

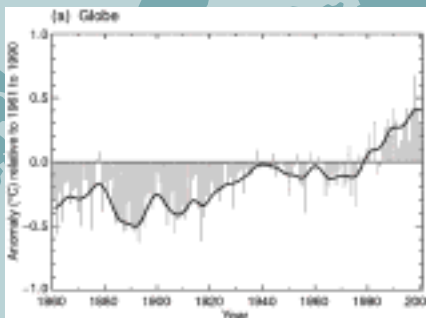
Long-Term Trends of Pan Evaporation Measurements in Japan and its Relevance to the Variability of the Hydrological Cycle

Jun Asanuma
Terrestrial Env. Res. Ctr, Tsukuba Univ.
(asanuma@suiiri.tsukuba.ac.jp)

Hideyuki Kamimera
Nagaoka Univ. of Tech

Observational facts of trend in the hydrological cycle

- Many research has been done to detect changes occurred in each component of hydrological cycle in response to the global warming.



Surface temperature rise



Changes in hydrological cycle?



Observational facts for changes in hydrological cycle

- Precipitation trend has been well analyzed using operational, satellite-based or model-based measurements.
- According to IPCC report (2001),
 - Global average precipitation has been increased in 2%/century.
 - non-uniform in time and space.
- Controversy, as well



Observational facts for changes in hydrological cycle

- Evaporation from the land surface
 - has no long-term measurement.
 - Recent growing interest is that
- “Pan evaporation trend may serve as an index of the trend of landsurface evaporation.”**



Pan evaporation

- Evaporation from open water stored in the pan evaporimeter.
 - operationally measured world-wide

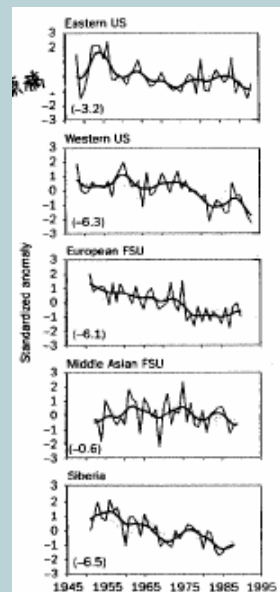


class A pan



Literature review

- Peterson et al.(1995, Nature)
 - decrease in pan evaporation in US and Former Soviet Union (FSU)
 - pan evaporation = potential evaporation (=wet surface evaporation)
 - suggests the decrease in the landsurface evaporation
- “Evaporation loses its strength”
- Similar reports from India and Venezuela.



Literature review 2

Brutsaert and Parlange (1998, Nature)

Peterson's interpretation

decrease in pan evaporation



decrease in potential evaporation



decrease in landsurface evaporation



contradiction

increase in precipitation

New interpretation

decrease in pan evaporation

 complimentary relationship

increase in landsurface evaporation



increase in precipitation



“accelerated hydro. cycle”?

Observational confirmation
with US and FSU data

Literature review 3

- Roderick and Farquhar (2002, Science)
 - Increase in cloud amount and aerosol caused decrease in the pan evaporation as well as the landsurface evaporation.
 - **3rd interpretation** of pan evaporation trends

decrease in pan evaporation



decrease in landsurface evaporation

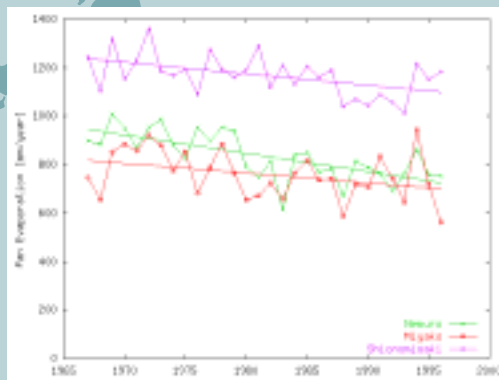
This study

- **Purpose:**
 - To investigate Japanese pan evaporation data to find out trends in it.
 - To infer what is the meaning of trend in the pan evaporation.
- **Data analyzed:**
 - 13 operational stations run by JMA (class A pan)
 - period: 1967-2000
 - Pan evaporation and meteorological vars.

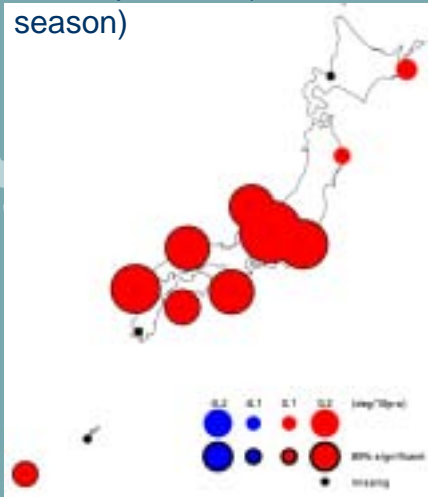


Analysis

- **Identification of linear trend with linear regression**
 - with statistical test of significance

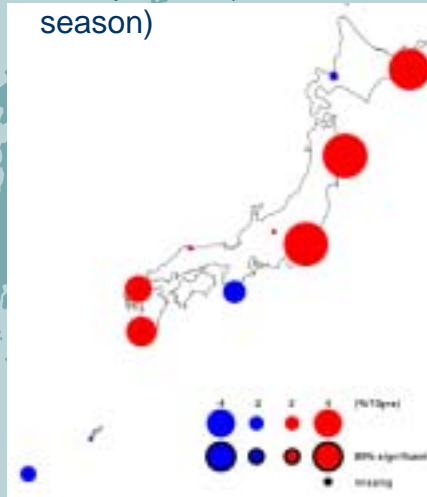


Air temperature (AT, warm season)



increasing air temperature

Precipitation (PR, warm season)

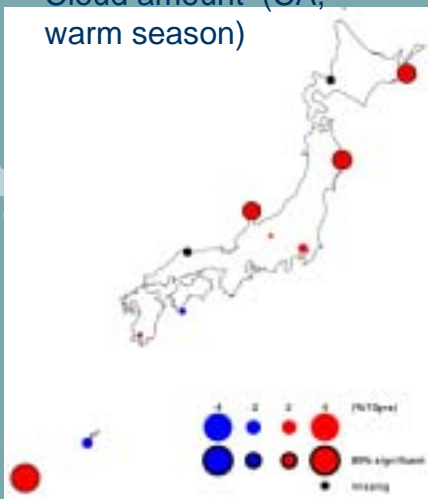


increasing precipitation, but not statistically significant

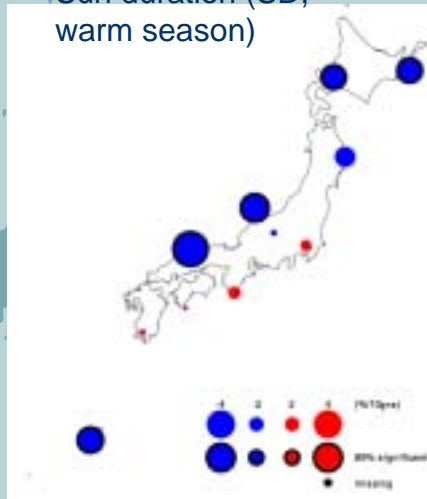
closed circles = 95 % statistically significant



Cloud amount (CA, warm season)



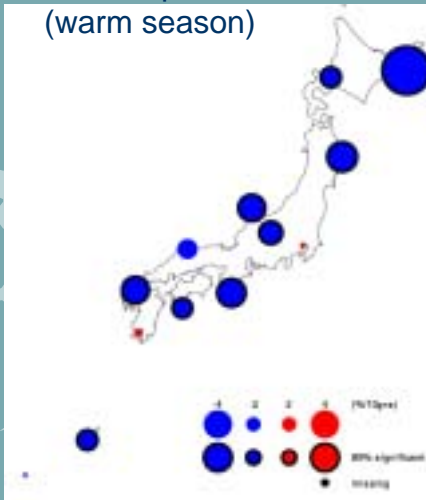
Sun duration (SD, warm season)



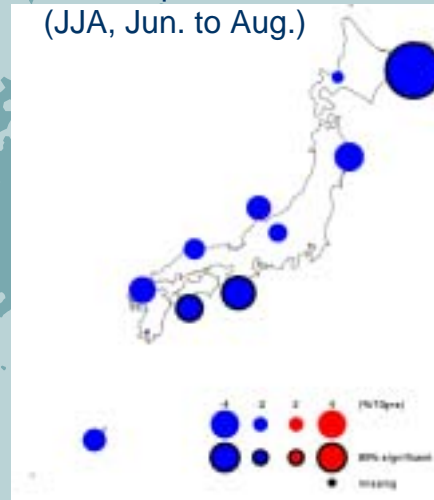
cloud amount is increasing and sun duration is decreasing in the northeastern Japan. No strong change seen in the southwestern region.



Pan evaporation trends (warm season)



Pan evaporation trends (JJA, Jun. to Aug.)

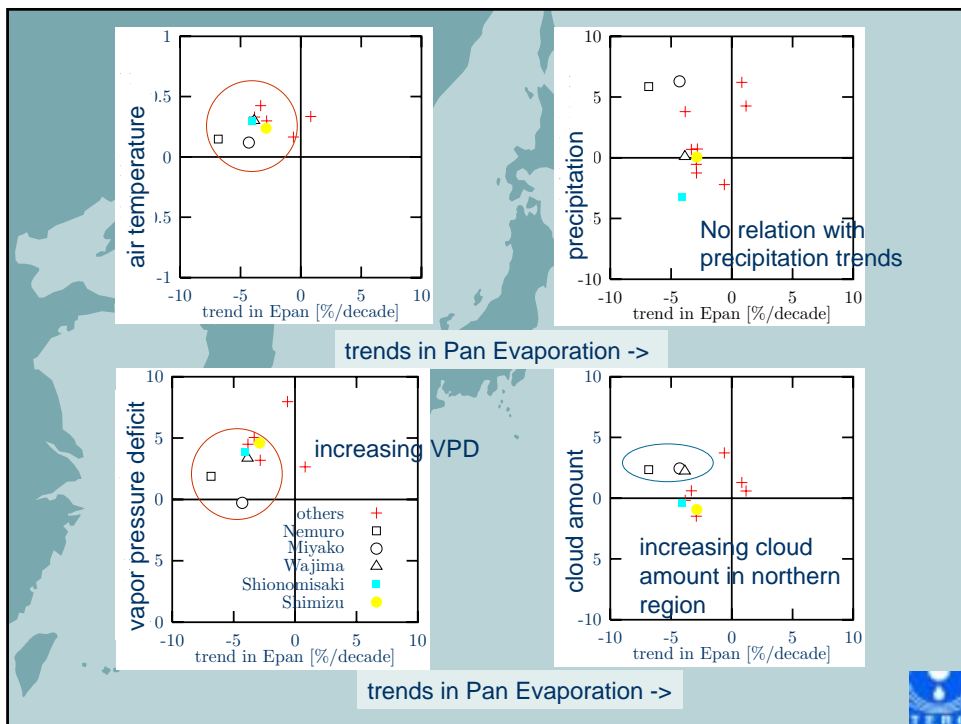


Decrease in pan
evaporation all over Japan

Detailed statistical analysis

- Objective: to identify the cause of the decreasing pan evaporation.
 - 5 stations with stronger decreasing trend and with less effect of the urbanization were selected.





Result of detailed analysis

- No systematic relationship with precipitation trends.
- VPD increases at 4 of the 5 sites.

- The atmosphere has become drier
- This can cause increase in landsurface evaporation.
 - Complimentary relationship between the pan evaporation and the landsurface evaporation
 - Supports Brutsaert and Parlange(1998)

Decreasing pan evaporation indicate increasing landsurface evaporation

- The northern stations give increasing cloud amount
 - supports Roderick and Farquhar(2002).

Decreasing pan evaporation indicate decreasing landsurface evaporation

Summary

- Pan evaporation shows decreasing trends in the last 35 years at most of the regions in Japan.
- Decreasing trend of the pan evaporation in southeast Japan can be connected to those in China, and India already found in the previous reports.
=> common to the monsoon Asia (?)



Summary 2

- Cause of the decreasing pan evaporation
 - Northern Japan
 - decreasing solar radiation and drying atmosphere
=> decreasing or increasing landsurface evaporation
 - Southern Japan
 - drying atmosphere
=> increasing landsurface evaporation
- Interpretation of pan evaporation trends differ in different climate systems.



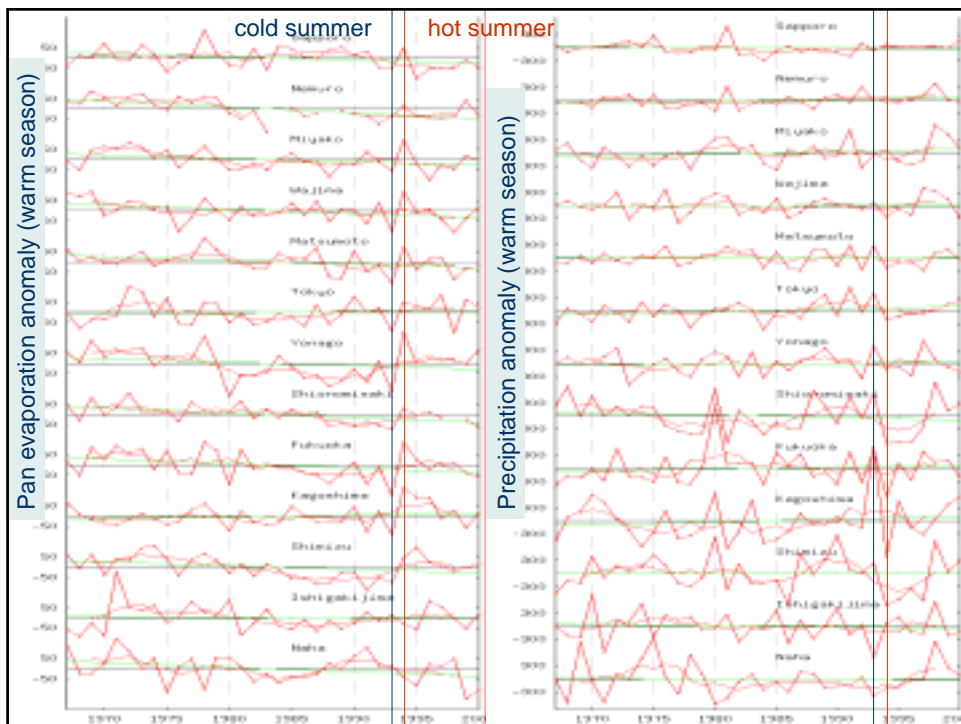


Literature review - Asia

- Pan evaporation decrease in Siberia (Peterson, 1995)
- Xu et al.(2001)
 - Pan evaporation measurements in China
 - Increase in the arid region.
 - Decrease in the moist region.



图15 JTG-潘蒸散量等值线及月蒸发量(单位:mm)分布(图11参照)。
Fig. 15 The same as in Fig. 11 except for pan evaporation flow (monthly total).



Analysis of Interannual Variability

- Stepwise regression analysis

$$Epan = a_1 X_1 + a_2 X_2 + \dots$$

X_1, X_2, \dots : variables (AT, PR, SD ...)

a_1, a_2, \dots : constants determined by the regression

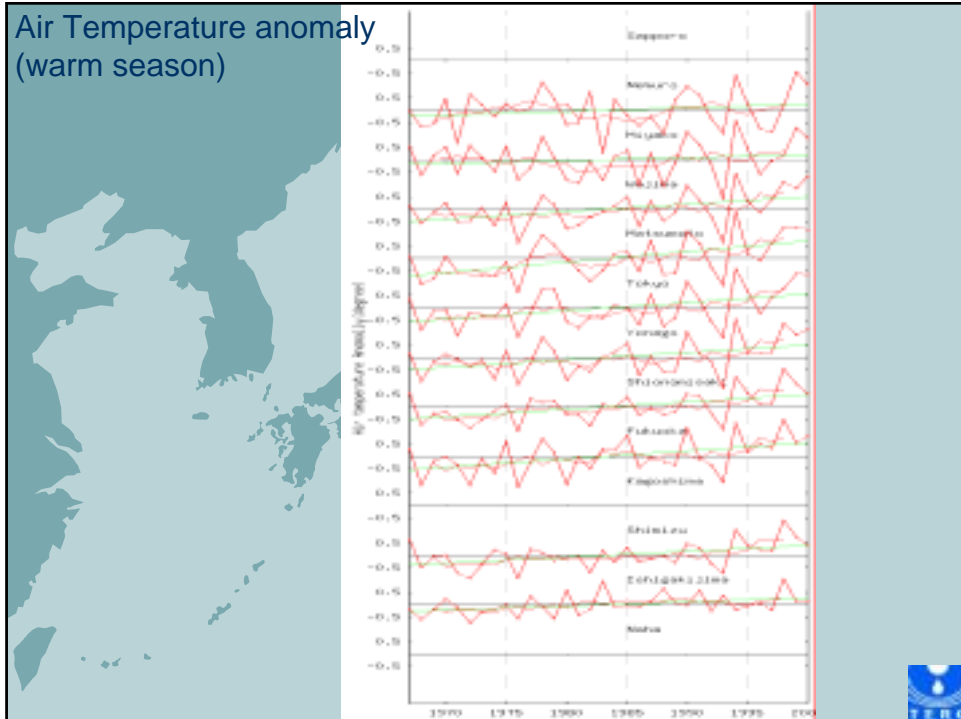
to find out the best set of (x_1, x_2, \dots) that best describe the variation of Epan

Result of Regression Analysis

| Station | X_1 | X_2 |
|--------------|-------|-------|
| Nemuro | DTR | VPD |
| Miyako | VPD | CA |
| Wajima | DTR | VPD |
| Shionomisaki | DTR | |
| Shimizu | SD | |

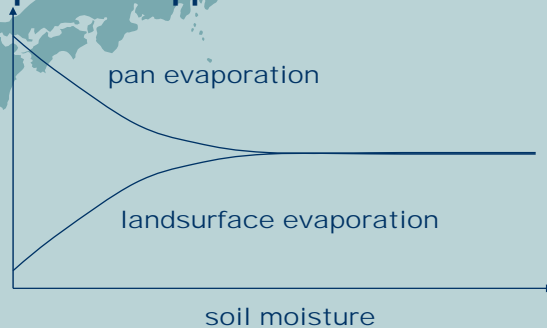


Air Temperature anomaly (warm season)



Complimentary Relationship

- Bouchet (1963)
 - Some kinds of potential evaporation (e.g. pan) is complimentary with landsurface evaporation.
 - Conceptual idea, empirically validated.
 - Seen some practical applications.



Observational Facts 1

- **Increasing air temperature**
 - due to either global climate change or local urbanization
- **Precipitation: increasing or decreasing, but not statistically significant**
 - due to large interannual variability
- **Cloud amount: increasing in the north and no change or slightly decreasing in the south (not significant)**
- **Pan evaporation**
 - contains larger scale climate information relative to the precipitation
 - all over decrease for all seasons



Quick View

- **Quick view of the pan evaporation data shows that the pan evaporation may have some information on the climate of broader region in contrast to the precipitation that is more local.**

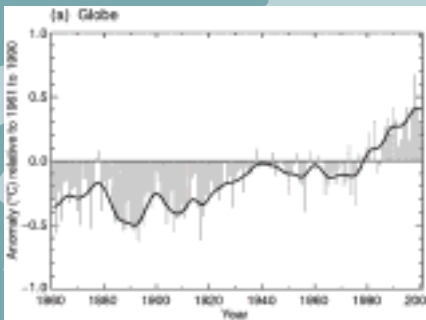


Five sites for detailed analysis



5 stations with stronger decreasing trend and with less effect of the urbanization were selected

Background 1 - climate change and hydro. cycle



IPCC report (2001)

- Global surface temperature rise has been witnessed in the last half century.



- Hydrologists' interest: “how large change has occurred/will occur in hydrological cycle?”