

## ***Interactive comment on “Spatial distribution of oxygen-18 and deuterium in stream waters across the Japanese archipelago” by M. Katsuyama et al.***

**M. Katsuyama et al.**

katsuyama.masanori.5m@kyoto-u.ac.jp

Received and published: 4 December 2014

### Reviewer's comment

General comments: Katsuyama et al. present a huge dataset (almost 1,300 records) of oxygen-18 and deuterium in Japanese stream headwaters, grouped into a number of regions representing the main climatic characteristics of the country and derived regression lines as well as multiple regression equations based on commonly known corollary parameters. In addition to that, Katsuyama et al. also collected precipitation oxygen-18 and deuterium data from existing published and unpublished sources. In total, Katsuyama et al. report to present the most comprehensive isoscape of oxygen-18 and deuterium in Japanese streamwaters. Unfortunately, the presentation of the

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



work is not fully stringent; a one-time streamwater sampling campaign is compared with precipitation isotopic data patchy in both space and time. Hence, the conclusions Katsuyama et al. draw seem to be made with caution. The collection methods (for samples as well as supporting data) lack a thorough description. Occasionally, there is vagueness in statements which may be read as obfuscation. After all, the authors however do not succeed to meet objective of presenting an isoscape (gridded data at high spatial resolution) and present small-scale contour maps instead. For details see the scientific comments below. A generic issue (though that's not a mistake of the authors) is that a number of key publications the authors refer to has been published in a local language and is hence often out of reach of the international scientific community. Finally, the authors are strongly encouraged to publish their data and/or gridded data files at an appropriate resolution as supplementary material, last but not least as an important step towards leveraging this (known) issue.

#### Authors' Reply

Thank you for valuable comments. We revised our manuscript following your specific comments. Please find our replies to your comments. As you mentioned here, many key publications we refer has been published in Japanese; In Japan, there are a lot of important works in this field including recent publications, however these are less referred by the international scientific community because of the accessibility, that is, language. Therefore, our research paper must be published in the international journal like HESS. Moreover, we will publish our data as supplementary material if this manuscript is published in HESS.

#### Reviewer's comment

Specific comments: Introduction (chapter 1): The relationship between precipitation isotopic values (with its pronounced seasonality) and streamwaters (which may include substantial peak flow and groundwater components) is complex; this should be borne in mind when using one-time samplings of streamwater for generic statements (cf.

**HESSD**

11, C5465–C5481, 2014

[Interactive  
Comment](#)

[Full Screen / Esc](#)

[Printer-friendly Version](#)

[Interactive Discussion](#)

[Discussion Paper](#)



e.g. Lachniet and Patterson, 2002; shallow groundwaters are less prone to the above mentioned effects, cf. the summary of Wassenaar et al. 2009 and their references), especially with few studies on this conducted previously (as mentioned by the authors). The superiority of streamwater over precipitation isoscapes may be given as per their applications (e.g. for migratory or forensic studies in areas where surface waters play an important role), however it is hard to see such a generic statement justified (p. 10906 lines 9-11).

### Authors' Reply

As you mentioned here, the relationship between precipitation isotopic values and streamwaters is complex; however, the signature in streamwater (and shallow groundwater) MUST reflect the hydrological processes, that is, transform processes from precipitation to streamwater, of each catchment. The source of streamwater is mainly shallow groundwater; many studies have clarified using hydrograph separation technique that the shallow groundwater is a dominant component of baseflow (e.g., Pinder and Jones, 1969; Katsuyama et al., 2001). Our samples were collected during baseflow conditions. Long-term monitoring is of course important to know these mechanisms, and the corresponding author is trying to do this (e.g., Katsuyama et al., 2011). We believe that the streamwater isoscape is available not only for applications, but also for basic researched of catchment hydrology.

(Reference)

Katsuyama, M., Ohte, N. and Kobashi, S.: A three-component end-member analysis of streamwater hydrochemistry in a small Japanese forested headwater catchment, *Hydrol. Process.*, 15, 249-260, 2001.

Katsuyama, M., Tani, M. and Nishimoto, S.: Connection between streamwater mean residence time and bedrock groundwater recharge/discharge dynamics in weathered granite catchments, *Hydrol. Process.*, 24, 2287-2299, doi: 10.1002/hyp.7741, 2010.

## HESSD

11, C5465–C5481, 2014

[Interactive  
Comment](#)

[Full Screen / Esc](#)

[Printer-friendly Version](#)

[Interactive Discussion](#)

[Discussion Paper](#)



Pinder, G. F. and Jones, J. F.: Determination of the ground-water component of peak discharge from the chemistry of total runoff, *Water Resour. Res.*, 5, 438-445, 1969

#### Reviewer's comment

Methods (2): While some of the data show remarkable evaporative tendencies, the authors unfortunately do not address some questions: Which definition of 'headwater catchment' is applied (given the broad range of catchment sizes)? How were catchments featuring lakes, swaps or geothermally altered spring waters dealt with? How are 'baseflow conditions' defined? It seems that many samples were taken during the precipitation-rich summer or during the tail of the annual rainfall peak. Furthermore, the explanations should include which sample containers were used (despite freezing), a short statement on the measurement calibration and uncertainty, and how much time passed between sampling and analysis (sampling: 2003, publication: 2014). Similar efforts should be made for the collected precipitation data; for synthetic collection this is known to be difficult and may presented in an annexed table rather than listing the method for only a few of the stations in the text. As for geographical parameters, it is not quite clear whether the elevation of the site has been used for further calculations, or the mean catchment elevation. The spatial resolution of the mesh climatic data could not be read from the manuscript. The generation of small-scale contour plots, based on the IDW method, does hardly match the definitions of a state-of-the-art 'isoscape' (cf. Bowen 2010 for a detailed history of isoscape generation); there are a number of reliable, open-source GIS and geostatistical tools available (QuantumGIS, R with 'gstat' extension etc.) to perform more robust calculations at higher spatial resolution.

#### Authors' Reply

We revised the method section to add appropriate information. Only few data (10 data or below within more than 1200 data) apart from the regression line and shows evaporative tendencies in figure 2. The definition of 'headwater' by Poehls and Smith (2009) is 'the source water or upper part of stream, river, or contained watercourse in

## HESSD

11, C5465–C5481, 2014

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



a drainage basin'. Our definition of 'headwater catchment' matches it. We selected the potential sampling points where whole the catchment was covered by forest on the road map before the sampling, and confirmed the existence of artificial pollution source such as dams, houses and/or farmlands, and properly changed the points in the field to avoid the effects of them. There were no lakes, swamps, and others which can affects the isotope values in each catchment. As the values can be also affected by precipitation, we collected the samples during baseflow condition and avoided to sample during and just after the precipitation to unify the collection conditions as much as possible between sites. The subdivided samples for the isotope were froze in polycarbonate bottles at -10C until analyzed in 2008. The details for precipitation samples also add in the section 2.2. The elevation used here is 'the elevation of the site', and the spatial resolution of the mesh climatic data is 1km. The Figures 4 and 5 are replaced to colour-coding maps according to observed delta18O and delta2H, as well as d-excess value. The data shown here are raw data, not interpolated (estimated) data. These maps clearly show the spatial distribution of the stream water isotope signature across Japan with high spatial resolution. We think it's sufficiently robust. If we need a map with much higher resolution, we should use geostatistical tools, and we are ready to open our data.

#### Reference

Poehls, D. J. and Smith, G. J.: Encyclopedic dictionary of hydrogeology, Academic Press, Amsterdam, 517pp., 2009.

#### Reviewer's comment

Regression lines (3.1): While there seems to be a disagreement among the cited references over the linear relationship between oxygen-18 and deuterium (and it is hence a difficulty to establish a general baseline), the authors present highly disperse regression lines for the individual regions. The usage of phrases like 'relatively similar (about 6-8)' (p. 10909, l. 22f.) is to be questioned since the slopes and intercepts deviate sub-

## HESSD

11, C5465–C5481, 2014

[Interactive  
Comment](#)

[Full Screen / Esc](#)

[Printer-friendly Version](#)

[Interactive Discussion](#)

[Discussion Paper](#)



stantially from the GMWL (not only in regions F and G), some of which suggest clear evaporative trends (or other alterations). A 'generally similar appearance' (p. 10910, l. 2) and a resulting validity as a proxy for precipitation isoscape data on a nationwide scale, with the small concession to evaporative processes during infiltration, looks a bit far-fetched. (A streamwater isoscape as such is a valuable achievement, but questions concerning seasonal or hydrographic biases need to be addressed.) The authors' comment on the need for further precipitation isotope data is fully supported, however that would be a precondition for using a streamwater isoscape as a proxy. In absence of appropriate precipitation isotope data, shallow groundwater isotopic records, as suggested by Wassenaar et al. (2009) may serve as a better means for cross-validating the streamwater isoscape. To this end, the authors should consider mining some of their source publications for shallow groundwater data, and comparing them region by region with (a) existing precipitation records and (b) the collected streamwater data.

#### Authors' Reply

As we mentioned above, the source of streamwater is mainly shallow groundwater; many studies have clarified using hydrograph separation technique that the shallow groundwater is a dominant component of baseflow, and we corrected samples during baseflow conditions (see also our reply above). The regression line by Machida and Kondo (2003) (Sorry! This is in Japanese!) (eq. 2) is calculated from the data of stream water and shallow groundwater; they didn't separate them. They collected many published data and built a database, however, the database is unexercised now. We partly agree with your comment that precipitation isotope data would be a precondition for using a streamwater isoscape as a proxy, however, it sounds a little bit negative; it is very difficult to collect precipitation data simultaneously at many sites within whole the country for long-term period in many countries, as well as in Japan. As you pointed out here, the regression lines for the individual regions are disperse. Similar patterns are also found in Kendall and Coplen (2001). However, at the nationwide scales, the regression will approach to GMWL. This fact means that GMWL is not universal for every

## HESSD

11, C5465–C5481, 2014

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



spatial scale but just comprehensive or 'global'. Needless to say, there are some inherent processes and mechanisms for the diverse regression (or LMWL) in each region, but this should be discussed in a detailed studies at small scales.

## Reference

Kendall, C. and Coplen, T. B.: Distribution of oxygen-18 and deuterium in river waters across the United States, *Hydrol. Process.*, 15, 1363-1393, doi: 10.1002/hyp.217, 2001.

Machida, I. and Kondoh, A.: Stable Isotope Ratios of Natural Water in Japan -The Analysis by Using Environmental Isotopes Database-, *J. Japan Soc. Hydrol. and Water Resour.*, 16, 556-569. (in Japanese with English Summary), 2003.

## Reviewer's comment

Spatial and seasonal distribution of d excess (3.2 and 3.3): A topographic map, based open-access data (DEM, e.g. ETOPO) and software should be included in the paper instead of a mere web URL. References should be given to d excess and its meanings (e.g. Dansgaard 1964 in general and references for the specific situation of the dual moisture source regime of Japan). The authors may consider explaining specific spatial patterns of d excess (e.g. areas with low d excess) instead of merely listing them (e.g. p. 10910 l.25 vs. p. 10911 l. 4). As for seasonality, they authors should consider showing typical plots of monthly average isotope values instead of picking specific 'typical' years for a few stations.

## Authors' Reply

Another reviewer also pointed about the topographic map. We replaced Figure 3 to 'Topography of the Japanese Archipelago and index of regional division'. We referred Dansgaard (1964) in Section 3.2. Waseda and Nakai (1983) is the pioneer work about the dual moisture source regime of Japan, and other studies also explained the same mechanism. One of the example, we referred Araguás-Araguás et al. (1998) in Section

# HESSD

11, C5465–C5481, 2014

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



3.3. The seasonal pattern of precipitation d-excess is important information to consider the specific spatial pattern of d-excess. This is discussed in Section 4.2. However, to consider, for example, why the d-excess value in Gunma Prefecture is smallest, we need sufficient climate data as well as monthly (or more detailed) d-excess in precipitation. As for seasonality, we revised Figure 6 to show the long-term variation of monthly d-excess in precipitation in addition to previous panels to clarify we didn't pick up 'specific' typical years.

The section 3.3 changed as follows;

The upper panel of Figure 6 shows the long-term variation of monthly d-excess in precipitation observed at Tottori (Sea of Japan side, Station No. 9 in Table 1), Shiga (Sea of Japan side, Station No. 6), and Nara (Pacific Ocean side, Station No. 8). The lower panels of Figure 6 show typical examples of monthly d-excess values with monthly precipitation and air temperature observed at Tottori in 2011, Shiga in 2008, and Nara in 2006. The climate conditions are clearly different among these stations. In Tottori, much snow falls from December to March with low air temperatures. In Shiga, less snow occurs but much more rain falls during summer. Summer rainfall is more plentiful in Nara. However, similar sinusoidal d-excess variations repeated at these three stations every year; i.e., higher during winter and lower during summer. The sinusoidal pattern is caused by the contribution of the dual moisture sources predominantly from the Pacific Ocean in summer and predominantly from the Sea of Japan in winter (Waseda and Nakai, 1983; Araguás-Araguás et al., 1998). Moreover, Tase et al. (1997) also reported that this seasonal pattern was commonly observed at six stations in the Kanto, Shikoku, and Kyushu regions (see also Figure 3). Unfortunately, we did not have sufficient data from 2003 when stream water sampling was conducted. Therefore, we will compare the precipitation values observed in various years with the stream water values, in the following.

Reference

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper





Araguás-Araguás, L., Froehlich, K. and Rozanski, K.: Stable isotope composition of precipitation over southeast Asia, *J. Geophys. Res.*, 103, D22, pp. 28721-28742, 1998.

Waseda, A. and Nakai, N.: Isotopic compositions of meteoric and surface waters in Central and Northeast Japan., *Chikyukagaku (Geochemistry)*, 17, 83-91. (in Japanese with English Summary), 1983.

#### Reviewer's comment

Correlations (4.1): Which definition of 'elevation' is used? (Elevation of the sampling point vs. mean catchment elevation) Consider showing a covariance matrix for the corollary variables. A minor glitch is that the lapse rate is -0.27/100m in p. 10912 l. 16 and -0.28 in l. 18. It should be considered that altitude lapse rates are not globally uniform, and the authors should use caution to interpret conformity with the global lapse rate as a criterion for proxy suitability. The criteria for the choice of a multiple regression is not clear (consider showing a covariance matrix or use of the Akaike Information Criterion [AIC], cf. Wassenaar et al. 2009). Finally, the authors should consider a combined multiple regression / interpolation approach (cf. Bowen 2010 for examples) to further refine resulting gridded data and to use subsequent interpolation to account for the residuals and to derive a state-of-the-art isoscape.

#### Authors' Reply

The elevation used here is the elevation of the sampling point. We revised the Method section 2.3. Regarding to the lapse rate, Poage and Chamberlain (2001) collected a lot of data from 68 studies and proposed the isotopic lapse rates of precipitation from most regions of the world (-0.28 ‰/100 m) except at the extreme latitudes. It is worth to consider or compare to that of our data, although we also compare with 'unknown' lapse rates of Japanese precipitation, as well as the comparison between GMWL and eq. 4). We referred the correlation matrix as Table 3. This table helps to clarify the criteria for the choice of a multiple regression. Regarding to the combination of multiple

## HESSD

11, C5465–C5481, 2014

[Interactive  
Comment](#)

[Full Screen / Esc](#)

[Printer-friendly Version](#)

[Interactive Discussion](#)

[Discussion Paper](#)



regression and interpolation approach, we did not adopt it in the revised manuscript, because our data is spatially dense (Figure 1). Moreover, the gridded (interpolated) is estimates even if the technique is the state-of-the-art, and the observed raw data have greater worth.

## Reference

Poage, M. A. and Chamberlain, C. P.: Empirical relationships between elevation and the stable isotope composition of precipitation and surface waters: considerations for studies of paleoelevation change, *American Journal of Science*, 301, 1-15, 2001.

## Reviewer's comment

D excess in streamwater vs. precipitation (4.2): For comments on the precipitation data considered, see 'figures and tables'. Notwithstanding the efforts undertaken by the authors, but considering the number of unexplained anomalies in their dataset, the claim for presenting a spatially AND temporally integrated isocape should be used with care, given the spatial and temporal heterogeneity of comparison datasets. The authors should consider cross-checking their future gridded data product with established precipitation isoscapes, e.g. by Bowen & Revenaugh (2003) or van der Veer et al. (2009) which used precipitation isotope datasets whose heterogeneity issues were analysed and discussed (cf. e.g. Bowen 2010).

## Authors' Reply

We are willing to compare with established precipitation isotope datasets. We respect previous studies by Bowen & Revenaugh (2003) and van der Veer et al. (2009), as well as Bowen (2010), however, all of these studies are based on GNIP data. As Wassenaar et al. (2009) pointed out, the GNIP station are often spatially deficient; for example, Wassenaar et al. (2009) mentions that Mexico has only 2 GNIP stations, and Japan HAD also only 2 stations. Both of stations in Japan were already closed. This information added to our introduction. This is the most important motivation of our

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



study, that is, the GNIP data is insufficient at the small country scale like Japan, even if the interpolation method is perfect. Therefore, we doesn't try to compare with the gridded precipitation isotope datasets here.

#### Reviewer's comment

Figures & tables: It would be good to incorporate record length information into table 1. The comment concerning 'arbitrary reading d excess from original papers' bears some explanation. The authors could consider constraining the map extent to the prefectures sampled; leaving out Okinawa prefecture would give approx. 4 times as much map space. Standard map elements (grid mesh, frame, legend) should be included. The region map could be transformed into a combined region and topography map. The authors may consider colour-coding the sampling locations in Fig. 1 according to their oxygen-18 or deuterium value, and presenting the gridded data products instead of the contour maps (Figs. 4 and 5). Finally, the panel Figure 6 does not show whether the isotopic values of one year (as suggested in the text) or multi-year averages are presented. Overall, it is suggested to present the seasonality patterns of several stations well-distributed over Japan.

#### Authors' Reply

The precipitation data length in Table 1 is 1 year for all points. The caption b is revised. In some point, there are long-term record, but the record length for other points are limited to one year. Therefore, we evenly used one-year record for all point. The caption d is changed as 'The d-excess of precipitation are picked up by us from the original papers'. The figure 1 is revised, including constraining the map extent to the prefectures sampled (leaving out Okinawa prefecture), standard map elements as well as colour-coding the sampling locations. This map need for quick-look the sampling points both of streamwater and precipitation at the same time. Figures 4 and 5 are also replaced to colour-coding maps according to observed  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ , as well as d-excess value, as mentioned above. The region map Figure 3 also changed

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



including topography.

Figure 6 is revised as mentioned above. The isotopic data is of one year. As these data from three stations are corresponding author's original data, we can show the values with the long-term variation in the revised Figure 6.

#### Reviewer's comment

Summary of comments: Katsuyama et al. present a huge dataset with a big potential for generating gridded isoscape products. Some conceptual aspects (linking of streamwater to precipitation etc.) and methodological (data selection and discussion) need to be elaborated more profoundly. Finally, an improved method for generating the graphic output should be sought. These revisions will help to exploit the full potential of the dataset collected. Finally, my sincere thanks for the interesting read.

#### Authors' Reply

We appreciate your many useful comments. We revised our manuscript considering your and another reviewer's suggestions. We hope this manuscript is acceptable for HESS.

---

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 10903, 2014.

**HESSD**

11, C5465–C5481, 2014

---

Interactive  
Comment

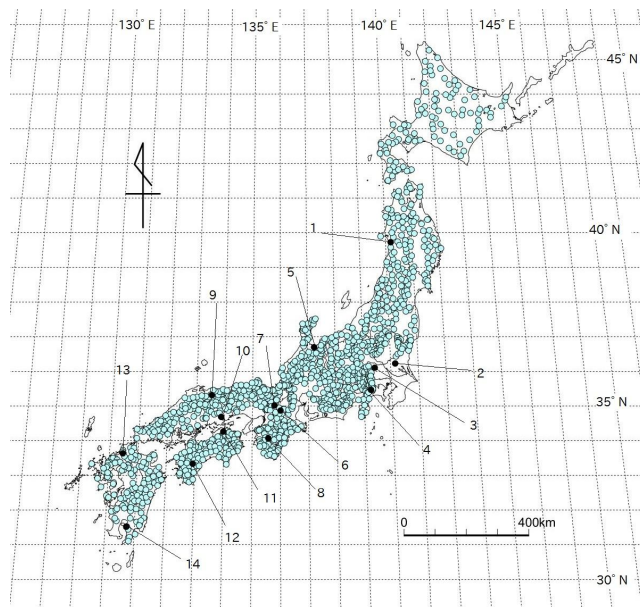
Full Screen / Esc

Printer-friendly Version

Interactive Discussion

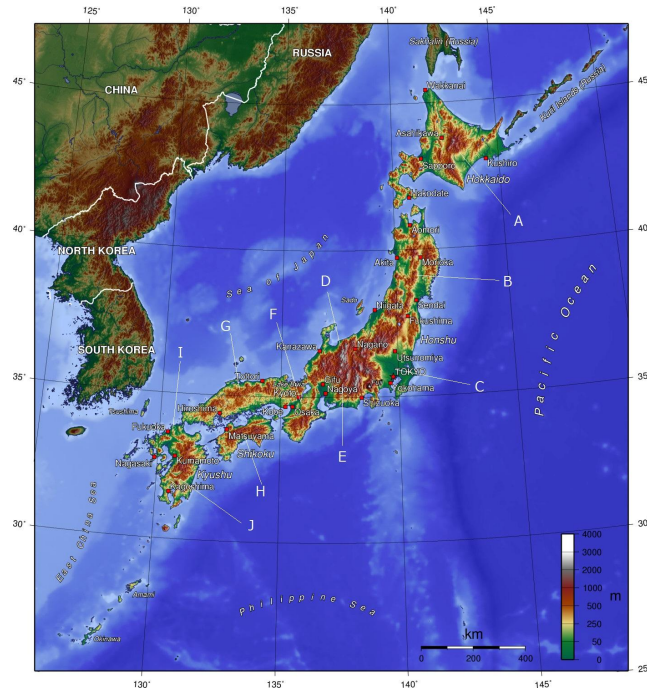
Discussion Paper





**Fig. 1.** Replaced Figure 1

Interactive  
Comment



**Fig. 2.** Replaced Figure 3

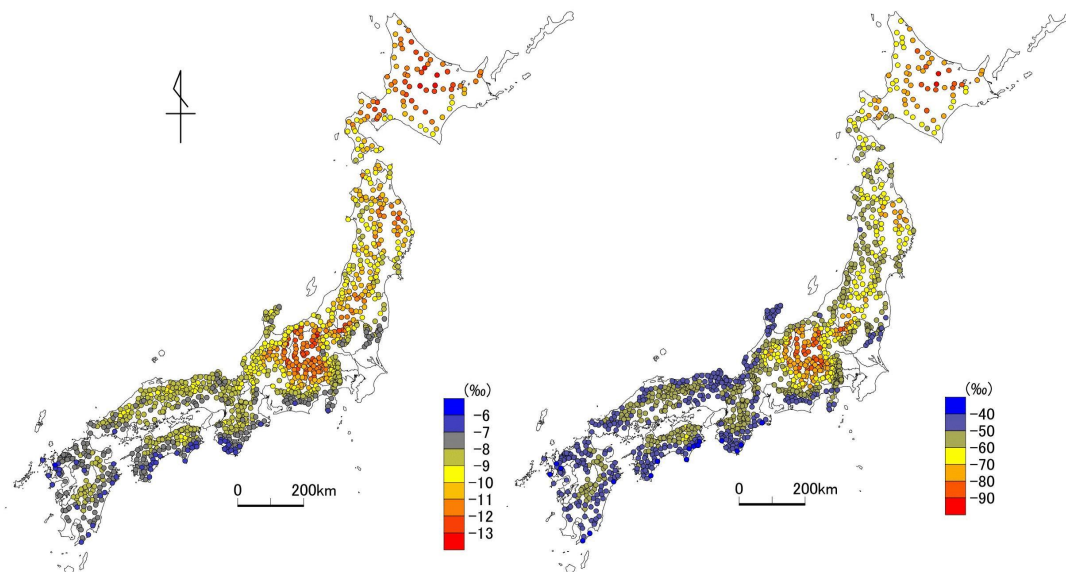
Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper





**Fig. 3.** Replaced Figure 4

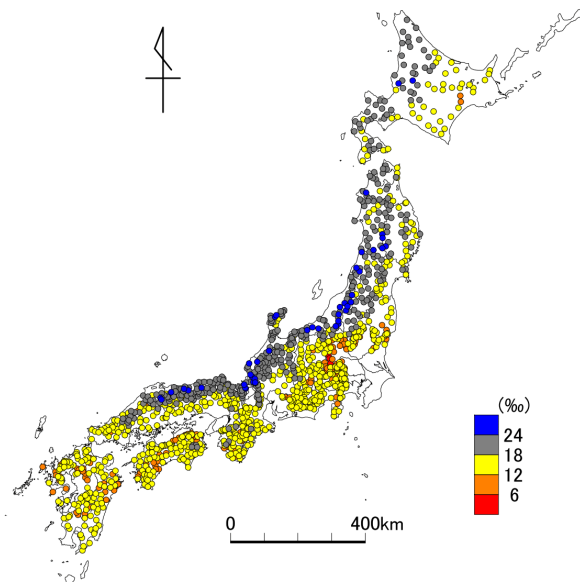
Full Screen / Esc

Printer-friendly Version

Interactive Discussion

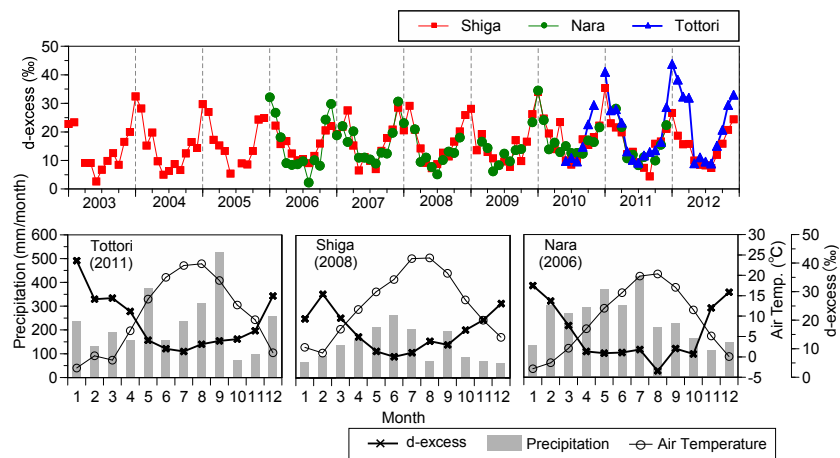
Discussion Paper





**Fig. 4.** Replaced Figure 5





**Fig. 5.** Replaced Figure 6

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper