

### 3D Rain Gauge and rainfall observation at the summit of Mt.Fuji

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New rain gauge so-called 3-dimensional rain gauge was developed and is able to measure the quantity and also the direction of blowing rain drops of wide range from fog to heavy rainfall under strong wind conditions. Once a rain gauge had been installed on the top of Mt. Fuji, it was removed due to the question of data reliability under strong wind blowing. The authors tried and proved that the new rain gauge could work suitably on the top of Mt. Fuji.

Keywords: 3D Rain Gauge, Rainfall direction, Rainfall observation, Mt.Fuji summit



転倒マス雨量計  
 3次元雨量計  
 3D転倒マス雨量計  
 超音波3次元風向風速計  
 図2 富士山頂での設置状況

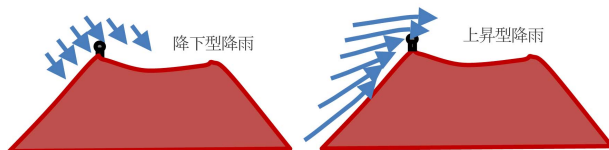


図3 降下型降雨と上昇型降雨の模式図

表-1 3次元雨量計の仕様

部位	項目	仕様
受水部	受水口(セル)数	12 (4方位×3傾斜)
	受水可能な雨水の飛来傾斜角	天頂から135°
	計算可能な雨水の飛来傾斜角	天頂から90°
計測部	解像度	1 drop
	最少計測雨水重量	0.1g
	分解能	20 drops/sec
	計測時間間隔	1sec以上、自由設定
	感応時間の長さ	2sec以内 (降雨開始直後を除く)

## The development of disturbance on the atmospheric density stratification

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There are many unknown issues about line-shaped rainbands (LRBs) which is one of the meso-scale meteorological phenomena making torrential rainfall events in Japan. The LRBs caused severe floods and landslide disasters such as the Fukui heavy rainfall 2004, the Hokkaido heavy rainfall 2010 and the Niigata-Fukushima heavy rainfall 2011. For disaster prevention, it is very important to reveal the formation mechanism of LRBs. To know the mechanism, the authors try to examine the stability of the density stratification using the small amplitude wave theory. In this study, the rainfall and thermodynamic effects are not considered. To simplify the discussion, this theory notes only the up/down motion of disturbance in the stratified atmosphere.

It is considered that LRBs are generated by disturbance of the unstable stratified atmosphere. Here, the authors apply the ship wave theory to explain the LRBs. Ship wave is the water surface wave generated by moving ships or waterfowls, and we can regard this ship as the origin of disturbance in the stratified water and air. Thus, this phenomenon is similar to the LRBs formation mechanism in the disturbance of stratified fluid.

However, the disturbance form of ship wave is different from the LRBs. On the one hand ship wave is formed by diverging waves and transverse waves, on the other hand LRBs is the long linear cloud. Therefore, we have to explain that these two phenomena are not completely different, so the authors have decided to observe ship waves in detail. As the observation objects, the authors use the satellite images of lee waves which are known to make the cloud shapes like ship waves. Observing more than 500 lee waves images, the authors found some lee waves which are like LRBs. So we can say that ship wave may become the line-shaped disturbance if it satisfies some conditions.

Based on the above, the authors attempt to give an origin of disturbance to the piecewise linear boundary layer which have a density interface using ship wave theory. This theory is based on the fundamental equation such as Navier-Stokes equation, continuity equation and invariant density equation, using small amplitude wave theory and method of stationary phase. These equations finally result in the dispersion relation and vertical direction velocity by disturbance. Calculating the disturbance amplitudes for all the wave numbers, the authors find three disturbance development forms. These forms are determined by the density difference and the internal Froude number as follow: 1) The stratification is stable. 2) The stratification is unstable and the internal Froude number is more than 1. 3) The stratification is unstable and the internal Froude number is less than 1. Among those three cases, the first case makes the form of ship wave. It is not important for the formation mechanism of LRBs which occur in the unstable atmosphere. The unstable stratification cases are the time development disturbance and change the horizontal existence region of disturbance by the base flow parameters. Especially, the second case changes its disturbance region significantly with the Froude number. The authors consider that this disturbance region is important for the form of LRBs.

Keywords: line-shaped rainbands, stability, ship wave, lee wave

## Land-Sea Circulation between Ishikari and Tomakomai in boreal summer

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This paper deals with the horizontal scale land and sea breeze circulation (LSBC) between Ishikari and Tomakomai and sea surface temperature (SST). The diurnal variation of LSBC during August of 1985-2008 is investigated using the data from the Automated Meteorological Data Acquisition System (AMeDAS) and Sapporo City Multisensor(MULTI) and analysis data of sea condition.

Area from Ishikari to Tomakomai has a unique topography. This area lies between Japan sea and Pacific ocean and it is not known whether it is affected by Japan sea's LSBC or that by Pacific ocean's LSBC. This area accounts for 30 percent of the total population of Hokkaido. Therefore, it is important to understand the characteristic of climate in this area. To discuss the LSBC effect, this area is divided into three regions: The first plain is from Ishikari city to Sapporo city (hereafter abbreviated as IS) and second plain from Ebetsu city to Chitose city (EC), and third is from Atsuma city to Tomakomia city (AT).

LSBC was observed between Ishikari and Sapporo. When Japan SST was higher than climatological temperature by 1 degree celsius, LSBC appeared clear because sea breeze's sojourn time increased. On the other hand, when Japan SST was 1 degree celsius lower than climatological temperature, sea breeze's sojourn time decreased. Therefore, it can be considered that LSBC over this area and SST have interactions.

Area between Tomakomai and Atsuma could have LSBC, too. When Pacific SST increased by one degree or decreased by one degree compared with climatological temperature, Tomakomai and Atsuma's sea breeze's sojourn time increased.

Between Ebetsu and Chitose, regardless of Japan or Pacific SST, southerly wind could be observed all day long and wind speed is not changed. It was presumed that area between Ebetsu and Chitose didn't have LSBC. Therefore, it can be concluded that wind direction was not related to SST.

These results suggest that the climate characteristics over Hokkaido region may change if global warming continues.

Keywords: topography, thermal balance, horizontal scale

## Influence of lake current, wave and local atmospheric circulation on bulk transfer coefficient over a lake surface

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The turbulence and atmospheric data have been collected at the center of Lake Kasumigaura since 2007, in order to develop an improved lake-atmosphere fluxes parameterization. To estimate the fluxes more accurately, the bulk transfer method which incorporates the water surface status including the effect of wave, wave age and lake current was considered. Also the atmosphere status such as atmosphere stability and gustiness induced by the convective circulations under calm mean winds were investigated. Considering above parameters, the roughness length for momentum, sensible heat, latent heat were calculated. These results were used to determine the factors affecting the bulk coefficients. The estimated fluxes with a bulk method were compared with measured fluxes.

Keywords: flux, bulk transfer coefficient, roughness, wave, lake current

## Separation of evapotranspiration into soil evaporation and transpiration over three maize fields of different irrigation

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The amount of evapotranspiration was measured by the eddy correlation method at three maize fields under different irrigation system of Nile delta; this was separated into its component of transpiration and soil evaporation by using the chamber method and oxygen and hydrogen stable isotope ratios, respectively over three maize fields of different irrigation systems of the Nile delta. The ratios of soil evaporation to evapotranspiration ( $E/ET$ ) during daytime are nearly 100% in wet soil condition immediately after surface irrigation. As soil dries condition,  $E/ET$  became smaller with LAI.  $E/ET$  of the drip irrigation is almost 60%. Moreover,  $E/ET$  is 40% in surface irrigation with mulching when soil moisture condition is dry. Finally,  $E/ET$  is nearly 100% when soil moisture condition is wet immediately after narrow furrows irrigation. To assess controlling evaporation effect, we estimated  $E/ET$  by using previous works (Kang, 2003) without LAI effect about transpiration.  $E/ET$  for LAI=1 is found to be 79%, 57%, 41% in surface irrigation and 40-50% in drip irrigation and 64% in wide furrows irrigation and 81% with mulching.

Keywords: Eddy correlation method, Chamber measurements, Oxygen and hydrogen stable isotope ratio, LAI, Soil moisture content

## Assessment of areas at risk of inside water inundation by topographical and geographical characteristics

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In Tokyo, various countermeasures to inside water inundation are proceeding. However, some areas where floods occur repetitively or small-scale floods occur are identified. Thus, it is necessary to understand topography or land cover of these areas. In Shinjuku, Toshima and Bunkyo, inside water inundation occurs frequently and some areas where floods occur repetitively are found. Therefore, in this study, we analyzed topographical and geographical characteristics of inundation records in these three districts and assess areas at risk of inside water inundation.

Inundation records in study area were 107 in 1989 -2008. We classified of these flood areas into 3 groups, those occurred in lowland, upland and valley on upland. The properties that were extracted as those involved in topographical or geographical characteristics of the flood areas were depression depth, depression volume, catchment, land cover of catchment, mean slope of catchment, mean slope from a flood area to a catchment exit, difference between these two slopes (slope difference), length from upper most of catchment to a flood area, length from a flood area to a catchment exit, difference between these two lengths (length difference), valley depth, valley width. We used ArcGIS10 to extract these all properties. Those properties were examined by principle component analysis (PCA) to assess topographical and geographical characteristics of the flood areas, resulting in two major components in lowland, three major components in upland and four major components in valley on upland.

The first PC in lowland, upland and valley represented the size of catchment, and length difference and the higher the PCA score, the larger catchment, and length difference. In the first PC in lowland also represented the size of depression. The second PC in upland, valley and the fourth PC in valley showed the size of depression. In the second PC in lowland and the third PC in upland and valley, the higher the PCA score, the larger mean slope of catchment, slope difference.

We calculated these PCA scores in the flood areas and all study area. Then areas over the minimum all PCA scores of the flood areas were extracted from the study area as the ones at risk of inside water inundation.

Keywords: inside water inundation, urban area, topographical and geographical characteristics, principal component analysis, GIS, Tokyo

## Investigating on the relationship between subsurface infiltration rate and hydraulic conductivity of forest soil

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The objective of this study was to closely investigate the relationship between infiltration rate and hydraulic conductivity of forest soil in forested hillslopes focusing approximately 0.1m below the ground surface. A total of 38 sampling points from forests with two different species (*Japanese cedar* and *Hiba arborvitae*) were selected with respect to their thinning period in Ishikawa prefecture. The study was conducted using artificial rainfall condition that employ oscillating nozzle simulator. Soil at different depth and surface vegetation samples were collected before and after thinning from each forest type. The collected soil samples of the specific depth then were used to determine the effect of thinning on the soil permeability and hydraulic conductivity. The soil permeability and hydraulic conductivity then were measured before and after thinning for each soil sample.

Results indicated that the maximum infiltration rate ( $FIR_{max}$ ) on surface soil ranged from 142 to 562 and 93 to 641 mm/h in *Japanese cedar* and *Hiba arborvitae* plantation, respectively and these values were higher than predetermined rainfall intensity. Although higher rates of hydraulic conductivity were measured at depth of 5 and 5 -10 cm, surface runoff has been observed at both depths. Exceptionally, a single surface soil sample collected from *Japanese cedar* showed a small value as observed in aquiclude while its maximum infiltration rate was over 300mm/h without undergrowth but litter. The effect of time after thinning was not reflected on the maximum infiltration rate and hydraulic conductivity. Moreover, the influence of slope, amount of cover-materials and soil characteristics were not observed on both measured parameters. As an advantage, forest cover reduces the direct rain drop impact that prevents the pore space of soil from being clogged and as a result higher values of both maximum infiltration and hydraulic conductivity rates were found.

Keywords: Infiltration rate, Hydraulic conductivity, Oscillating nozzle rainfall simulator, Japanese cedar, Hiba arborvitae

## Interaction between Surface water and Groundwater in Baiyangdian Lake Watershed, North China Plain

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The people in North China Plain are mainly using groundwater as a major water resource. Because of an excessive pumping due to a rapid industrialization and expansion of the irrigated field, groundwater table drawdown and the water quality deteriorated recently in the North China Plain. On the other hand, as progress of scientific researches about the hydrology and the water resources, it has been clear that a development of either surface water or groundwater has affected on the quantity and the quality of the other. Therefore, it is urgently necessary to improve an understanding of the characteristic of the water quality and the groundwater processes in the North China Plain for sustainable water use.

The purpose of this study is to investigate the characteristics of the water quality and the groundwater flow process in Baiyangdian Lake watershed, the North China Plain. The field survey and the water sampling of the groundwater, the river water and the lake water were performed in June, 2011. Inorganic constituents and stable isotopic composition of deuterium and oxygen were determined on every water sample. The results of the study are as follows.

The water of Tang reservoir has a characteristic ion composition and the water of Baiyangdian has a distinctive isotopic composition and also water quality of Fu river is characterized high concentration of nitrate. So, each of surface water is affected by different process of water quality formation.  $\text{Na}^+$ ,  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$  concentrations and  $\delta^{18}\text{O}$  distributions in groundwater suggest that <sup>1)</sup> groundwater around Tang reservoir is recharged from Tang reservoir and flow in the direction of Northeast, <sup>2)</sup> groundwater around Baiyangdian is recharged from Baiyangdian which is influenced by high evaporation, <sup>3)</sup> in the region of Fu river, influence of interaction between surface water and groundwater is lighter than that of Tang or Baiyangdian region. Concentration of  $\text{NO}_3^-$  in deep groundwater indicate the intrusion of this contaminant from shallow to deep aquifers with downward groundwater flow, but in this study, we have few data of deep groundwater. To understand accurate mechanism of interaction between shallow groundwater and deep groundwater, we need more fruitful data.

Keywords: North China Plain, recharge of groundwater, water quality formation, stable isotope, cluster analysis



## Age dating of spring water and estimation of water storage in mountainous watersheds using chlorofluorocarbons

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It is important to understand the groundwater flow system in quality and quantity for using the groundwater as major water resource sustainably and efficiently. The groundwater residence time and the water storage produce useful information for us. However, in the previous studies, there are few studies on age dating of the groundwater in large area with different geology, and evaluation of the water storage at the same time. In this study, the author performed age dating of the spring water using chlorofluorocarbons (CFCs) and estimation of the water storage, and then compared the groundwater flow system in geology conditions by showing the spatial distribution. The author sampled spring water in Kaikoma-type granite, Hoo-type granodiorite, the Tertiary deposit and the Paleozoic strata in Kamanashi River basin in Yamanashi prefecture, central Japan, in March, April, August, and November, 2011. The author analyzed water ion concentrations, hydrogen and oxygen stable isotope ratios, and CFCs concentrations of all spring water samples, and calculated the water storage volume using the age of the spring water.

The author estimated the residence time of the spring water by using Exponential Model. The age in the granite basin ranges from 11 to 36 years, in the Paleozoic strata ranges from 28 to 31 years, and in the Tertiary deposit ranges from 6 to 22 years.

In the granite basin, the difference of water quality and residence time suggests an existence of two types of the groundwater flow system. One is large contribution from the shallow groundwater flow in the composed granite, and the other is contribution from the preferential groundwater through the joint of decomposed bedrock or fracture zone. The smaller basin with the older age, it seems to contribute to the groundwater recharge flowing in the deep aquifers. On the other hand, in the Tertiary deposit, it is suggested that large-scale and the quick groundwater flow system is dominant due to the heterogeneity of the geological setting.

The water storage is estimated to be from  $10^5$  to  $10^7$  m<sup>3</sup>. It seems to be higher in the granite and lower in the Tertiary deposit. Therefore, the capacity of the water storage is higher in the granite and lower in the Tertiary deposit.

Keywords: groundwater flow system, residence time, chlorofluorocarbons (CFCs), water storage

## Flow history of deep groundwater in a sedimentary basin by fluorescence EEM spectroscopy

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Recent and wider usages of deep groundwater due to increased demands for industrial water and hot spring resources require better understanding of the nature of hydrologic deep groundwater flow patterns in a sedimentary basin from the point of view of conservation of groundwater and evaluation of environmental effect as well as utilization of underground spaces such as CO<sub>2</sub> storage and waste disposal. Although major elements and stable isotope ratios have been employed to examine deep groundwater flows, more indices would lead to a better understanding of the groundwater flow patterns. We focused to a fluorescence excitation-emission matrix (EEM) spectroscopy, which needs only a small amount of samples, as it is highly sensitive for dissolved organic matter (DOM) with conjugated bonds at natural abundance levels. In this study, origins of DOM in groundwater samples with varying depth in the eastern Tokachi sedimentary basin were investigated with the EEM spectroscopy. EEM spectra were collected for the groundwater samples and for isolated humic acid and fulvic acid samples from the groundwater. Parallel factor analysis (PARAFAC) modeling for the corrected spectra and subsequent principal component analysis statistics of the PARAFAC data showed that they distribute within three end-members, a humic-like component originated from soil and peat, a subsurface microbial fulvic-like component and a degraded humic-like component. The difference of the DOM nature depends on origins of the aquifer, which possibly shows interaction of groundwater with surrounding rocks. This result agrees well with groundwater flow patterns in this area investigated with major elements and stable isotope ratios; thus the EEM spectroscopy combined with PARAFAC could also evaluate hydrologic behavior of deep groundwater containing DOM.

Keywords: EEM spectroscopy, sedimentary rock, groundwater flow, DOM, Humic substances

## Lake-level change history of Nojiriko and its impact to human society

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Lake level of Nojiri-ko changed drastically at eight times during the last 4500 years. Maxima of lake level can be correlated with abrupt cooling events, namely, Heinrich events, Bond events, etc. Although lake-level change ratio is very low, which is ca. 5 to 10 mm per year, possibility of emergence of water shortage is high. Global warming can lead more frequent water shortages. Intensity variation of winter monsoon is assumed to be the cause of lake-level change. Arctic Oscillation is thought to be the most probable working hypothesis of winter-monsoon oscillation at present.

Keywords: lake-level, history, sediment, Lake Nojiri

## Nitrogen and sulfur isotope analyses of river water in the Northwestern Chiba Prefecture

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To identify anthropogenic sources of nitrogen in the river waters in the northwestern Chiba Prefecture, stable isotope composition of nitrogen and sulfur as well as nitrate concentration were determined.

Keywords: nitrogen pollution, nitrogen isotope, sulfur isotope, river water, Tone canal

## Flow system and hydrochemistry of hot springs around Mt.Haruna,Central Japan.

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In this study,23 samples of water (including ground water) were collected to analyze major chemical components and isotopic compositions of oxygen,hydrogen and sulfur to discuss recharge mechanisms and Water-rock interaction

Keywords: Mt.Haruna, hot spring, water-rock interaction

## Hydrochemical study of non-volcanic hot springs in Yamanashi Prefecture, Central Japan.

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Hot springs have great significance as local promotion and so on.

In this study, 60 samples of water (including ground water, and river water, and natural springs) were collected to analyze major chemical components and isotopic compositions of oxygen, hydrogen and sulfur to discuss recharge mechanisms and Water-rock interaction processes to make chemical properties of the fluids and flow system of deep fluids.

Keywords: Yamanashi, hot spring, non-volcanic, water-rock interaction

## Hydrochemistry and isotopic composition of hot springs the East Matsumoto Basin Faults, Itoigawa-Shizuoka Tectonic Line

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Hydrochemistry and isotopic composition of hot springs the East Matsumoto Basin Faults, Itoigawa-Shizuoka Tectonic Line Active Fault System, Central Japan

Keywords: Itoigawa-Shizuoka Tectonic Line Active Fault System, hot springs