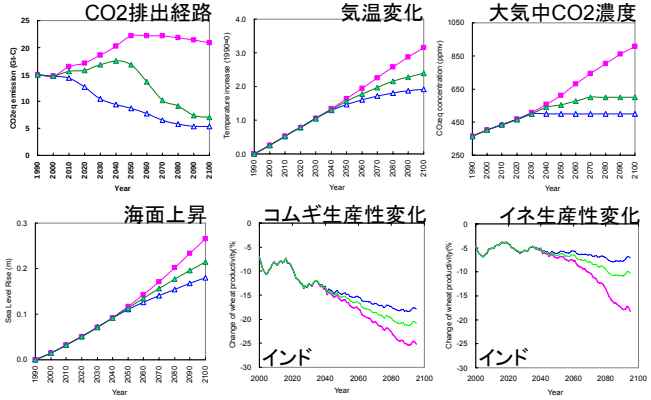
Impact assessment considering extreme climate events

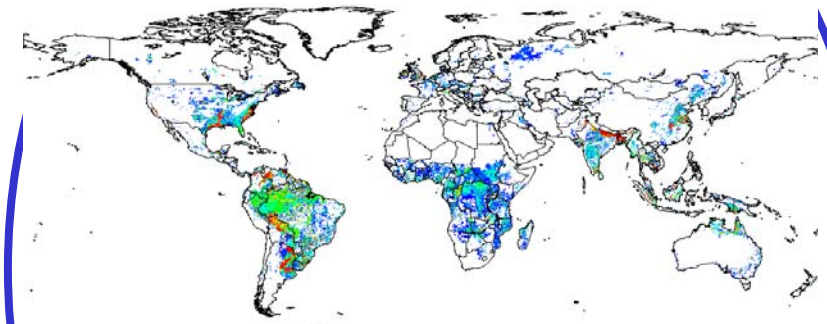
Kiyoshi Takahashi (NIES)

(1) Comprehensive assessment of climate change impact for discussing long-term stabilization target



Optimal emission path for achieving 2 degC target and consequent temperature change, SLR and crop impacts.

(2) Impact assessment considering effects of extreme climate events



Climate change impact on crop productivity using daily climate scenario with high spatial resolution.

Application to the discussion of post-2012 framework

(Project S-3-2 and S-4)

Development of AIM/Ecosystem

(Project B-52)

Improvement of impact model

(Project B-12)

(3) Impact assessment considering interaction between climate change, other environmental problems, and development target.

Three main research directions of AIM impact study

Impact assessment considering effects of extreme climate events

- Collaborative research project with NIES/CCSR climate modeling team from FY2004.
- Backgrounds of the project
  - Extreme climate events (hot summer, heavy rain, dry spell etc.) are expected to increase in frequency and/or severity, so the severity of their impacts will also increase.
  - Availability of climate model outputs more suitable for extreme event analysis is increasing.
- Research objective of the project
  - Validation of recent climate model's ability to reproduce frequency and magnitude of extreme events
  - Refinement and development of impact assessment models for considering extreme events
  - More realistic impact assessment considering extreme events

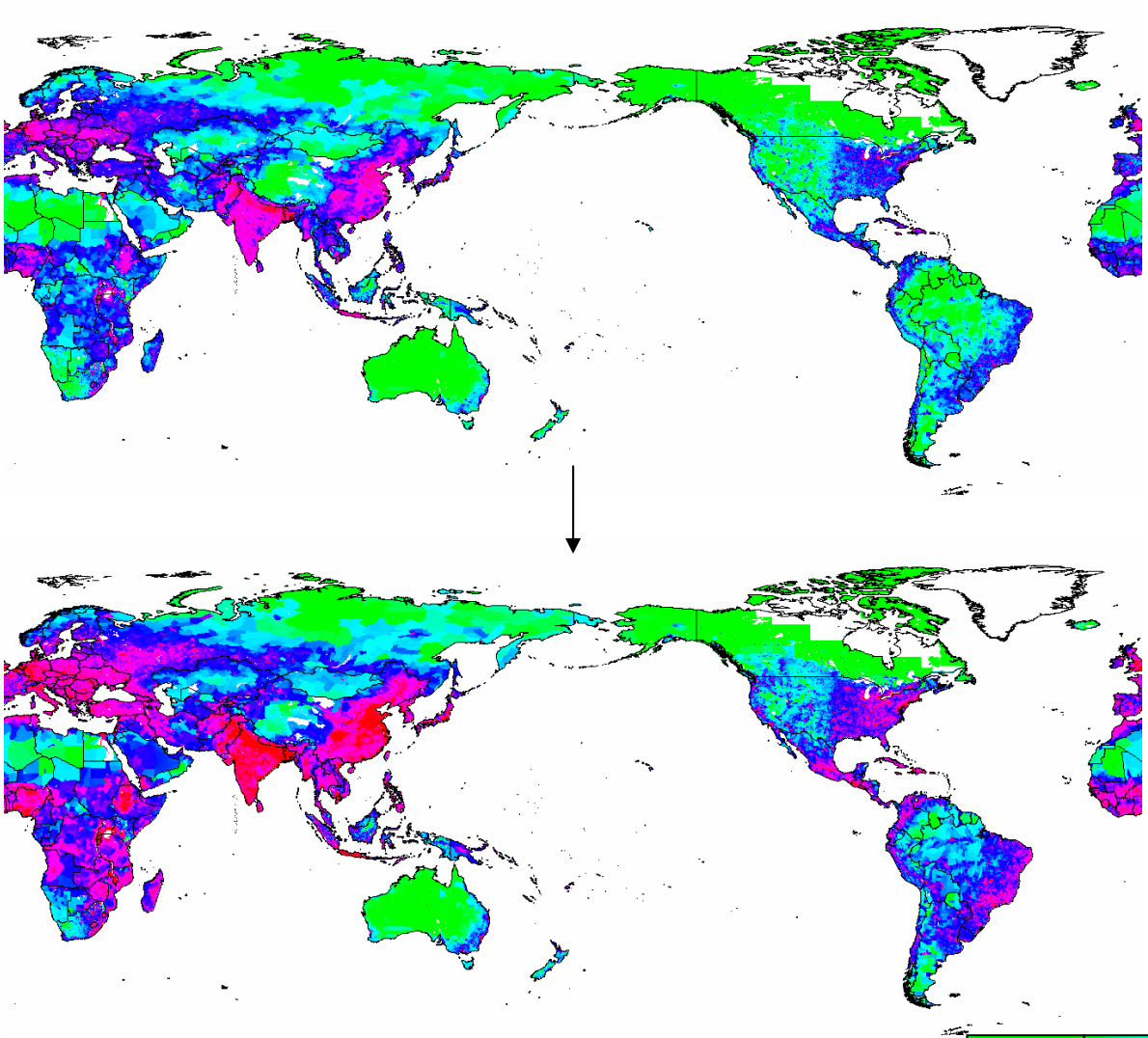
Works in FY2005

- Impact assessment using daily outputs of general circulation model with high spatial resolution.
  - Estimation of change in mortality due to heat stress
  - Estimation of change in crop productivity with considering negative effect of typhoon and heat wave.

Works in FY2005

- Estimation of change in mortality due to heat stress
  - With the increase in very hot day in a year, mortality due to heat stress is expected to increase.
  - Monthly climate scenario is not sufficient for estimating heat stress mortality, thus estimation was done using daily climate scenario based on the latest GCM with high resolution.
- Estimation of change in crop productivity with considering negative effect of typhoon and heat wave.

Change in excess mortality per unit area (1990s and 2090s)



1990s

2090s

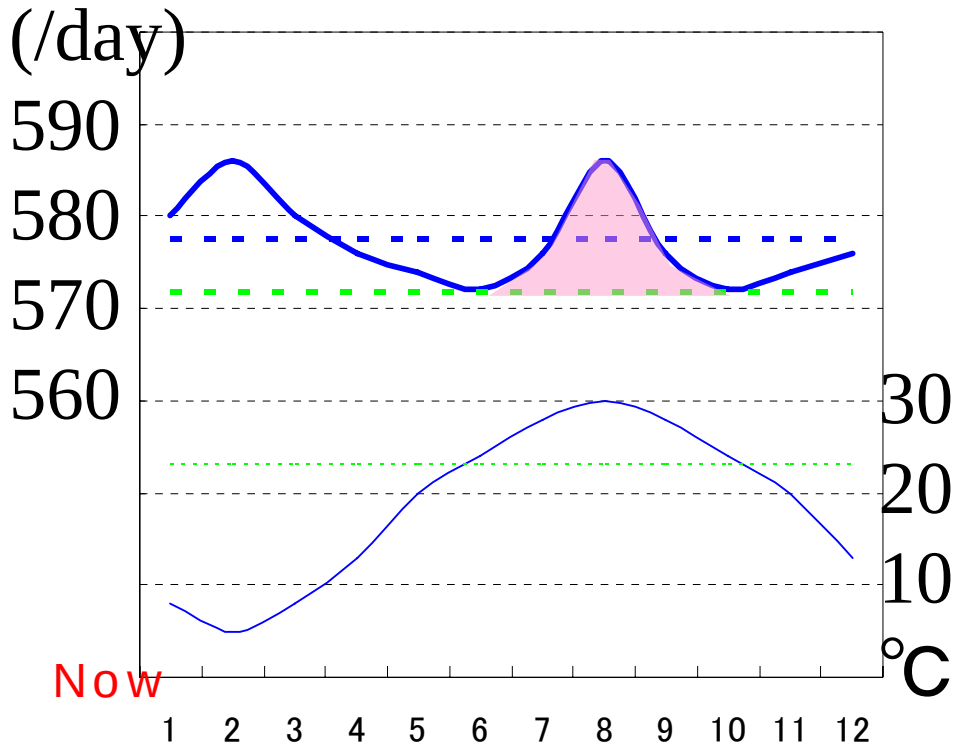
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}

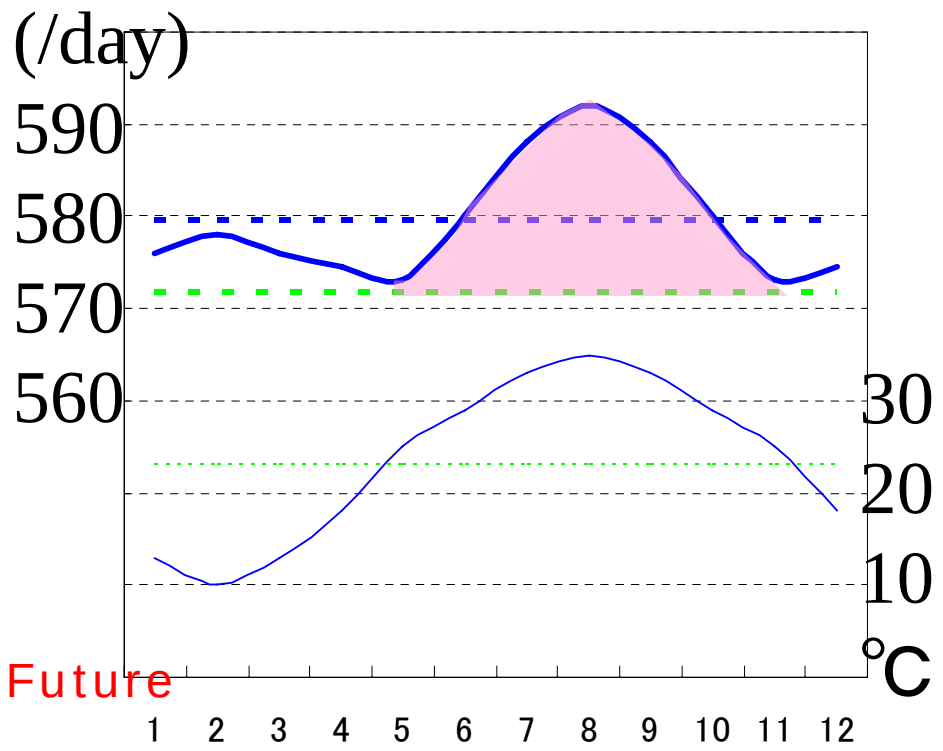
(person/km^2)

Estimation of excess mortality due to heat stress in future

- Procedure to estimate
  - Model development and parameter estimation using mortality statistics in Japan
  - Development of daily climate scenario using GCM output
  - Application of the model to global scale assessment of excess mortality due to heat stress
- What is “excess mortality” ?

“Excess mortality due to heat stress”
- definition in this study -





Mortality (death/day)

Mortality at To

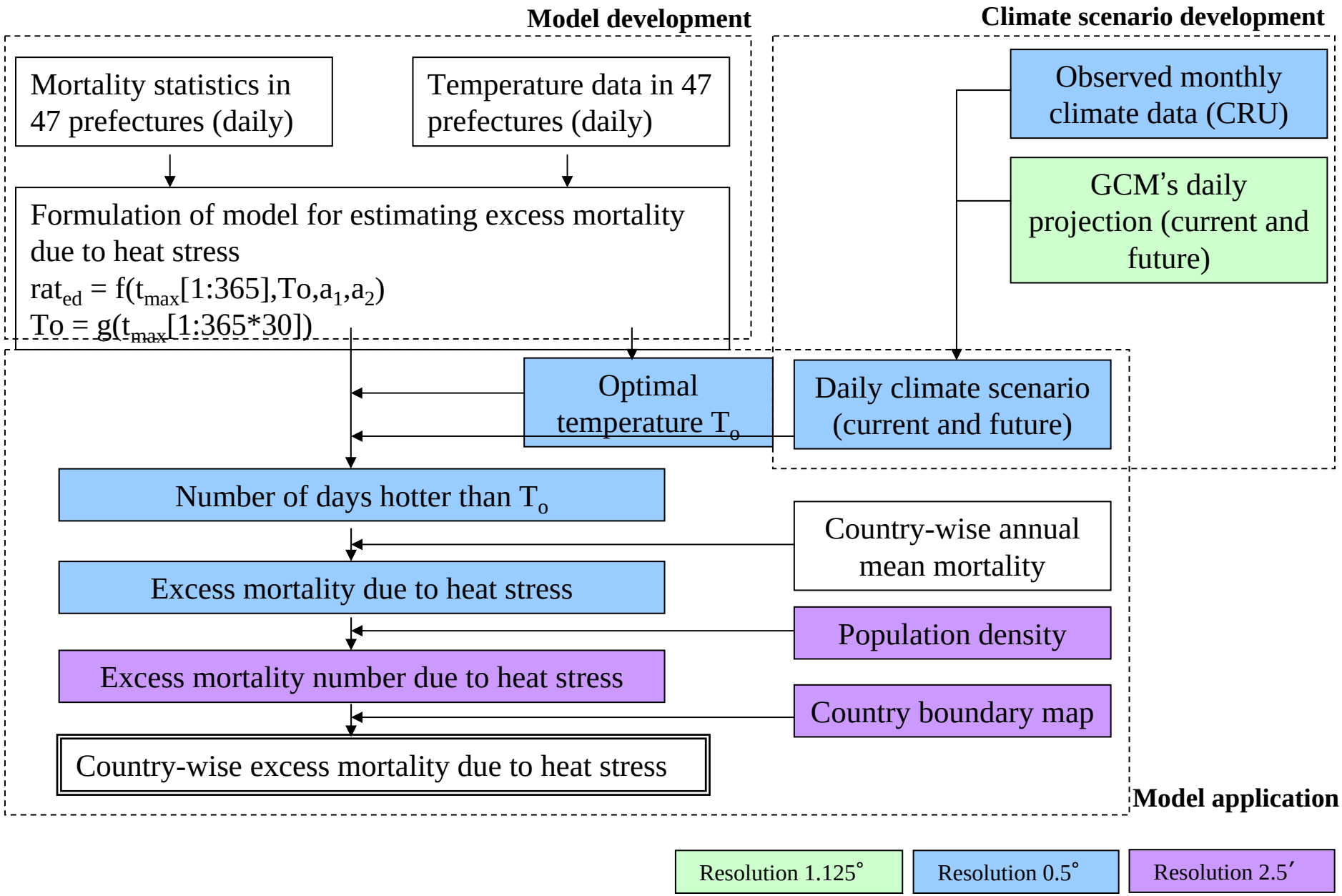
Mortality (Annual average)

Temperature (℃)

Optimal temperature To (℃)

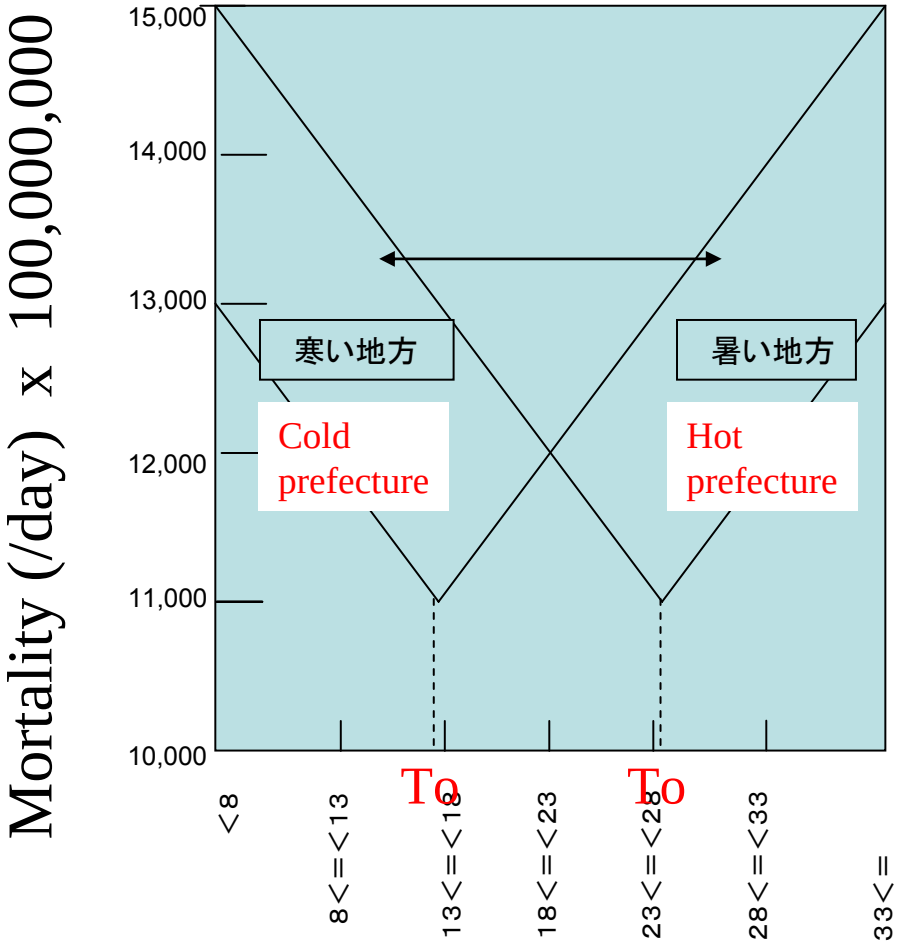
Excess mortality

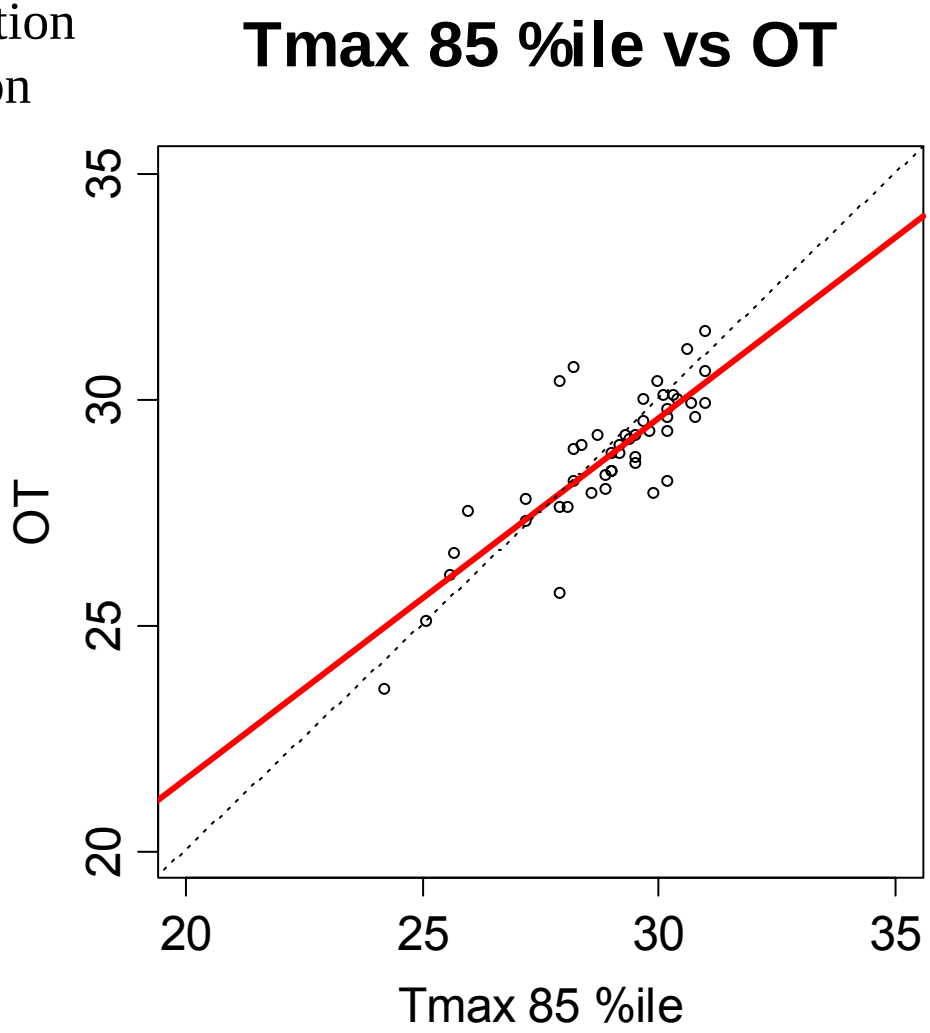
Estimation flow of excess mortality



Good correlation between 85%ile value of daily maximam temperature and optimal daily maximam temperature To

Physiologic acclimatization to hot condition
Social/cultural adaptation to hot condition

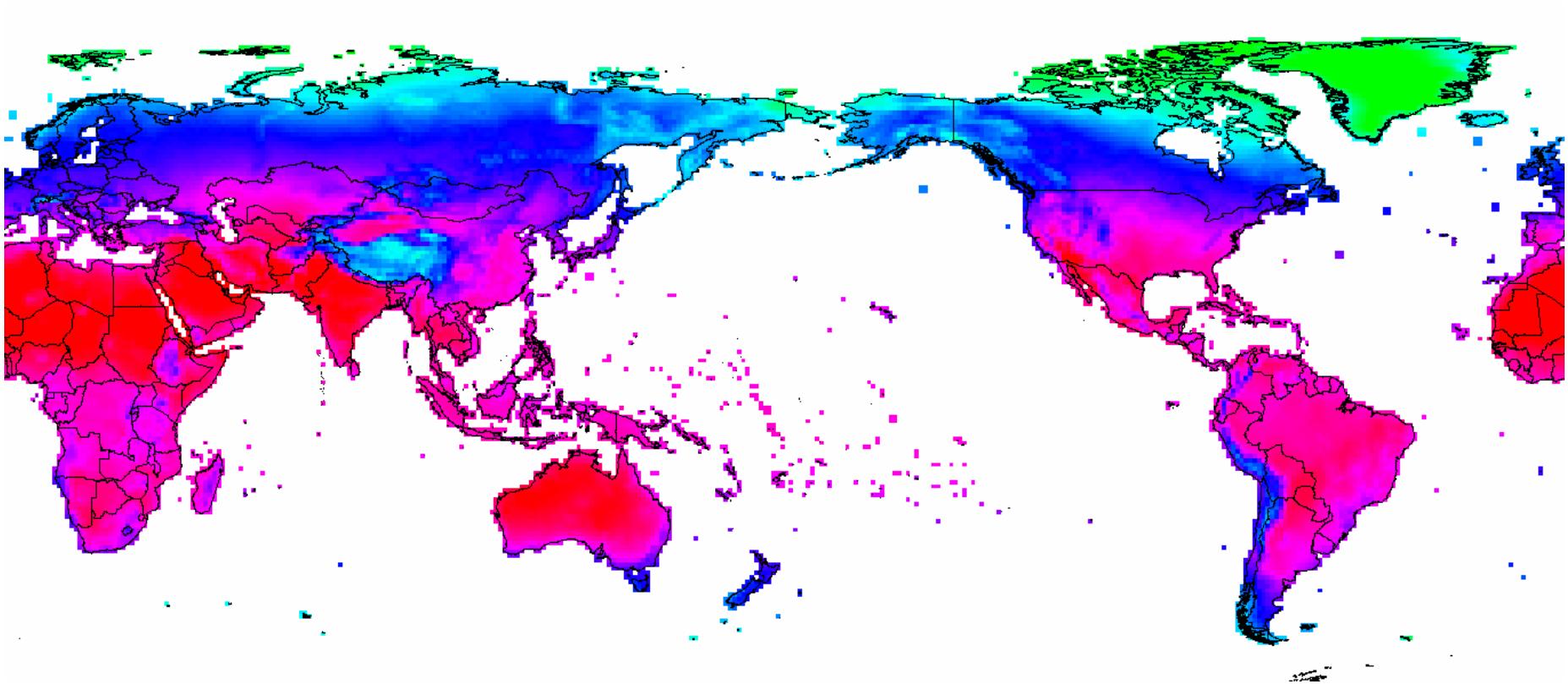


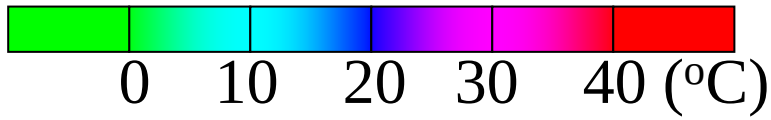


It was found that optimal daily maximum temperature has a good correlation with 85%ile value of daily maximum temperature

Estimated optimal temperature

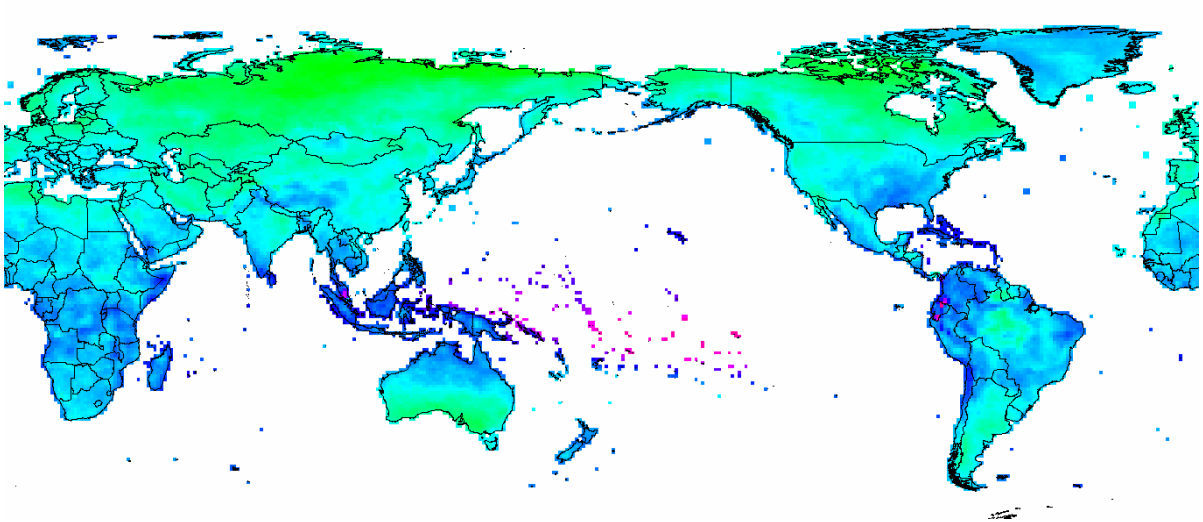
＝85%ile value of daily maximum temperature among 30years x 365 samples.



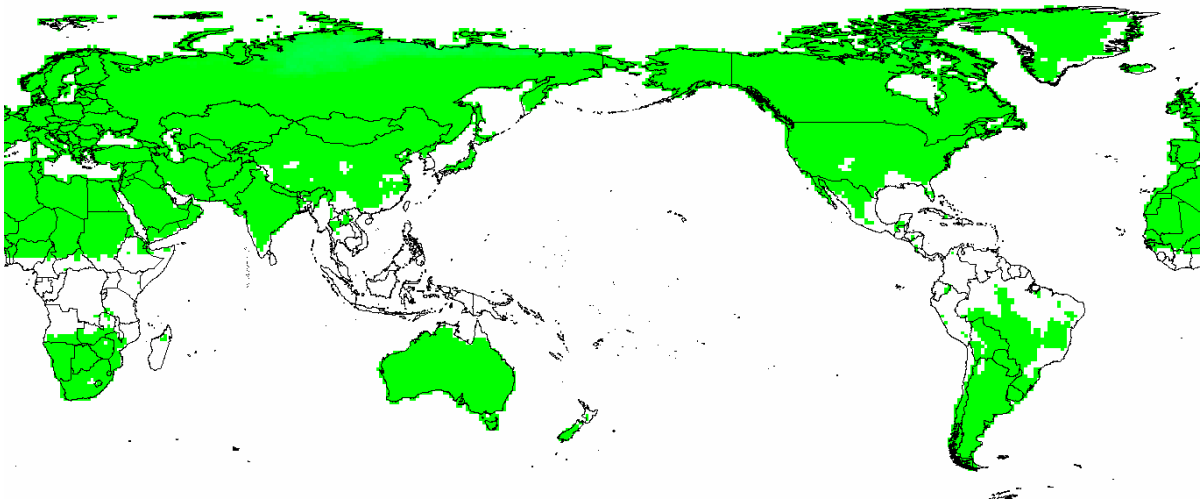


Estimated number of days with heat stress in 1990s

（Number of days when daily max temp exceeds optimal temperature To per year)



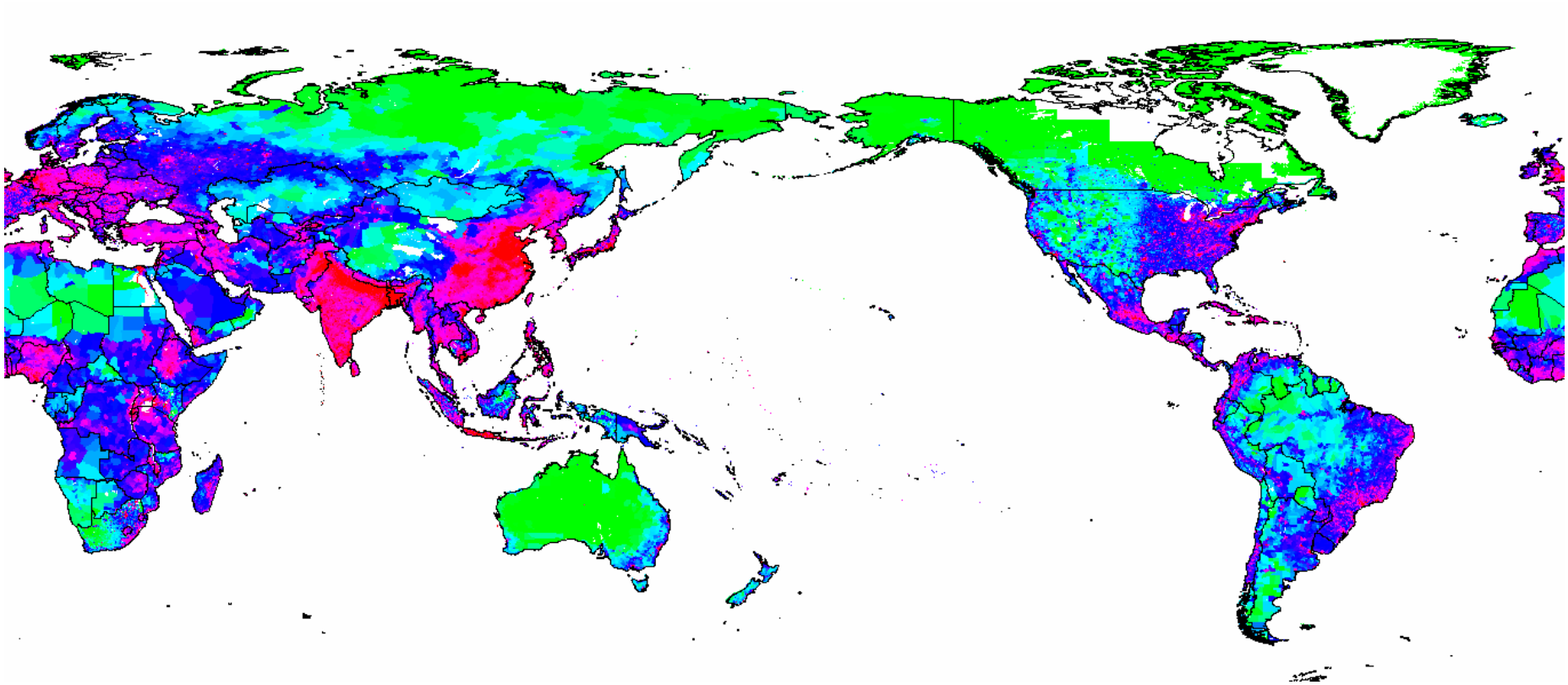
Number of days with moderate heat stress
To<T<To+5



Number of days with severe heat stress
To+5<T

Population density in 2000

（GPW3： http://beta.sedac.ciesin.columbia.edu/gpw/index.jsp）

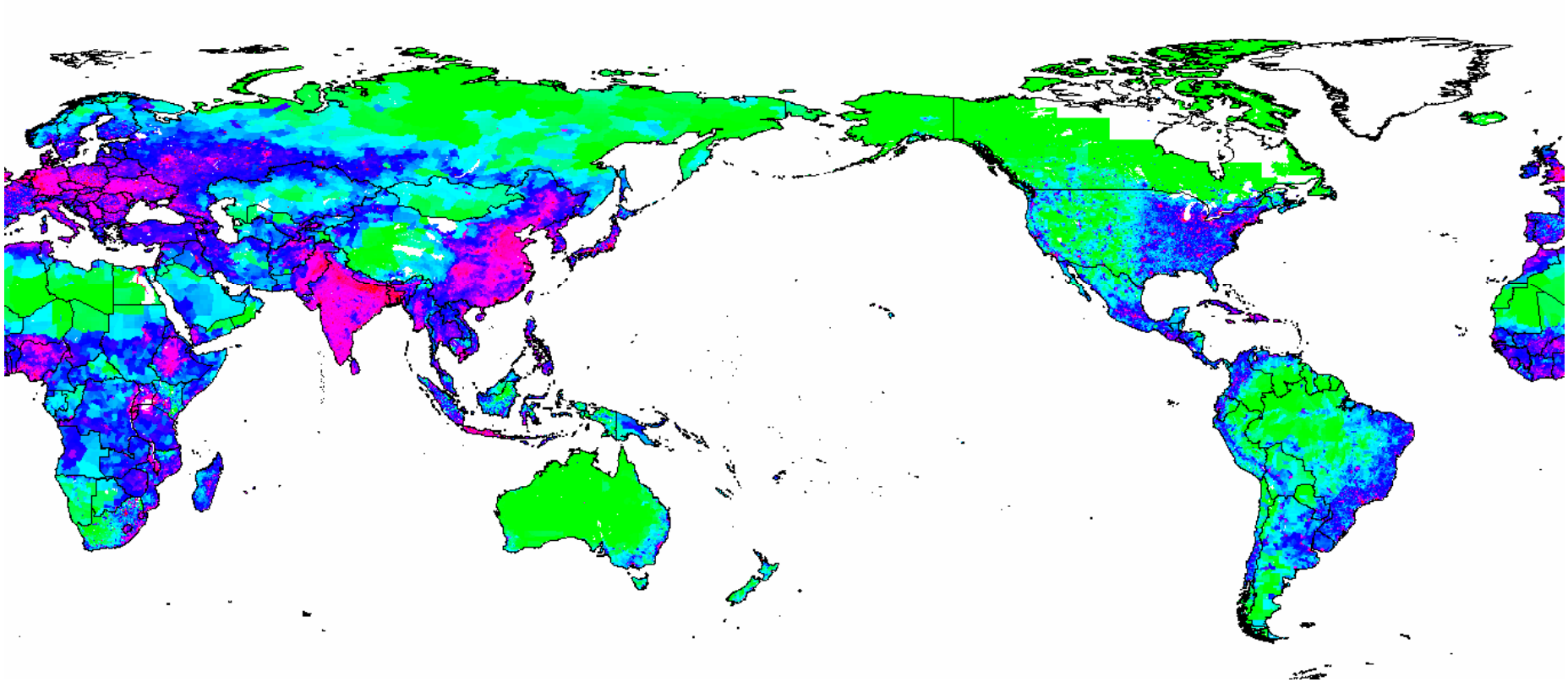


0.1 1 10 100 1000

(person/km^2)

Density of excess mortality due to heat stress

(Total mortality - mortality assuming optimal temperature through whole year)



10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}

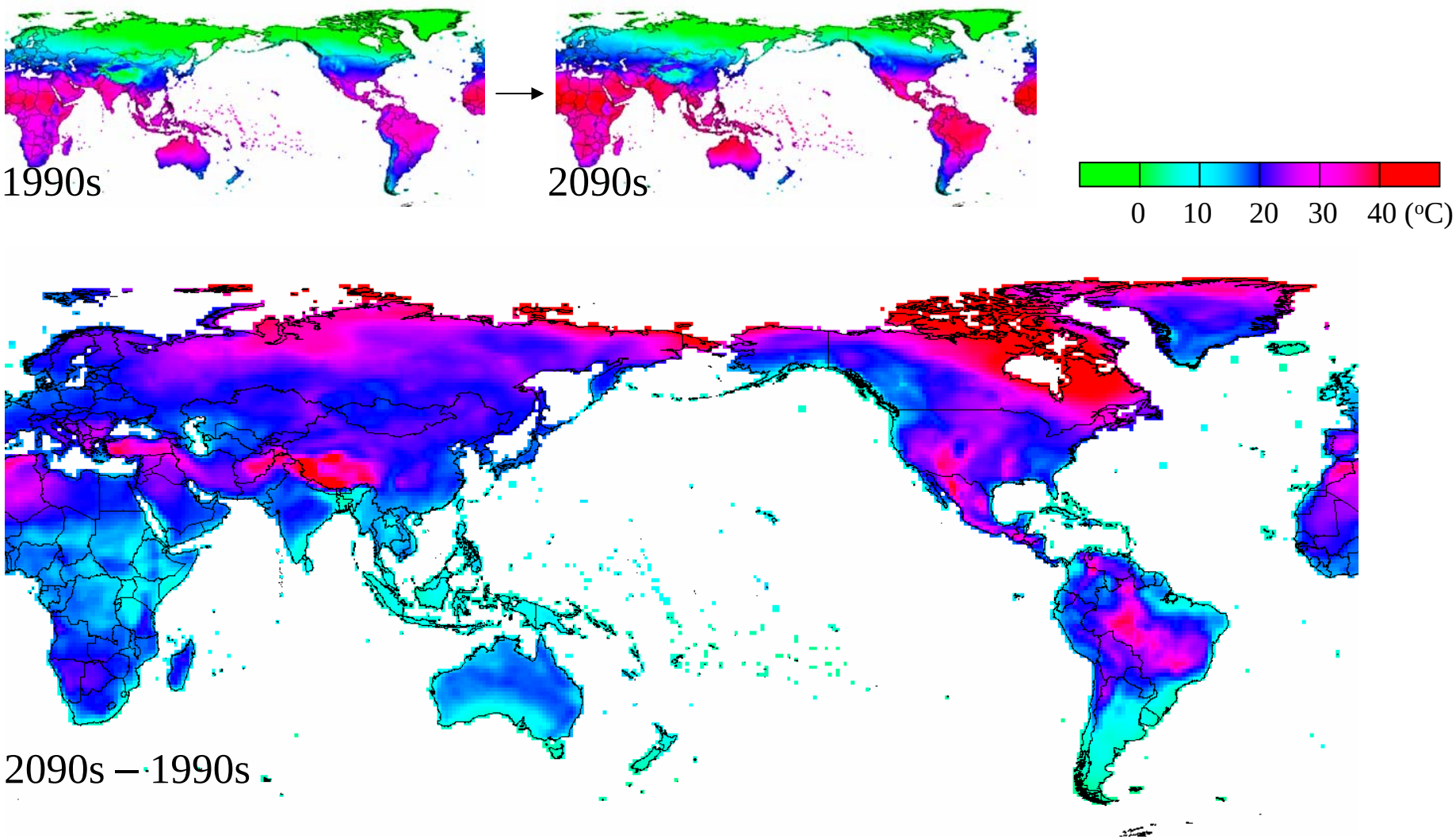
(person/km^2)

Scenarios for future projection

- Climate change
  - Temperature increase projected by CCSR/NIES/FRCGS-MIROC (SRES-A1B) was multiplied with the factor of 2/3 and then it was added to CRU observed monthly climate data for creating daily climate scenario without model bias.
- Population
  - Gridded Population of the World Ver.3 (GPW3)
    - Compatible with WB2000 estimates; 2.5′ x 2.5′
  - No change in future
- Adaptation / Acclimatization
  - No change in future

Change in daily maximum temperature in 100 years

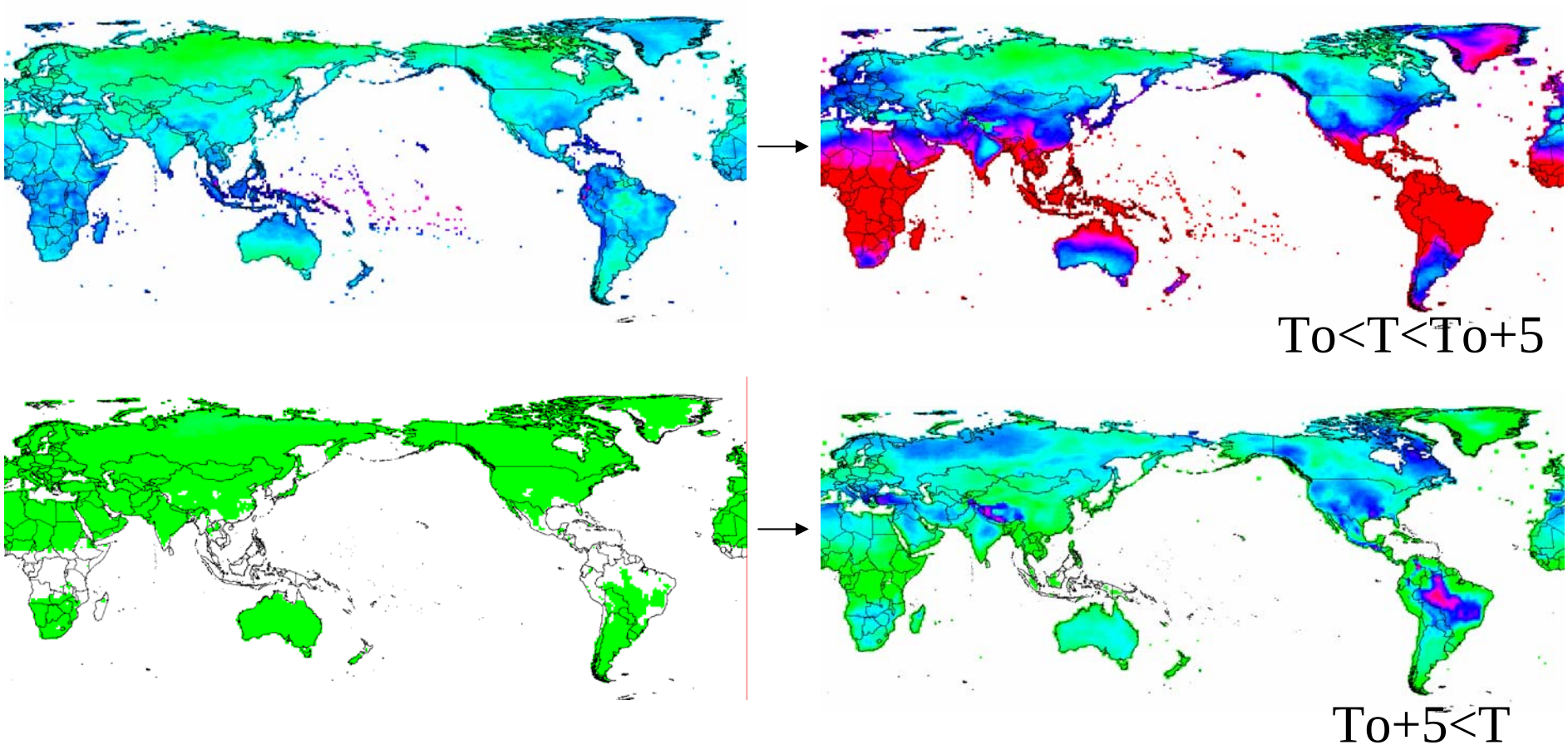
(10year-mean ; (2090s – 1990s) × 2/3 ; SRES-A1B ; MIROC-hires)



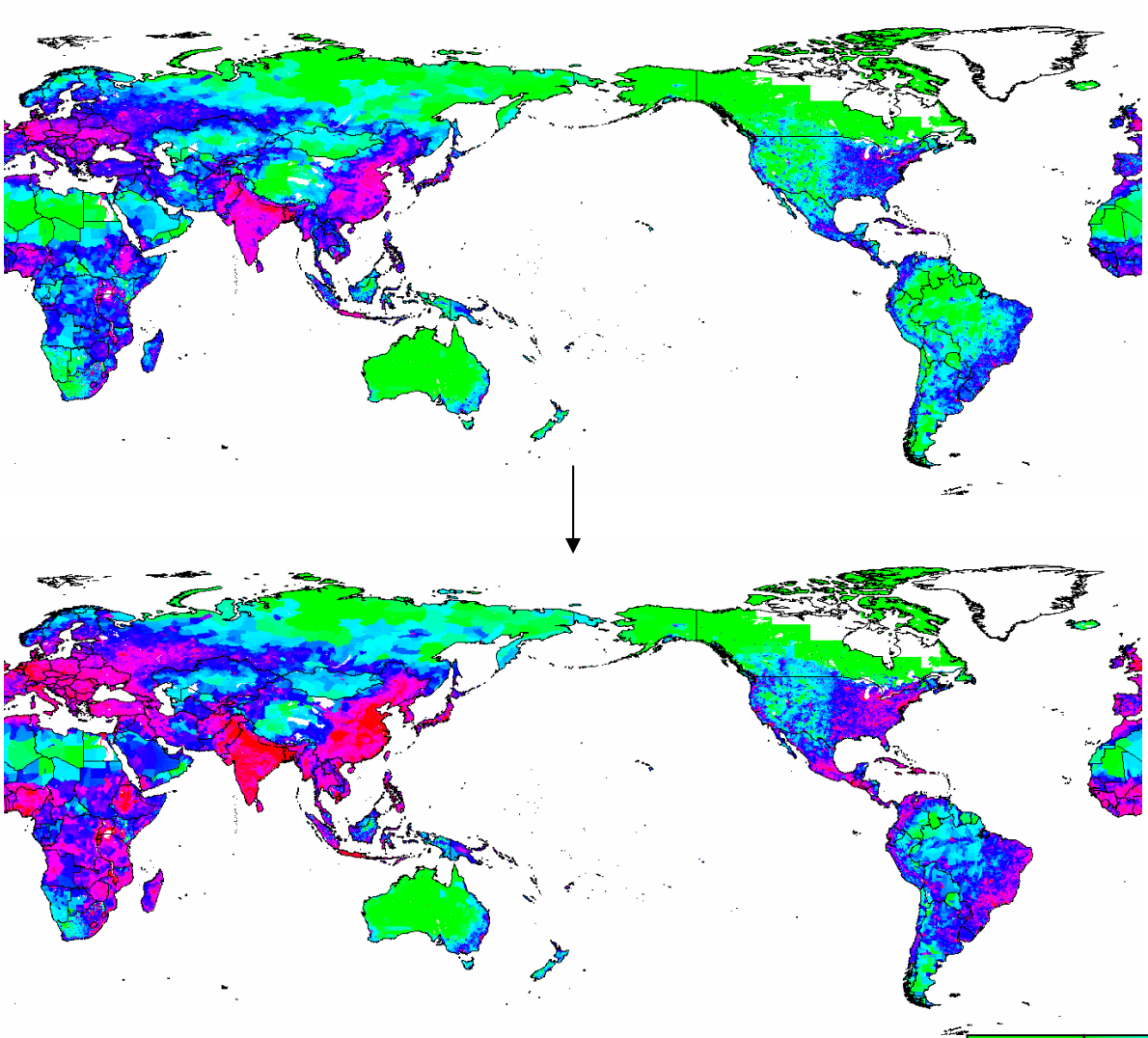
Change in number of days when daily maximum temperature exceeds optimal temperature To.

1990s

2090s



Change in excess mortality per unit area (1990s and 2090s)



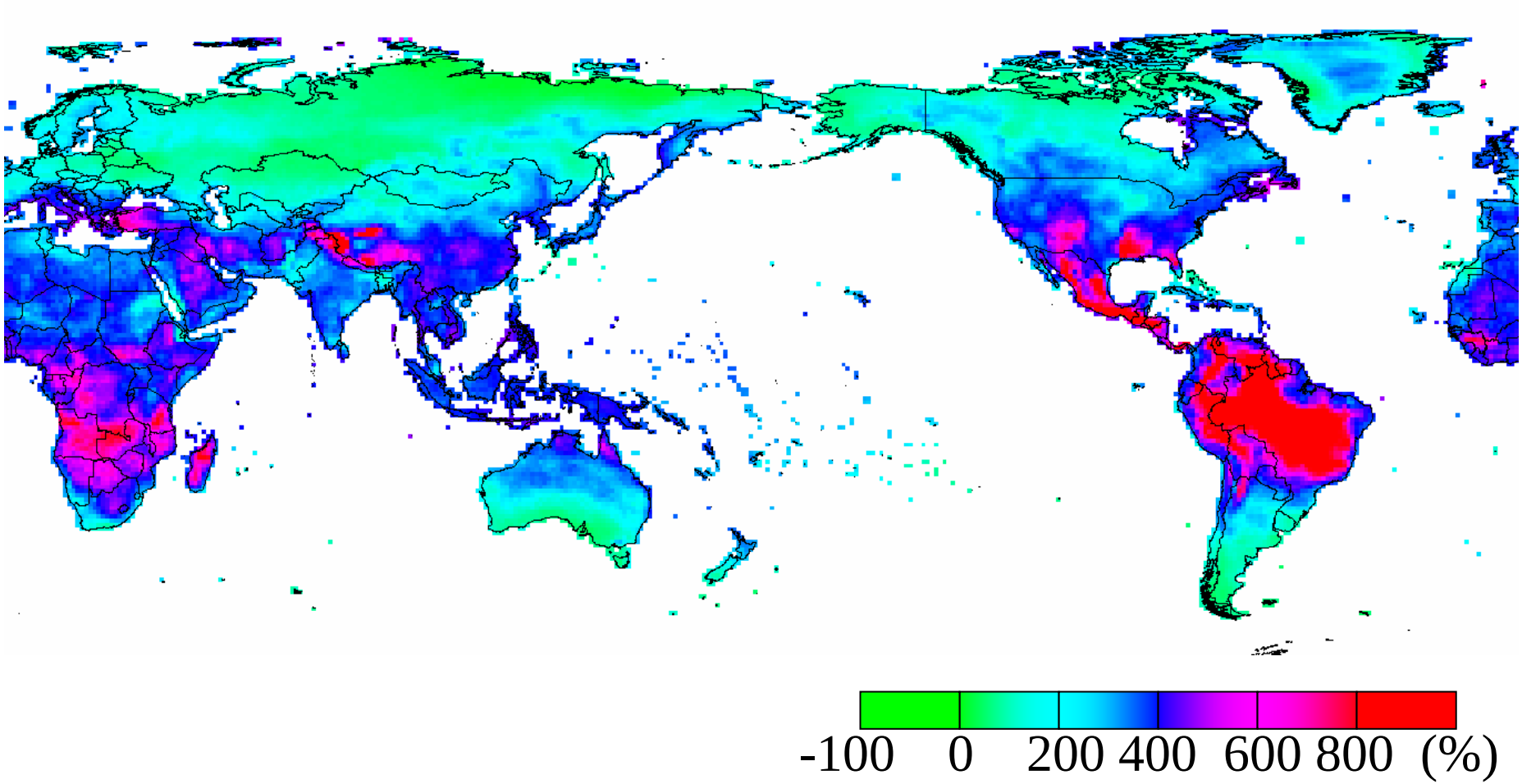
1990s

2090s

10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}

(person/km^2)

Percentage of change in excess mortality per area
（ 2090s / 1990s × 100 − 100 ）



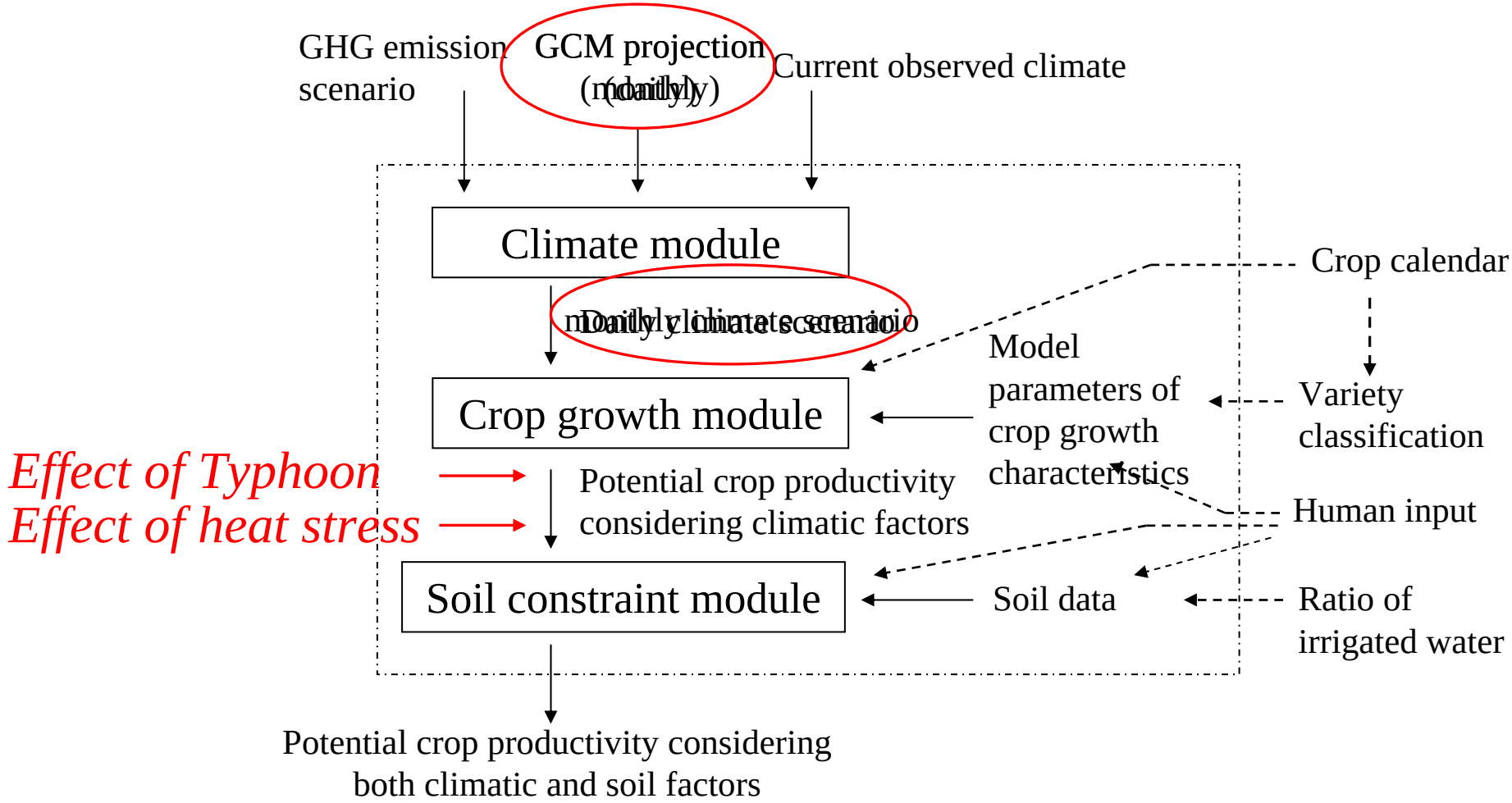
Challenges for the future in this study on heat stress mortality

- Mortality model developed using Japanese statistics has been applied to other countries.
  - Especially, for the regions hotter than Okinawa (Most south prefecture) or colder than Hokkaido (Most north prefecture), it is extrapolation.
  - Level of acclimatization/adaptation might be different among Japan and other countries.
  - Revision using data collected in Europe / U.S. is planned.
  - How about the availability of mortality data in developing countries?
- Assessment answers to the question “what happens if climate suddenly changes tomorrow morning?”.
  - No physiological/social/cultural acclimatization/adaptation is considered.
  - Population and its age structure is assumed to be constant even in future.

Works in FY2005

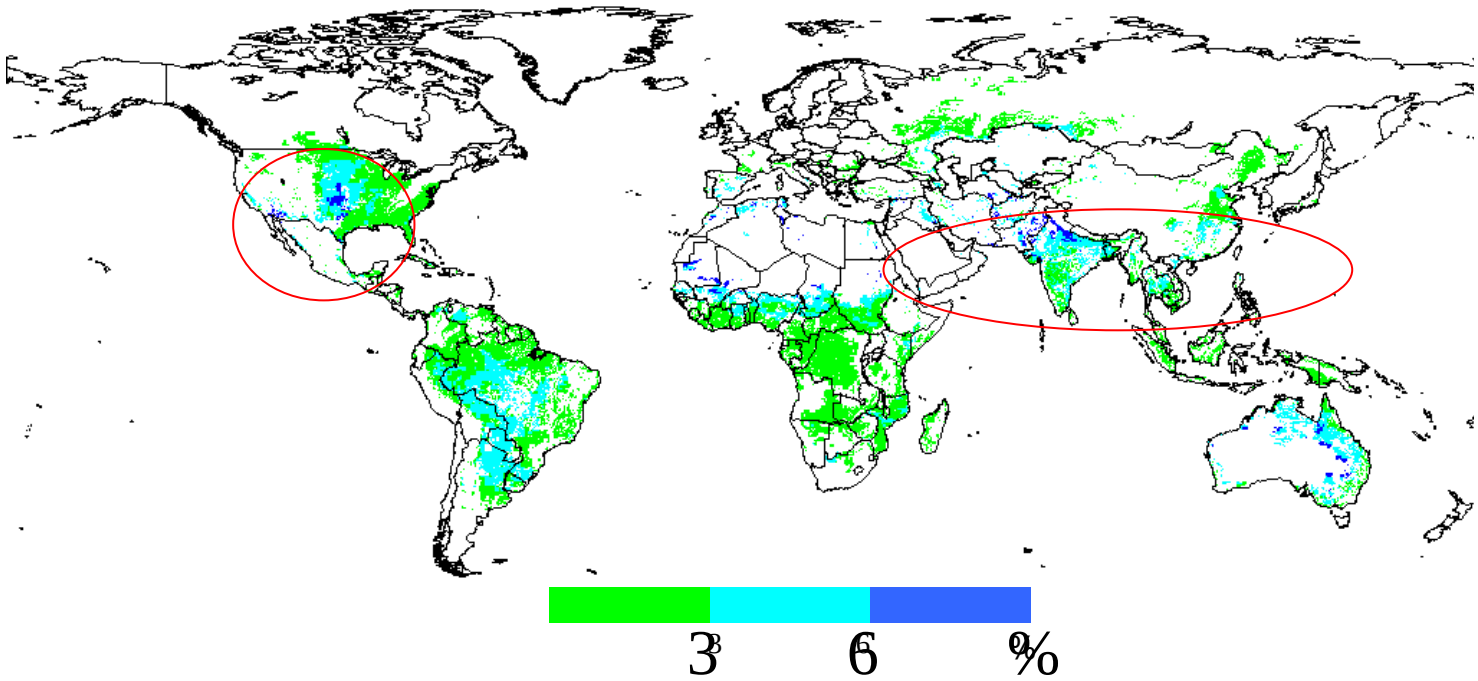
- Estimation of change in mortality due to heat stress
- Estimation of change in crop productivity with considering negative effect of typhoon and heat wave.
  - Crop production is affected by occurrence of extreme climate events as well as by average of climate condition.
    - Magnitude of typhoon (wind and rain) is expected to increase under future changed climate. It may disturb crop growth.
    - Too high temperature during growing season disturbs crop growth. It is very likely that very hot day will more frequently occur in future.
  - Estimation was done using daily climate scenario based on the latest GCM with high resolution.

Revision of crop productivity model for
(1) using daily climate scenario and
(2) considering extreme climate events (Typhoon and Heat)



Ratio of damage due to heat stress

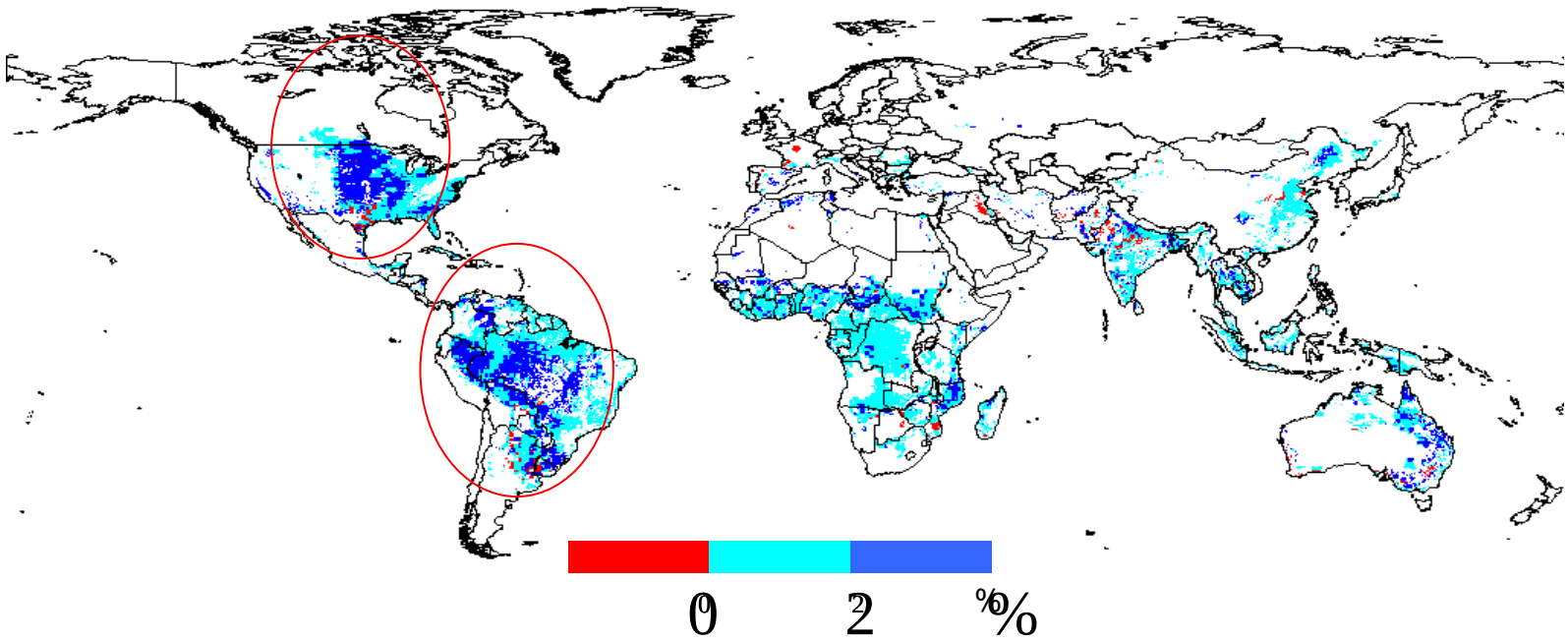
Ratio of damage (%) = 100 * (1 – productivity considering effect of heat stress / productivity without considering effect of heat stress)



(Validation is needed from now.)

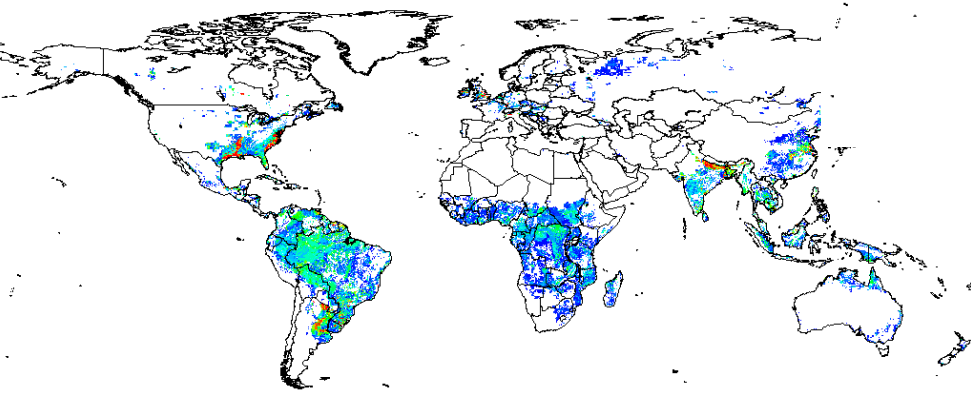
Future change in ratio of damage due to heat stress

Change in ratio of damage (%) = Ratio of damage in 2060 – that in 1990

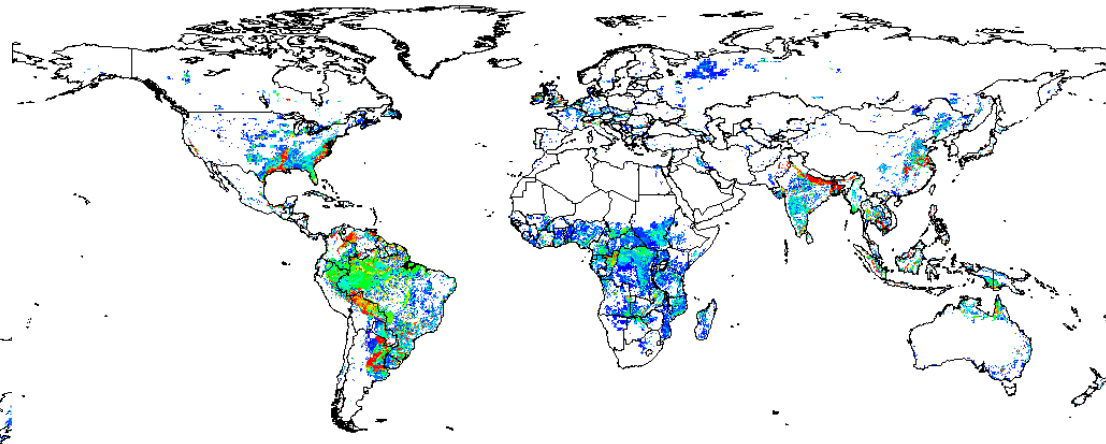


(Just for reference,
since validation is needed.)

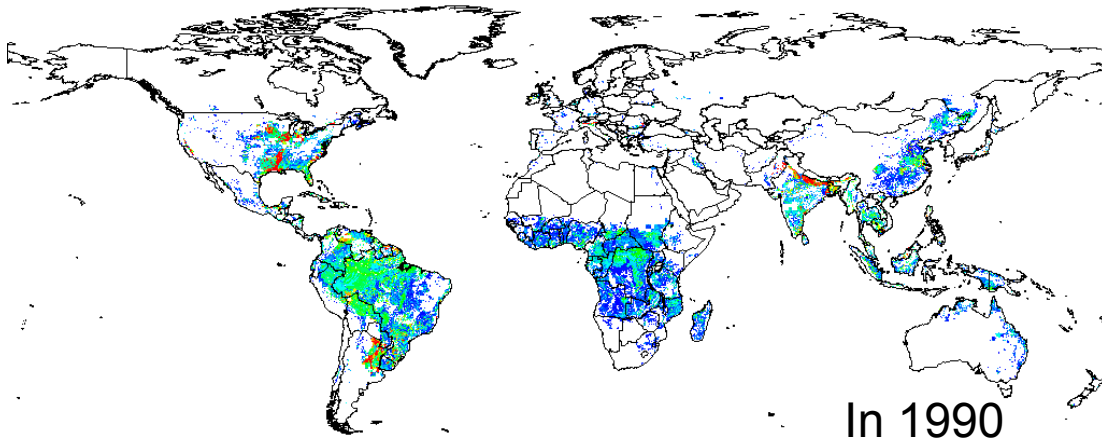
Potential productivity of rice considering effect of extreme events



In 2060（Constant irrigation and human input is assumed）



In 2060（Irrigation and human input is assumed to increase in accordance with GDP/Capipta）



In 1990

0 1 2 3 4 (t/ha)

Conclusion

- Development and revision of impact assessment model is being done in order to consider future change in extreme climate events such as heat wave, heavy rain, typhoon through the use of the latest climate model daily output with high spatial resolution. The object sectors are agriculture and human health.
- Future change in excess mortality due to heat stress was assessed. As a result, with the assumption of no acclimatization/adaptation, the excess mortality due to heat stress may increase by 100% - 500%.

The roles of detailed impact assessment in policy context?

- Adaptation
  - For detecting regions where adaptation measures are needed.
  - For providing information to prioritize adaptation measures in a qualitative/quantitative manner
- Burden sharing
  - Burden sharing in a future international framework may require to consider mitigation cost, adaptation cost and residual impact cost (in monetary/non-monetary unit) in each country/region.
  - Not only global total amount of impact but also distribution of impact needs to be known.