

Overview of the Center for Computational Sciences  
Summary of Activities for 2008 to 2013

*Division of Global Environmental  
Science*

Atmospheric Science Group  
Hiroshi L. Tanaka  
(Group Leader)



# Group Member

- Hiroshi L. Tanaka, Prof. CCS Staff (Since 2004)
- Hiroyuki Kusaka, Assoc. Prof. CCS Staff (Since 2006)
- Hiroaki Ueda, Affiliated Prof. University of Tsukuba
- Yasutaka Wakazuki, Affiliated Asst. Prof. U. Tsukuba
- Researchers in CCS : Drs. Akimoto, Ikeda, (Terasaki)

Graduate Student in CCS:

DC: (7) Kondo, Aizawa, Yamagami, Koshiba, Katoh, Doan, Nishi

MS:(10) Umino, Kino, Baba, Kudoh, Kuno, Fujita, and others



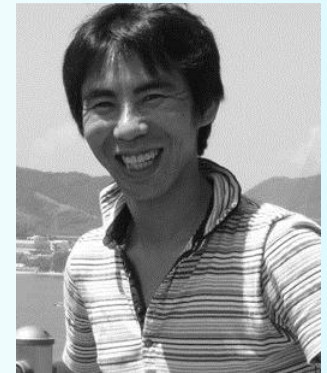
**Tanaka**



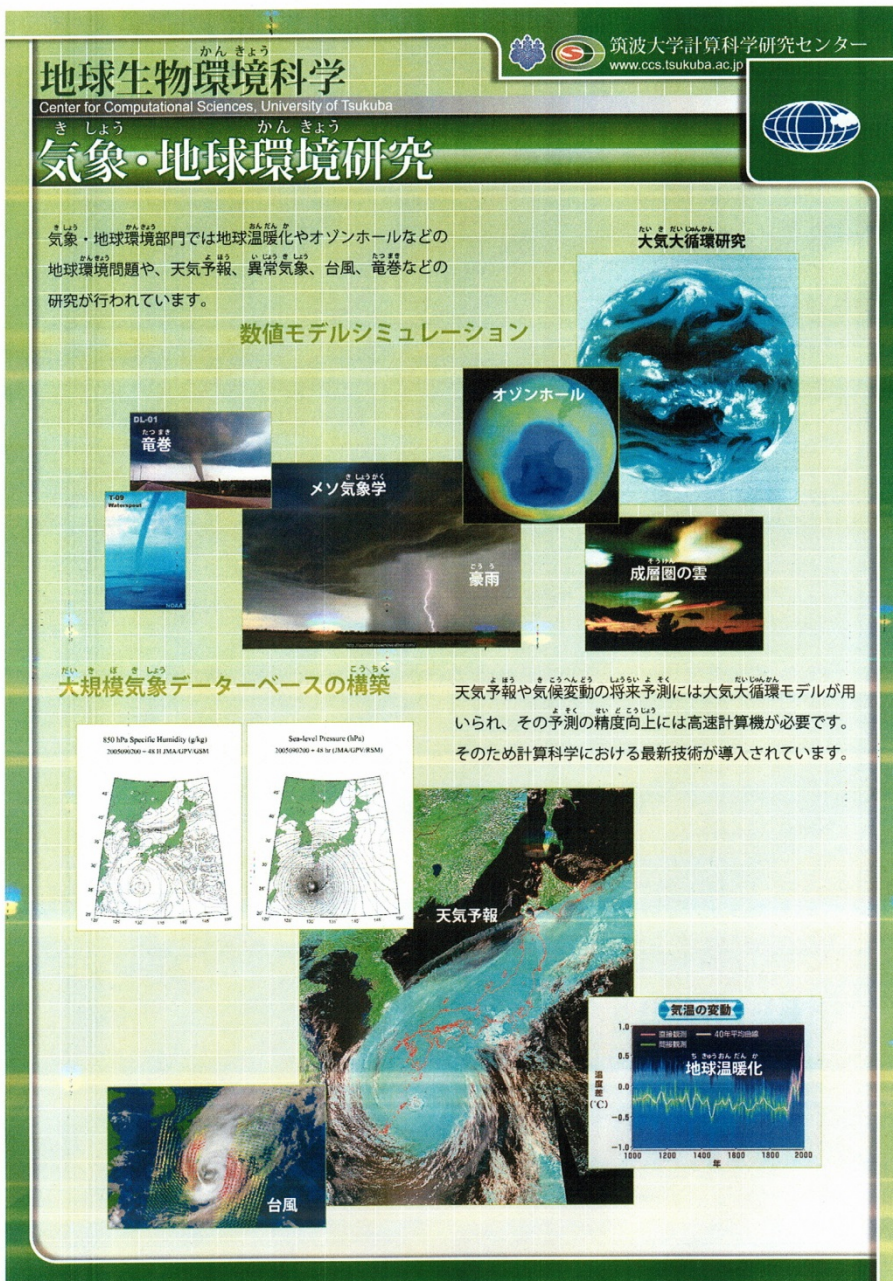
**Kusaka**



**Ueda**



**Wakazuki**



## Research activity (H.L. Tanaka)

- General circulation of the atmosphere
- Global warming and Arctic Oscillation
- Global warming and tropical circulation
- Global spectral energetics
- Blocking and abnormal weather
- Dynamics of baroclinic waves

## Research activity (H. Kusaka)

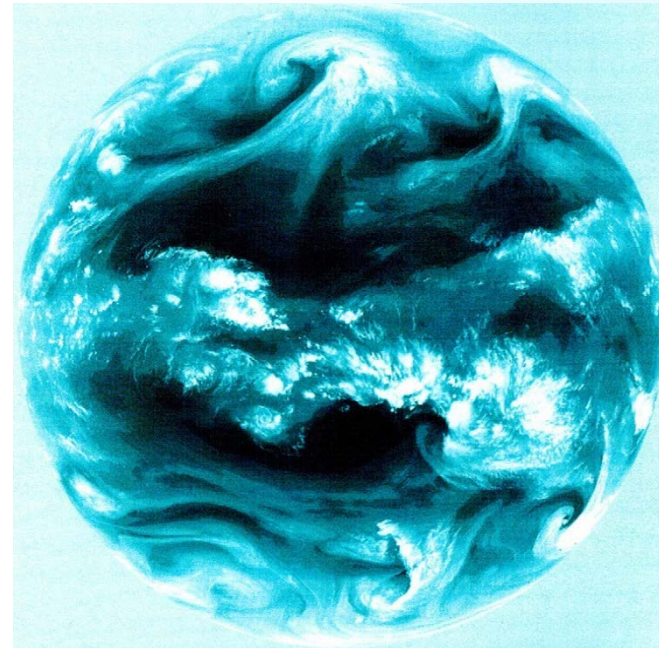
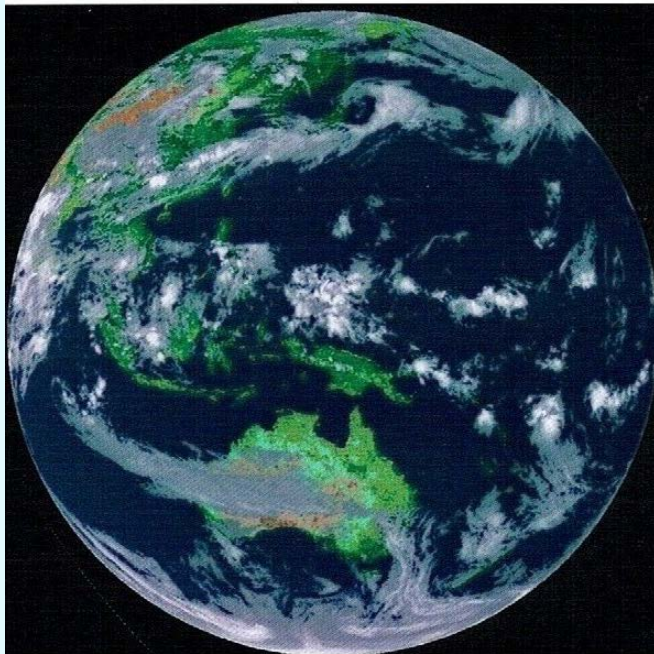
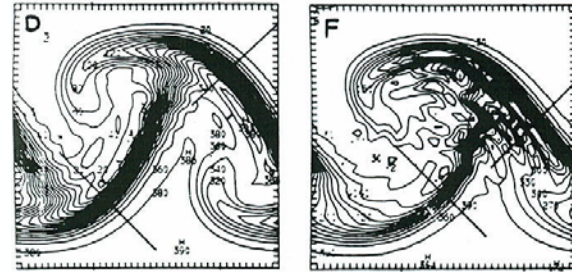
- Regional modeling using WRF
- Urban climate modeling
- Meso-scale precipitation system
- GPS and data assimilation
- Surface heat budget and radiation
- Real-time regional prediction system



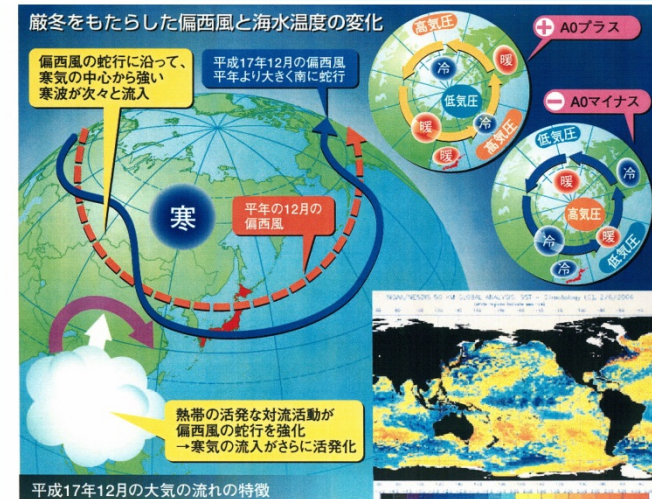
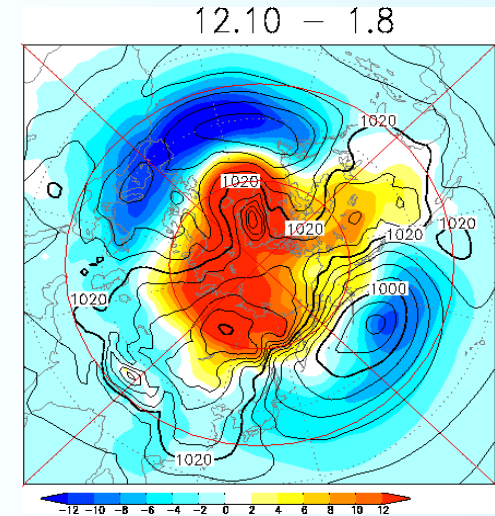
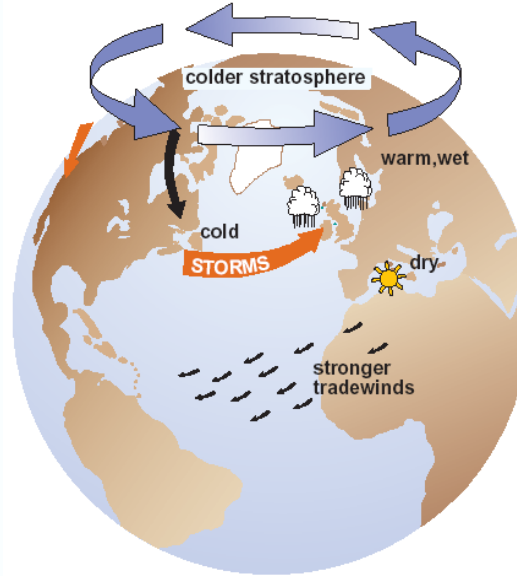
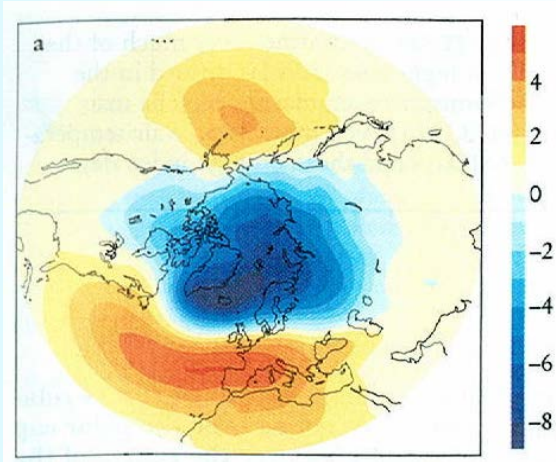


# General Circulation Study

- Data analysis
- Dynamical theories
- Numerical modeling



# Global warming and Arctic Oscillation





# Arctic Oscillation

## Singular eigenmode theory

### AO (DJF)

Barotropic Height

Arctic Oscillation (DJF)

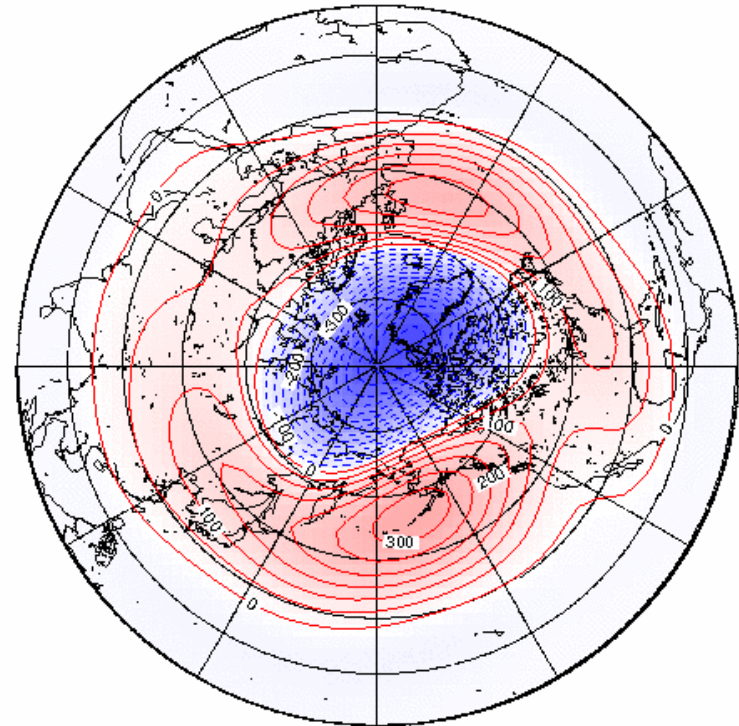
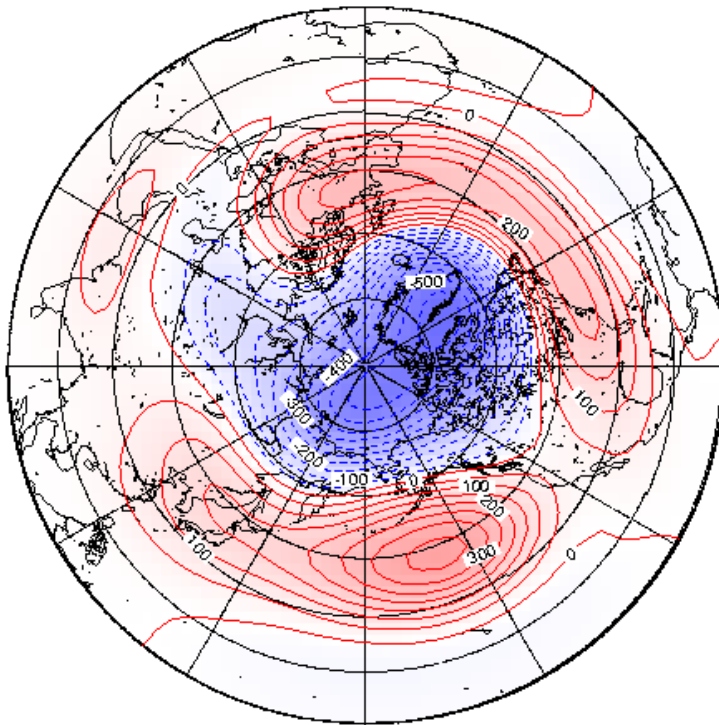
EOF-1

EVP-1

### Eigenmode

Barotropic Height

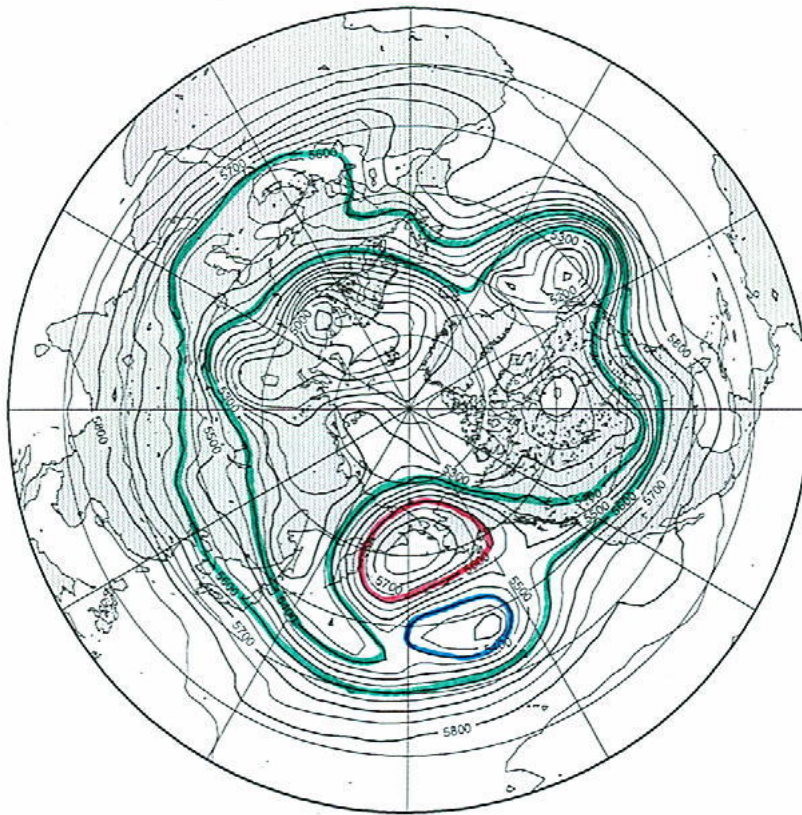
Standing eigenmode EVP-1



# Blocking in the Barotropic S-model

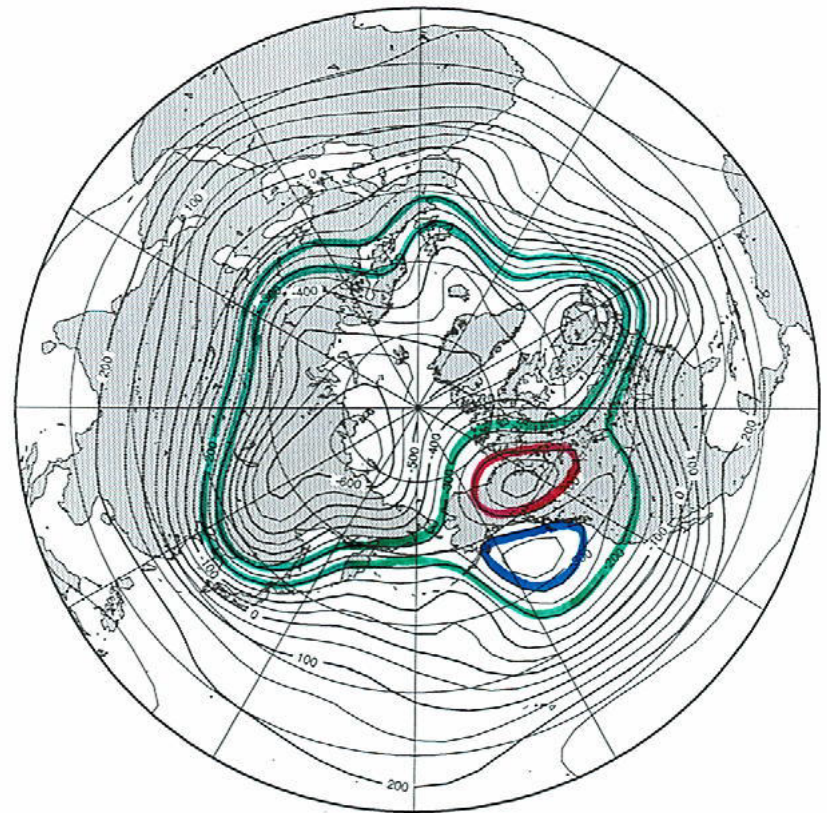
500 hPa Height

JMA GPV 97031412+00



Geopotential Height

Run-02 Day 955



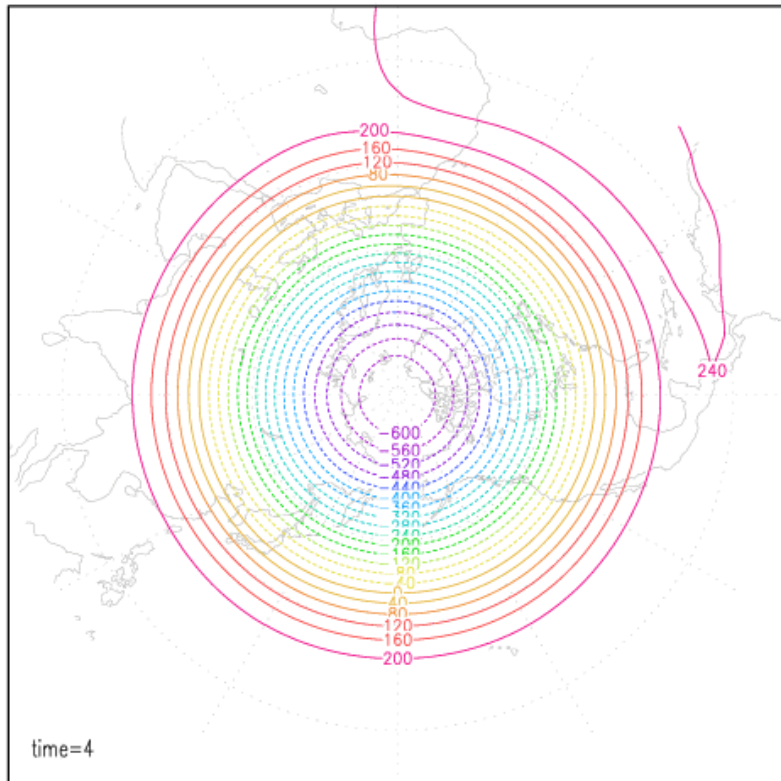


# Up-scale energy cascade

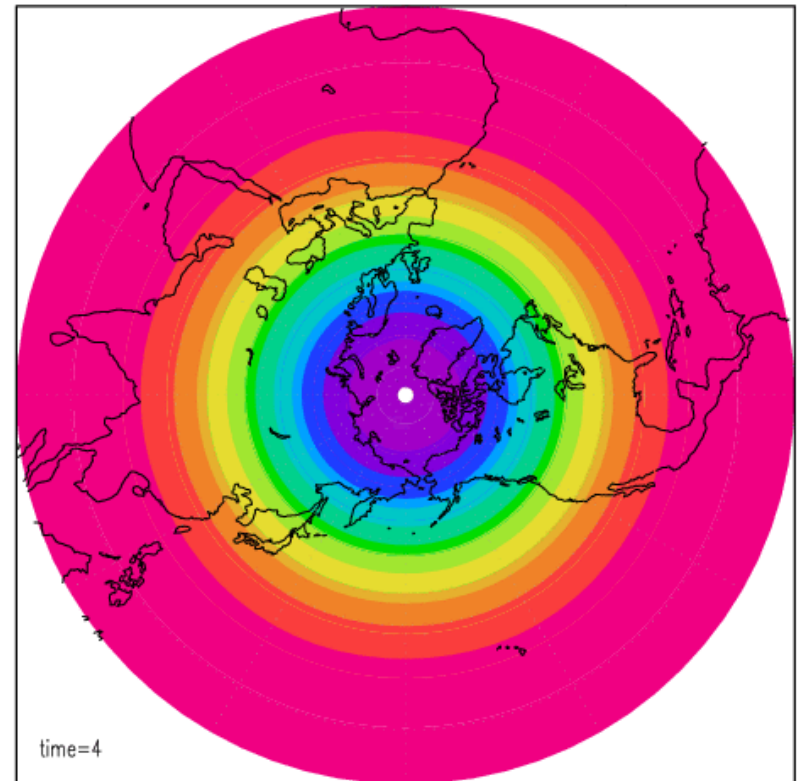
## Rossby wave breaking for $n=6$

Growth rate  $\times 1.7$

Barotropic Height  
Wavenumber 6



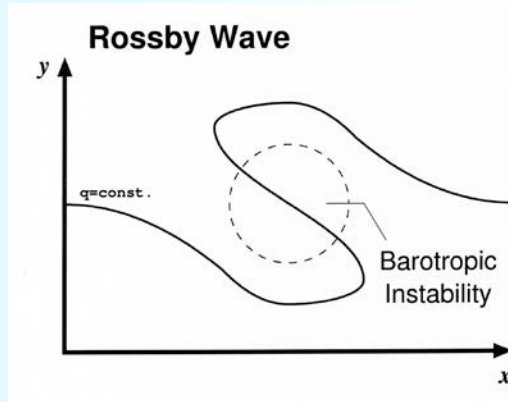
Barotropic Height  
Wavenumber 6





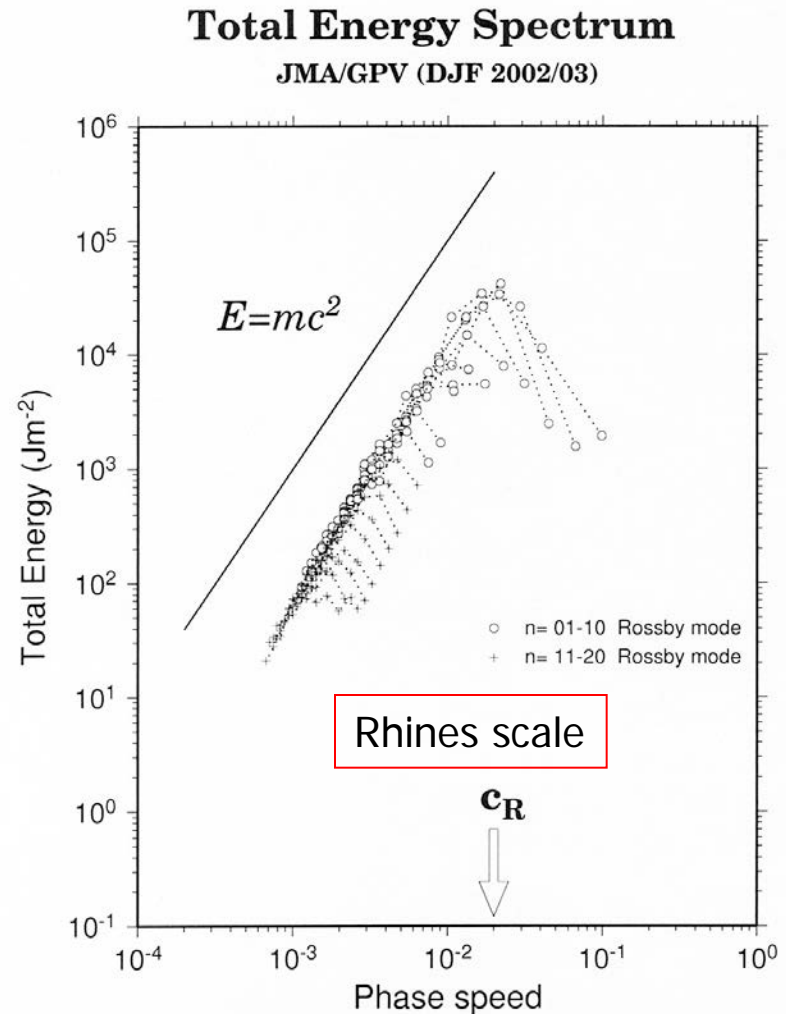
# Global energy spectrum of $E = mc^2$

(Tanaka et al. 2004 GRL)



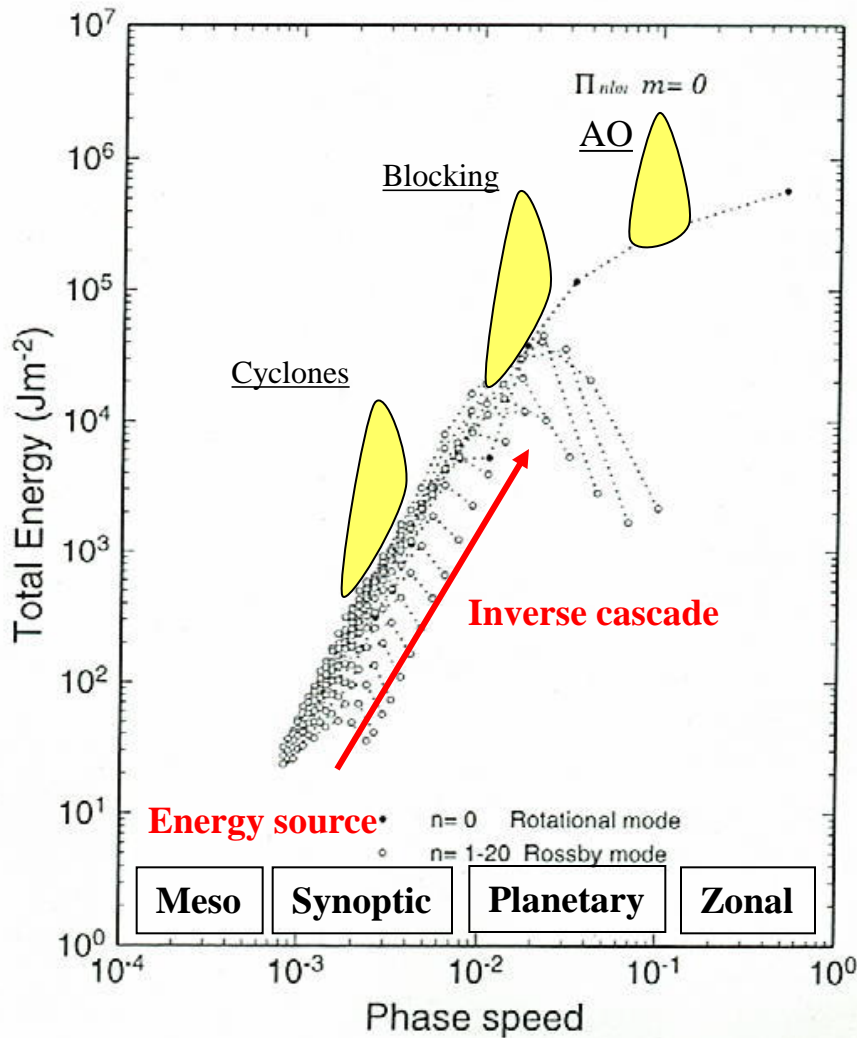
$$\frac{\partial q}{\partial y} < 0 \Rightarrow E = mc^2$$

$c$  Rossby phase speed  
 $m = p_s / g$  Mass of the air

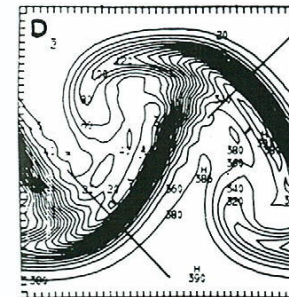
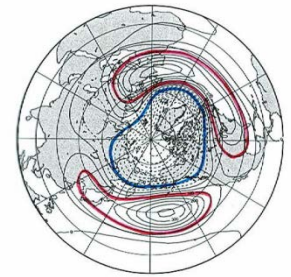
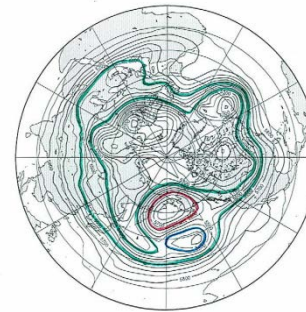


# Total Energy Spectrum

NCEP/NCAR DJF 1950-1999

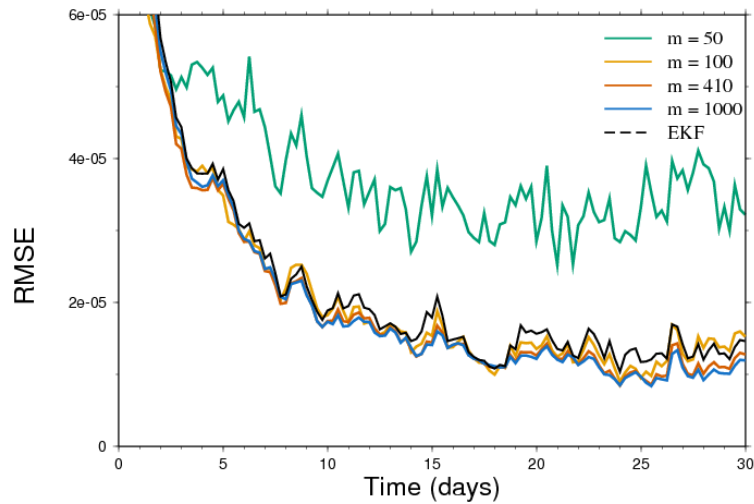


## Low-frequency variability of the atmosphere





## RMSE for EKF and EnKF

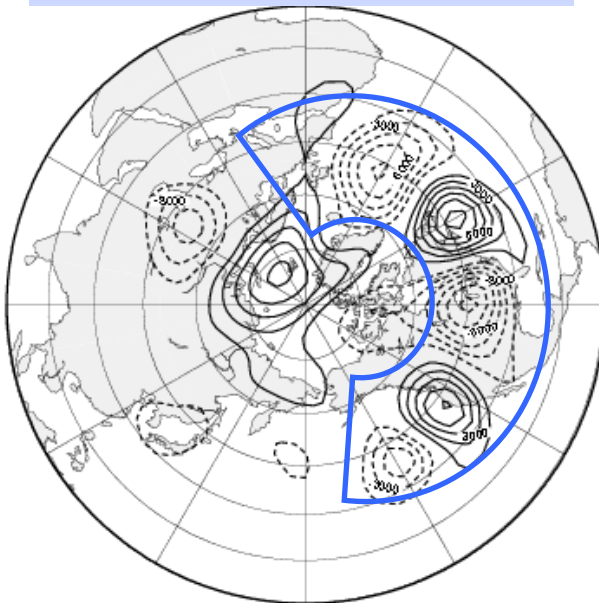


## Data Assimilation

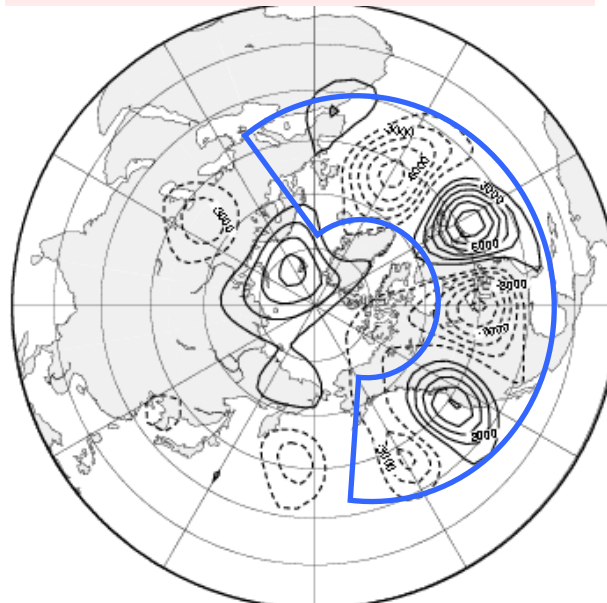
By Kalman Filter and  
Ensemble Kalman Filter

Barotropic S-Model  
at University of Taukuba

EnKF ( $m=1000$ ), 12.6%



EKF (linear model), 8.8%



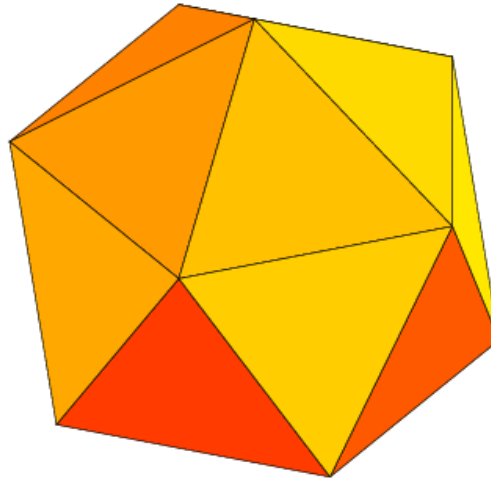
# NICAM

by T2K-Tsukuba

Original Icosahedron

Satoh et al. AORI

Glevel-0



Glevel-5:  $\Delta x=250\text{km}$

Glevel-6:  $\Delta x=120\text{km}$

Glevel-7:  $\Delta x=60\text{km}$

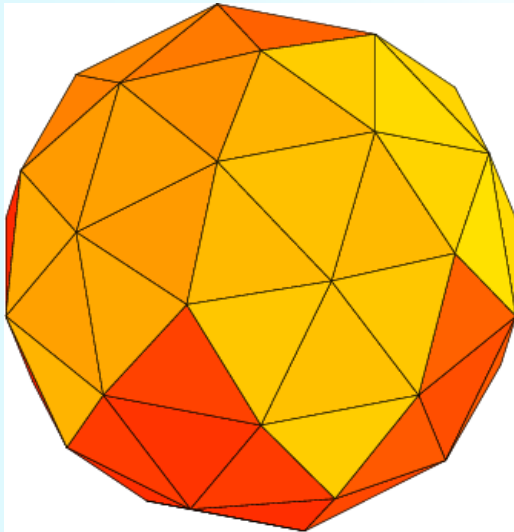
Glevel-8:  $\Delta x=28\text{km}$

Glevel-9:  $\Delta x=14\text{km}$

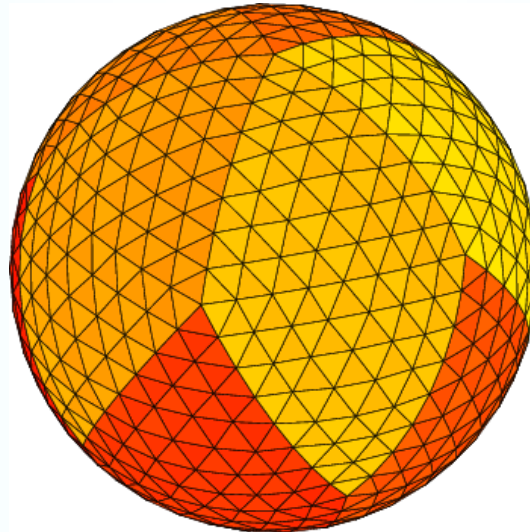
Glevel-10:  $\Delta x=7\text{km}$

Glevel-11:  $\Delta x=3.5\text{km}$

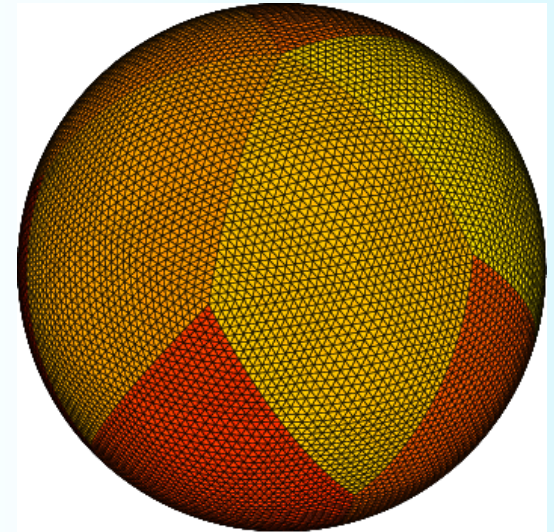
Glevel-1



Glevel-3

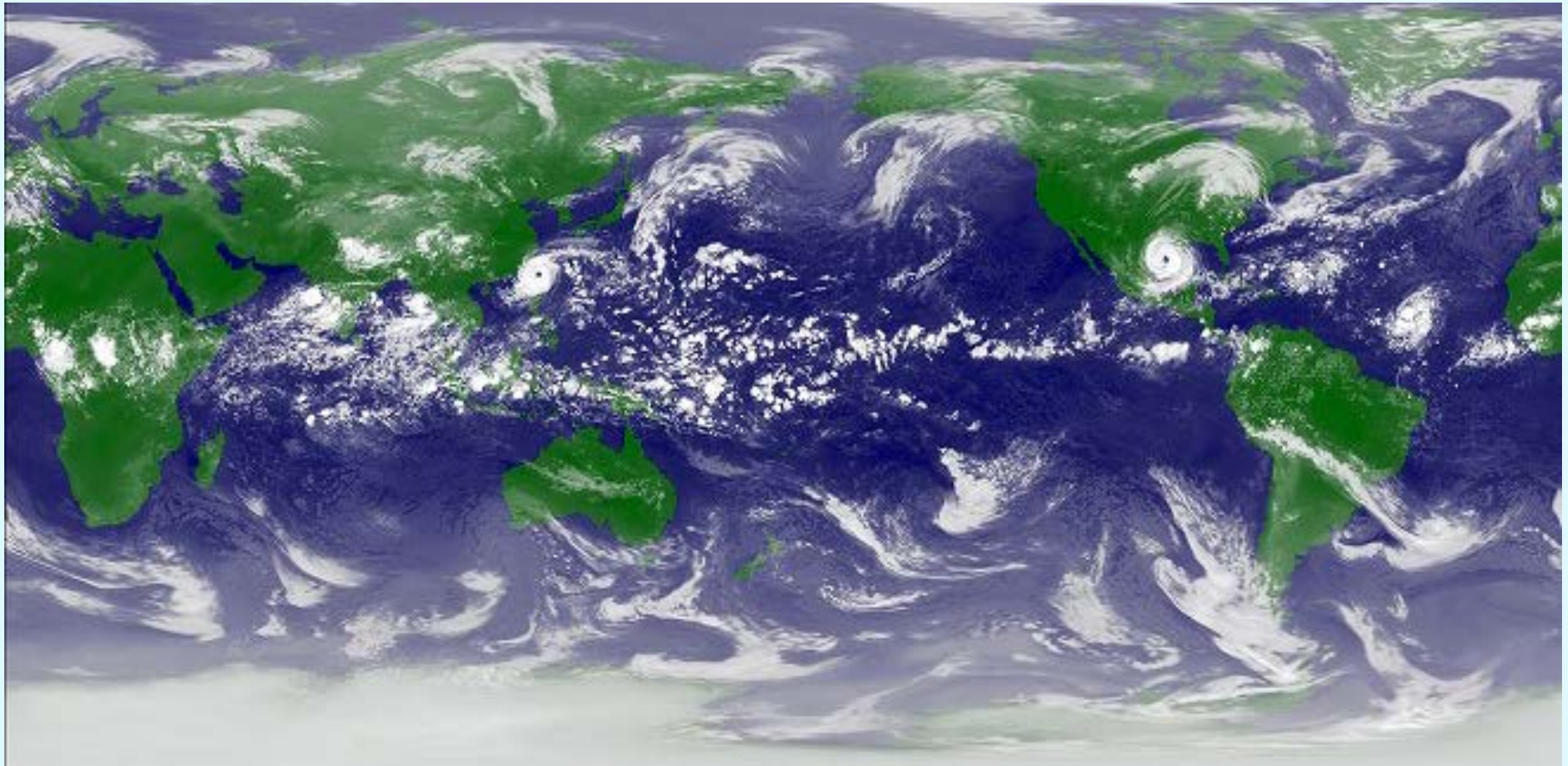


Glevel-5



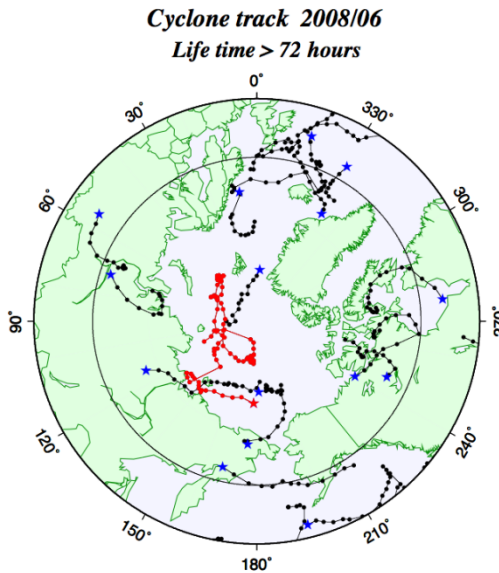
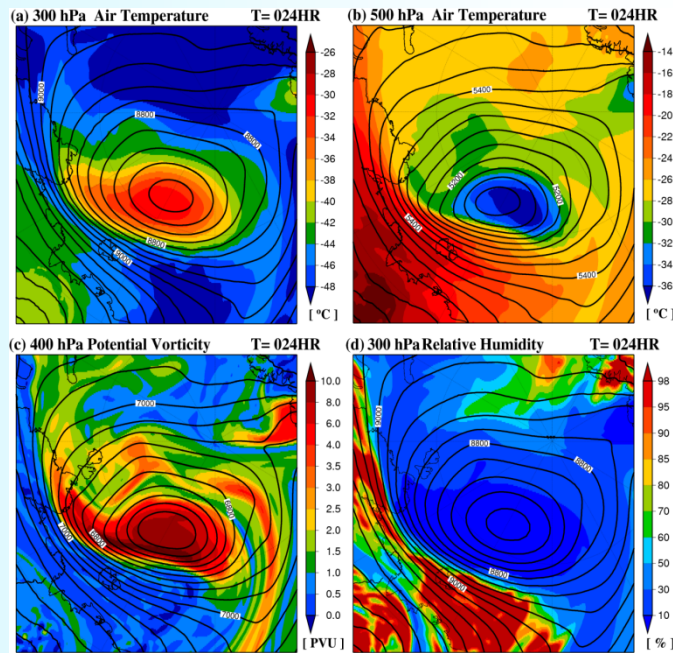


# Study of cyclones using NICAM



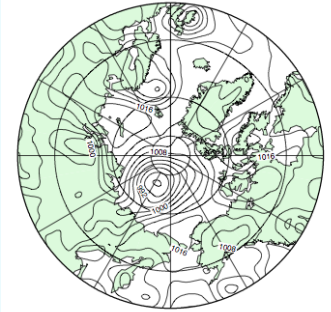
# Arctic Cyclone in JRA-25 and NICAM

Tanaka and Yamagami 2012

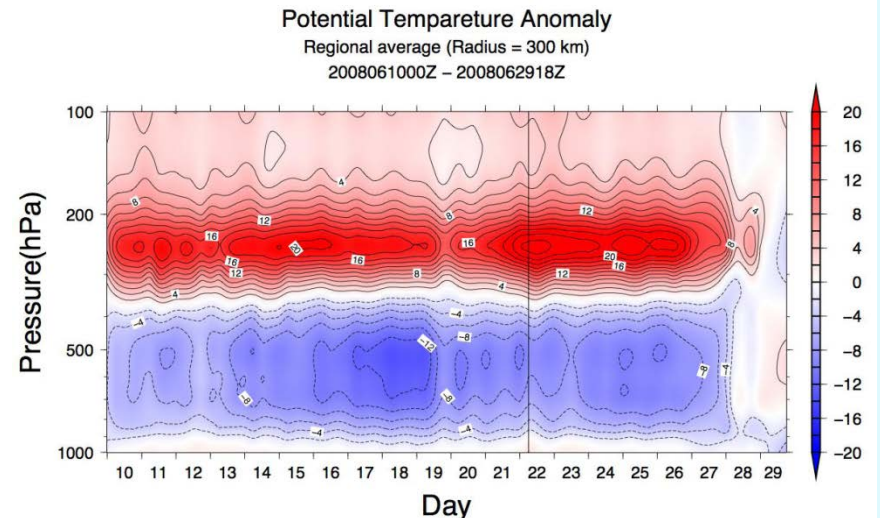
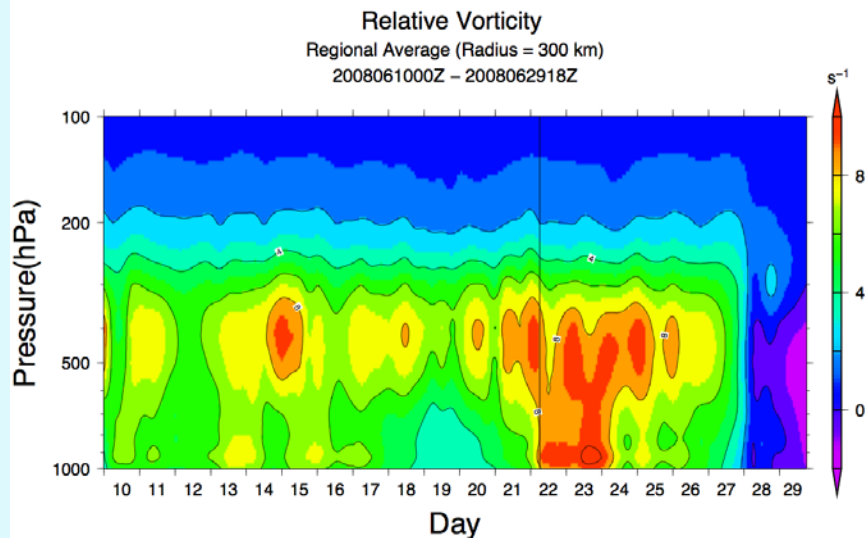
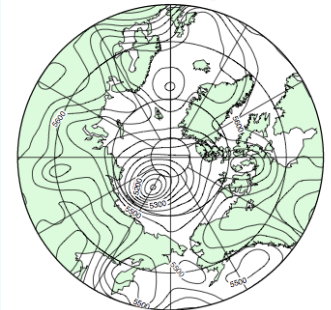


2008062206Z JRA25/JCDAS

PRMSL



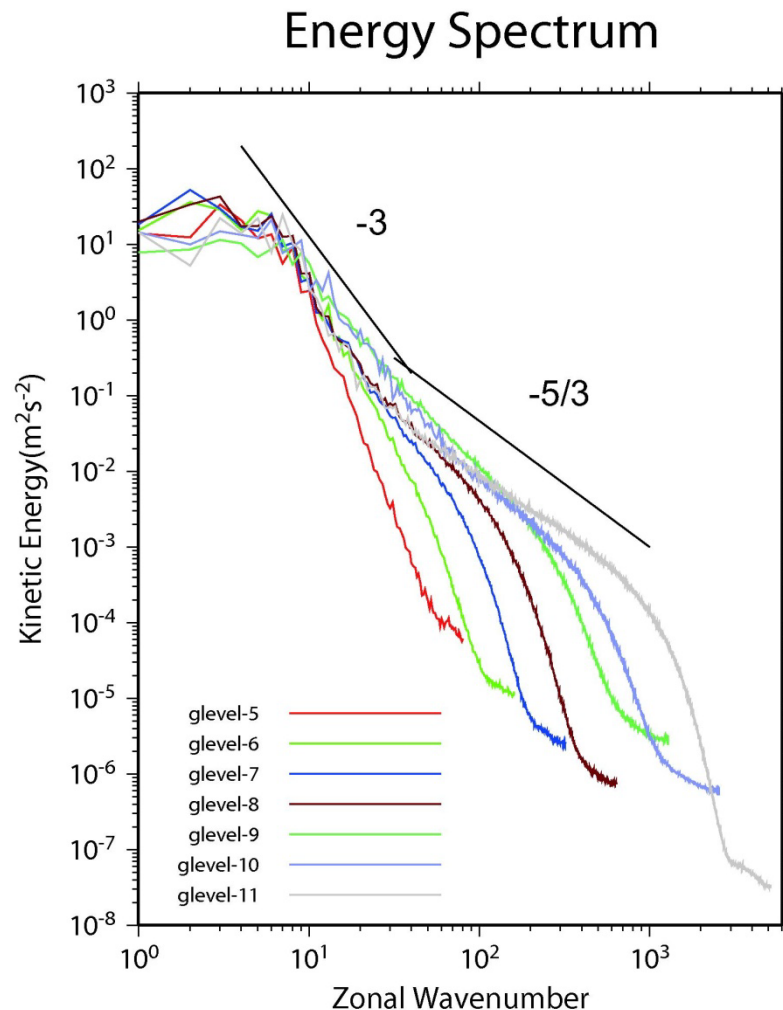
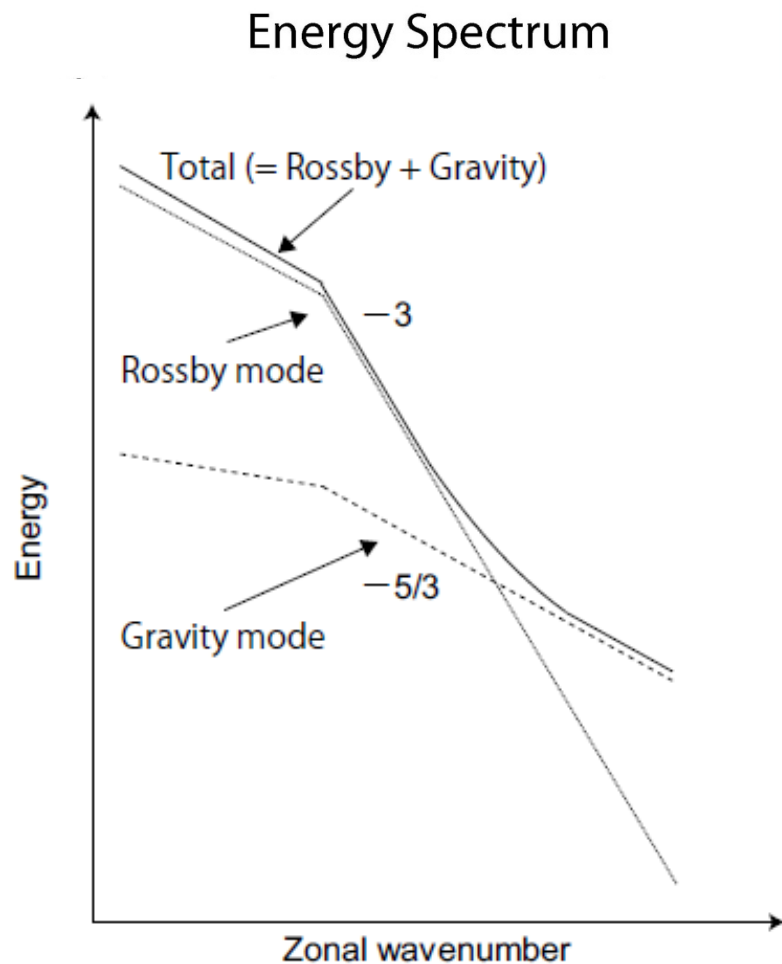
500hPa Height





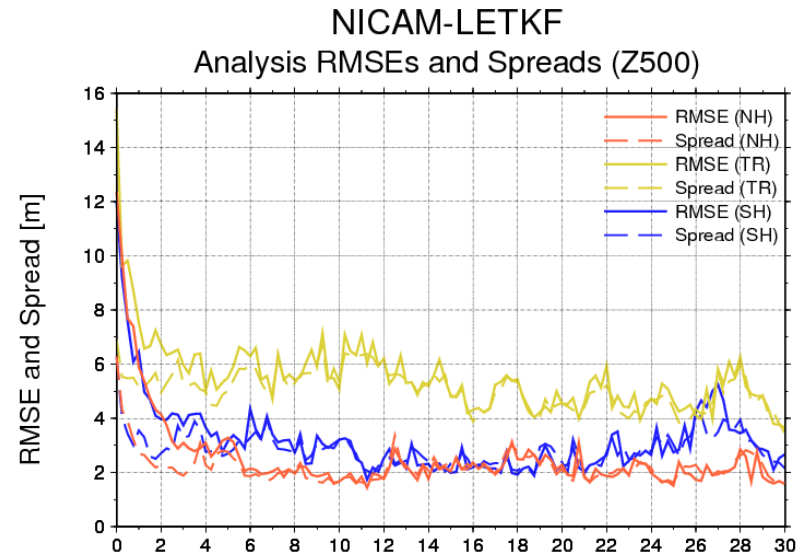
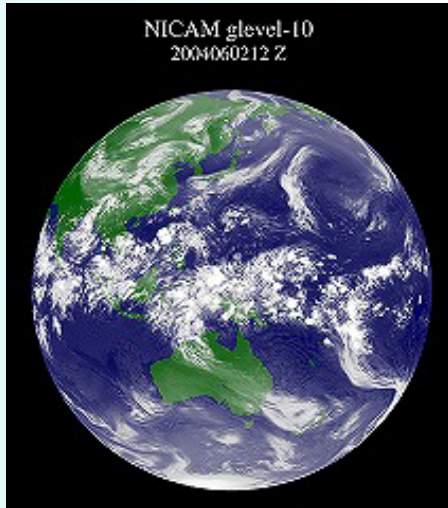
# Global Energy Spectrum of NICAM

## Normal mode energetics analysis

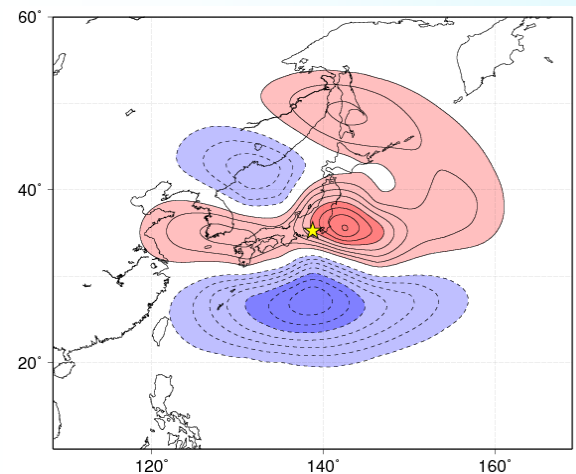
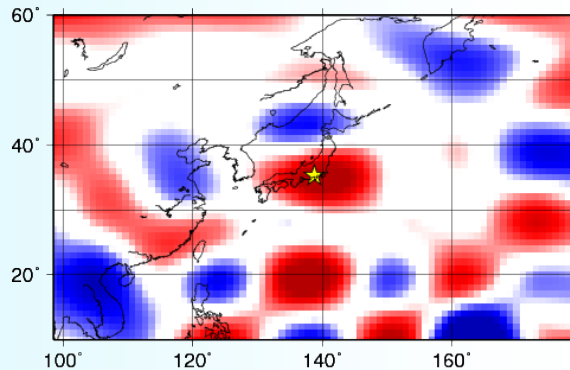


(Terasaki, Tanaka, and Satoh 2009, SOLA)

# Developing NICAM-LETKF

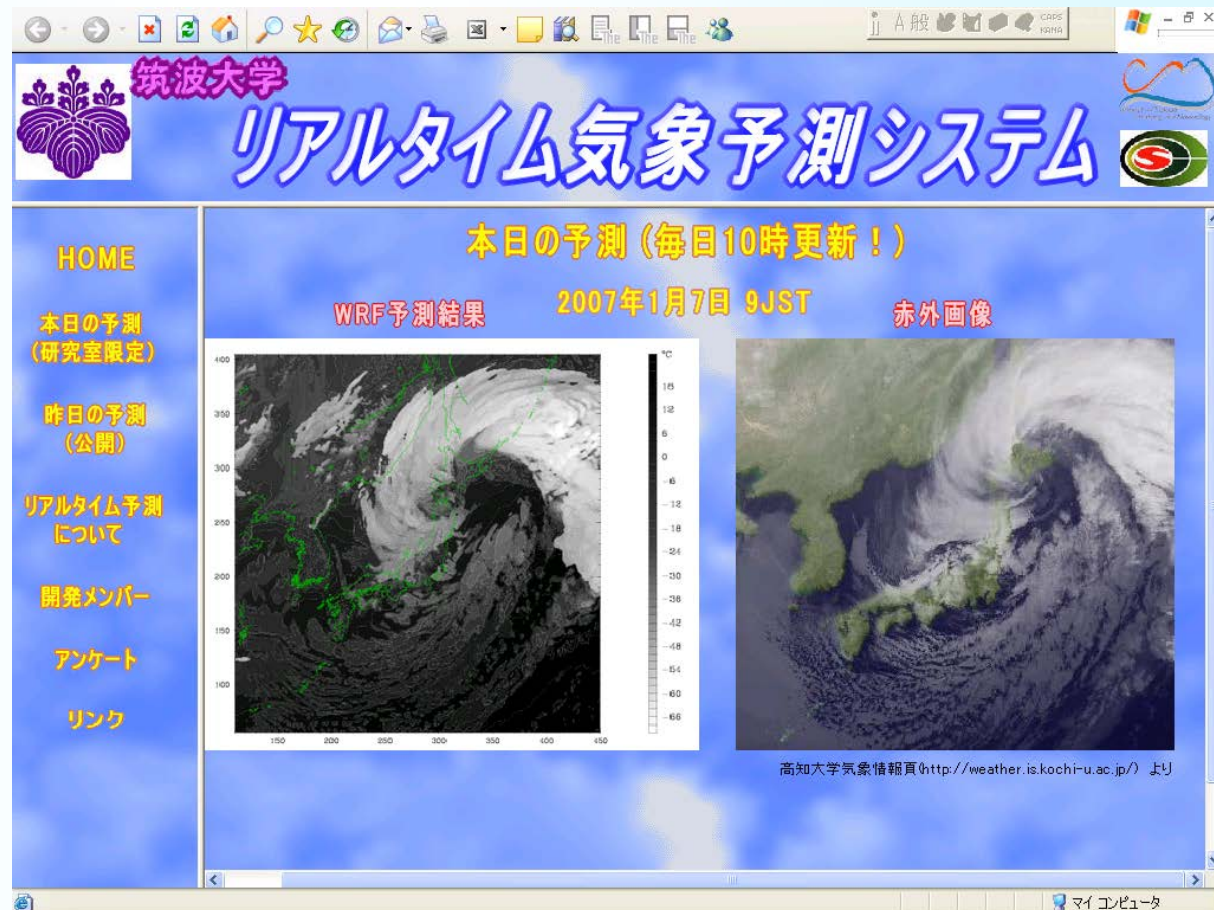


## Multi-scale localization

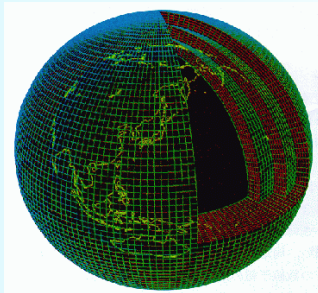


# Realtime weather prediction system

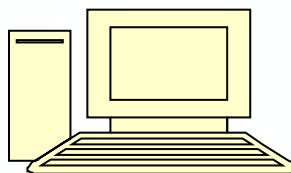
1. WRF with urban model
2. Data analysis and assimilation
3. Initial data by JMA/GPV data



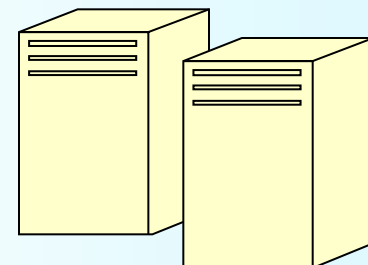
JMA/GPV



WPS



WRF



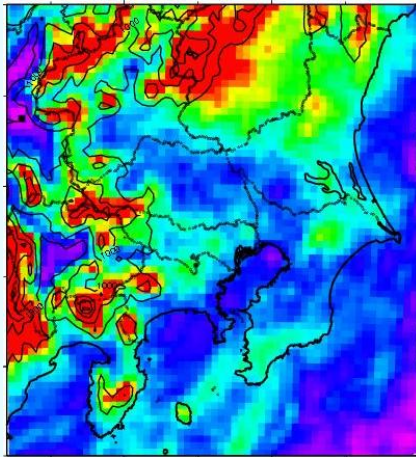


# WRF simulation on urban precipitation

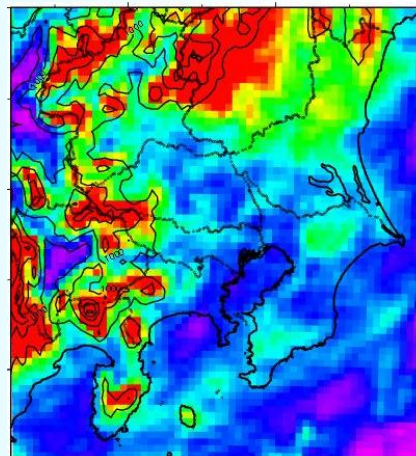
WRF with PACS-CS and T2K-Tsukuba

Urban Canopy Model

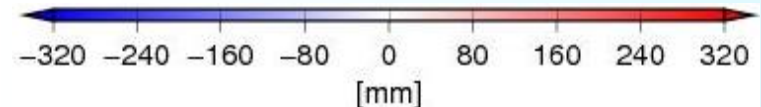
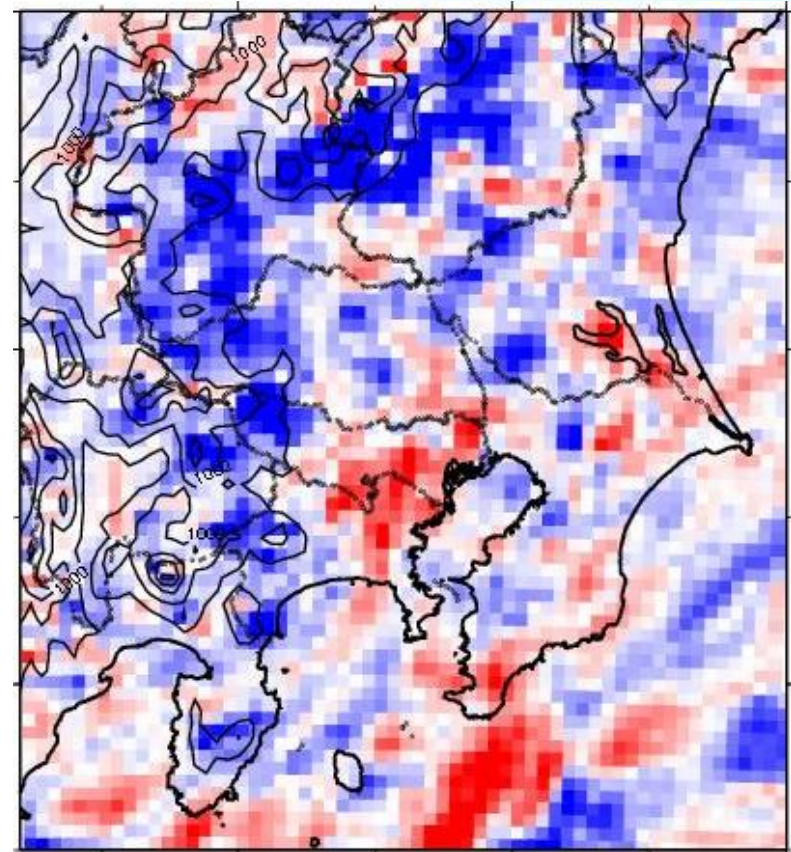
Urban  
Model



No Urban  
Model

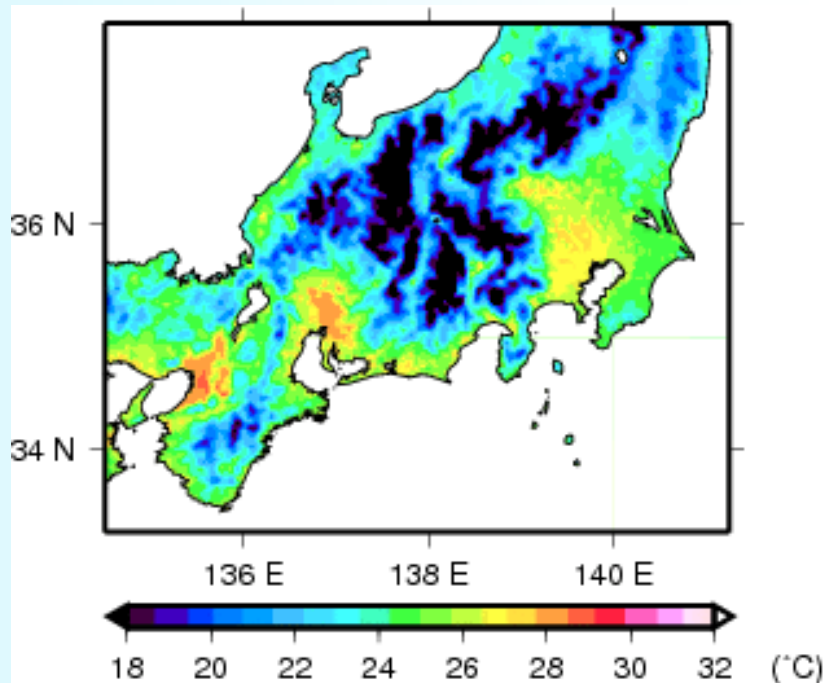


Difference

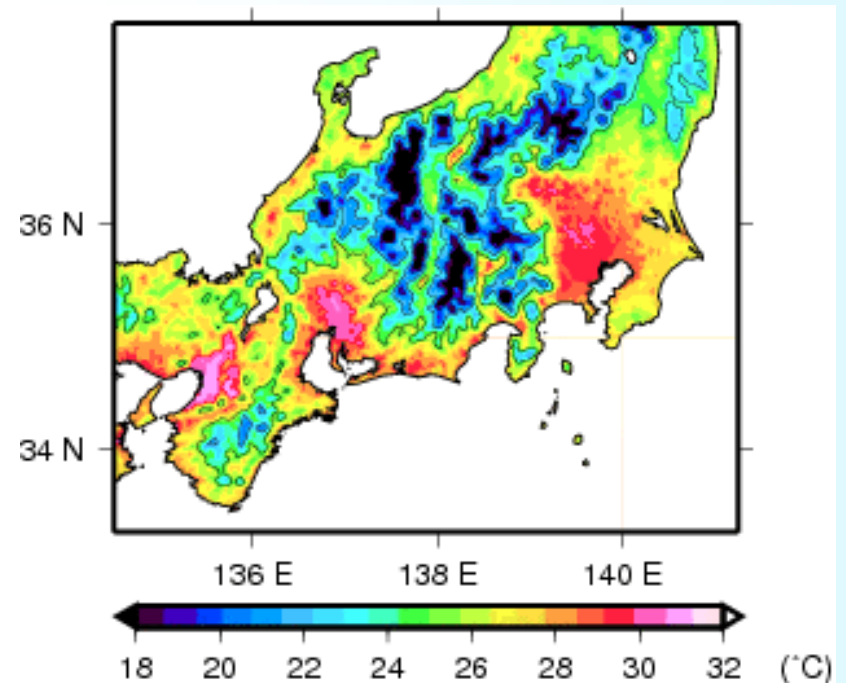


# WRF Simulation of climate for 2070

August 2010

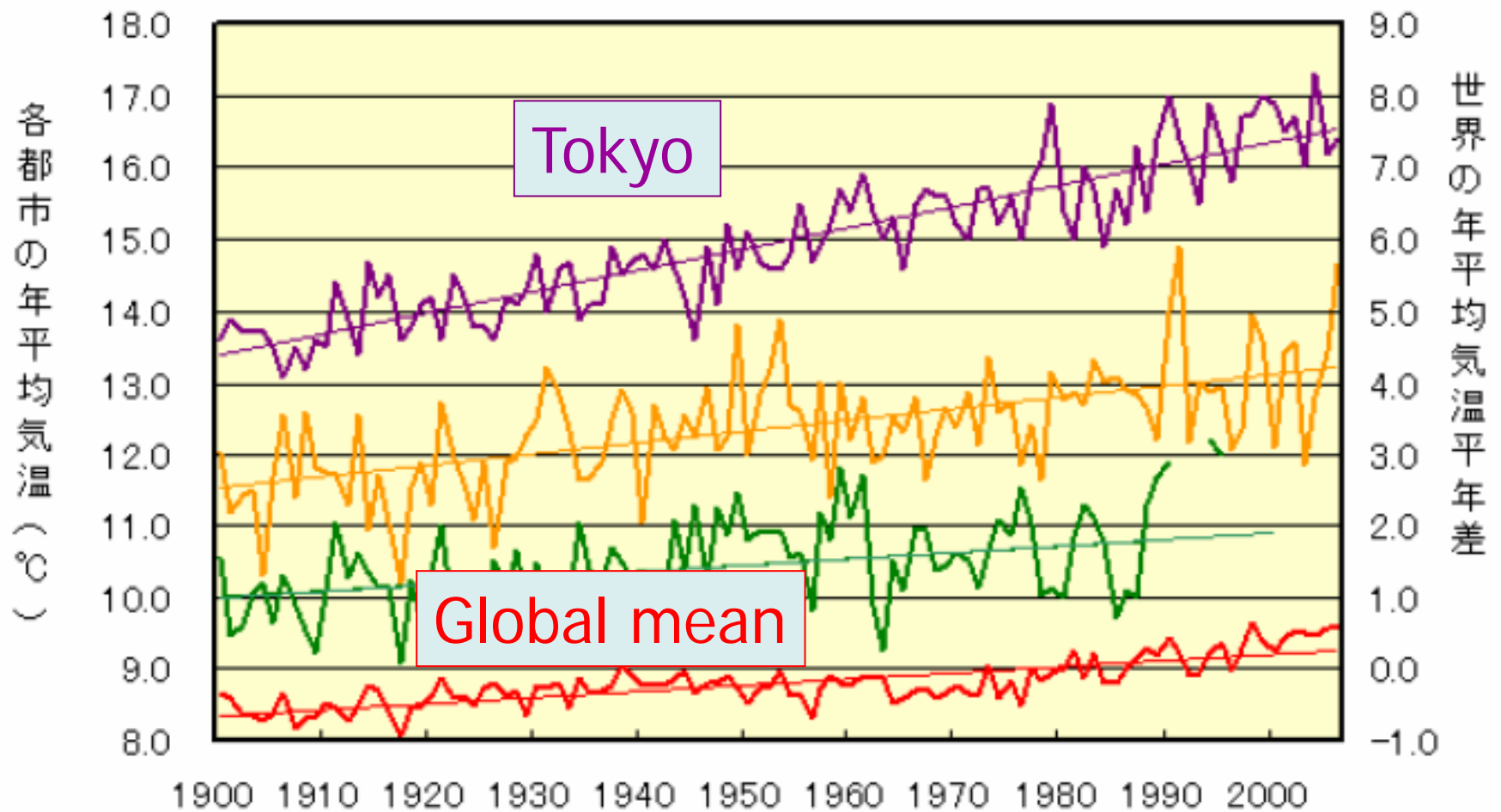


August 2070



Tokyo, Osaka and Nagoya metropolitan warming

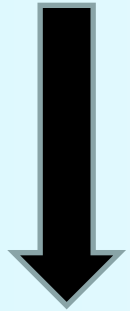
# Urban climate and heat island



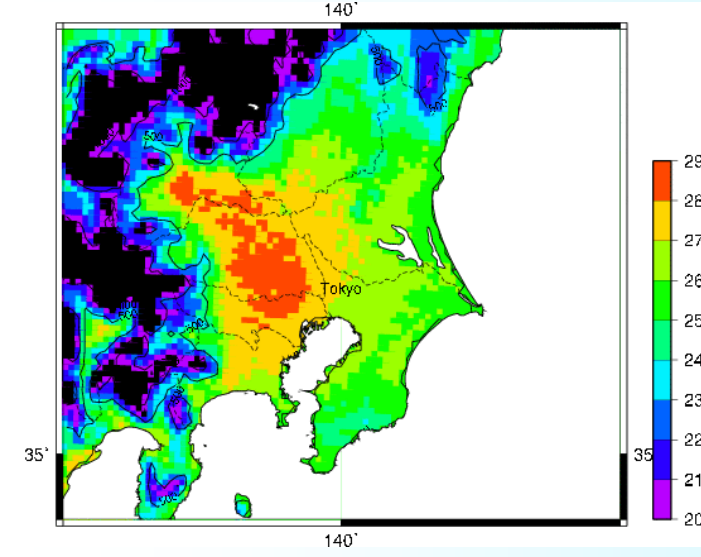
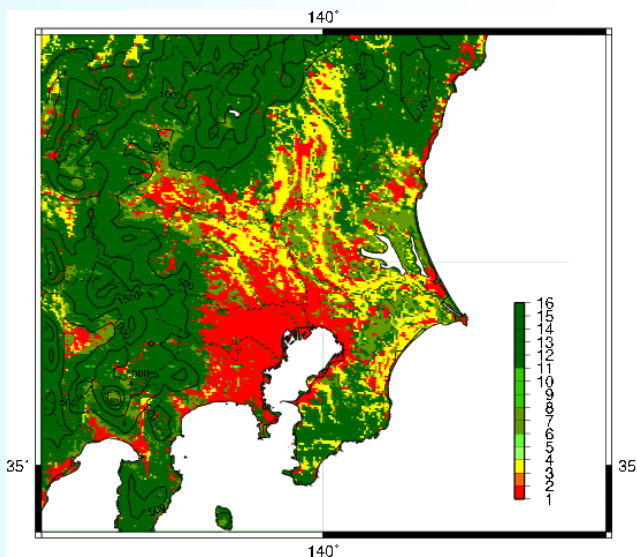
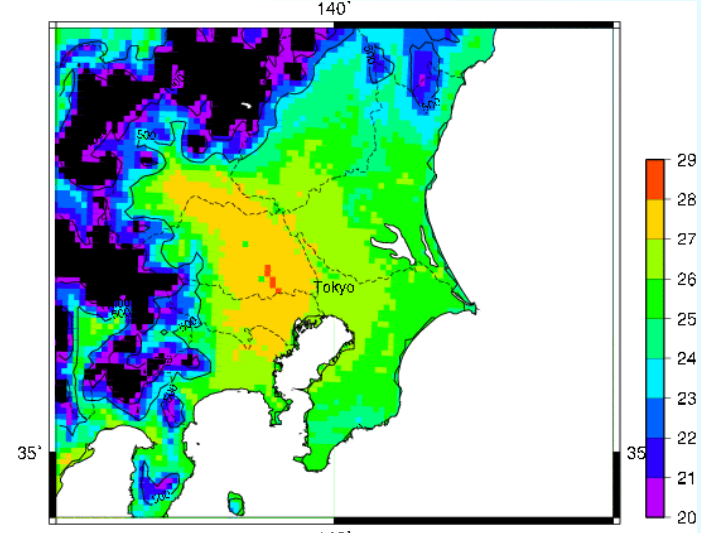
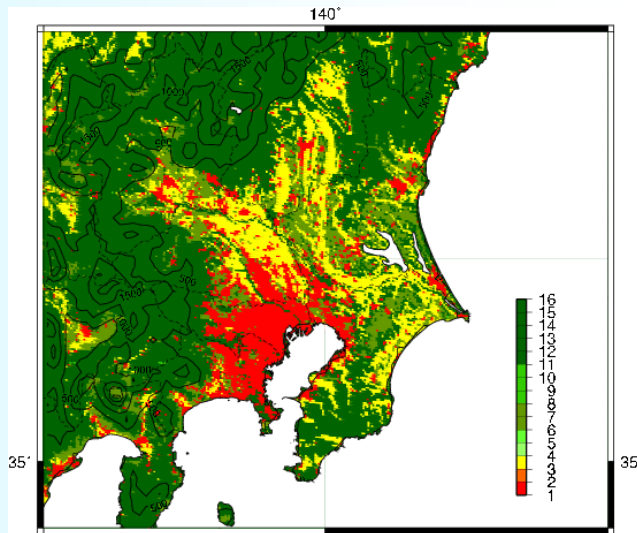


# Urban climate simulation with 3km-WRF in August for last 30 years

1970s



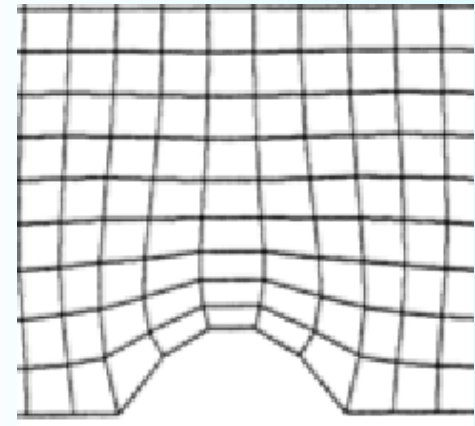
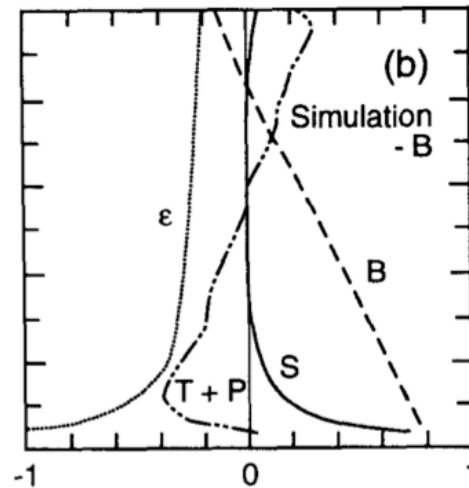
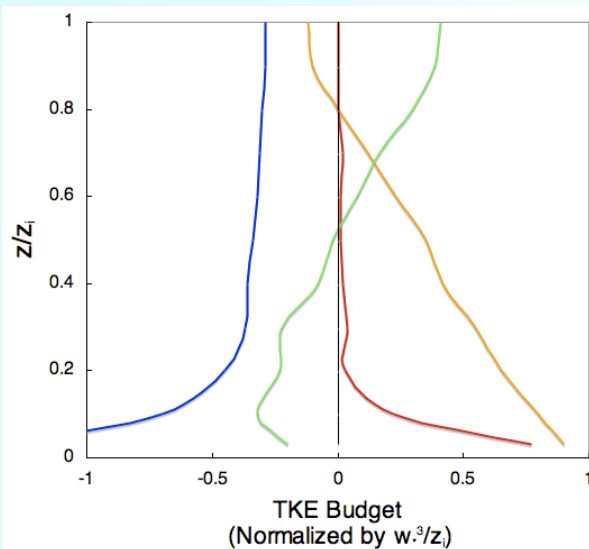
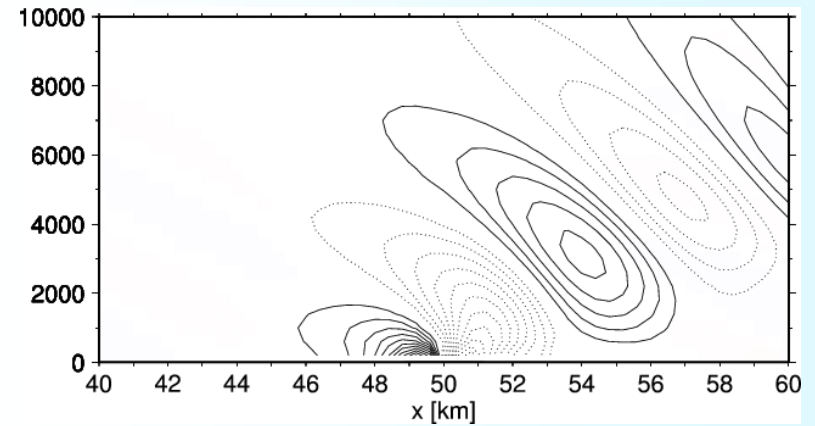
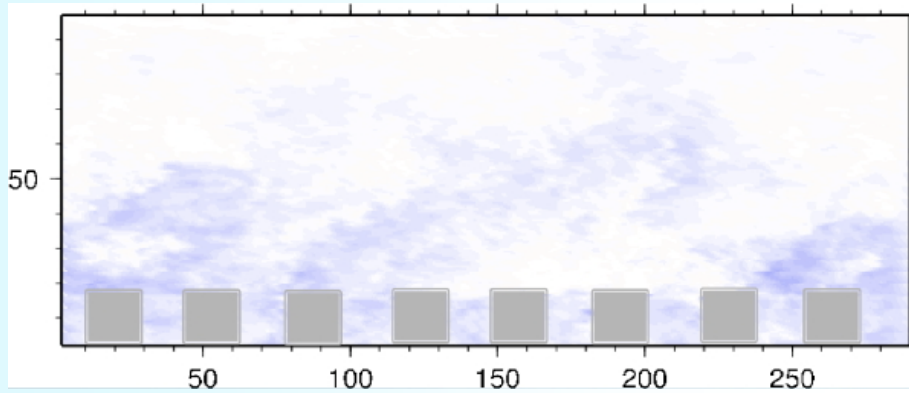
2000s



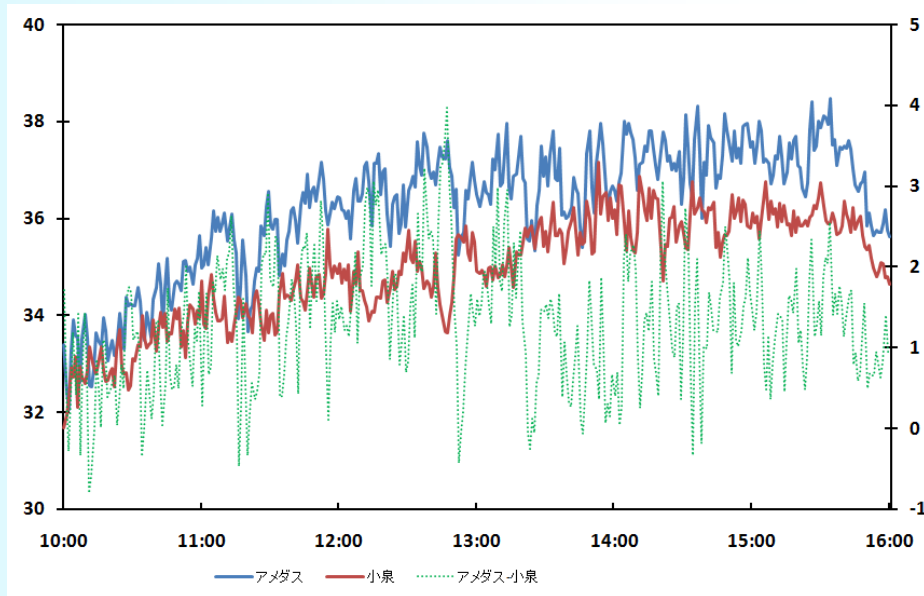
Urban in red

Surface temperature

# Development of new LES model



# Extreme record hot in Aug. 2007



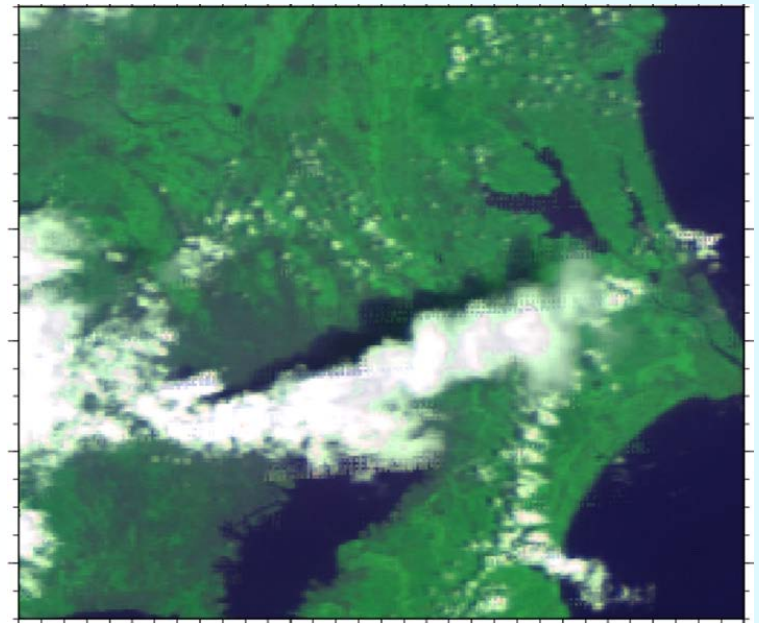
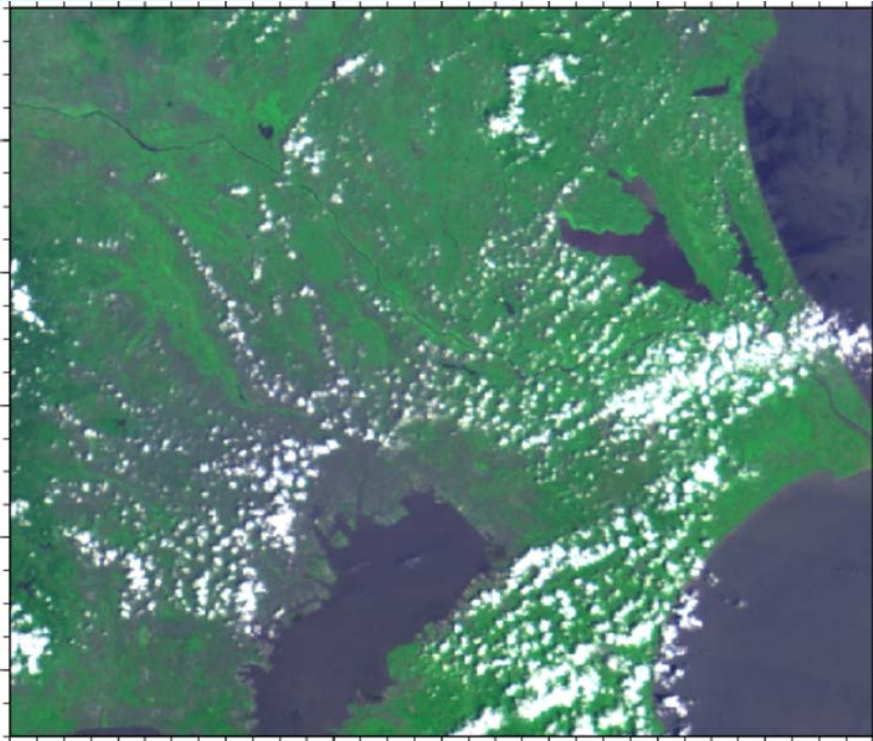
**Tajimi AMeDAS Observation**  
is hotter than city park (red)



Field observations



# Urban effects on local clouds





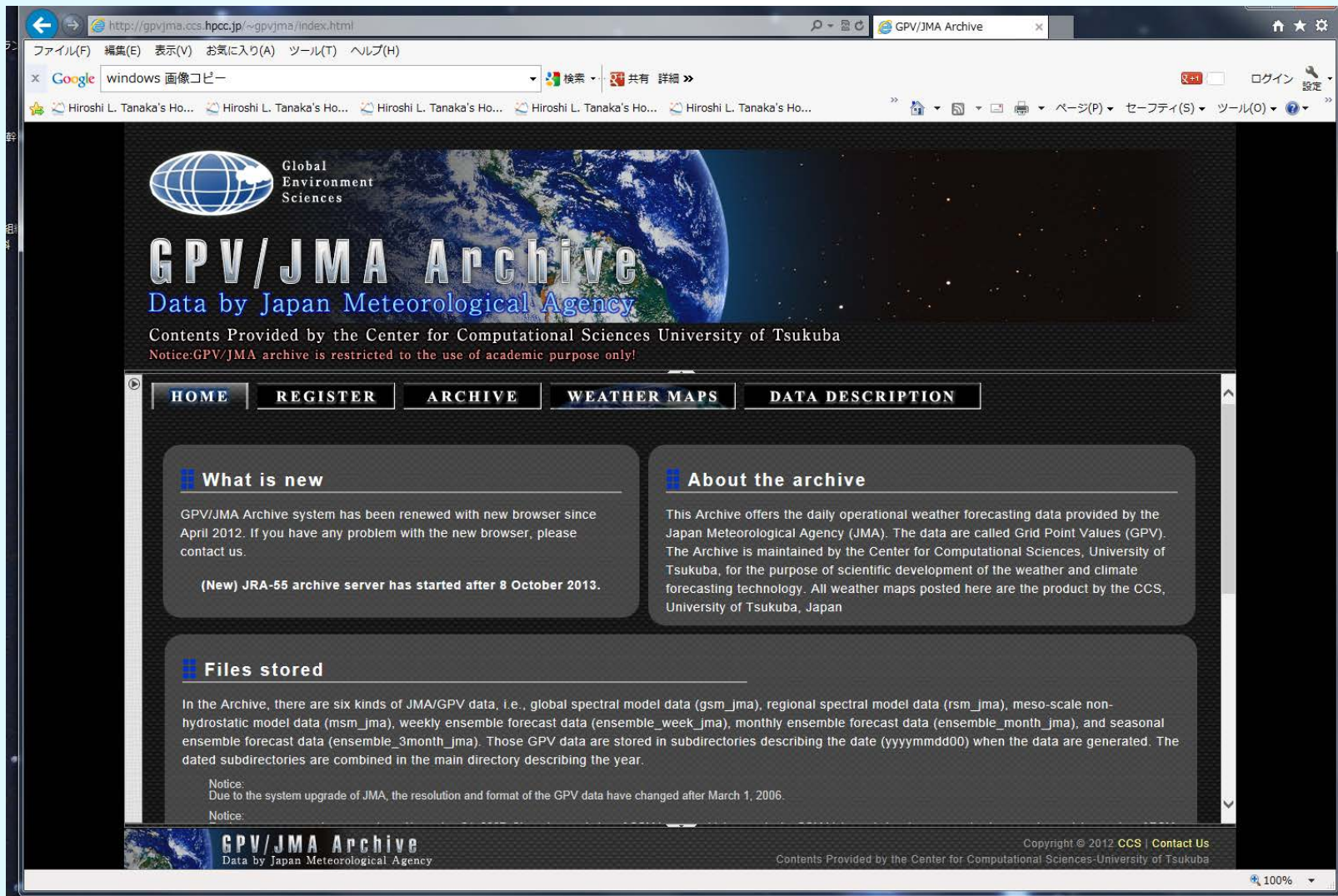
# Collaborations with other Divisions

- Division of Computational Informatics  
=> JMA/GPV Data archive project
- Division of High Performance Computing Systems  
=> LES, WRF and NICAM with T2K-Tsukuba
- Division of Astrophysics and Nuclear Physics  
=> Life in universe project, planetary atmosphere



# Joint work with Computational Informatics

## GPV/JMA Archive



The screenshot shows a web browser window displaying the GPV/JMA Archive website. The browser's address bar shows the URL `http://gpv.jma.ccs.hpc.jp/~gpv/jma/index.html`. The website features a header with the logo of the Global Environment Sciences and the title "GPV/JMA Archive Data by Japan Meteorological Agency". Below the header, there is a navigation bar with links to HOME, REGISTER, ARCHIVE, WEATHER MAPS, and DATA DESCRIPTION. The main content area is divided into three sections: "What is new", "About the archive", and "Files stored". The "What is new" section mentions a system renewal in April 2012 and a new JRA-55 archive server starting on October 8, 2013. The "About the archive" section describes the data as daily operational weather forecasting data provided by the Japan Meteorological Agency (JMA). The "Files stored" section lists six kinds of JMA/GPV data and their storage structure. The footer includes the website title, copyright information for 2012, and contact details for the Center for Computational Sciences at the University of Tsukuba.

Global Environment Sciences

# GPV/JMA Archive

Data by Japan Meteorological Agency

Contents Provided by the Center for Computational Sciences University of Tsukuba  
Notice: GPV/JMA archive is restricted to the use of academic purpose only!

[HOME](#) [REGISTER](#) [ARCHIVE](#) [WEATHER MAPS](#) [DATA DESCRIPTION](#)

### What is new

GPV/JMA Archive system has been renewed with new browser since April 2012. If you have any problem with the new browser, please contact us.

(New) JRA-55 archive server has started after 8 October 2013.

### About the archive

This Archive offers the daily operational weather forecasting data provided by the Japan Meteorological Agency (JMA). The data are called Grid Point Values (GPV). The Archive is maintained by the Center for Computational Sciences, University of Tsukuba, for the purpose of scientific development of the weather and climate forecasting technology. All weather maps posted here are the product by the CCS, University of Tsukuba, Japan

### Files stored

In the Archive, there are six kinds of JMA/GPV data, i.e., global spectral model data (gsm\_jma), regional spectral model data (rsm\_jma), meso-scale non-hydrostatic model data (msm\_jma), weekly ensemble forecast data (ensemble\_week\_jma), monthly ensemble forecast data (ensemble\_month\_jma), and seasonal ensemble forecast data (ensemble\_3month\_jma). Those GPV data are stored in subdirectories describing the date (yyyymmdd00) when the data are generated. The dated subdirectories are combined in the main directory describing the year.

Notice:  
Due to the system upgrade of JMA, the resolution and format of the GPV data have changed after March 1, 2006.

Notice:

GPV/JMA Archive  
Data by Japan Meteorological Agency

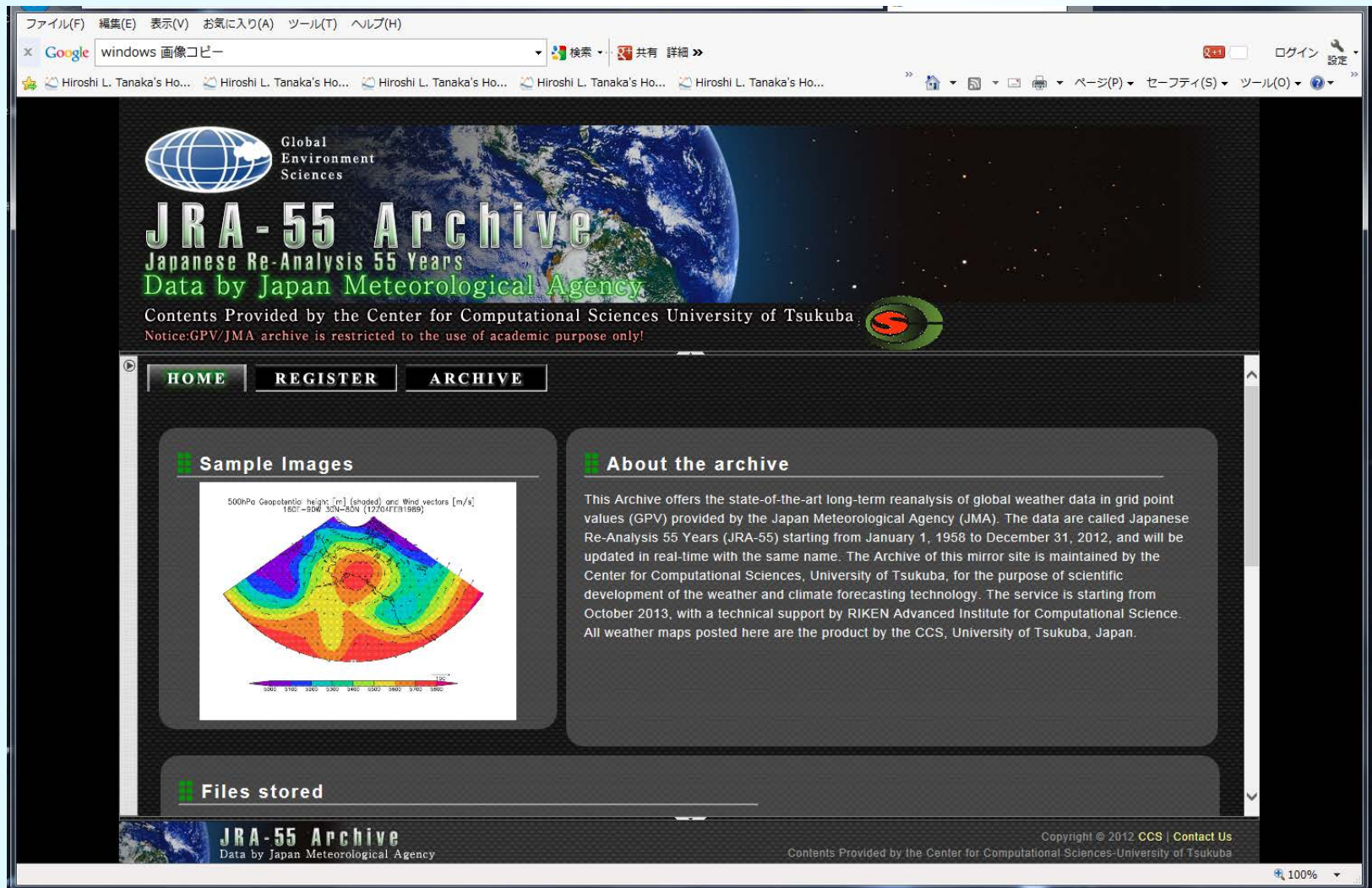
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100%



# Joint work with Computational Informatics

## JRA-55 Archive



The screenshot shows a web browser window displaying the JRA-55 Archive website. The browser's address bar shows a Google search for "windows 画像コピー". The website header features the Global Environment Sciences logo and the text "JRA-55 Archive Japanese Re-Analysis 55 Years Data by Japan Meteorological Agency". Below this, it states "Contents Provided by the Center for Computational Sciences University of Tsukuba" and includes a notice: "Notice:GPV/JMA archive is restricted to the use of academic purpose only!". The main navigation bar has three buttons: "HOME", "REGISTER", and "ARCHIVE". The "Sample Images" section displays a polar projection map of the Northern Hemisphere showing 500hPa Geopotential height and wind vectors. The "About the archive" section provides a detailed description of the data and its use. The "Files stored" section is partially visible at the bottom. The footer includes the JRA-55 Archive logo, copyright information for 2012, and contact details for the Center for Computational Sciences at the University of Tsukuba.

Global Environment Sciences

# JRA-55 Archive

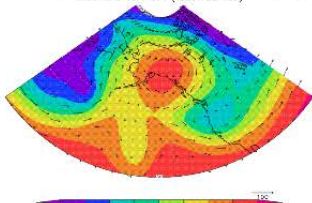
Japanese Re-Analysis 55 Years  
Data by Japan Meteorological Agency

Contents Provided by the Center for Computational Sciences University of Tsukuba  
Notice:GPV/JMA archive is restricted to the use of academic purpose only!

[HOME](#) [REGISTER](#) [ARCHIVE](#)

### Sample Images

500hPa Geopotential height [m] (shaded) and Wind vectors [m/s]  
180°-90° 30°N-80°N (12704FEB1989)



### About the archive

This Archive offers the state-of-the-art long-term reanalysis of global weather data in grid point values (GPV) provided by the Japan Meteorological Agency (JMA). The data are called Japanese Re-Analysis 55 Years (JRA-55) starting from January 1, 1958 to December 31, 2012, and will be updated in real-time with the same name. The Archive of this mirror site is maintained by the Center for Computational Sciences, University of Tsukuba, for the purpose of scientific development of the weather and climate forecasting technology. The service is starting from October 2013, with a technical support by RIKEN Advanced Institute for Computational Science. All weather maps posted here are the product by the CCS, University of Tsukuba, Japan.

### Files stored

**JRA-55 Archive**  
Data by Japan Meteorological Agency

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# Collaborations with other Agency

- Collaborative Research with Japan Weather Association (JWA) => improvement of WRF, weather prediction, disaster analysis
- Collaborative Research with Toshiba => improvement of weather prediction.
- Collaborative Research with Tajimi City => to clarify the formation mechanism of the extreme heat.
- Collaborative Research with Academia Science, Taiwan => regional future climate projection for Taipei
- Collaborative Research with Weather News Inc. (WNI) => fog forecast and the discrimination of precipitation (rainfall, snowfall forecast).



# Collaborations with other Agency

- Collaborative Research with Nippon Telegraph and Telephone Corporation. (NTT) => Research about down scalar using WRF with NTT
- Collaborative Research with Meteorological Research Institute for Technology Corporation. (MERIT) => Research about prediction of snow damage to influence on power line
- Collaborative Research with MRI for Atmosphere-Ocean coupled model => Research about future projection including paleo-climate study
- Palaeoclimate Modeling Intercomparison Project (PMIP) => Research about paleo-climate modeling across the globe





# Collaborations



- **JMA**: Thorpex ensemble prediction technique
- **MRI**: Data assimilation and Kalman filter
- **NIPR**: Arctic amplification and AO studies
- **IARC**: Global change connection to the Arctic
- **AORI**: NICAM by PACS-CS and T2K
- **DPRI**: PUFF model for volcanic ash transport
- **AWI**: Normal mode energetics and stability
- **Pukyong National University**: Ice dynamics



# Outside Funds

- Environment Research and Technology Development Fund of the Ministry of the Environment, Japan 2010-2014. (S-8-1). (JPY 115,586,000)
- Research Program on Climate Change Adaptation, Initiative for Strategic Adaptation to Climate Change (RECCA). The Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT). 2010-2014. (JPY 56,200,000)
- Analysis of urban air temperature. Grant-in-Aid for Scientific Research B of the Japan Science and Technology Agency (JST), Japan. 2010-2012. (JPY 1,400,000)
- Urban precipitation observations. Grant-in-Aid for Scientific Research B (22300316) of the Japan Science and Technology Agency (JST), Japan. 2010-2012. (JPY 800,000)
- Urban precipitation observations. Grant-in-Aid for Scientific Research A of the Japan Science and Technology Agency (JST), Japan. 2013-2017. (JPY 20,000,000)
- Environment Research and Technology Development Fund of the Ministry of the Environment, Japan. 2007-2011. (S-5-3) (JPY 74,138,000)
- Actual condition and mechanism of urban heat island of Tsukuba city.
- The Grant-in-Aid for Young Scientists B of the Japan Science and Technology Agency (JST), Japan. 2007-2010. (JPY 4000,000)
- Green network of excellence (GRENE) of Arctic Climate Study under Ministry of Education, Culture Sports, Science and Technology (MEXT), Japan. 2011-2015. (PI: J. Ukita, JPY 500,000,000)
- Environment Research and Technology Development Fund of the Ministry of the Environment, Japan 2008-2013. (S-5-2; A1201). (JPY 45,000,000)
- Program for Risk Information on Climate Change, Ministry of Education, Culture, Sports, Science and Technology, 2012-2013. (JPY 440,000,000).



# Future Plan of Research

- New multi-layer vegetation canopy model considering rainfall interception and dew deposition.
- Vegetation model to our LES model.
- Evaluate the degree of impact of buildings, parks, and trees on the local temperature distribution using our LES model.
- Interdisciplinary research activities in climate-health interaction.
- Expanding our research activities in this arena, especially in conjunction with global warming projections and mitigation/adaptation planning.





# Future Plan of Research

- Cloud resolving global mode NICAM for the study of arctic climate change, especially for the arctic amplification, arctic oscillation, and arctic cyclone under the collaboration with AORI.
- Expand the 3D normal mode energetics study not only for Rossby wave world, but also for gravity wave world. The tropical low-frequency variability, like MJO, is expected to be normal mode solutions.
- International collaboration is planned for implementing the volcanic ash dispersal model PUFF for volcanos in Indonesia under the collaboration with DPRI of Kyoto University.

END

Thanks !