Development of Global Terrestrial Hydrological Monitoring and Forecasting System "Today's Earth"

Kei Yoshimura[1,2], Yuta Ishitsuka[3], Wenchao Ma[1], Kenshi Hibino[1], Akira Takeshima, Dai Yamazaki[1], Kosuke Yamamoto[2], Misako Kachi[2], Riko Oki[2]

[1]Institute of Industrial Science, The University of Tokyo
[2]Earth Observation Research Center, JAXA
[3]University of Massachusetts, Amherst

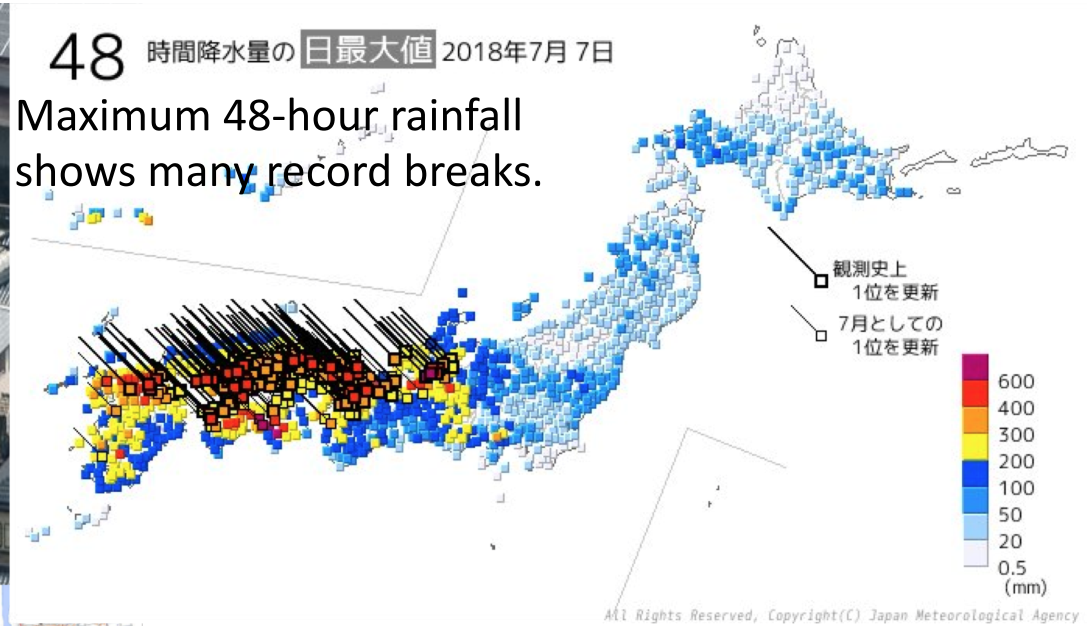
Kinu-River Flood on Sep 10 2015

- Heavy precipitation for 8 to 10 September 2015 over Tochigi and Ibaraki prefectures was caused by clustered linear rain bands influenced by Typhoon Etau (No 18) and Kilo (No 17).

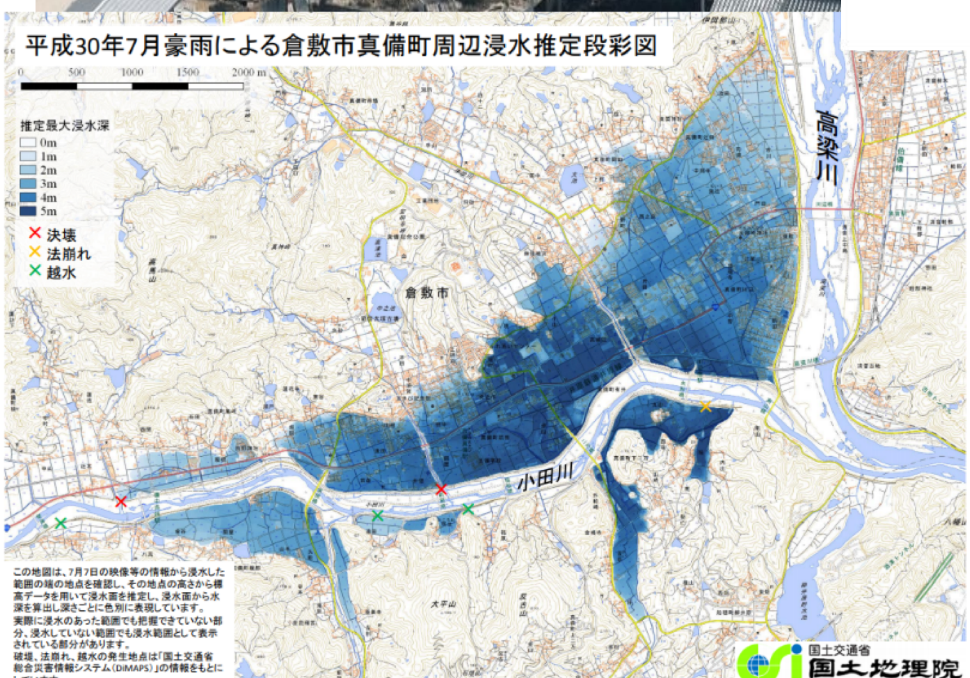
- The rain event caused an over-topping and an outburst of the left levee of Kinu-river in Wakamiyato and Misaka-cho districts in Joso city, Ibaraki prefecture around 6am and 1pm on 10 September, respectively.

- Over 40 km^2 in Joso-city including 11,000 houses were inundated, evacuation orders/recommendations were issued for more than 10,000 citizens, and over 2,000 people were rescued by helicopters and boats.

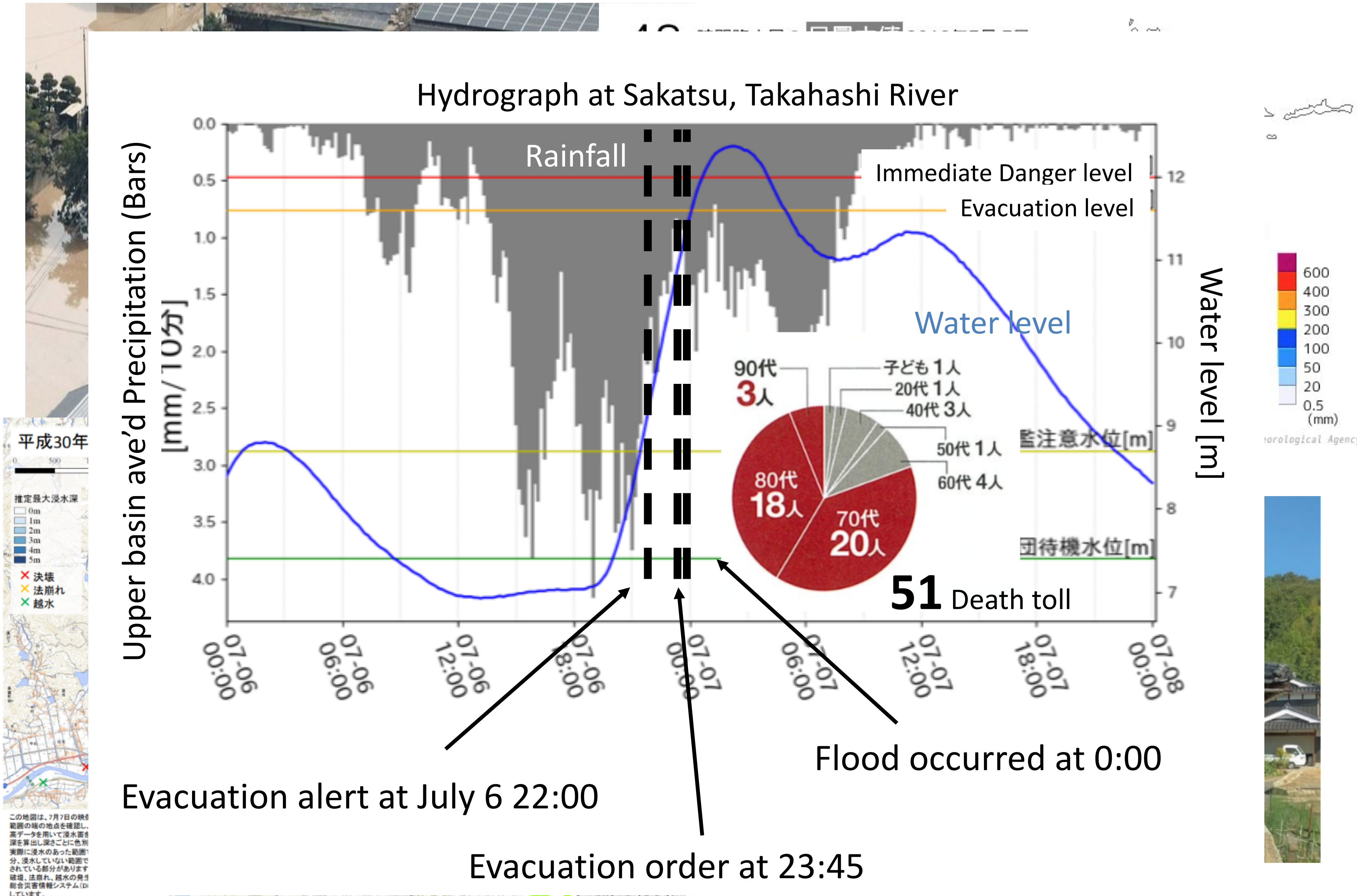
Takahashi-river Floods in 2018 July



Maximum 48-hour rainfall shows many record breaks.



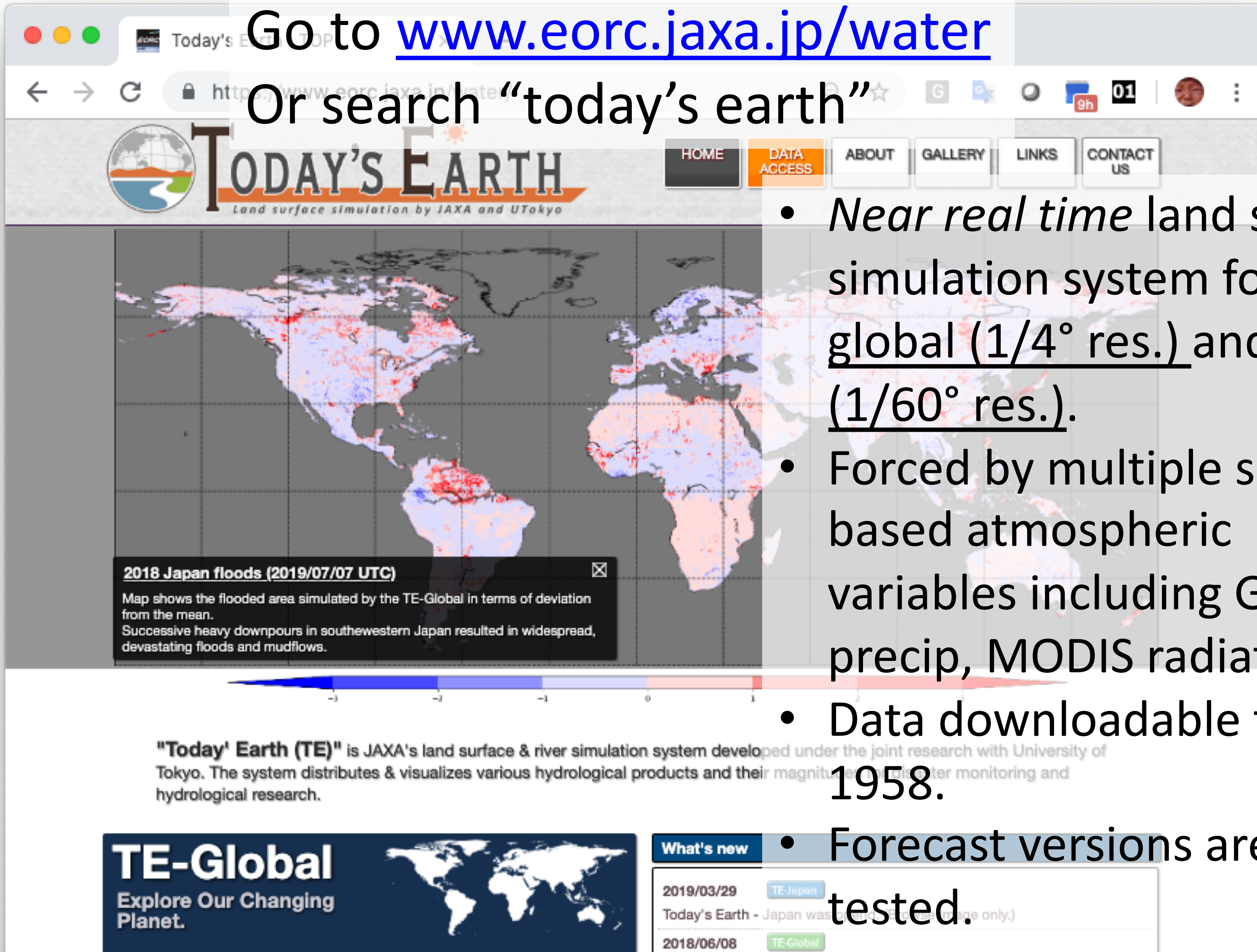
Takahashi-river Floods in 2018 July



Today’s Earth system

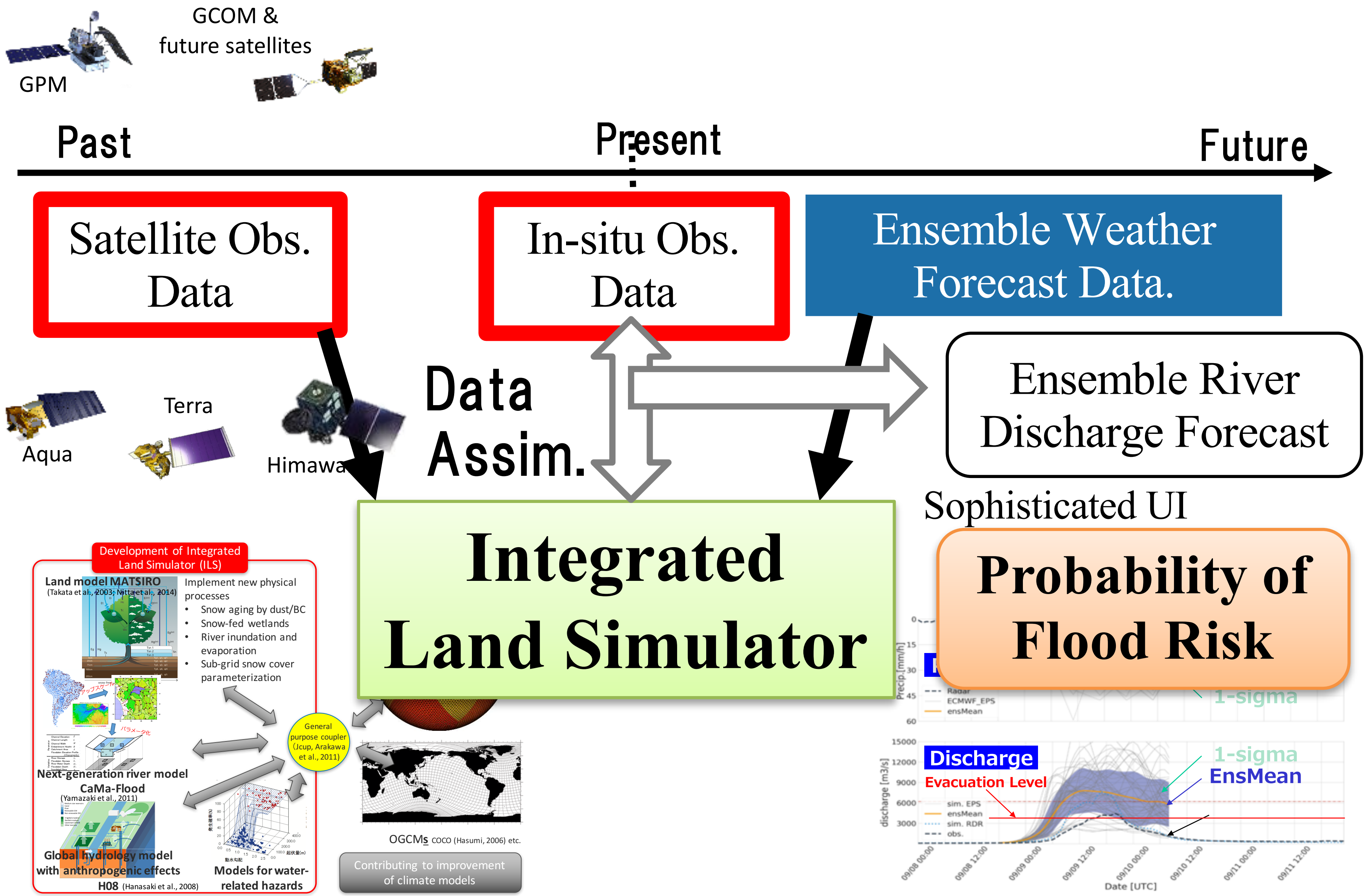
Go to www.eorc.jaxa.jp/water

Or search “today’s earth”



- *Near real time* land surface simulation system for global (1/4° res.) and Japan (1/60° res.).
- Forced by multiple satellite based atmospheric variables including GSMaP precip, MODIS radiation.
- Data downloadable from 1958.
- Forecast versions are being tested.

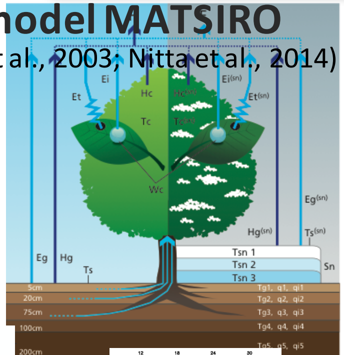
Design of Today's Earth

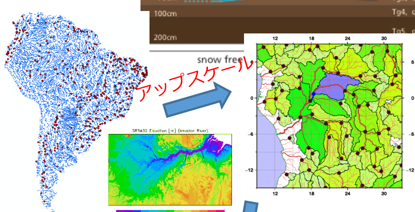


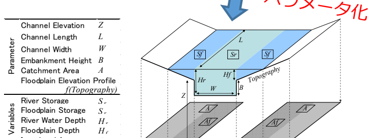
Integrated Land Simulator (committed to MIROC7)

Development of Integrated Land Simulator (ILS)

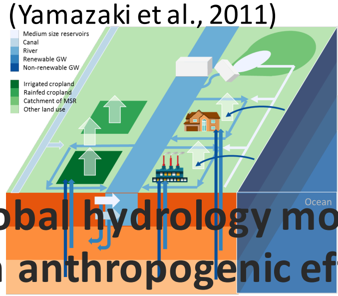
Land model MATSIRO
(Takata et al., 2003; Nitta et al., 2014)







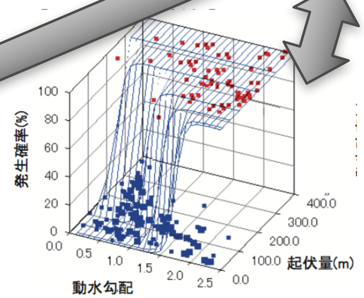
Next-generation river model
CaMa-Flood
(Yamazaki et al., 2011)



Global hydrology model with anthropogenic effects
H08 (Hanasaki et al., 2008)

Implement new physical processes

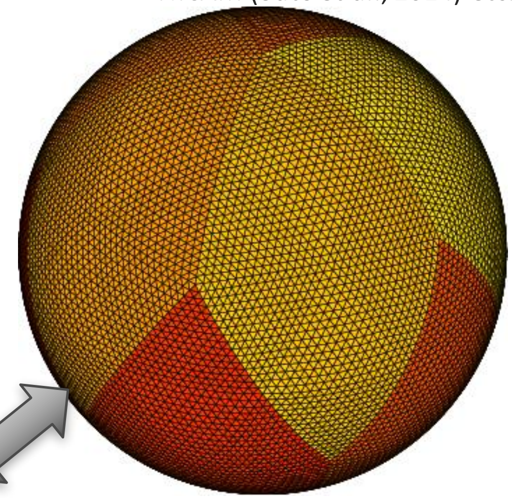
- Snow aging by dust/BC
- Snow-fed wetlands
- River inundation and evaporation
- Sub-grid snow cover parameterization

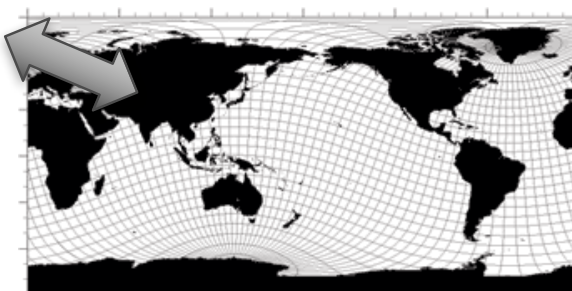


Models for water-related hazards

General purpose coupler (Jcup, Arakawa et al., 2011)

AGCMs
MIROC (Watanabe et al., 2010),
NICAM (Sato et al., 2014) etc.



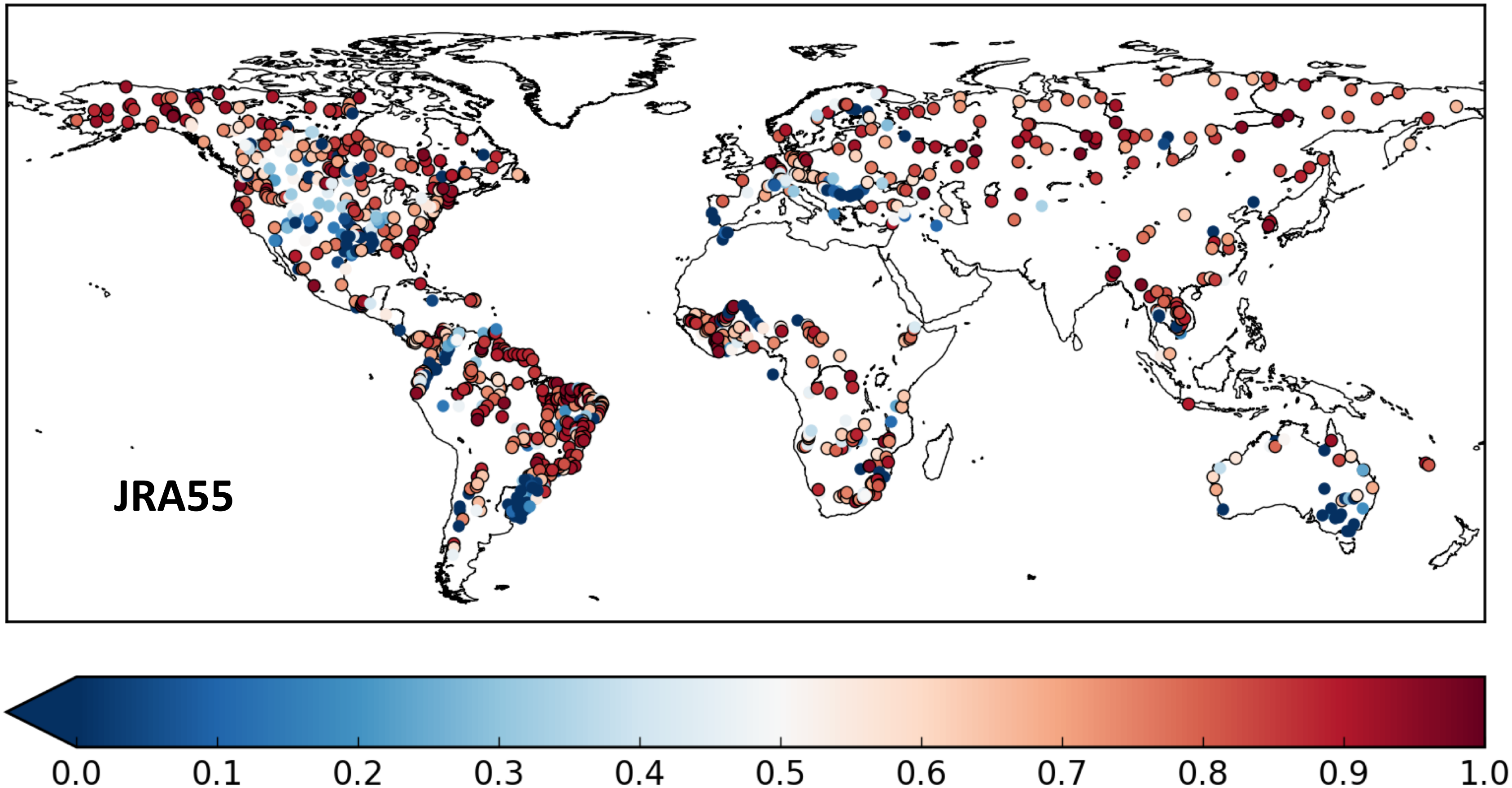


OGCMs COCO (Hasumi, 2006) etc.

Contributing to improvement of climate models

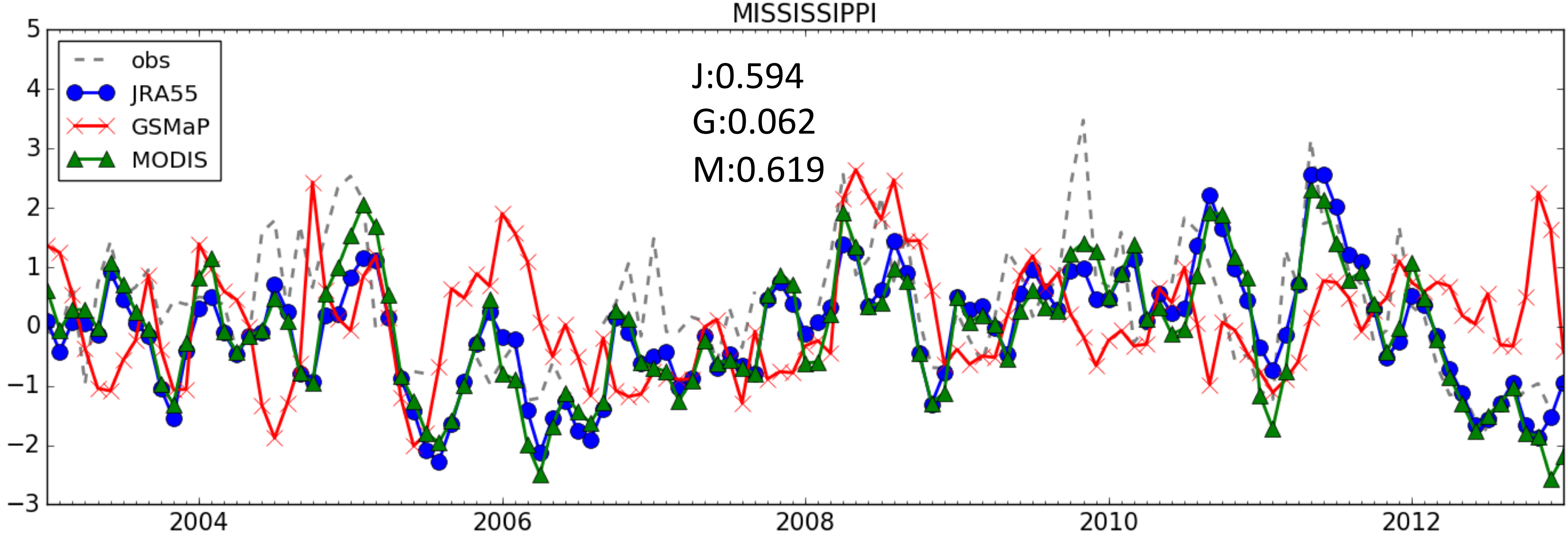
Hatono et al., in prep.

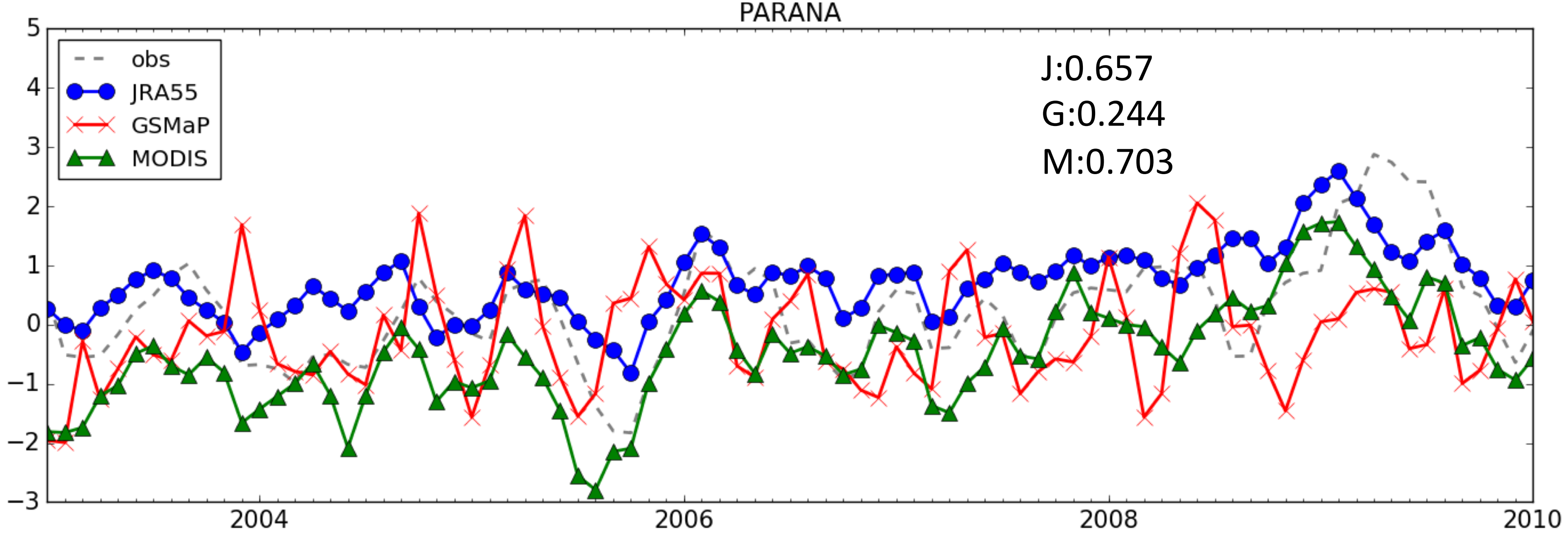
Monthly ave'd river discharge validation



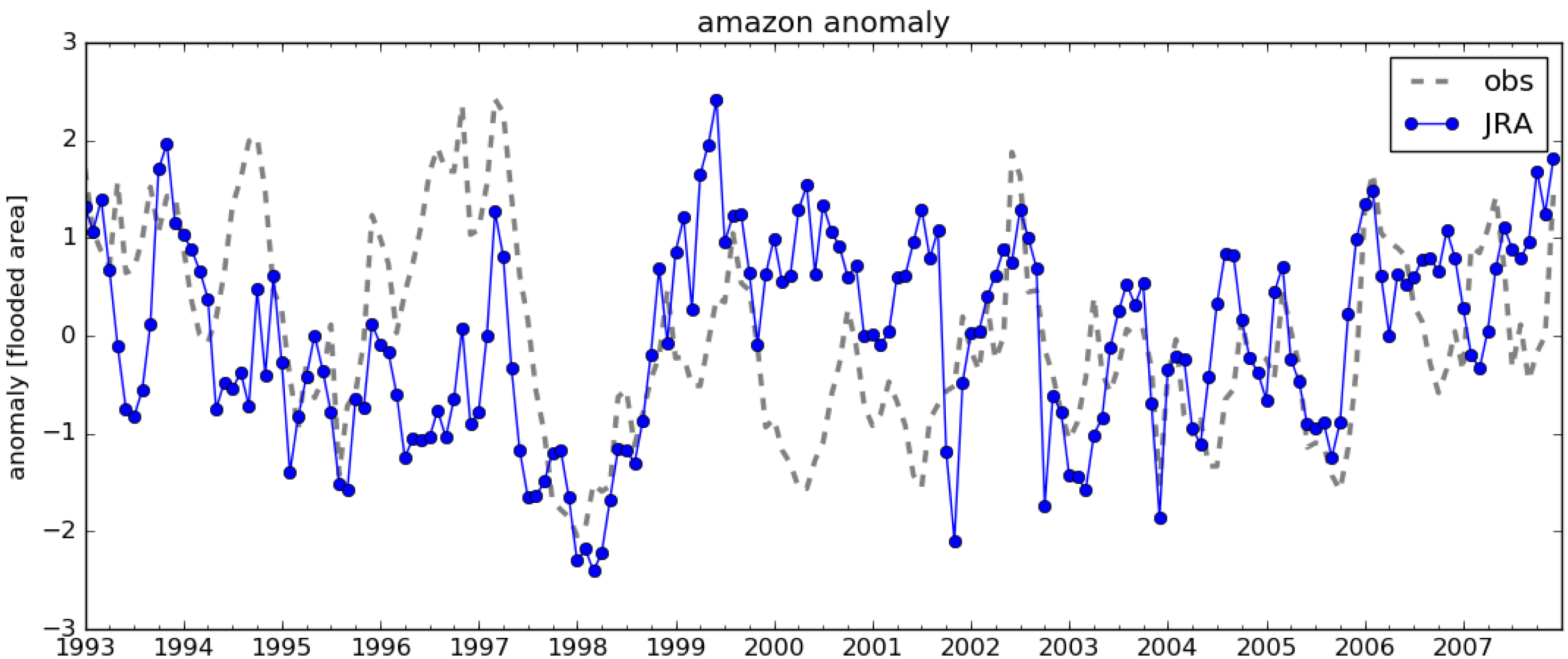
- Validation data: GRDC
- YEE-JRA55: 1958-2015
- Black circle filled by color: >95% significance

Interannual variability in river discharge





Interannual variability in Water inundation area



Anomalies in inundation area in Amazon river basin
YEE-JRA, R=0.30, 1993-2007

Comparison w/ GloFAS

Analysis in the reference paper

- ☐ Correlation Coefficient
- ☐ Coefficient of Variation
- ☐ Peierce's Skill Score

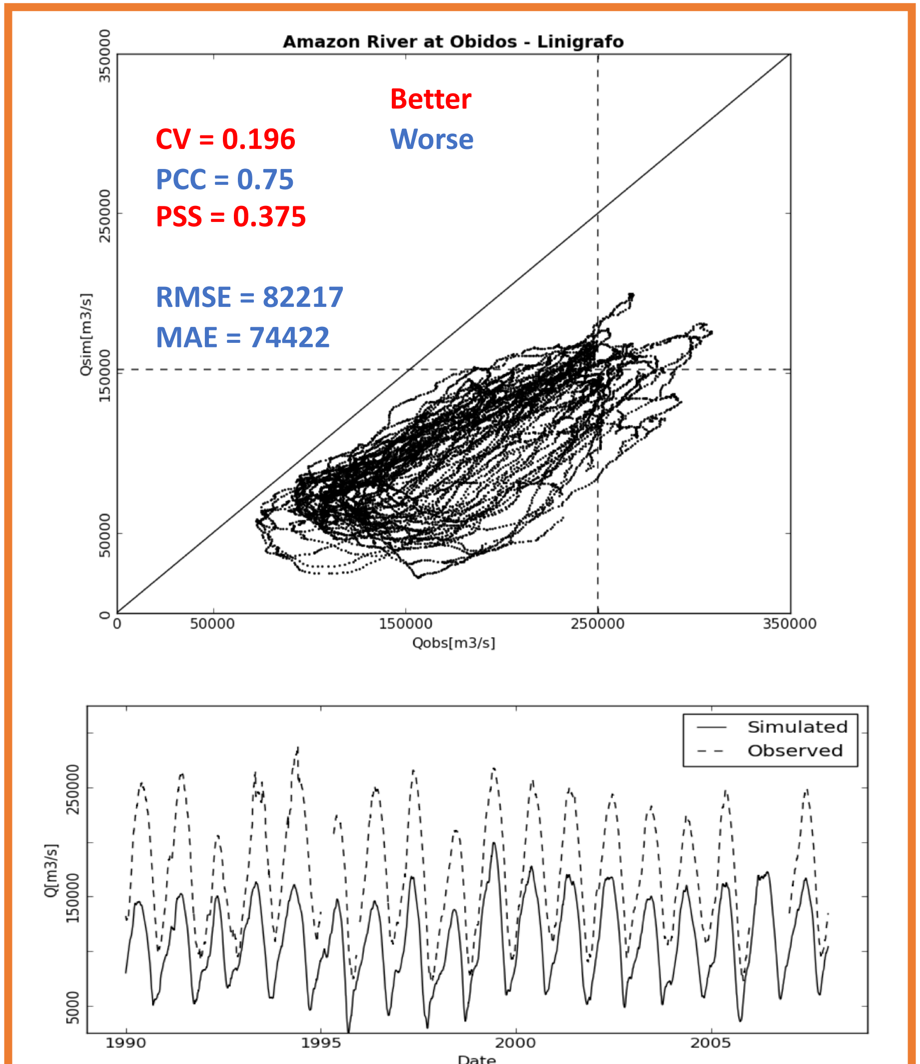
$$CV = \frac{\sigma(Q_{sim} - Q_{obs})}{\overline{Q_{obs}}}$$

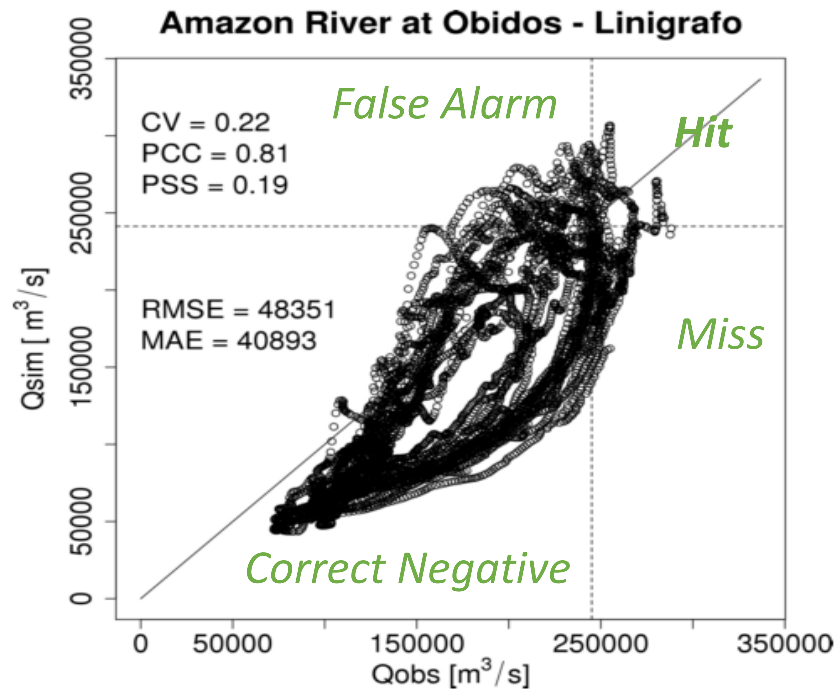
PSS=1 : Perfect

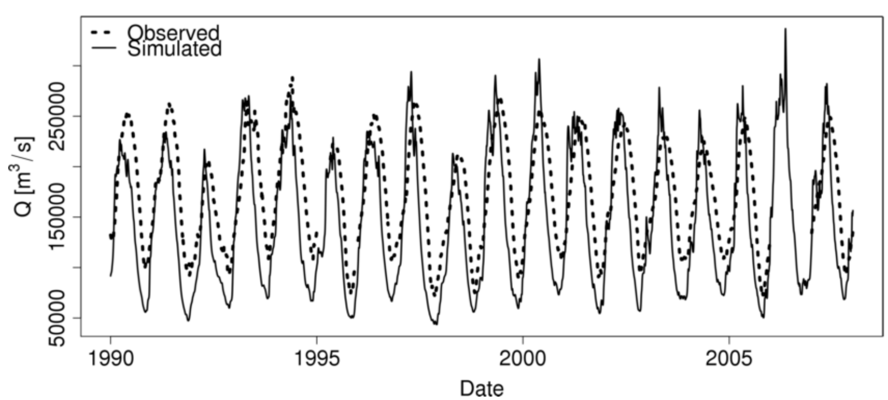
PSS<0 : No skill

$$PSS = \frac{\text{hits}}{\text{hits} + \text{misses}} - \frac{\text{false alarms}}{\text{false alarms} + \text{correct negatives}}$$

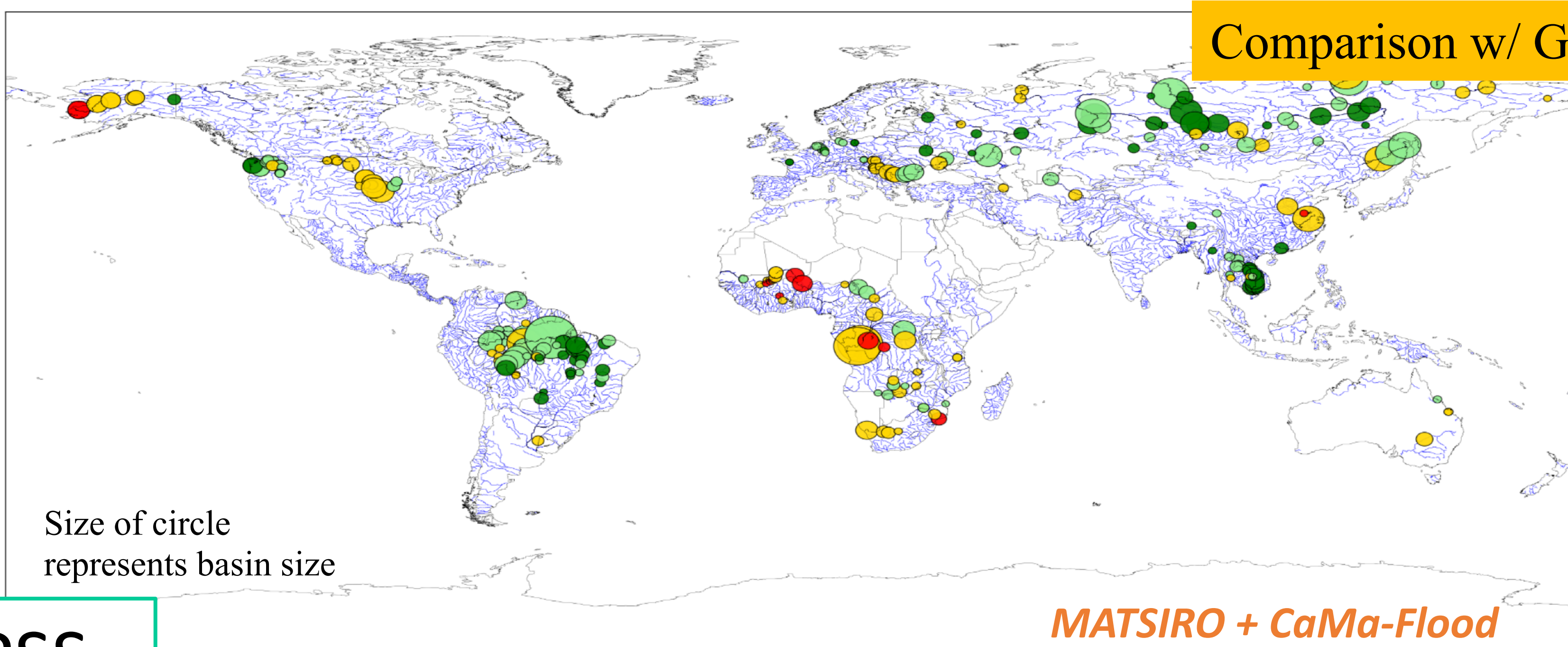
MATSIRO + CaMa-Flood



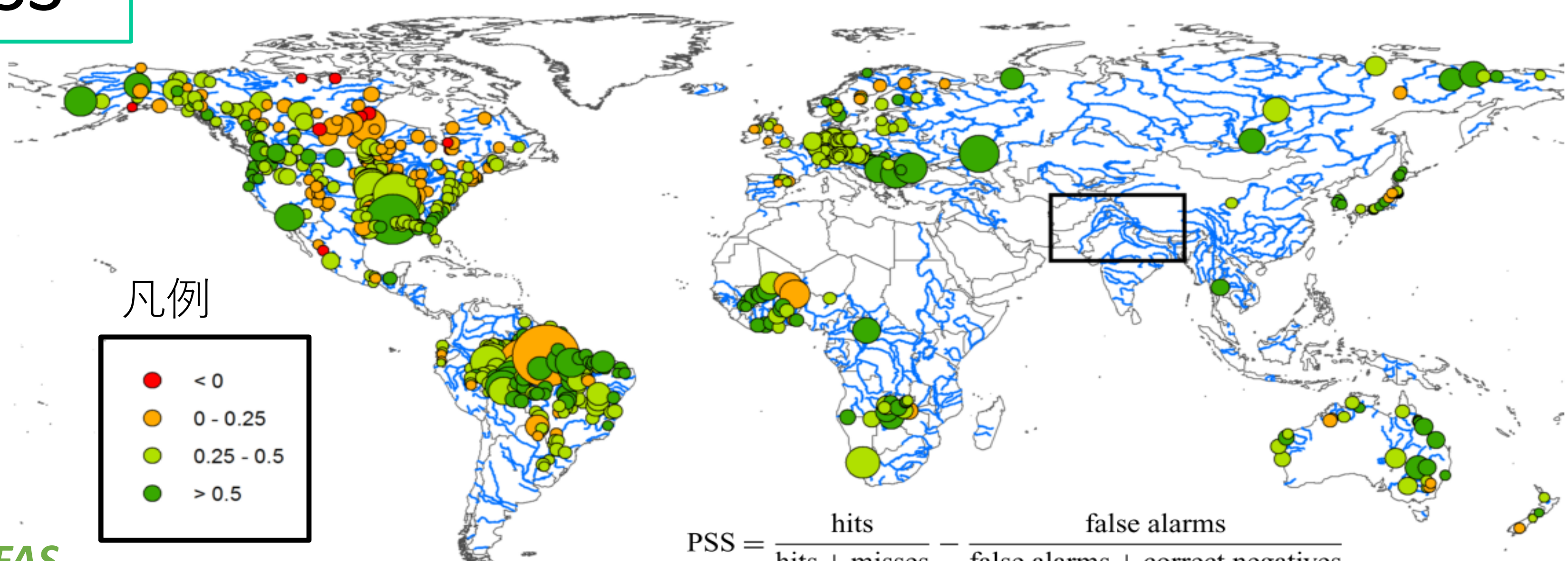




Comparison w/ GloFAS



PSS

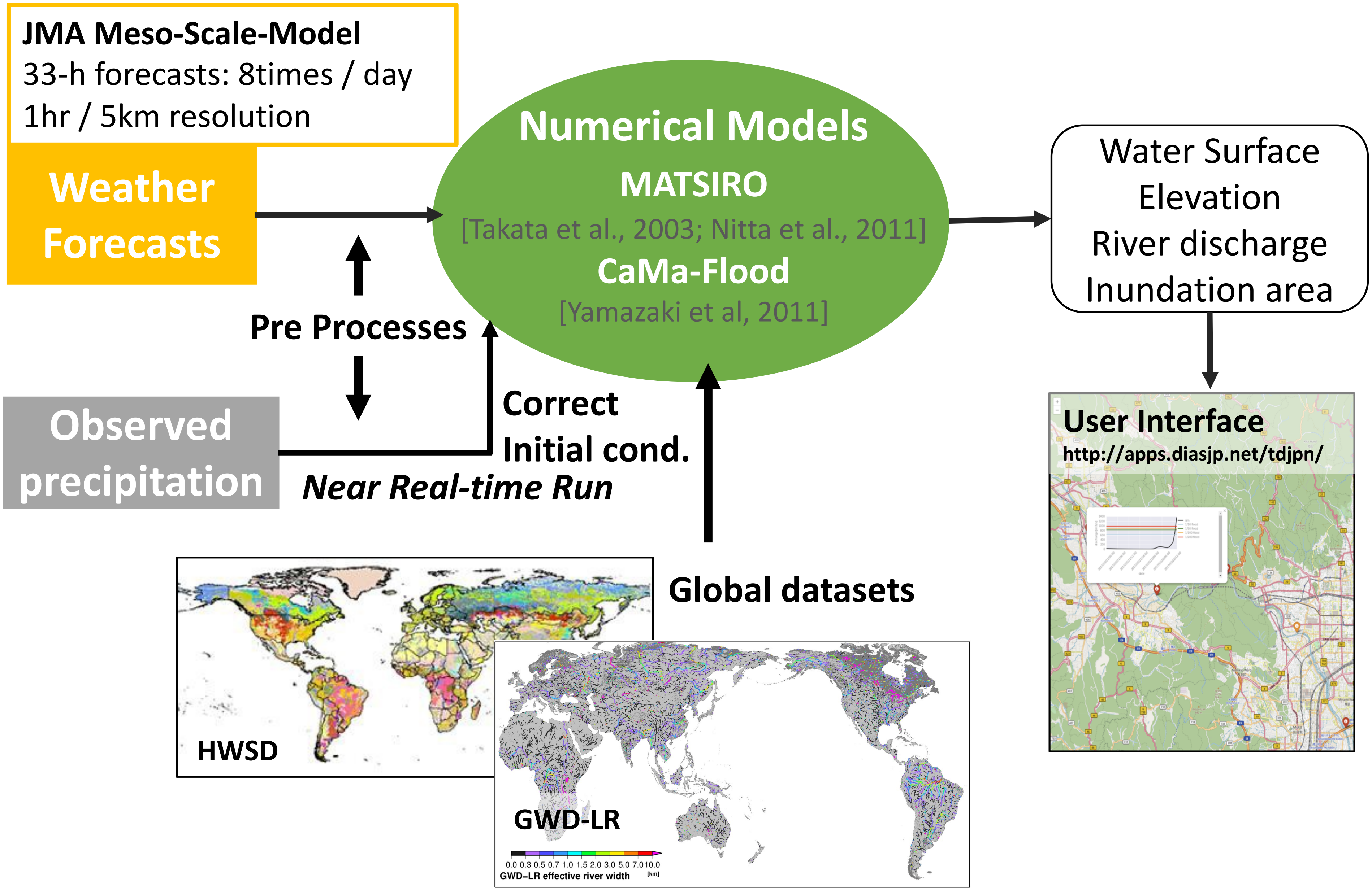


$$\mathrm{PSS} = \frac{\text{hits}}{\text{hits} + \text{misses}} - \frac{\text{false alarms}}{\text{false alarms} + \text{correct negatives}}$$

Fig. 6. Peirce's skill score of simulated versus observed discharge for the 620 stations considered. Circle size is proportional to the upstream area of the river station. The black-contoured rectangle indicates the area shown in Fig. 10.

Alfieri et al. (2013)

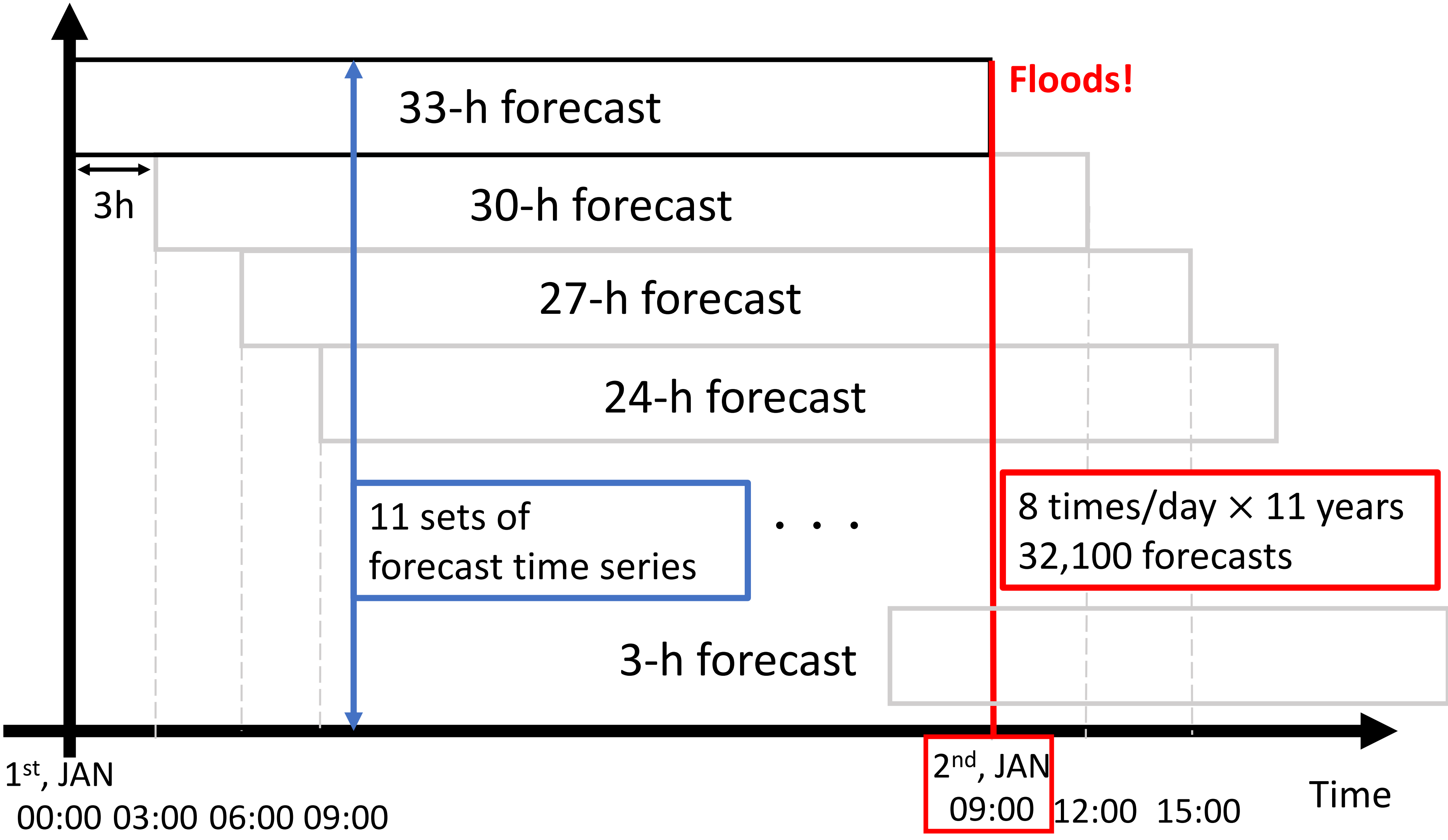
Using TE for Forecasting Floods



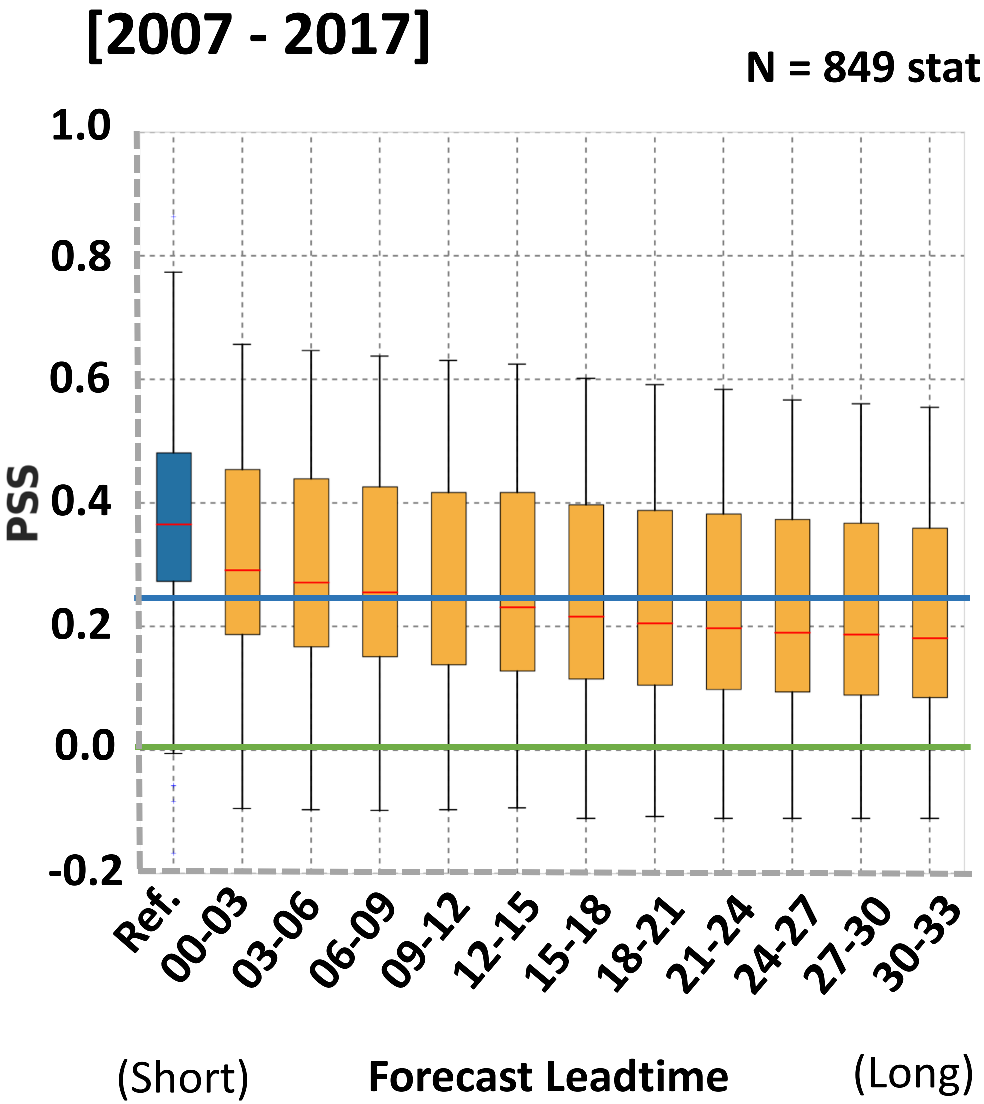
Validation for 11-year hindcast runs

Forecasts: 33-h lead time, Issued every 3hours

Assessing the accuracy in each lead time from short to long



Forecast ability for high flows



Reference Values

[e.g., Addor et al., 2011; Alfieri et al., 2013]

- PSS ≥ 0.00 : **Have a Predictability**

Forecasts 33-h before:
Having a positive PSS at more than ***90%*** out of 849 stations.

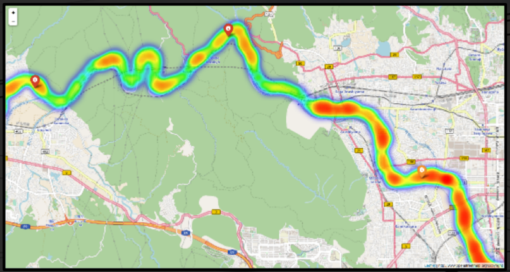
Forecasts 12-h before:
Having PSS > 0.25 at more than ***50%*** out of 849 stations.

Ensemble flood forecasting using TE-system

An ensemble flood forecasting system based on TE system framework

ECMWF
0.2° global
51 members

TODAY'S EARTH
Land surface simulation

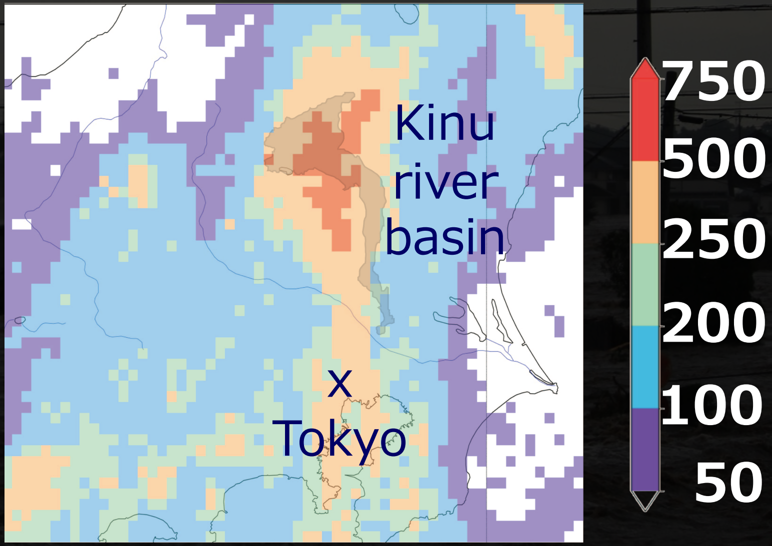


Ensemble prediction

Kinu-river flood

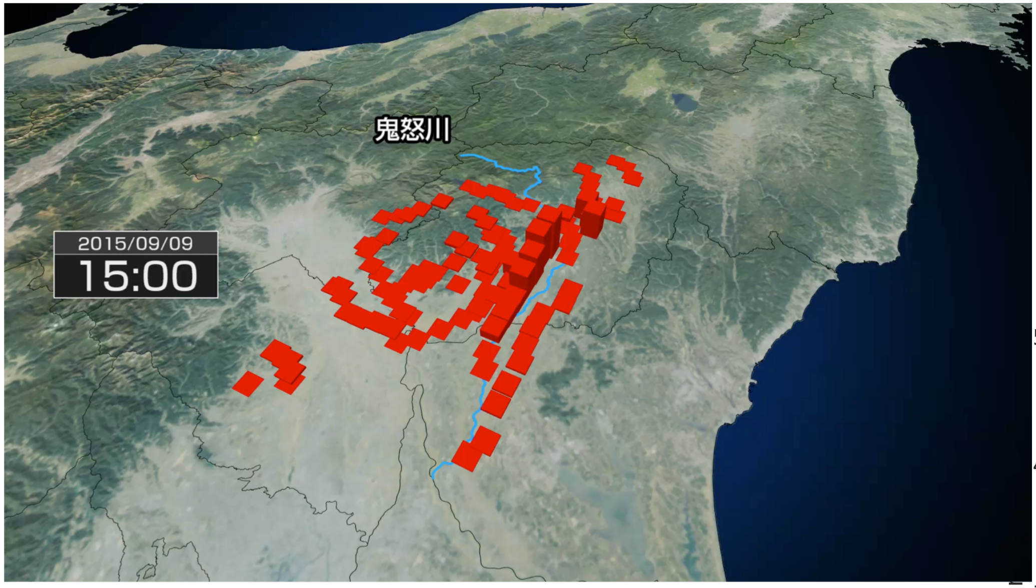
(Catchment Area 1,761 km²)

- Devastating flood happened in 2015 due to heavy rainfall
- 300-500 [mm] rainfall over the basin in 24 hour
- Overbank flow and levee break caused serious inundation.



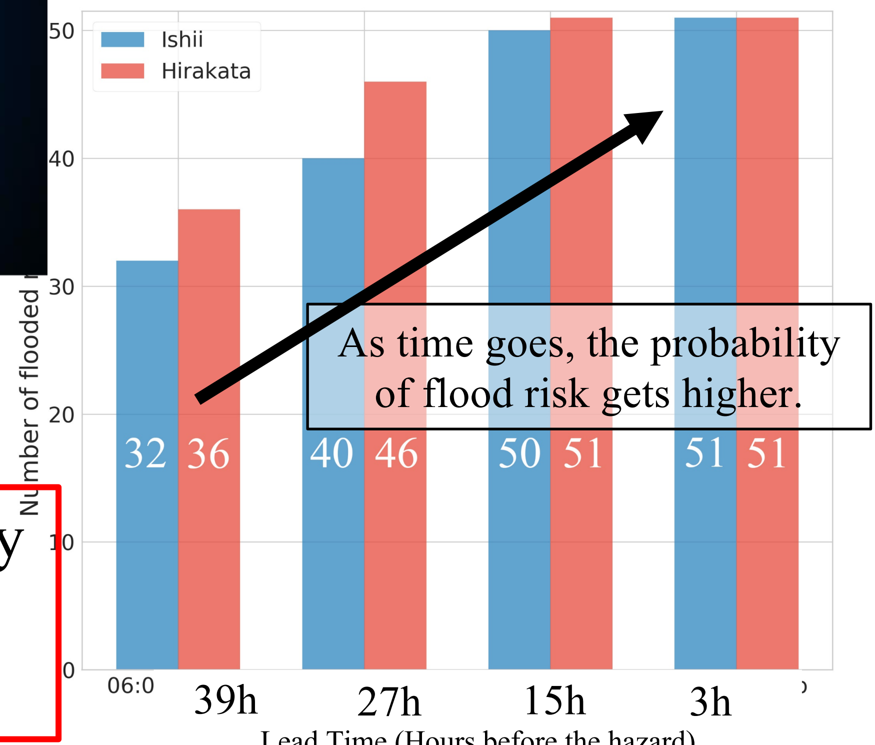
Accumulated Precip.
08-10, Sep. 2015

Ensemble forecasts of 39-hour ahead: Case study for 2015 Kinu River



Flood risk forecast from 2015/9/9 3pm (longer bar shows larger probability of flood)

Predicted flood occurrence possibility at 39-hour before, increasing risk by 15-hour before.



Number of ensemble members (out of 51) at different lead times

Results from TE-Japan for 2018-Floods

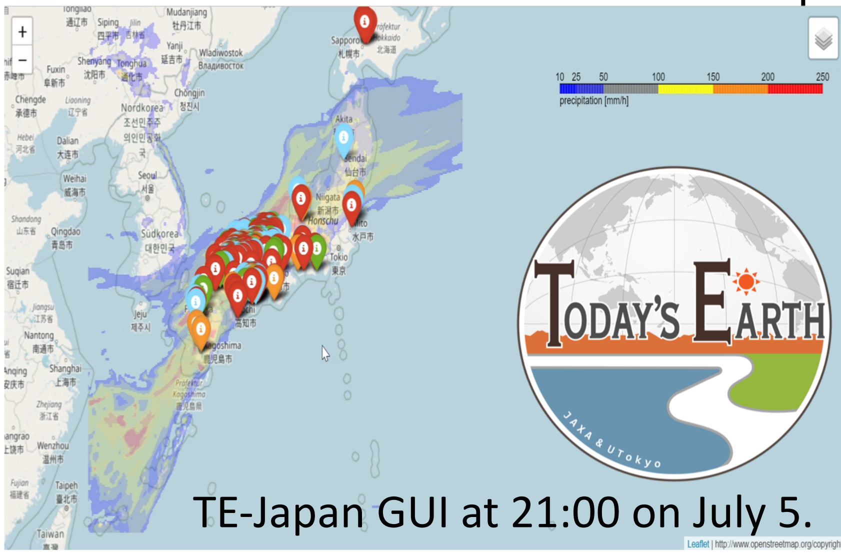
7/6/19:40 Heavy rain alert in Okayama

7/6/22:00 Evacuation alert
7/6/22:20 Reached an evacuation level
7/6/22:40 Heavy rain alert at Kurihashi

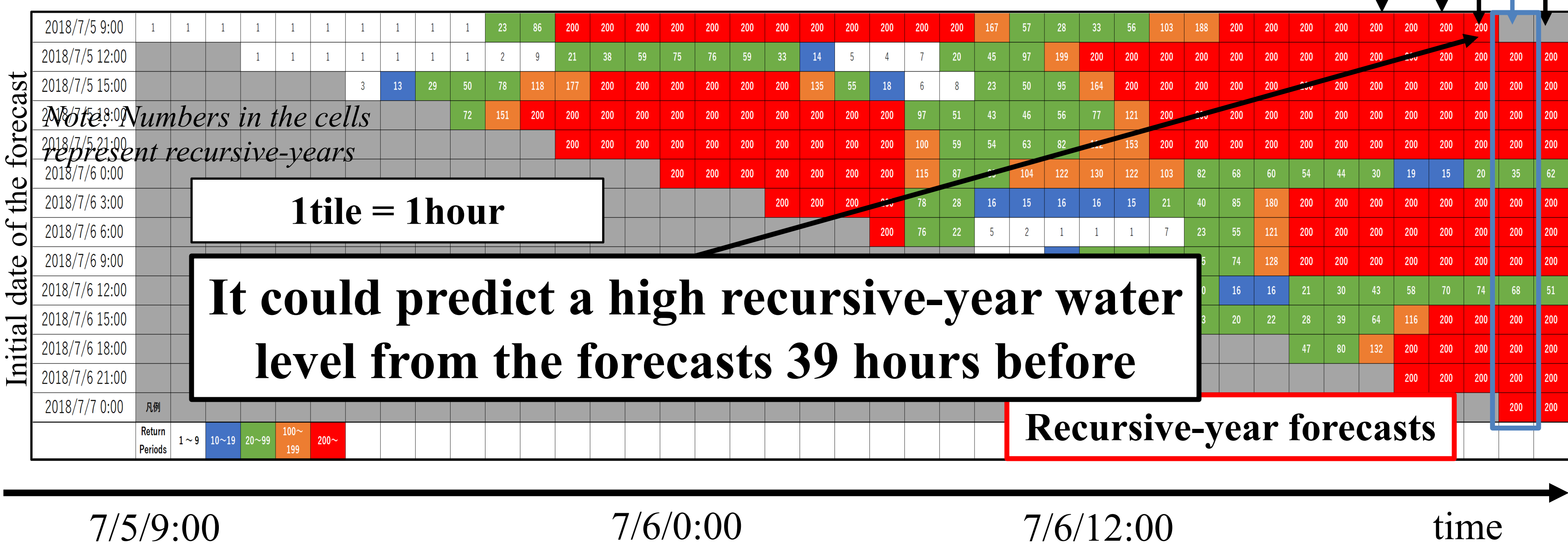
7/6/23:35 Evacuation order

7/7/00:30 Flood occurred

7/7/00:30 Evacuation order



TE-Japan GUI at 21:00 on July 5.



Thank you for your attention!