



Recent research results on

# Global monsoon system in the **future**, **present** and **past**

**Hiroaki UEDA**

Professor, Life and Environmental Science  
(Joint Researcher of CCS)

Mission of my laboratory

- (1a) Evaluation of CMIP3&5 climate models for IPCC-AR4 and AR5
- (1b) Provide risk information of climate change for the society
- (2) Understanding and explaining unusual climate event such as anomalous hot year and extreme snowy winter
- (3) Paleoclimate modeling and its possible linkage with proxy-based researchers

(i) This work was supported by the **Global Environment Research Fund of the Ministry of the Environment (USD 750,000; JPY75,000,000)**.

Approx. USD 500,000, FY2008- FY2011, Code S5-2

Approx. USD 250,000, FY2012- FY2014, Code 2A1201



(ii) Job opportunities

PD researcher, Tomoshige INOUE (2008-2012)

PD researcher, Masamitsu HAYASAKI (2012-15)

(iii) Publication and Outreach

5 papers published in the international Journals  
(GRL, JGR, JAM, JMSJ, SOLA)

Among these, Ueda et al (2006; GRL) and extended papers revealed the physical process involved in the wind-precipitation paradox of the Asian summer monsoon and raised a question for uncertainties in the climate models. - which were cited in IPCC-AR4 as well as AR5.

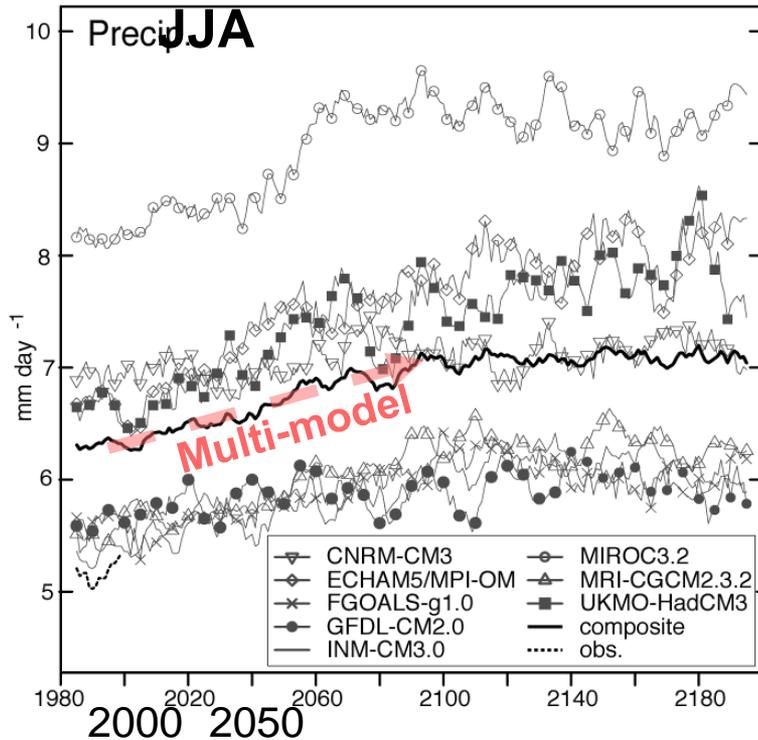
We made **outreach booklet** about the global warming and monsoon

# Wind-Precipitation Paradox in CMIP3

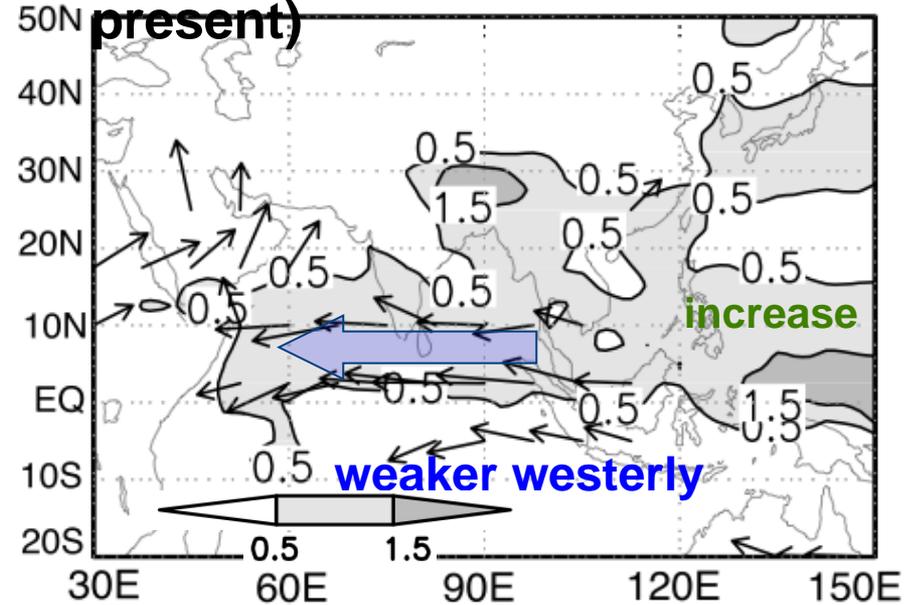


Multi-model ensemble

## Monsoon rain



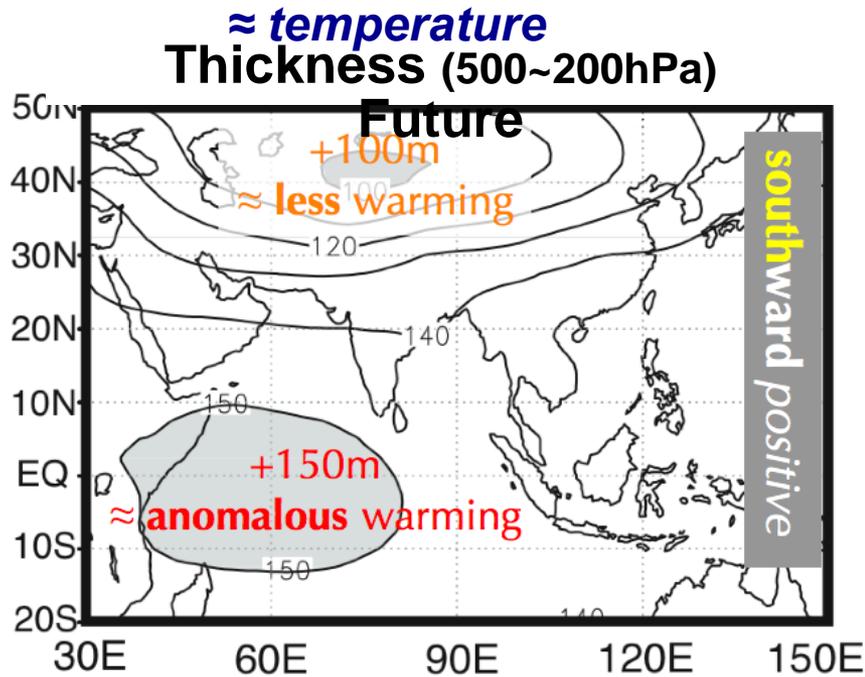
## Rain, winds (future minus present)



Ueda et al. (2006; GRL)

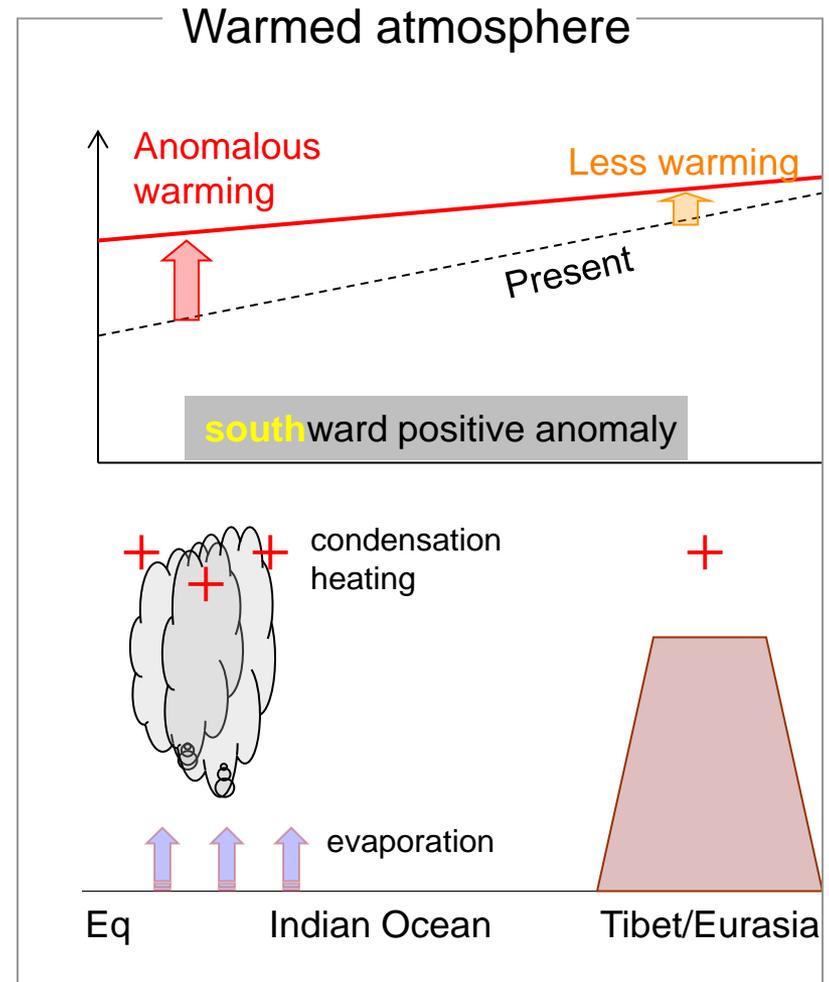
Monsoon rainfall is projected to increase while the low-level westerlies will be weakened

# Anomalous Tropical Warming



Anomalous upper tropospheric warming in the western Indian Ocean cause to decrease in MTG

- consistent with the attenuated circulation

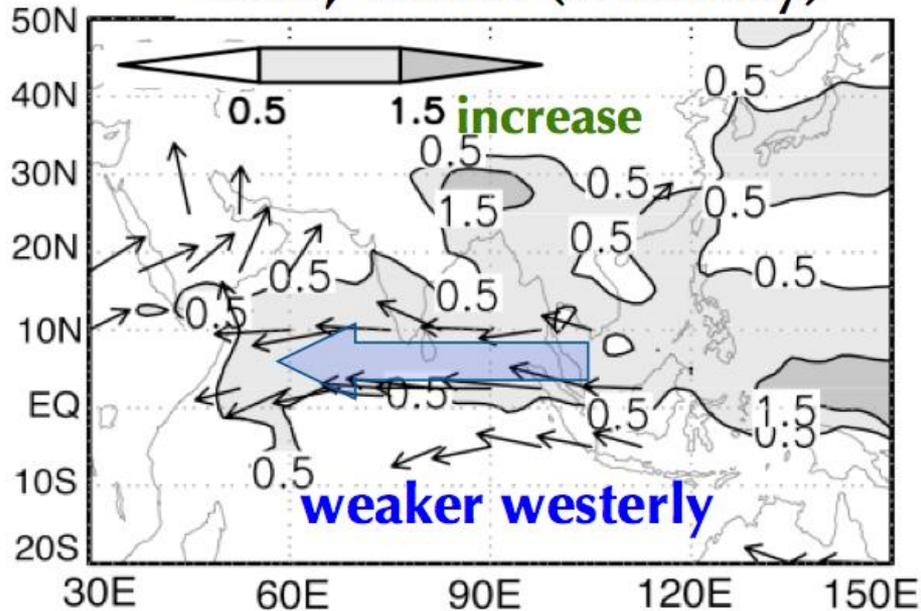


Ueda (2012, Climate system study)

# Comparison between CMIP3 and CMIP5

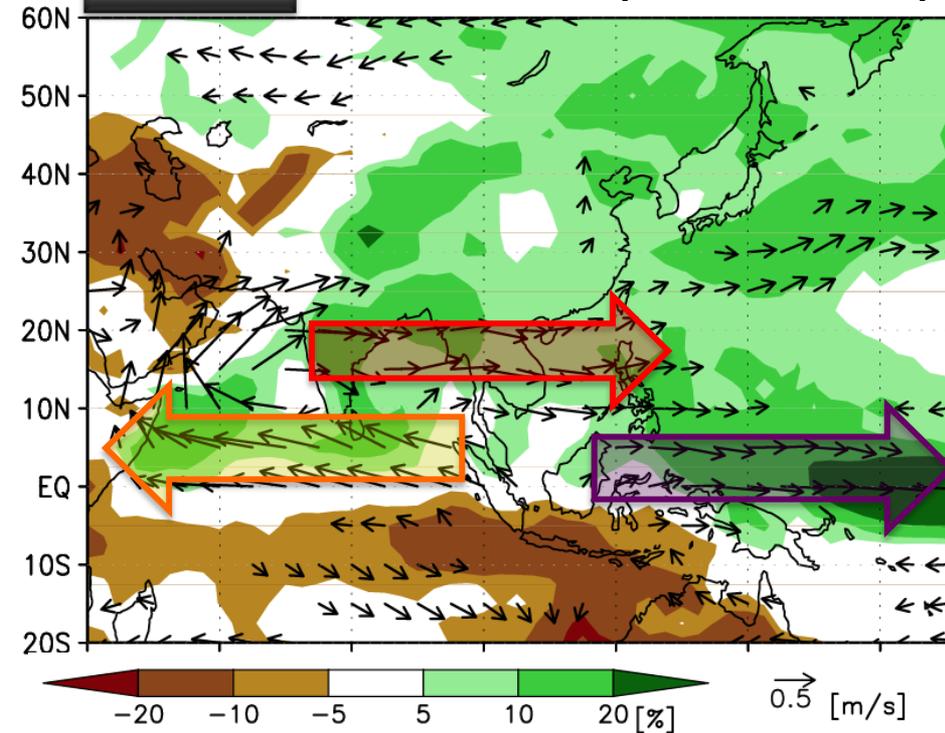
CMIP3

Rain, winds (anomaly)



CMIP5

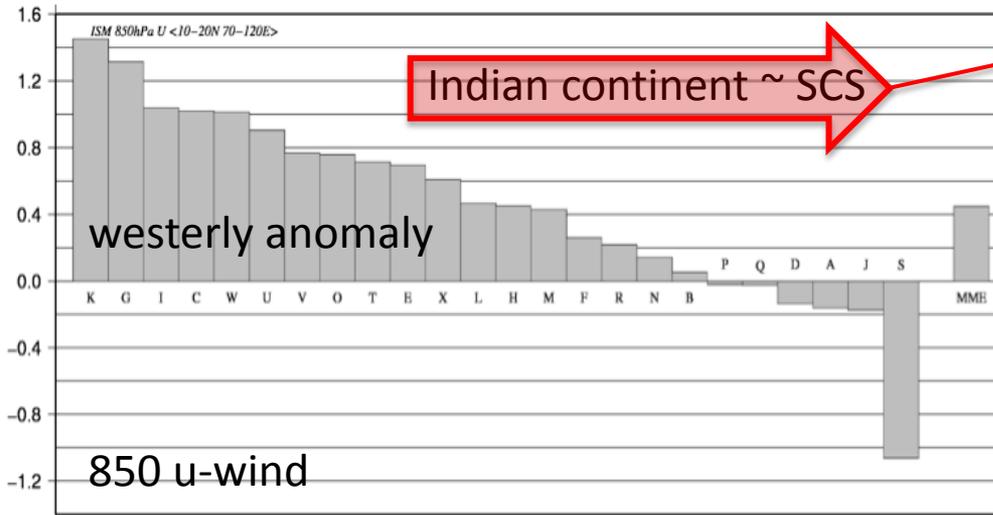
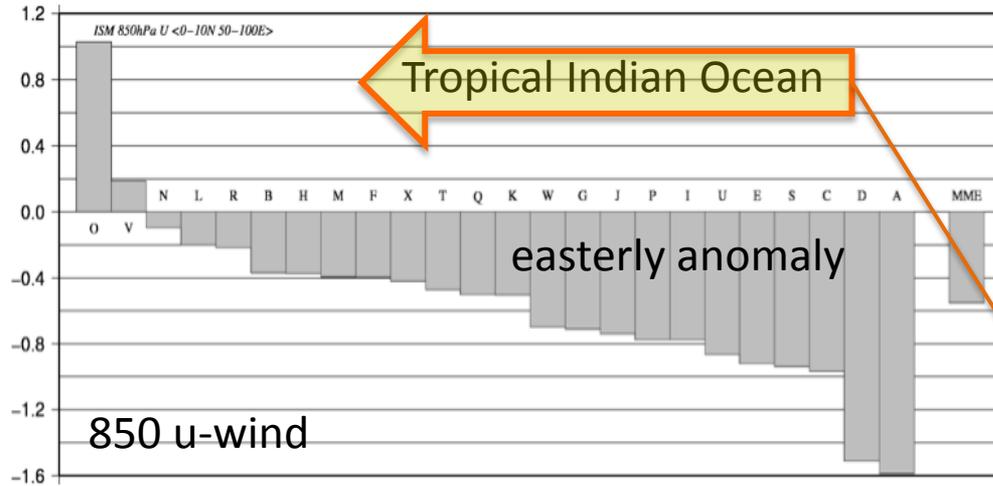
Rain, winds (MME, Future)



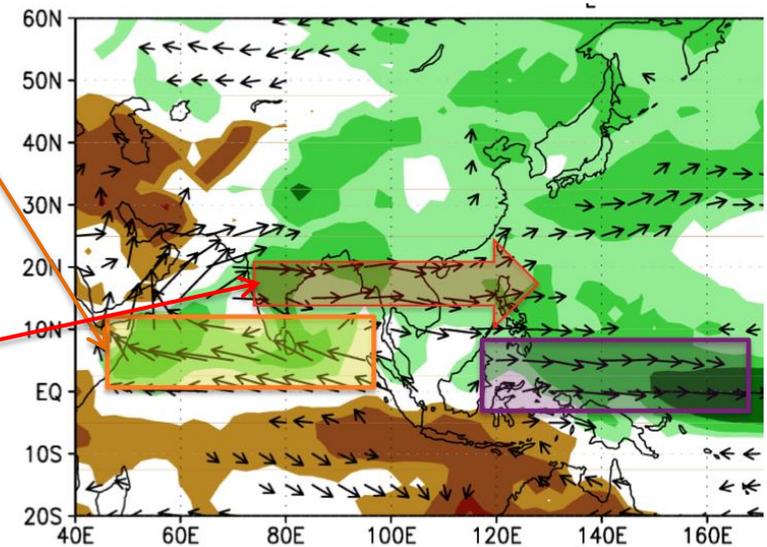
Ogata, Ueda, Hayasaki et al.(submitted)

In the CMIP5, the monsoon flows in the tropical Indian Ocean are projected to decrease, however... outside of the tropical Indian Ocean, **enhanced monsoon westerlies** and **weakened trade winds** newly emerge.

# Inter-model variability among CMIP5



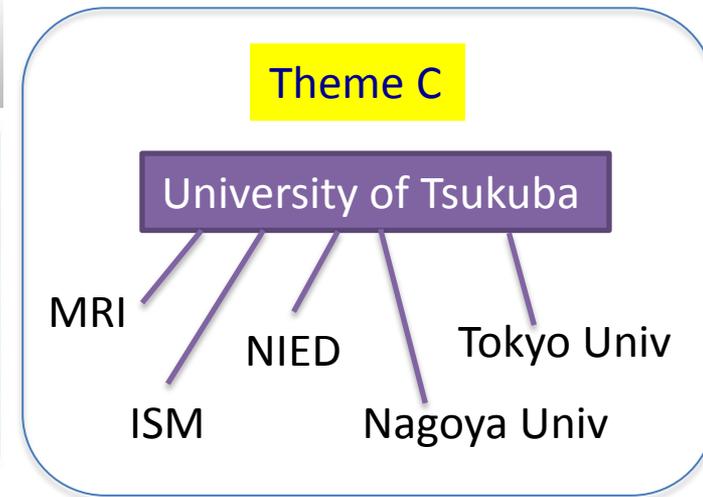
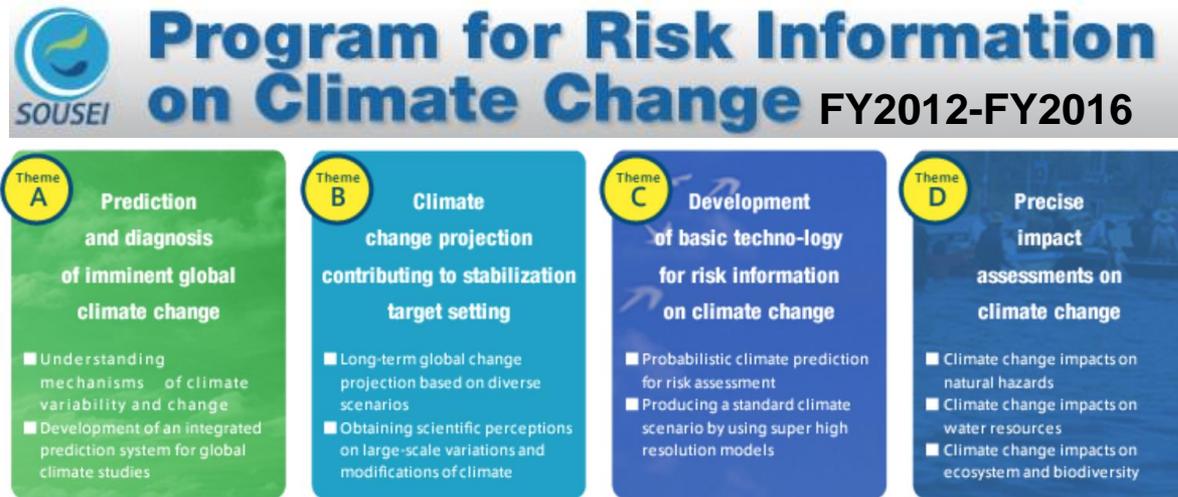
The most models show **weakening of the westerlies**



More than 70% models show **enhancement of westerlies**

Ogata, Ueda, Hayasaki et al.(submitted)

# (1b) Provide risk information of climate change for the society



(i) This work has been supported by the SOUSEI Program of the Ministry of Education, Culture, Sports, Science, and Technology of Japan since December 2012 until March 2017 (USD 11,000,000; JPY1,100,000,000).

11 billions

(ii) Job opportunities

- 5 PD researchers and 4 assistant staffs in UT
- Supervising 28 researchers in Meteorological Research Institute

(iii) Publication and Outreach

- Projected future change of tropical cyclone (Nature C.-C., 2013) etc etc

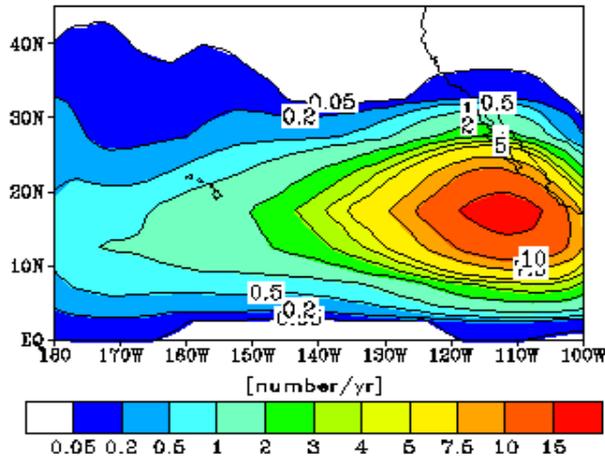
# Projected increase in tropical cyclones near Hawaii

nature  
climate change

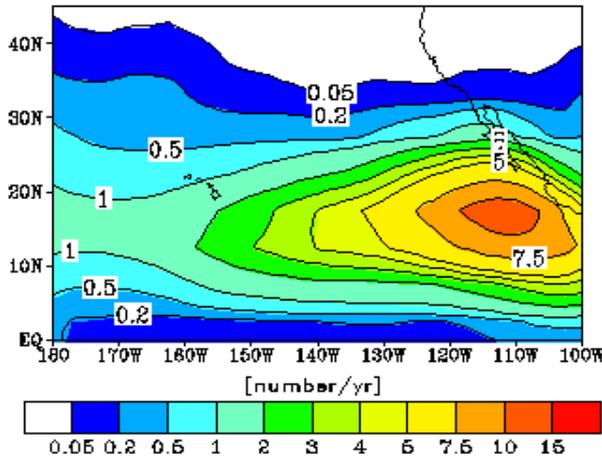
LETTERS

PUBLISHED ONLINE: 5 MAY 2013 | DOI: 10.1038/NCLIMATE1890

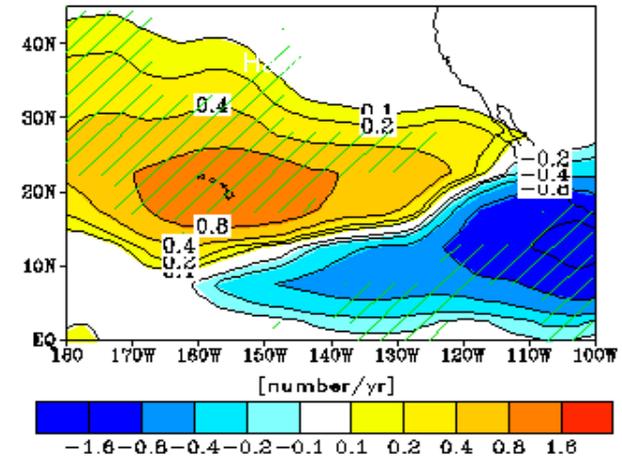
(a) Observations (1979–2003)



(b) Present-day (1979–2003)



(c) Future Change

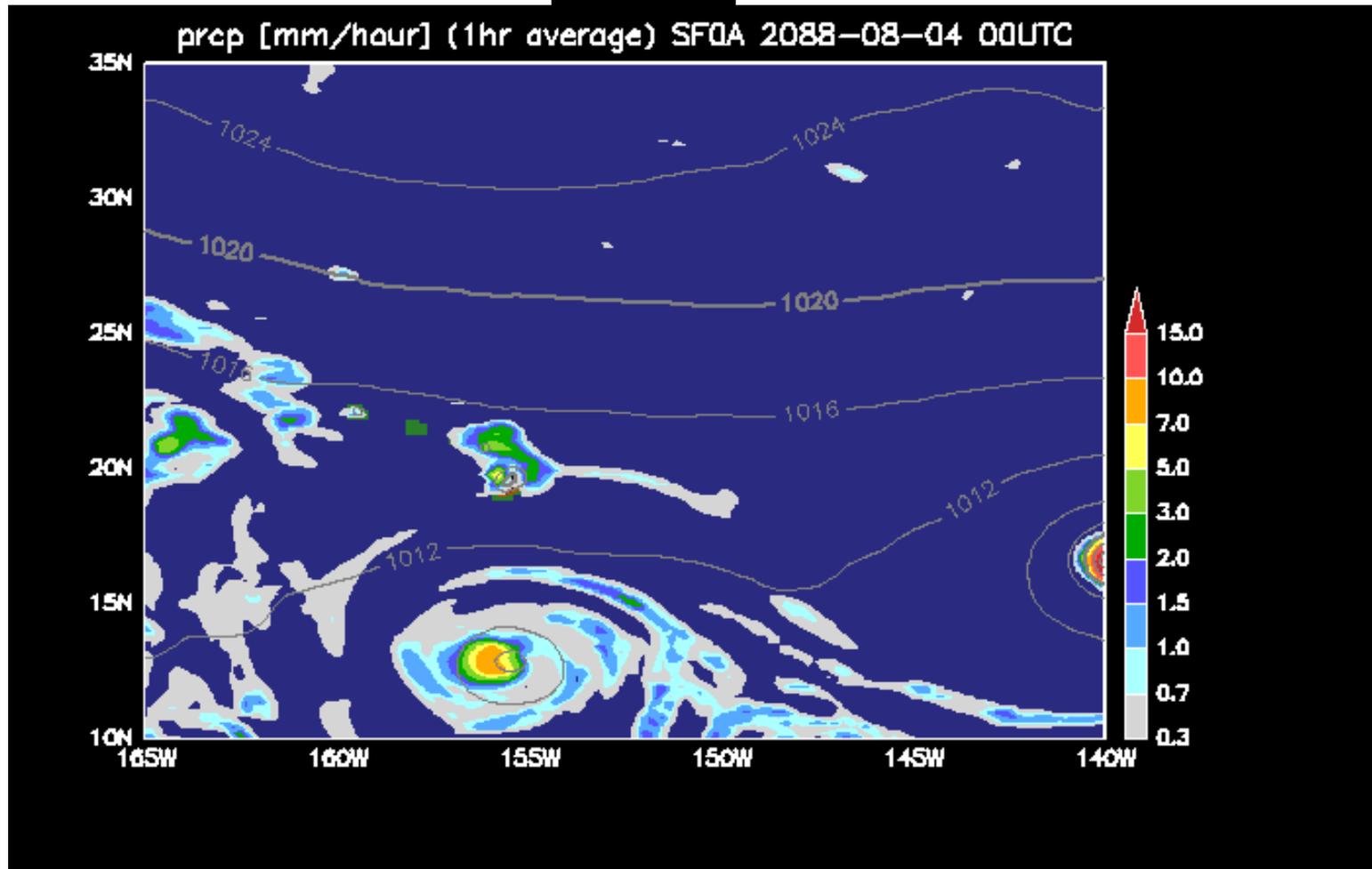


**A suite of future warming experiments (2075–2099), using a state-of-the-art high-resolution global climate model<sup>1–3</sup>, robustly predicts an increase in tropical cyclone frequency of occurrence around the Hawaiian Islands.**

Murakami et al. (2013, Nature-C.C.)

# Projected increase in tropical cyclones near Hawaii

movie



Murakami et al. (2013, Nature-C.C.)

## (2) Understanding and explaining unusual climate event such as anomalous hot year and extreme snowy winter

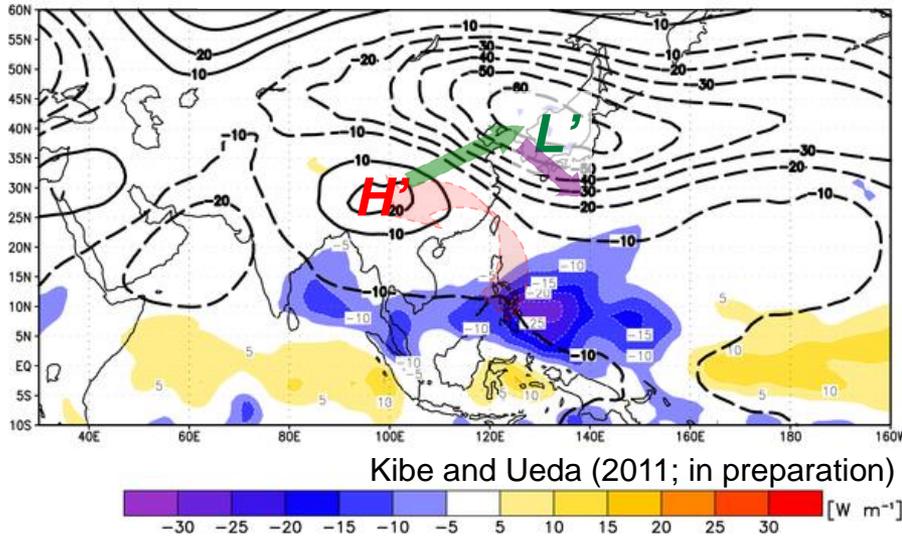
- The aim of this theme is to reveal physical processes that are responsible for anomalous climate event occurred in Japan and neighboring regions
- Ueda and Tanaka have contributed to ALL-JAPAN working group for “extreme climate” as researcher and advisor.
- Focused on excessive snowfall event occurred in 2009, 2010 and 2011 winters in terms of continued La Niña event by use of in situ observations together with linear baroclinic model, which has been submitted to IJC.

# La Niña related heavy snowfall around Japan

Statistical analysis

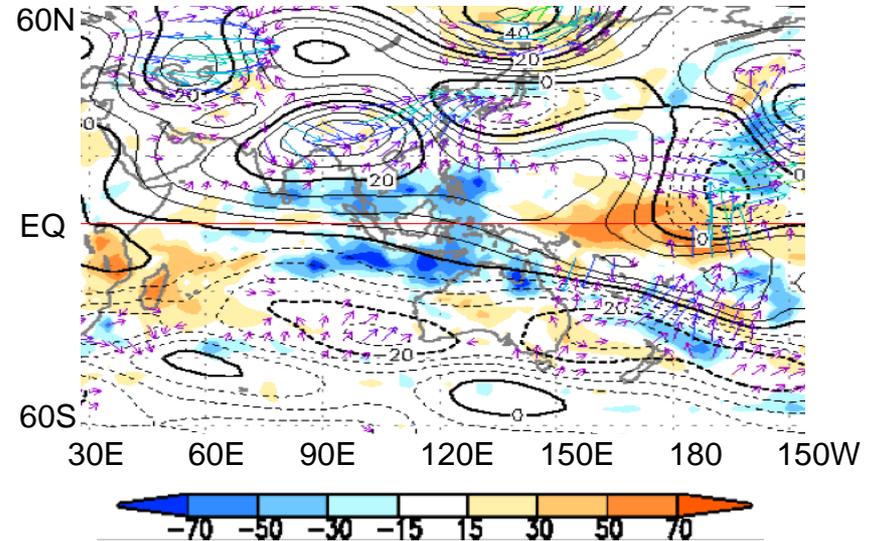
Heavy snow years in Japan

OLR &  $\psi_{200}$  anomaly



2010/11 winter (12/28-1-3)

OLR &  $\psi_{200}$  anomaly with WAF



Enhanced tropical **convection** induces **H'** over the Asian continent and resultant **L'** is responsible for strong **north-westerly** and ensuing heavy **snowfall** over Japan

Ueda et al.(2014; IJC, in revision)

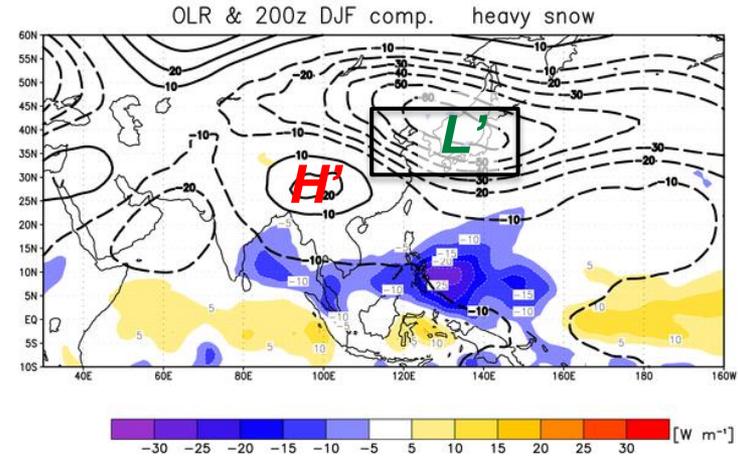
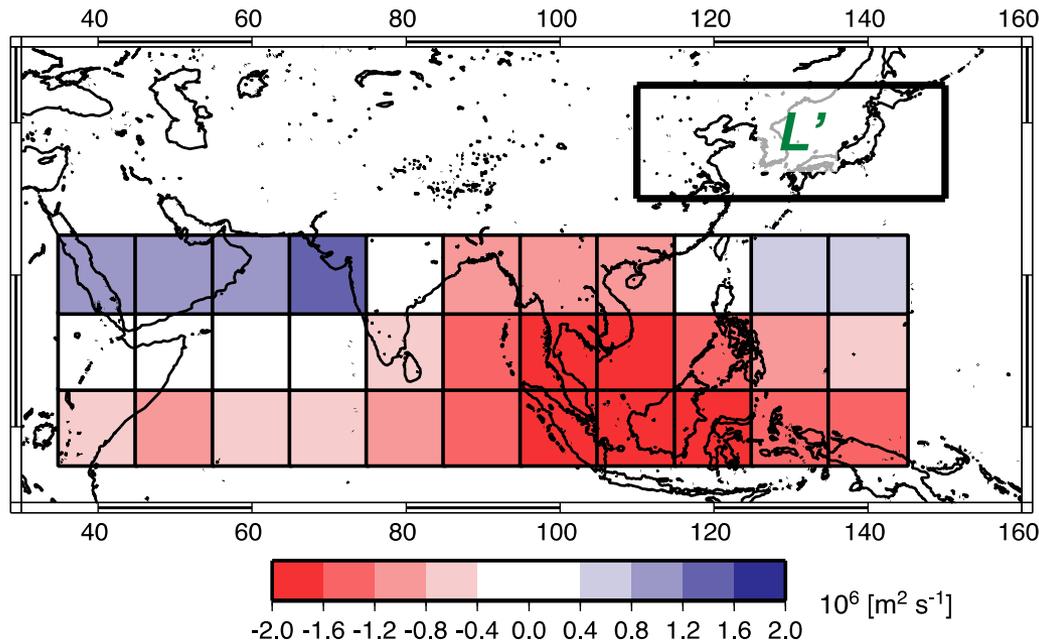


Aizu



Tottori

# Heat-induced response to the atmosphere



Contribution of idealized grid heating to the development of the **anomalous cyclonic circulation over Japan**. The plotted values of each grid are the regional mean of the stream function at 500 hPa averaged over  $110^{\circ}$  -  $150^{\circ}$  E,  $30^{\circ}$  -  $45^{\circ}$  N, corresponding to the same individual heating anomaly.

The largest **contribution** can be seen over the **maritime continent** and its **neighboring regions**, which is caused by the **enhanced convection** relevant to the **La Niña**

### (3) Paleoclimate modeling and its possible linkage with proxy-based researchers

- Joined paleoclimate modeling Intercomparison project (PMIP) since 2009  
KYOTO WS.

This project is not supported financially, but yields many papers on Pliocene with joint researchers in the world (8 papers)

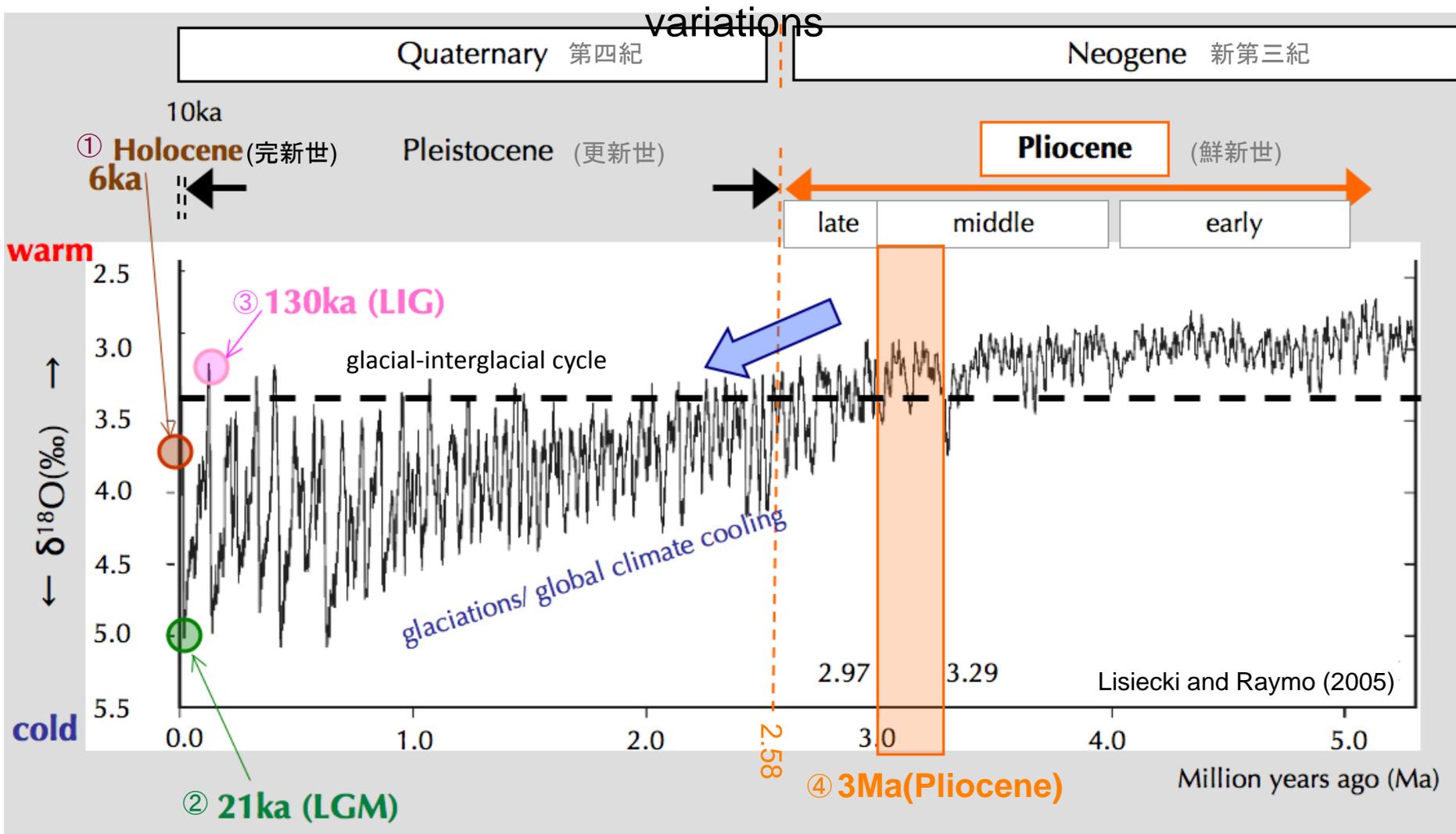
ex.) Nature Climate Change (2013).

One students got Ph. D.

- Studied the Last Glacial Maxima (LGM) and Cretaceous climate, which get published in the international journals (Clim. Dyn, JMSJ)
- Made collaboration between proxy-based researchers through “JALPS” project  
One exchange student from Shinshu univ. got Master degree

# Paleoclimate Modelling Intercomparison Project

PMIP targets 4 periods to understand inherent process in the climate

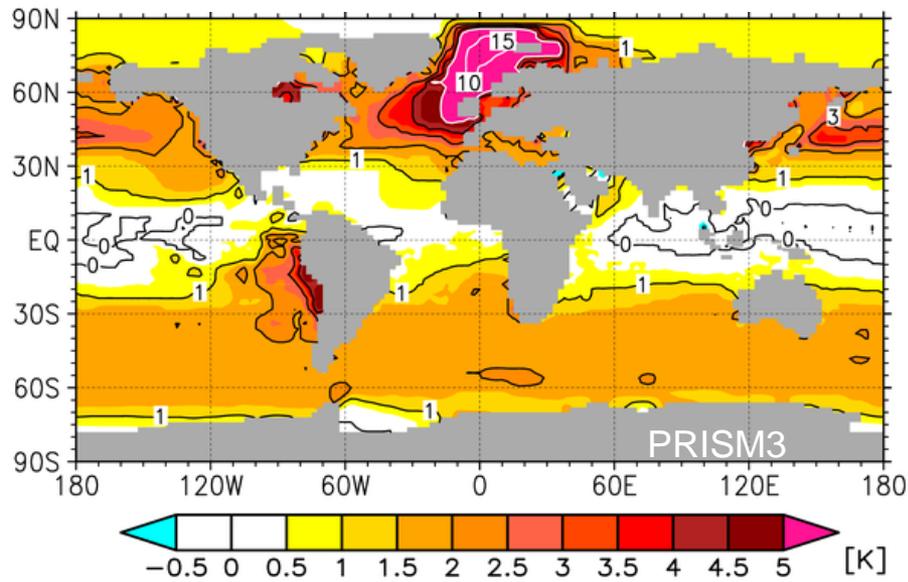


LGM: Last Glacial Maximum (最終氷期最大期)

6ka~ Hypsitherml (氣候最適期/繩文海進)

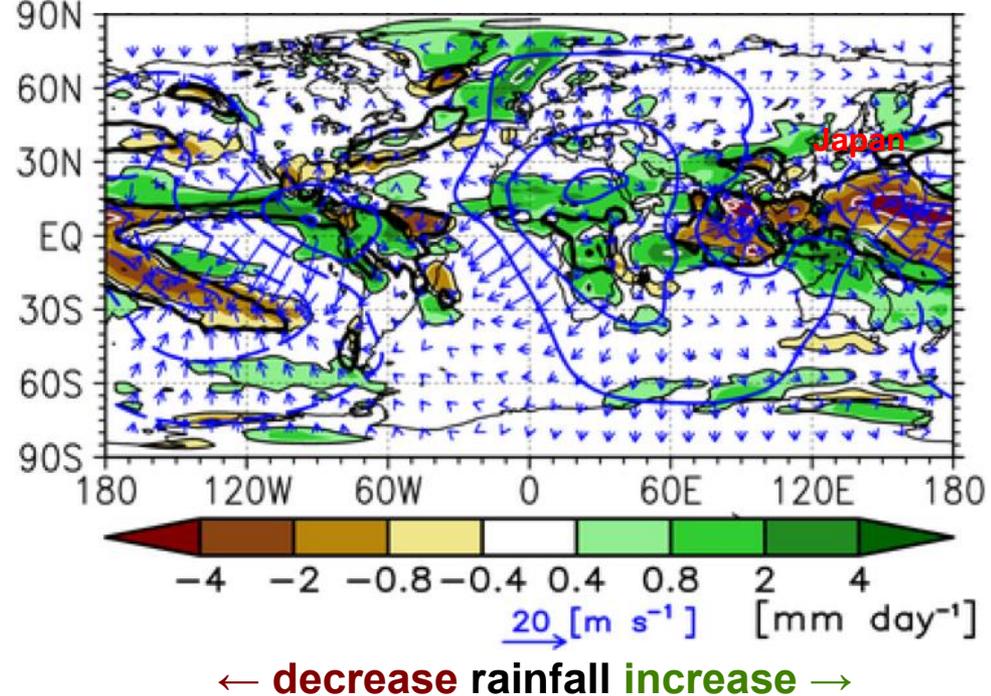
# Mid-Pliocene (3Ma)

SST Anomaly (relative to present)



Reconstructed SST from proxy data shows remarkable **warming** in the **Atlantic**, especially in the **higher** latitudes while the anomalies are obscure in the tropics.

Rain and  $\chi$  200 Anomaly (relative to present)



Monsoonal rainfall is much suppressed, while African monsoon expands poleward ( $\approx$  green Sahara?)

=> Implicating **reversed** *monsoon-desert* mechanism

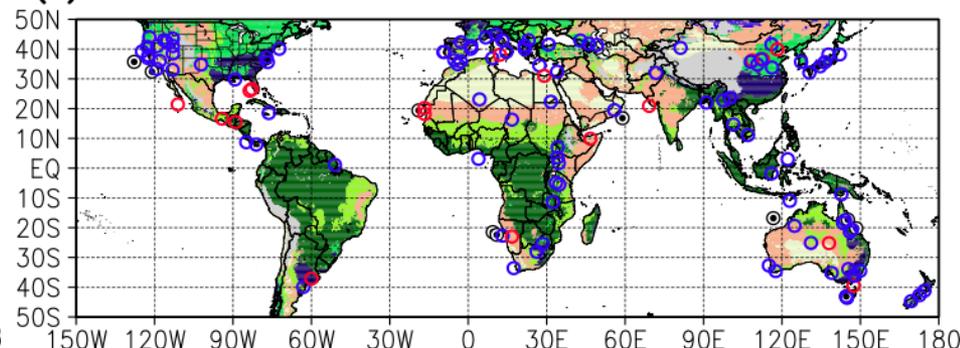
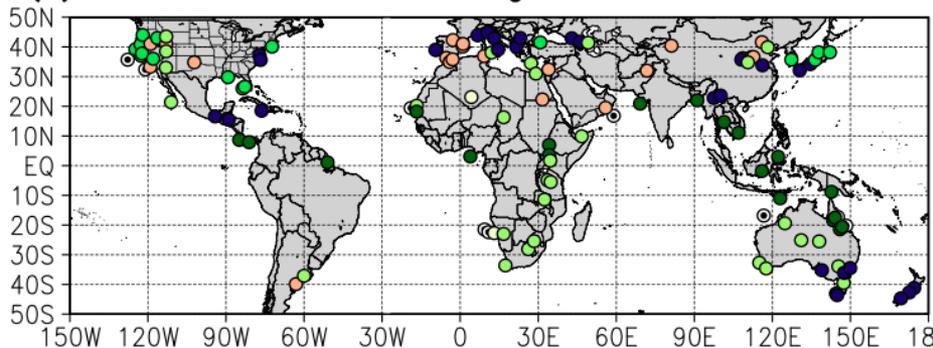
# Reconstructed Vegetation in MPWP

Prox

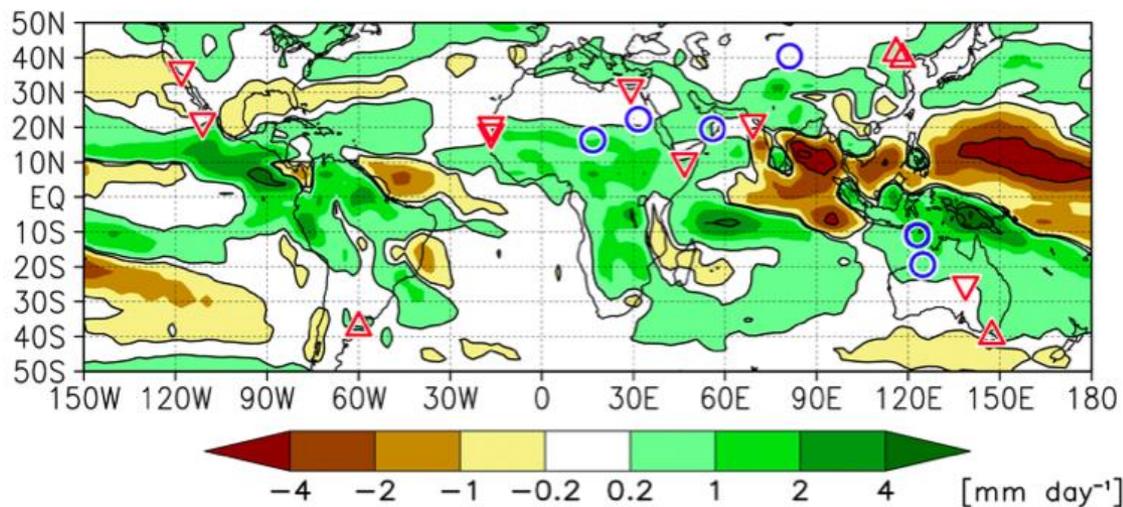
Simulation

(a) PRISM3 reconstructed vegetation

(c) BIOME4 MPWP



(b) precipitation MPWP-PD



Evaluation

Kamae and Ueda (2012; SOLA)

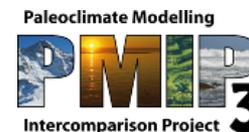
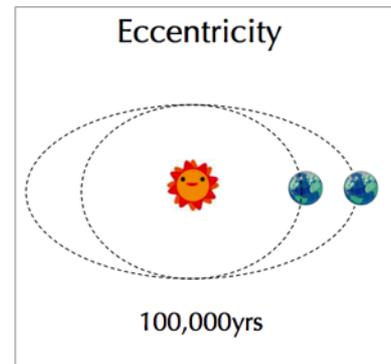
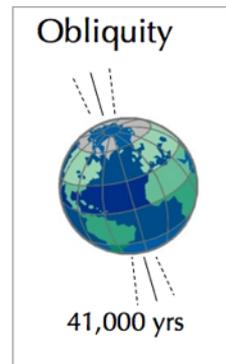
# Pliocene Joint Studies 2009~

- 1) **Kamae, Y.**, [Ueda, H.](#), and A. Kitoh, 2011: Hadley and Walker circulations in mid-Pliocene warm period simulated by an atmospheric general circulation model. *J. Meteor. Soc. Japan*, 89, 475-493.
- 2) **Kamae, Y.**, [Ueda, H.](#), 2011: Evaluation of simulated climate in lower latitude regions during the mid-Pliocene warm period using paleovegetation data. *SOLA*, 7, 177-180, doi:10.2151/sola.2011-045.
- 3) **Kamae, Y** and [Ueda, H.](#): Mid-Pliocene global climate simulation with MRI-CGCM2.3: set-up and initial results of PlioMIP Experiments 1 and 2, *Geosci. Model Dev.*, 5, 793-808, doi:10.5194/gmd-5-793-2012, 2012.
- 4) Haywood, A. M., D. J. Hill, A. M. Dolan, B. Otto-Bliesner, F. Bragg, W.-L. Chan, M. A. Chandler, C. Contoux, A. Jost, **Kamae, Y.** G. Lohmann, D. J. Lunt, A. Abe-Ouchi, S. J. Pickering, G. Ramstein, N. A. Rosenbloom, L. Sohl, C. Stepanek, Q. Yan, [Ueda, H.](#), and Z. Zhang, 2013: Large scale features of Pliocene climate: Results from the Pliocene model intercomparison project. *Clim. Past*, 8, 2969-3013.
- 5) Zhang, Z.-S., K. H. Nisancioglu, M. A. Chandler, A. M. Haywood, B. L. Otto-Bliesner, G. Ramstein, C. Stepanek, A. Abe-Ouchi, W.-L. Chan, F. J. Bragg, C. Contoux, A. M. Dolan, D. J. Hill, A. Jost, **Kamae, Y.** G. Lohmann, D. J. Lunt, N. A. Rosenbloom, L. E. Sohl, and [Ueda, H.](#), 2013: Mid-pliocene Atlantic Meridional Overturning Circulation not unlike modern. *Clim. Past*, 9, 1495-1504.
- 6) Dowsett, H.J., K. M. Foley, D. K. Stoll, M. A. Chandler, L. E. Sohl, M. Bentsen, B. L. Otto-Bliesner, F. J. Bragg, W.-L. Chan, C. Contoux, A. M. Dolan, A. M. Haywood, J. A. Jonas, A. Jost, Y. **Kamae, Y** Lohmann, D. J. Lunt, K. H. Nisancioglu, A. Abe-Ouchi, G. Ramstein, C. R. Riesselman, M. M. Robinson, N. A. Rosenbloom, U. Salzmann, C. Stepanek, S. L. Strother, [Ueda, H.](#) Q. Yan, and Z. Zhang, 2013: Sea surface temperature of the mid-Piacenzian ocean: A data-model comparison. *Scientific Reports*, 3, 2013, doi:10.1038/srep02013.
- 7) Zhang, R., Q. Yan, Z. S. Zhang, D. Jiang, B. L. Otto-Bliesner, A. M. Haywood, D. J. Hill, A. M. Dolan, C. Stepanek, G. Lohmann, C. Contoux, F. Bragg, W.-L. Chan, M. A. Chandler, A. Jost, **Kamae, Y.** A. Abe-Ouchi, G. Ramstein, N. A. Rosenbloom, L. Sohl, and [Ueda, H.](#), 2013: Mid-Pliocene East Asian monsoon climate simulated in the PlioMIP. *Clim. Past*, 9, 2085-2099.
- 8) Hill, D. J., A. M. Haywood, D. J. Lunt, S. J. Hunter, F. J. Bragg, C. Contoux, C. Stepanek, L. Sohl, N. A. Rosenbloom, W-L. Chan, **Kamae, Y.** Z. Zhang, A. Abe-Ouchi, M. A. Chandler, A. Jost, G. Lohmann, B. L. Otto-Bliesner, G. Ramstein, and [Ueda, H.](#), 2014: Evaluating the dominant components of warming in Pliocene climate simulations. *Clim. Past*, accepted.
- 9) Salzmann, U., Dolan, A.M., Haywood, A M., Chan W.-L., Voss, J., Hill, D.J., Lunt, D. J., Abe-Ouchi, A., Otto-Bliesner, B., Bragg, F., Chandler, M. A., Contoux, C., Dowsett, H.J., Jost, A., **Kamae, Y.**, Lohmann, Pickering, S.J., Pound M.J., Ramstein, G., Rosenbloom, N.A., Sohl, L., Stepanek, C., [Ueda, H.](#) Zhang, Z. (2013): Challenges in reconstructing terrestrial warming of the Pliocene revealed by data-model discord. *Nature Climate Change*. 3, doi:10.1038/nclimate2008.

# AO-GCM Experiment in LGM

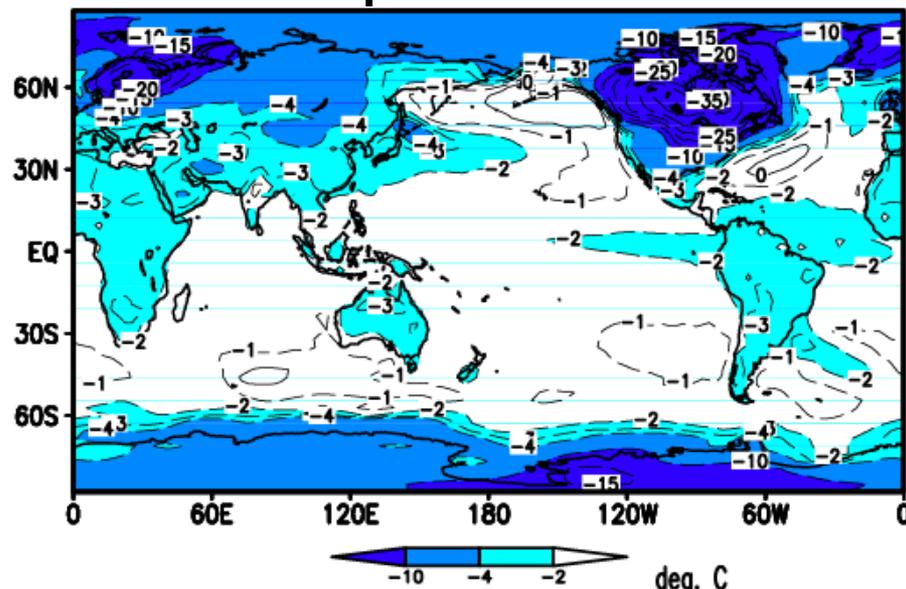
		Present	LGM
<b>Greenhouse effect gas</b>	CO <sub>2</sub>	280	185
	CH <sub>4</sub>	760	350
	N <sub>2</sub> O	270	200
<b>Orbital Parameters</b>	Eccentricity	0.0167	0.0189
	Obliquity	23.45	22.95
	Precession	102.04	114.42
<b>Ice sheet</b>			ICE-5G

lowered

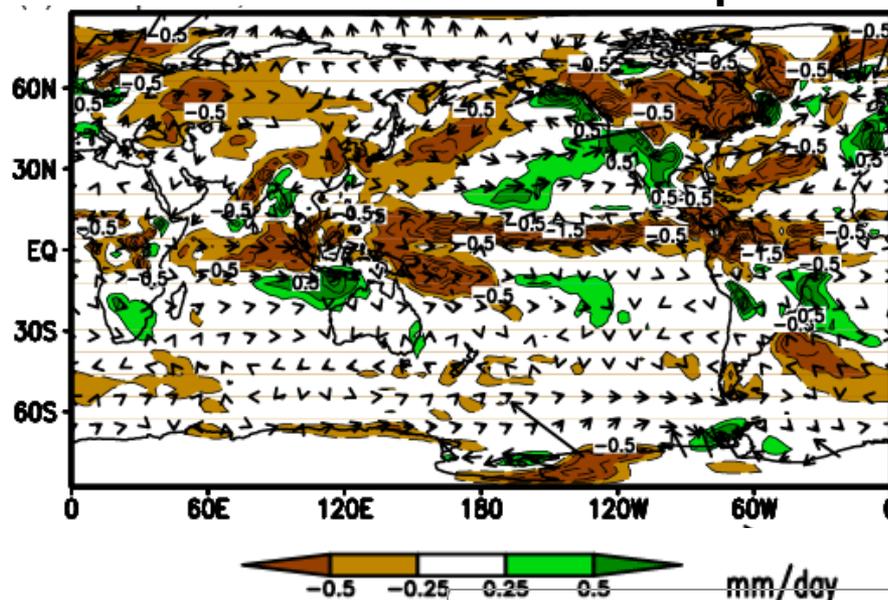


## LGM-anomaly (annual mean)

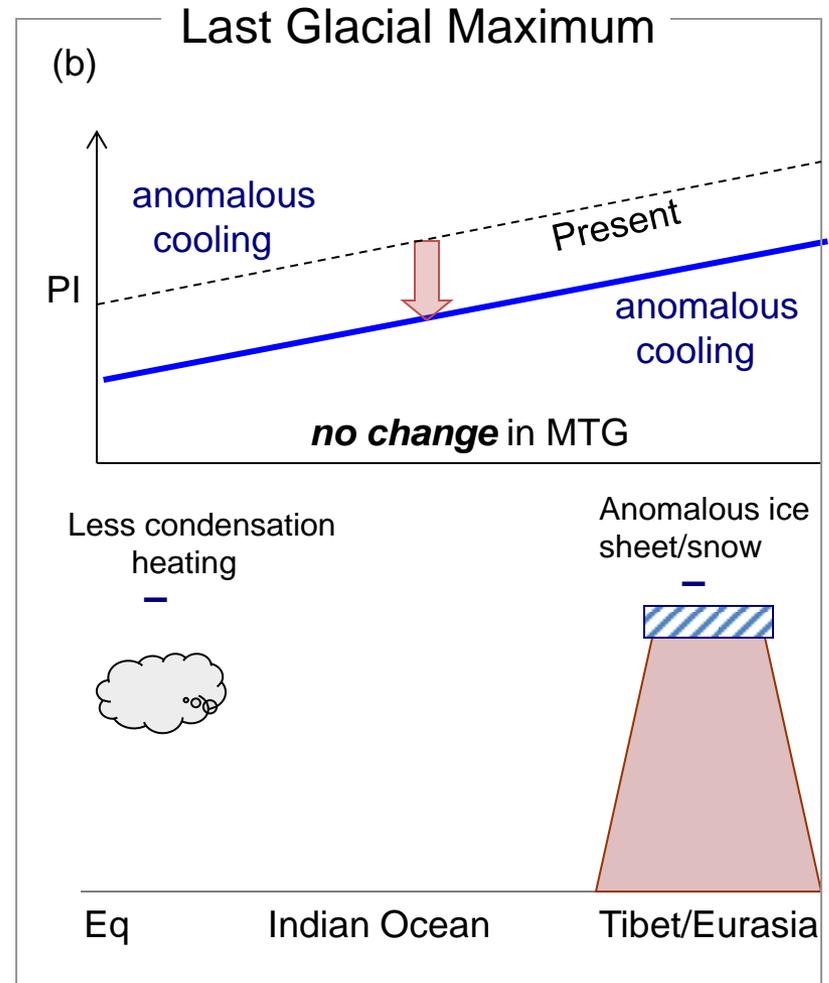
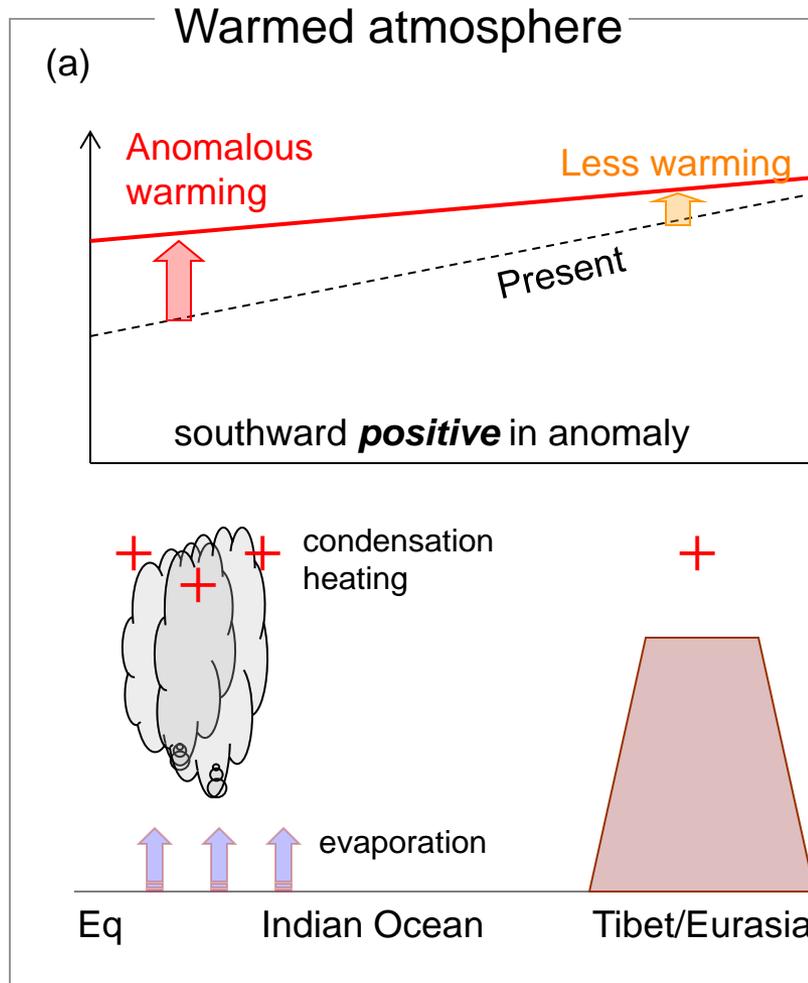
### Surface Temperature



### Precipitation



# Comparison in MTG with LGM Climate



植田宏昭 topage 著作物(論文等) 共同研究 研究  
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 候システム論 (書籍)

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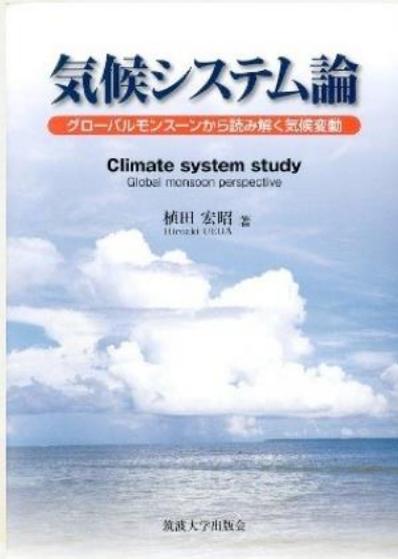
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植田宏昭 topage 著作物(論文等) 共同研究 研究  
 サービス 教育サービス メンバー 外部資金 プロ  
 フィール・連絡先 リンク 授業資料 presentation 気  
 候システム論 (書籍)

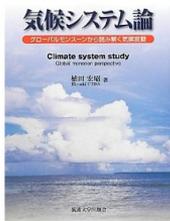


この度、筑波大学出版会より、「気候システム論」を上梓しました。本の執筆を通し、気候変動研究の奥深さを再認識するとともに、この分野の研究と教育への想いを新たにしております。

ここでは、「はじめに」、「目次」、「ニニコラム」、「Appendix」、「おわりに」をご紹介します。

買う前の参考になればと思います。

→ [\[Sample download\]](#)



気候システム論—グローバルモンスーンから読み解く気候変動 (単行本)

植田 宏昭 (著)

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皆さんの勉強はもとより、筑波大出版会の存続のためにも、どうぞお買い求めください(植田には印税は入りません)

“Climate System Study” will appear in English in this spring (2014)



University of Tsukuba  
Press

ISBN000-0-000-00000-0

C0000 ¥0000E

定価 (本体0,000円+税)

発売所 丸善出版



9784621078754



1921082024007

Climate System Study

Global monsoon perspective Hiroaki UEDA

University  
of Tsukuba  
Press

# Climate System Study

Global monsoon perspective

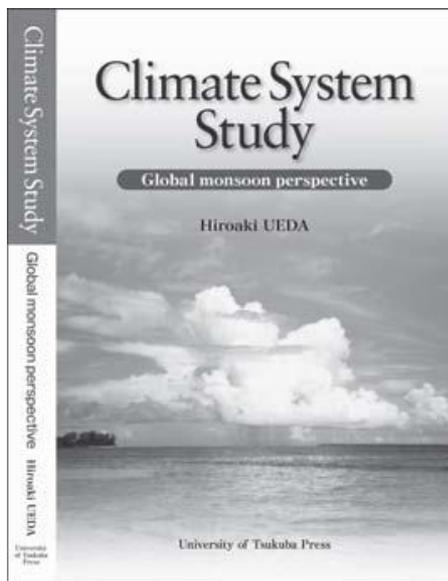
Hiroaki UEDA



Cover photograph  
Morning shower in the vicinity of Manus Island,  
New Guinea ( 09 LT in November 1992)

Back Cover photograph  
Daytime enhanced convection over Manus Island,  
New Guinea ( 13 LT in November 1992)

University of Tsukuba Press



# Climate System Study

- Global monsoon perspective -

by Hiroaki UEDA,  
Tsukuba University of Press

This book is intended for graduate students and research workers in earth system studies and global change research who may have interest in extreme climate event, global warming and paleo-climate.

The global monsoon is by far the most striking phenomenon in the climate system that is regulated by atmosphere-ocean-land interactions, varying various time-scales. To know the mechanisms involved in the unusual climate such as hot summer, torrential rainfall, drought and heavy snowfall etc, which requires the high level details about the dynamic and thermodynamic processes.

This volume also provides basic framework of the climate and ocean dynamics that can explain fluctuation of the El Niño-Southern Oscillation as well as establishment and maintenance of the global monsoon. There has been updating topics such as future projection of the global monsoon, which is added to the original Japanese book.

will appear March, 2014

ISBN978-4-904074-31-2\_\_272 pp.  
3,500 Yen (tax. is not included)

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