where they can cause high lethality rates. Case fatality rates of H5N1 influenza virus infections in humans, known as bird flu, are higher than 50%. The recent H7N9 outbreak in China results in approximately 20% lethality in humans.

Thus, influenza is a continuous threat to human health. Here, the ingredients of a pandemic will be analyzed and presented.

Literature:
www.who.int

Field:
Biology/Life Science

Session Topic:
The Pandemic

Speaker:
Hiroshi NISHIURA, The University of Tokyo

Introduction
When a novel influenza virus starts to infect humans, both experts and non-experts are immediately concerned with the possibility of the virus to cause a devastating pandemic. We aim to devise an epidemiological model to assess the pandemic potential shortly after the emergence.

Methods
Transmissibility (i.e. how infectious the virus is) and virulence (i.e. how severe the infection is) are statistically estimated using limited data of infected individuals. The real-time estimation effort is illustrated with actual applications to H1N1-2009 and avian H7N9 viruses.

Results
To precisely quantify the transmissibility, heterogeneous patterns of transmission (e.g. different transmissibility by age-group) force us to analyze substantially large number of cases. Because of mild nature of influenza virus infection, it is difficult to quantify the virulence relying on infected individuals who were diagnosed and reported.

Conclusion
Real-time estimation practice has greatly evolved in its concepts and techniques through the experience of past emergence events. Novel analytic methods are gradually devised to practical process of epidemiological assessment.

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《The Pandemic》Glossary

HA (hemagglutinin) and NA(neuraminidase)： 【ヘマグルチニン, ノイラミニダーゼ】
Influenza viruses consist a variety of subtypes each of which displays distinct pathogenic and infectious property. They are categorized depending on its genetic features such as the type of HA (hemagglutinin) and NA (neuraminidase). HA and NA are the surface molecules on the viral particle and are essential for the infection and reproduction. Well-known anti-viral drugs including Oseltamivir (Tamiflu) and Zanamivir (Relenza) are designed to inhibit NA's function.
インフルエンザウイルスの主要な表面抗原で、ウイルスの感染や増殖過程に必須である。HA と NA にはそれぞれ 16 ならびに９種類の亜型があり、インフルエンザウイルスの分類の指標となっている。オセタミビルやリレンザなどの抗ウイルス薬はノイラミニダーゼの機能を阻害することで宿主細胞からのウイルス粒子の分離・放出を抑制する。

Pandemic：【パンデミック】(from Greek *pan* "all" + *demos* "people") is an epidemic occurring worldwide or over a very wide area, crossing international boundaries, and usually affecting a large number of people.
感染症の世界的な感染の流行を表す用語