



Development of Global Terrestrial Hydrological Monitoring and Forecasting System “Today’s Earth”

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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 km² 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.

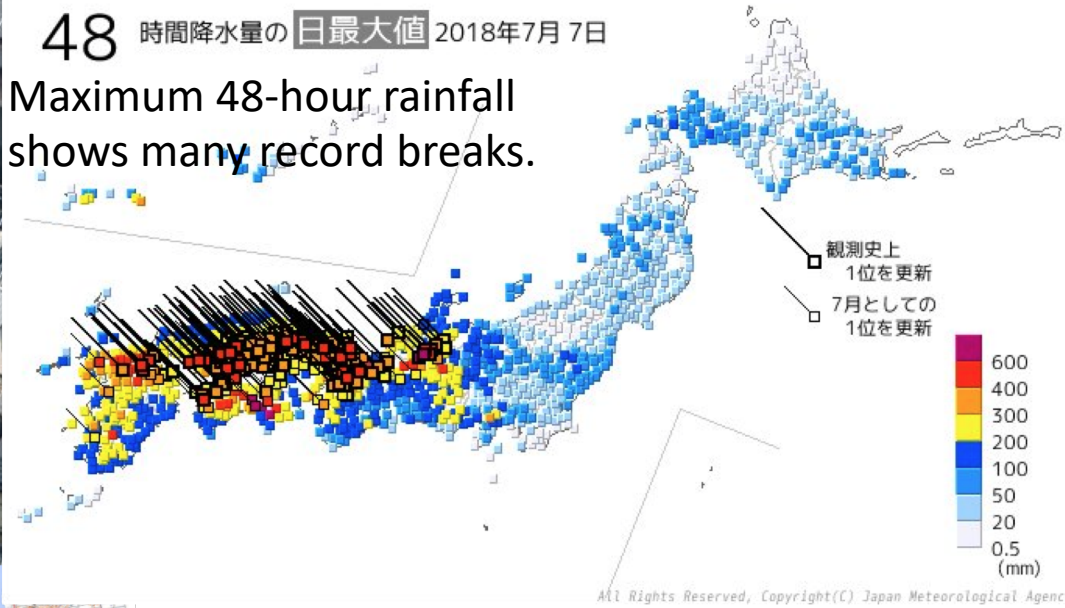


2015 Sep 10 17:00
Misaka-cho, Joso city

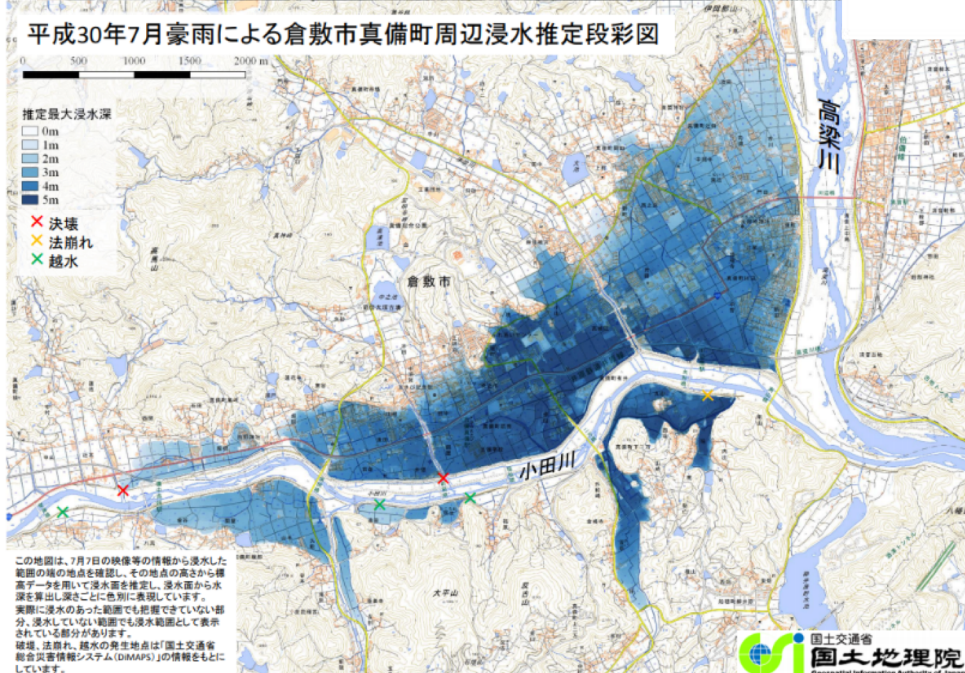
Takahashi-river Floods in 2018 July



48 時間降水量の **日最大値** 2018年7月7日
 Maximum 48-hour rainfall shows many record breaks.



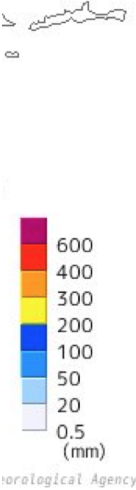
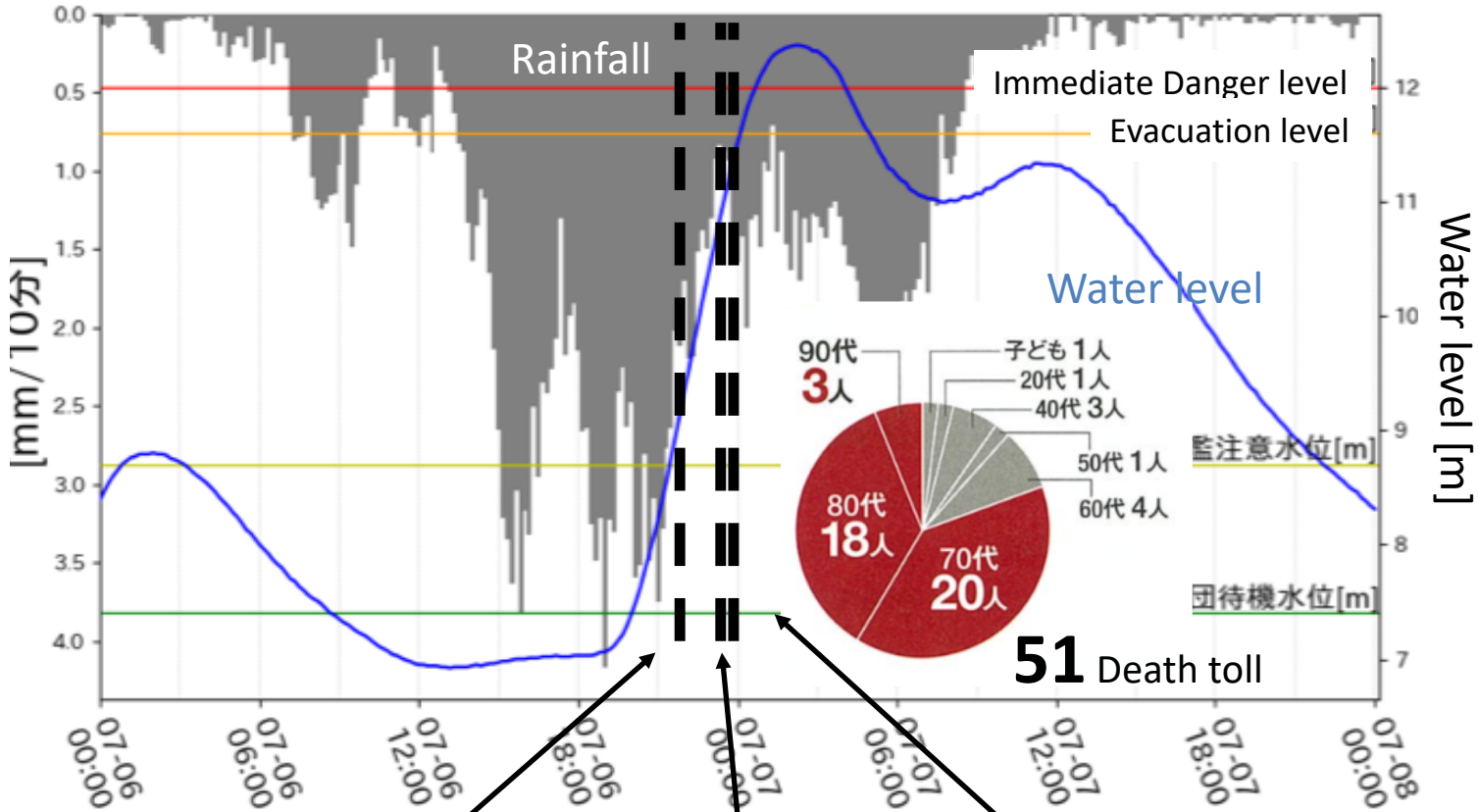
平成30年7月豪雨による倉敷市真備町周辺浸水推定段彩図



Takahashi-river Floods in 2018 July

Hydrograph at Sakatsu, Takahashi River

Upper basin ave'd Precipitation (Bars)



Evacuation alert at July 6 22:00

Flood occurred at 0:00

Evacuation order at 23:45

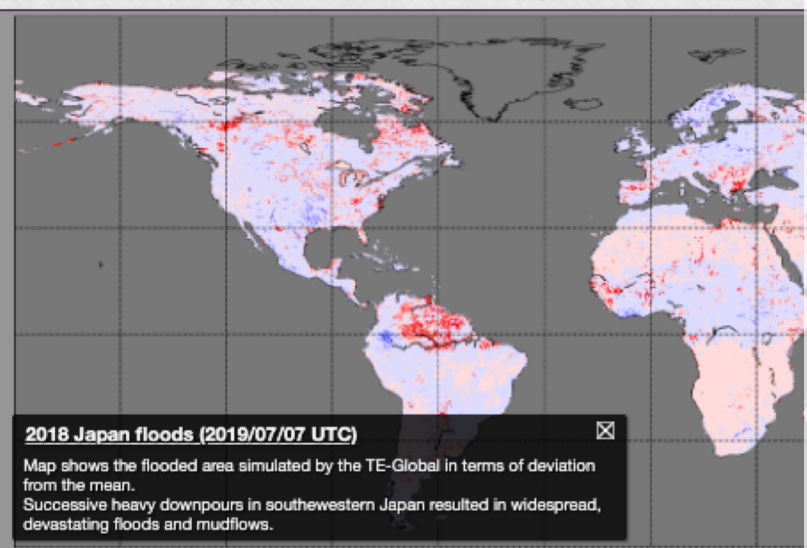
この地図は、7月7日の検討範囲の地点を確認し、高さを取って浸水深を算出して深さごとに色別実際に浸水のあった範囲分、浸水していない範囲で示されている部分があります。破堤、法崩れ、越水の発生は総合災害情報システム(DI)しています。

Geospatial Information Authority of Japan

Today's Earth system

Go to www.eorc.jaxa.jp/water

Or search "today's earth"



2018 Japan floods (2019/07/07 UTC)

Map shows the flooded area simulated by the TE-Global in terms of deviation from the mean. Successive heavy downpours in southwestern Japan resulted in widespread, devastating floods and mudflows.

"Today' Earth (TE)" is JAXA's land surface & river simulation system developed under the joint research with University of Tokyo. The system distributes & visualizes various hydrological products and their magnitudes for water monitoring and hydrological research.

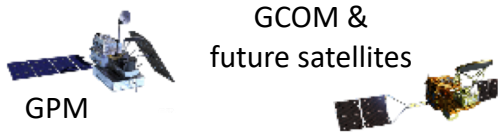
TE-Global
Explore Our Changing Planet.

What's new

- 2019/03/29 **TE-Japan**
Today's Earth - Japan was (see only.)
- 2018/06/08 **TE-Global**

- *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



Past

Present

Future

Satellite Obs.
Data

In-situ Obs.
Data

Ensemble Weather
Forecast Data.



Data
Assim.

Ensemble River
Discharge Forecast

Sophisticated UI

Integrated
Land Simulator

Probability of
Flood Risk

Development of Integrated Land Simulator (ILS)

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

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

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

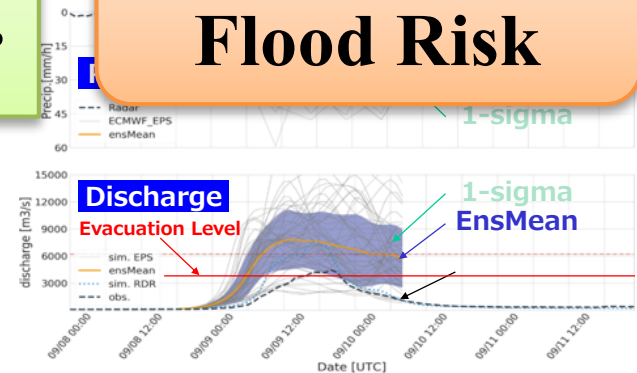
Global hydrology model with anthropogenic effects H08 (Hanasaki et al., 2008)

Models for water-related hazards

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

OGCMs COCO (Hasumi, 2006) etc.

Contributing to improvement of climate models

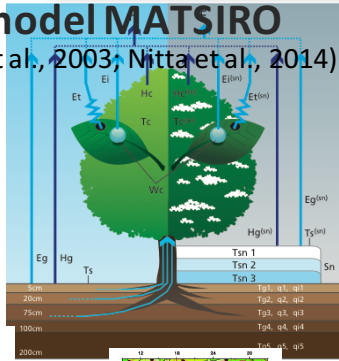


Integrated Land Simulator (committed to MIROC7)

Development of Integrated Land Simulator (ILS)

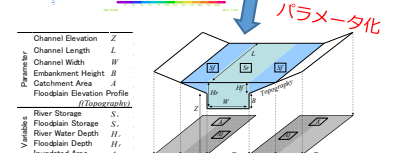
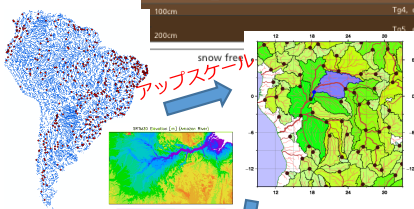
Land model MATSIRO

(Takata et al., 2003; Nitta et al., 2014)



Implement new physical processes

- Snow aging by dust/BC
- Snow-fed wetlands
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- Sub-grid snow cover parameterization



Next-generation river model

CaMa-Flood

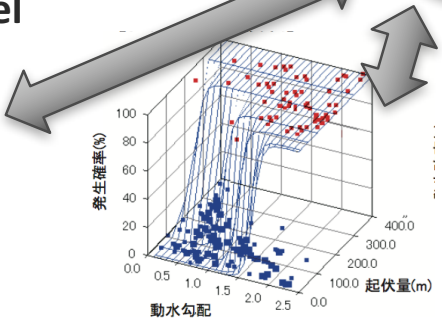
(Yamazaki et al., 2011)



Global hydrology model with anthropogenic effects

H08 (Hanasaki et al., 2008)

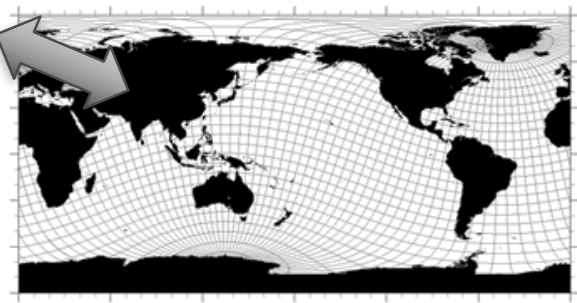
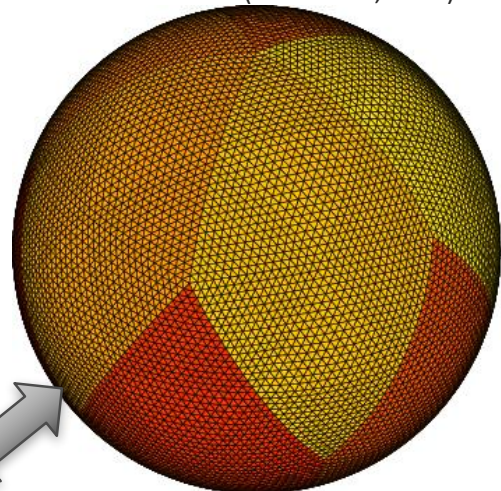
General purpose coupler (Jcup, Arakawa et al., 2011)



Models for water-related hazards

AGCMs

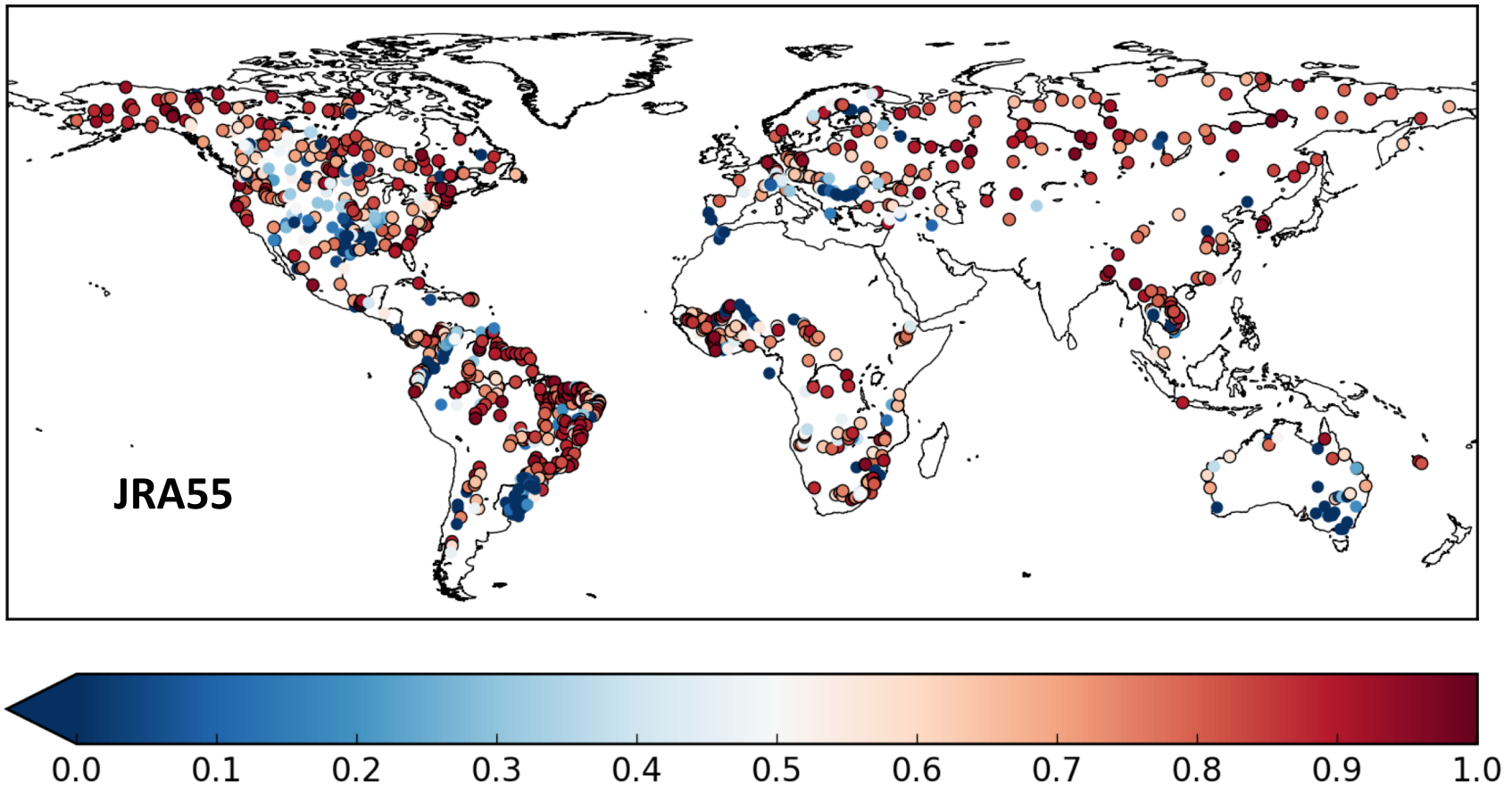
MIROC (Watanabe et al., 2010), NICAM (Sato et al., 2014) etc.



OGCMs COCO (Hasumi, 2006) etc.

Contributing to improvement of climate models

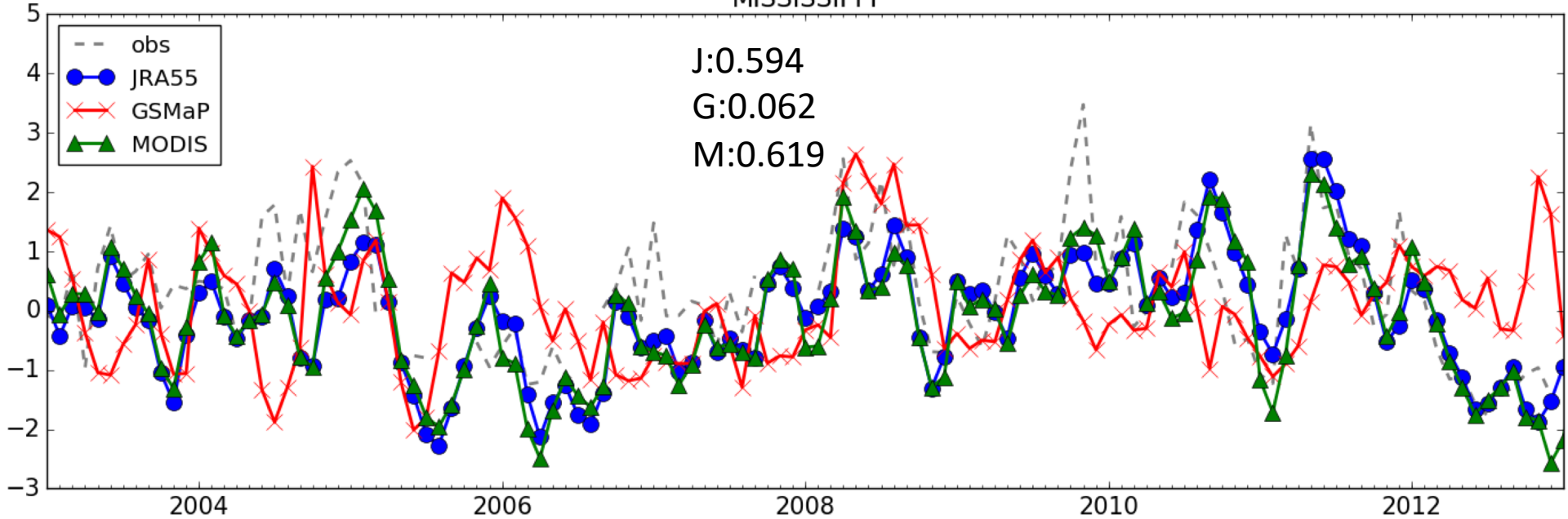
Monthly ave'd river discharge validation



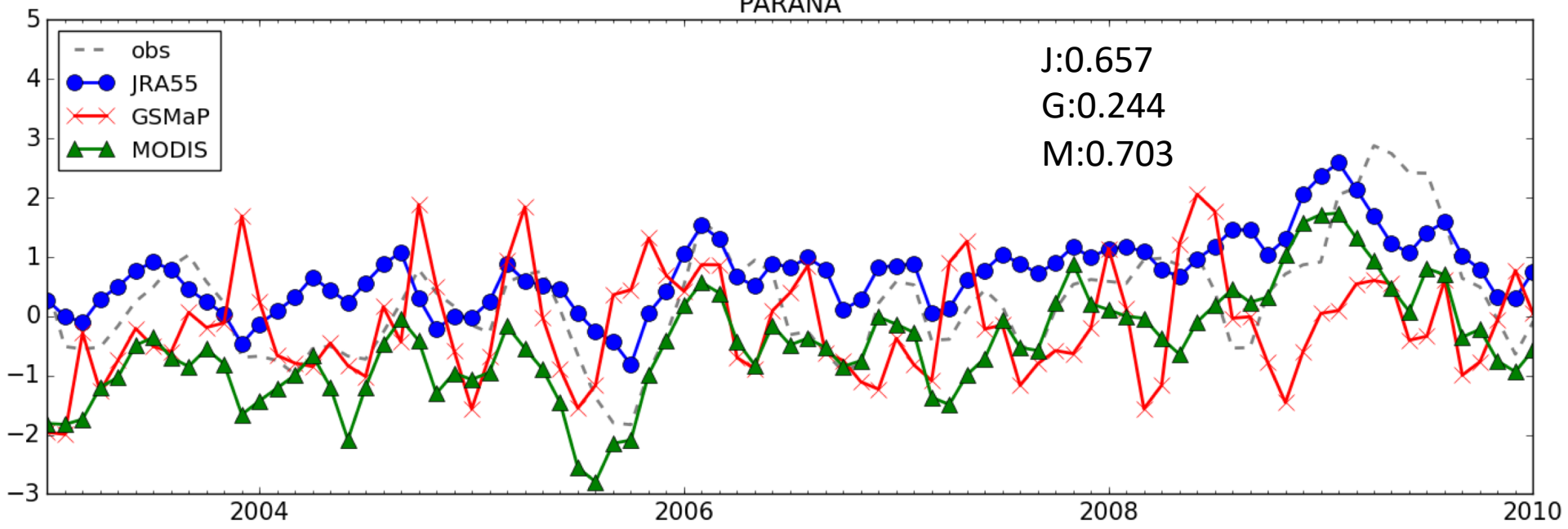
- Validation data: GRDC
- YEE-JRA55: 1958-2015
- Black circle filled by color: >95% significance

Interannual variability in river discharge

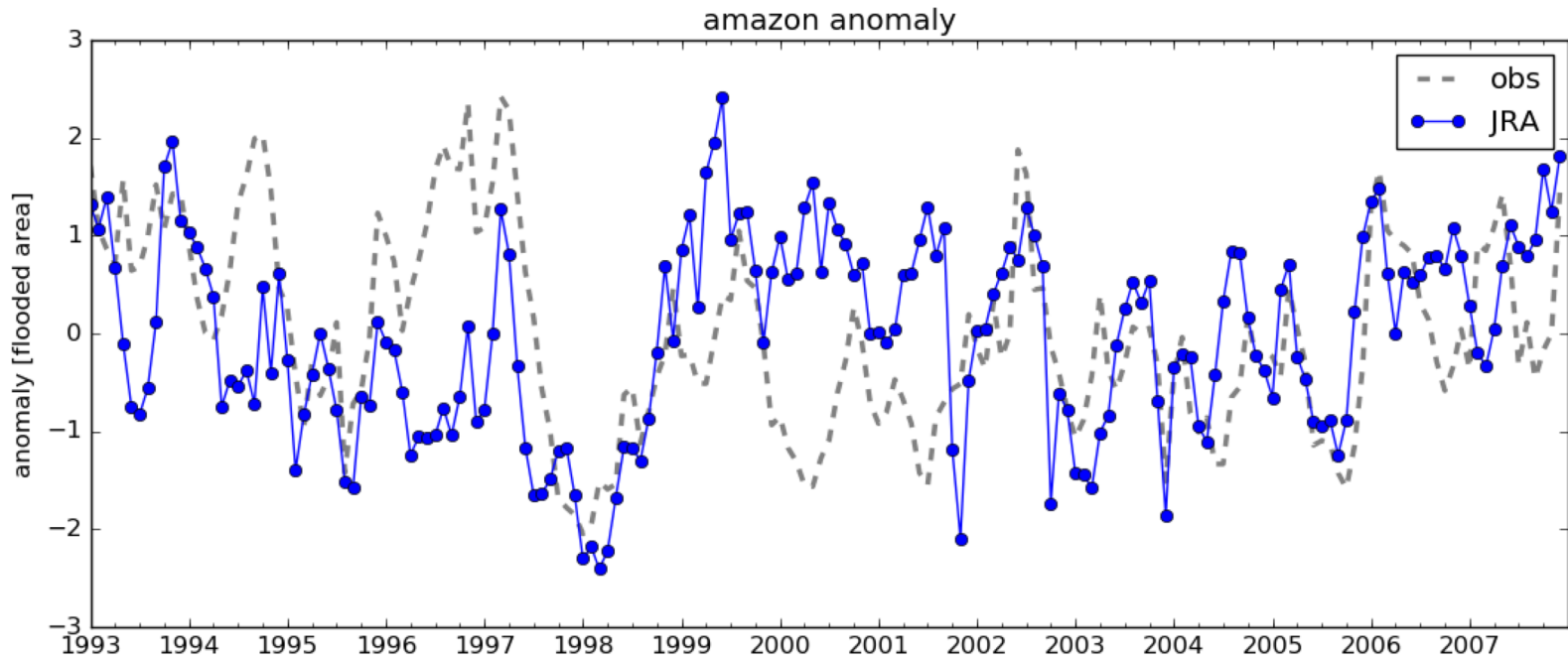
MISSISSIPPI



PARANA



Interannual variability in Water inundation area



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

Analysis in the reference paper

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

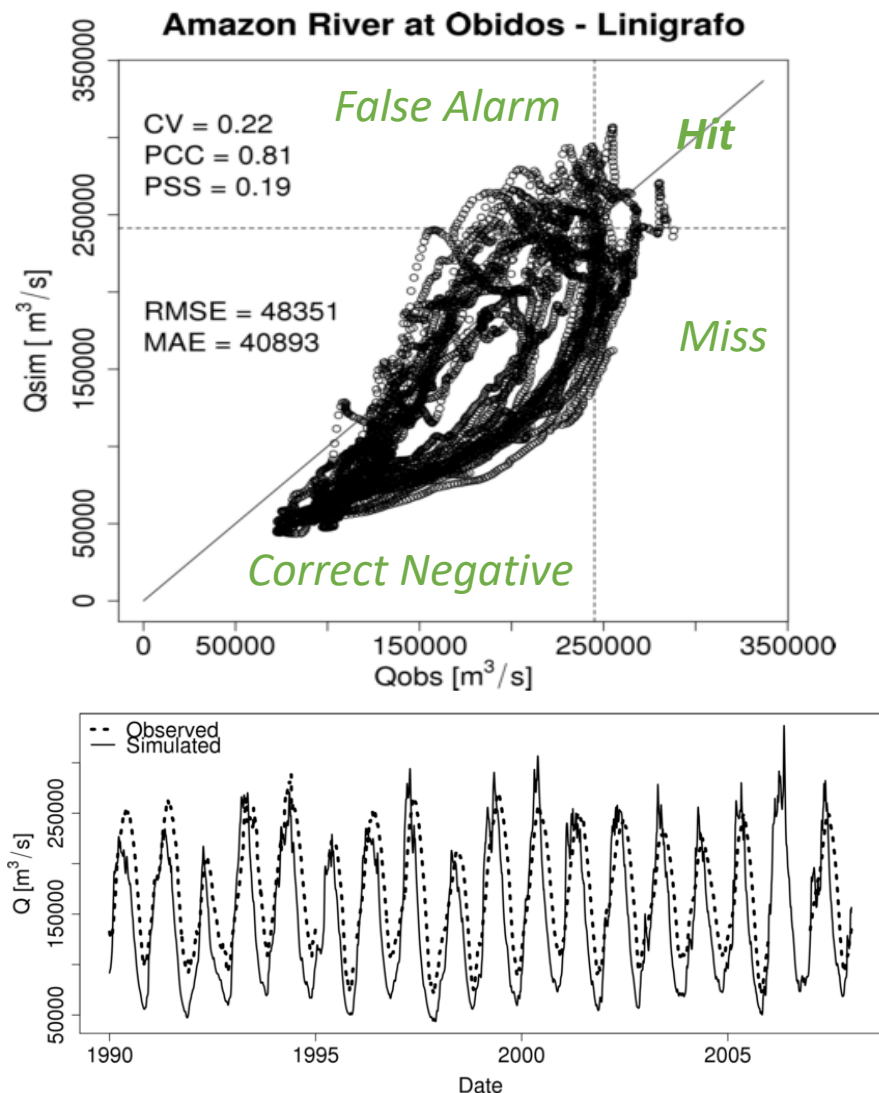
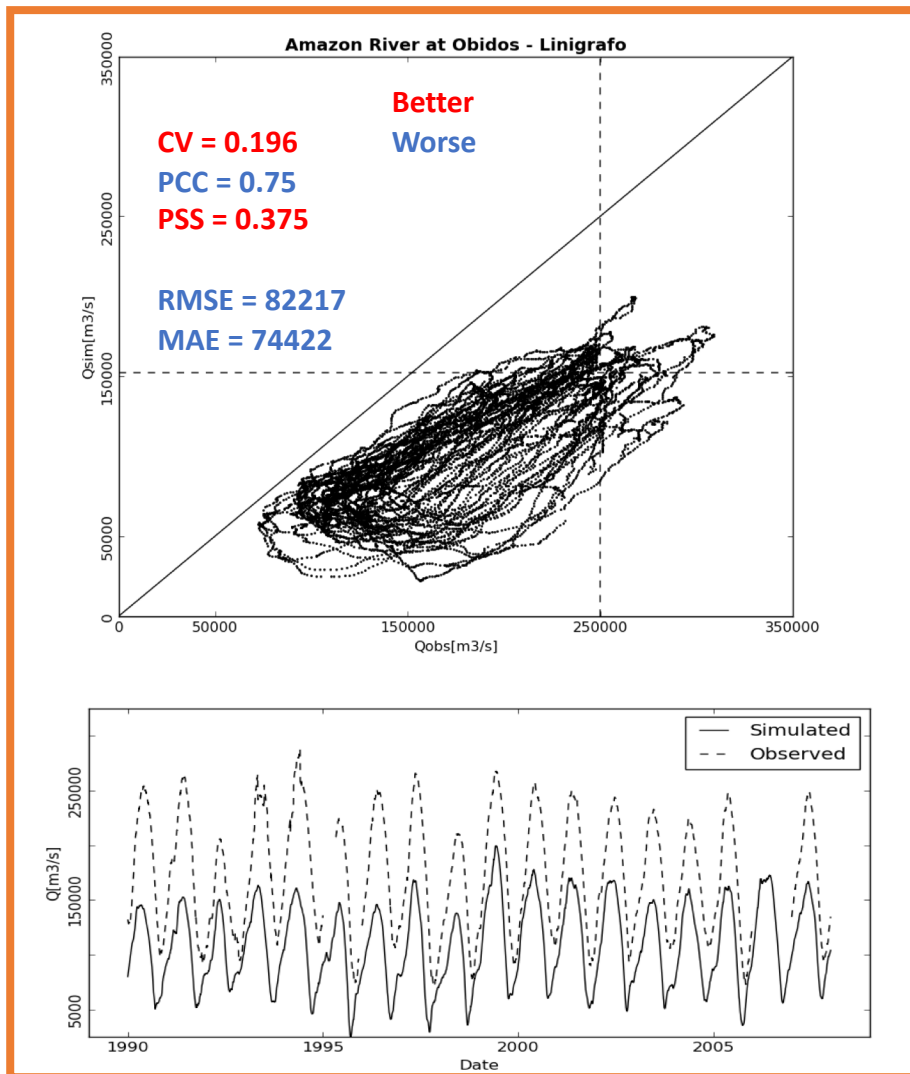
$$CV = \frac{\sigma(Q_{sim} - Q_{obs})}{Q_{obs}}$$

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

Comparison w/ GloFAS

PSS=1 : Perfect
PSS<0 : No skill

MATSIRO + CaMa-Flood



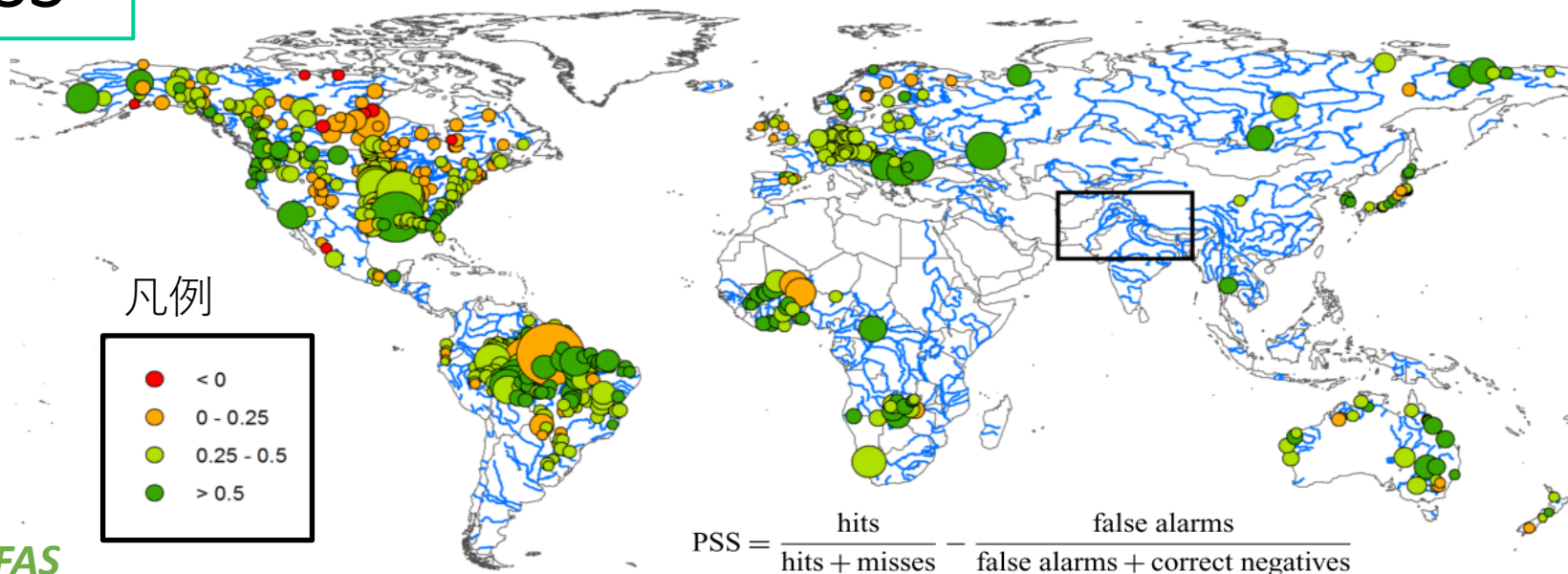
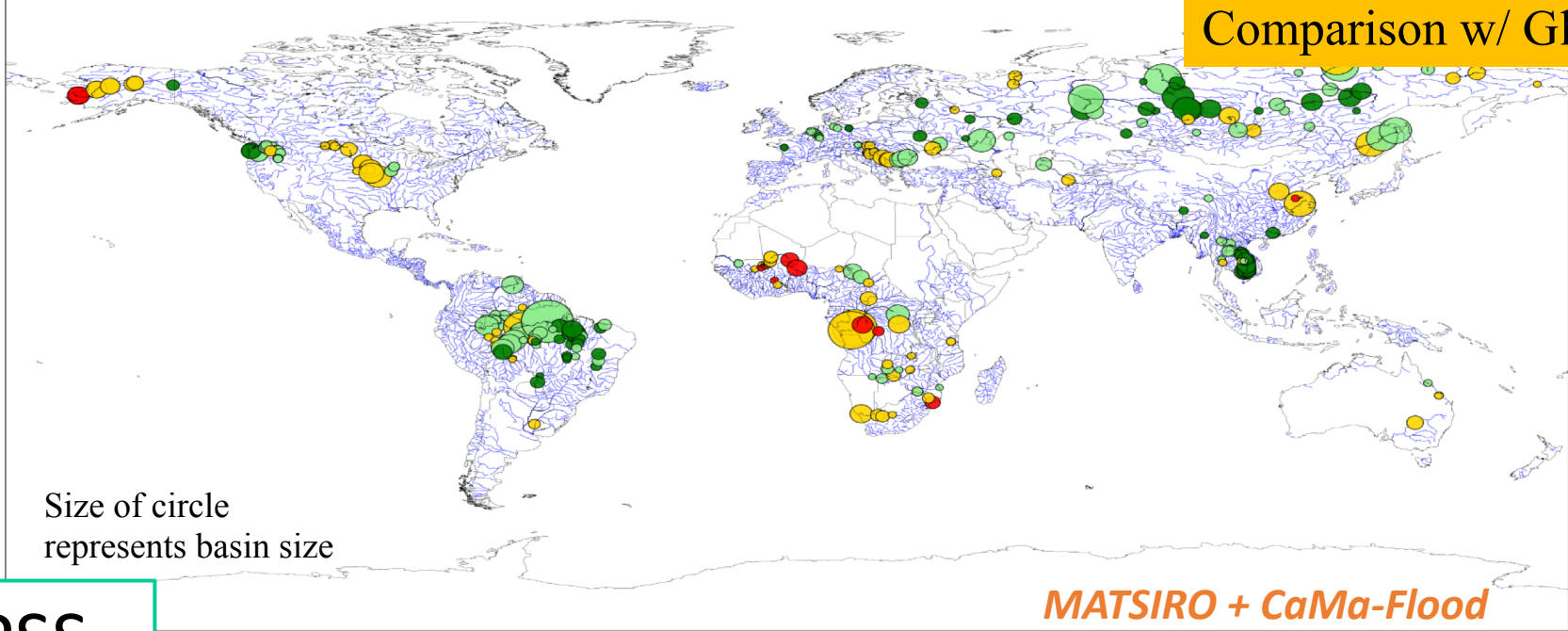


Fig. 6. Peirce's skill score of simulated versus observed discharge for the 620 stations considered. Circle size is proportional to the upstream area of the river station. The black-contoured rectangle indicates the area shown in Fig. 10.

Using TE for Forecasting Floods

JMA Meso-Scale-Model

33-h forecasts: 8times / day
1hr / 5km resolution

**Weather
Forecasts**

Numerical Models

MATSIRO

[Takata et al., 2003; Nitta et al., 2011]

CaMa-Flood

[Yamazaki et al., 2011]

Water Surface
Elevation
River discharge
Inundation area

Pre Processes

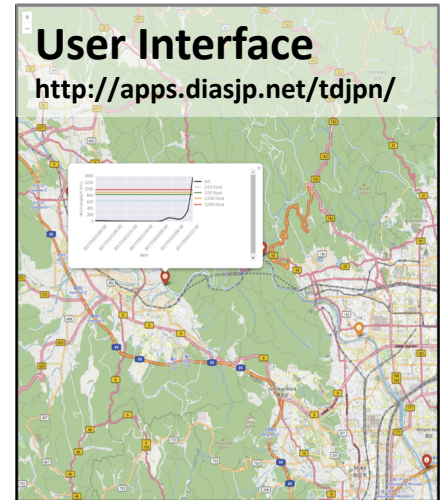
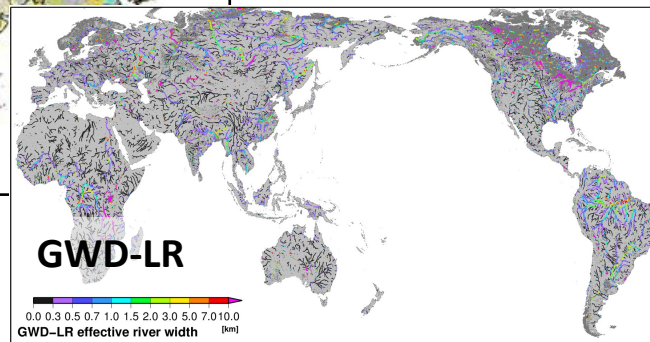
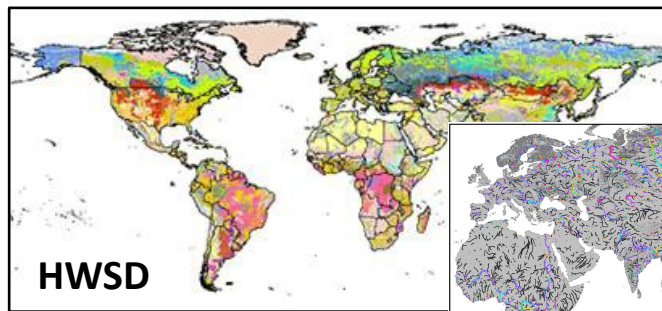
**Correct
Initial cond.**

**Observed
precipitation**

Near Real-time Run

Global datasets

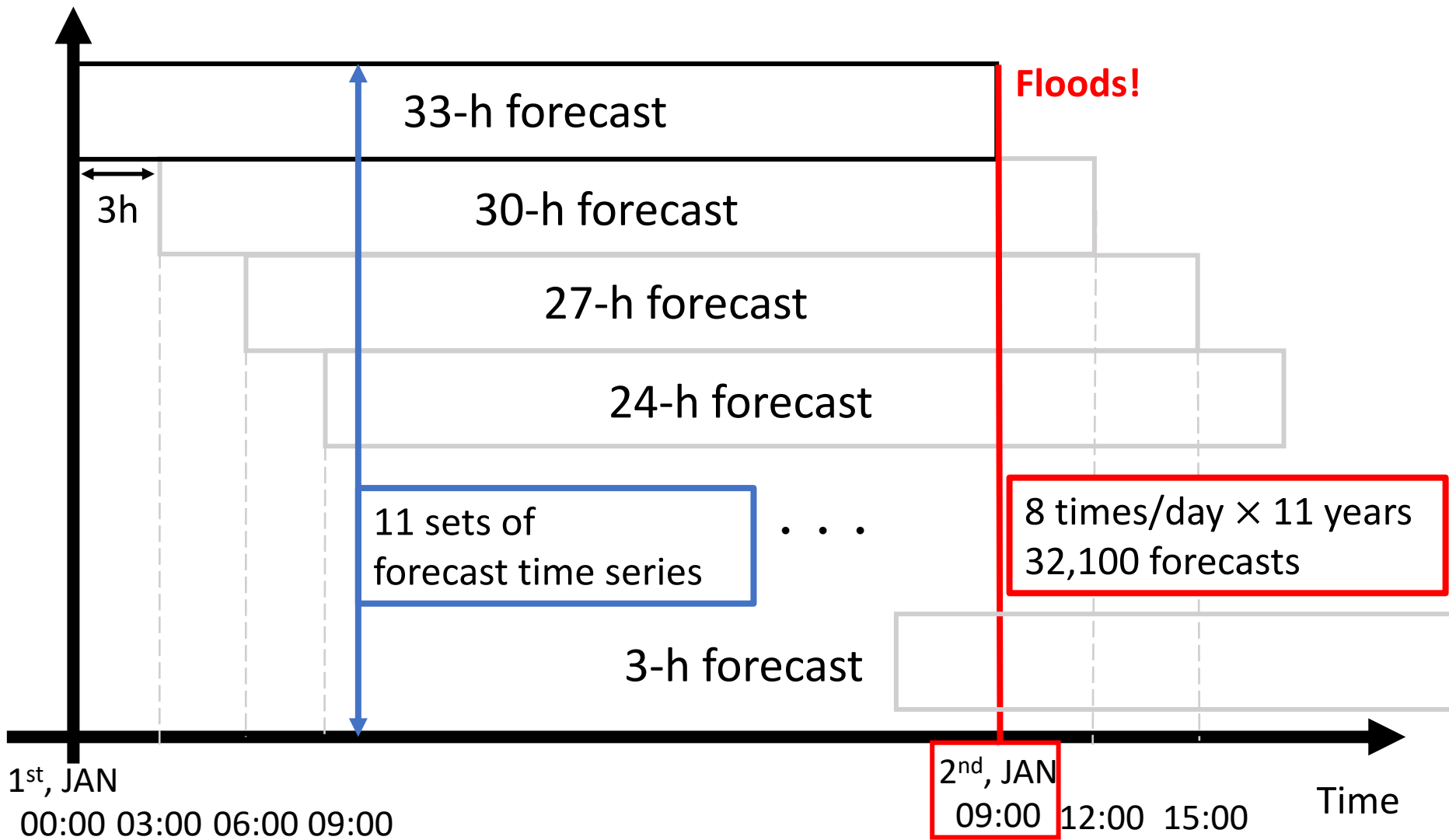
User Interface
<http://apps.diasjp.net/tdjpn/>



Validation for 11-year hindcast runs

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

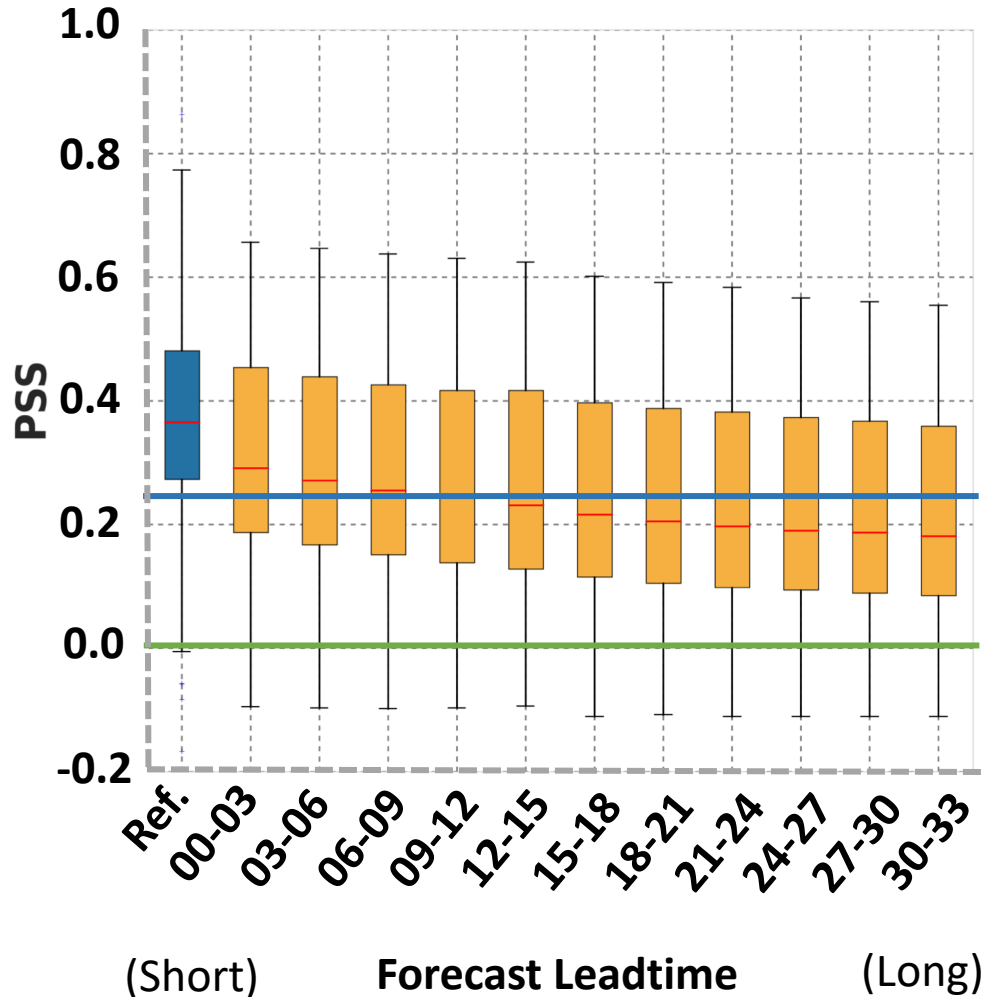
Assessing the accuracy in each lead time from short to long



Forecast ability for high flows

[2007 - 2017]

N = 849 stations



Reference Values

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

➤ PSS \geq 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

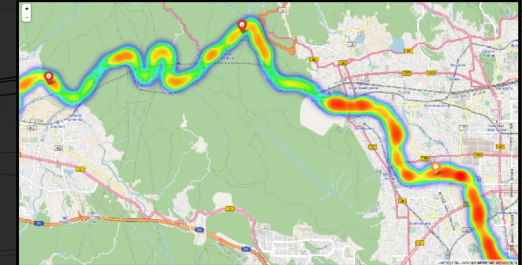
An ensemble flood forecasting system based on TE system framework



0.2° global
51 members



Land surface
simulation

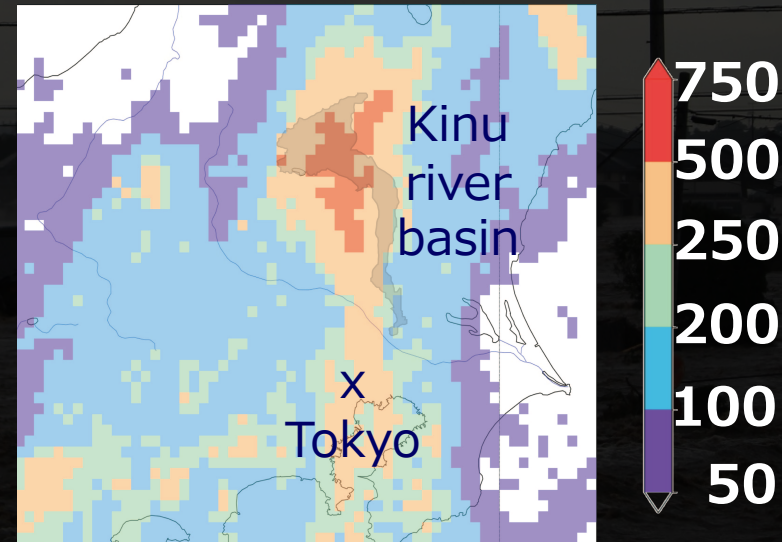


Ensemble
prediction

Kinu-river flood

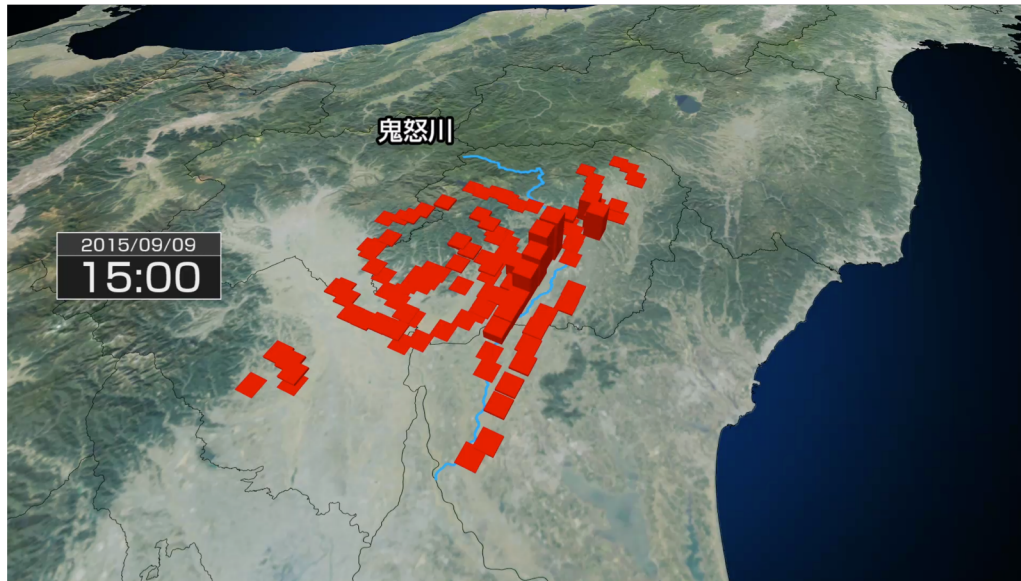
(Catchment Area 1,761 km²)

- 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.



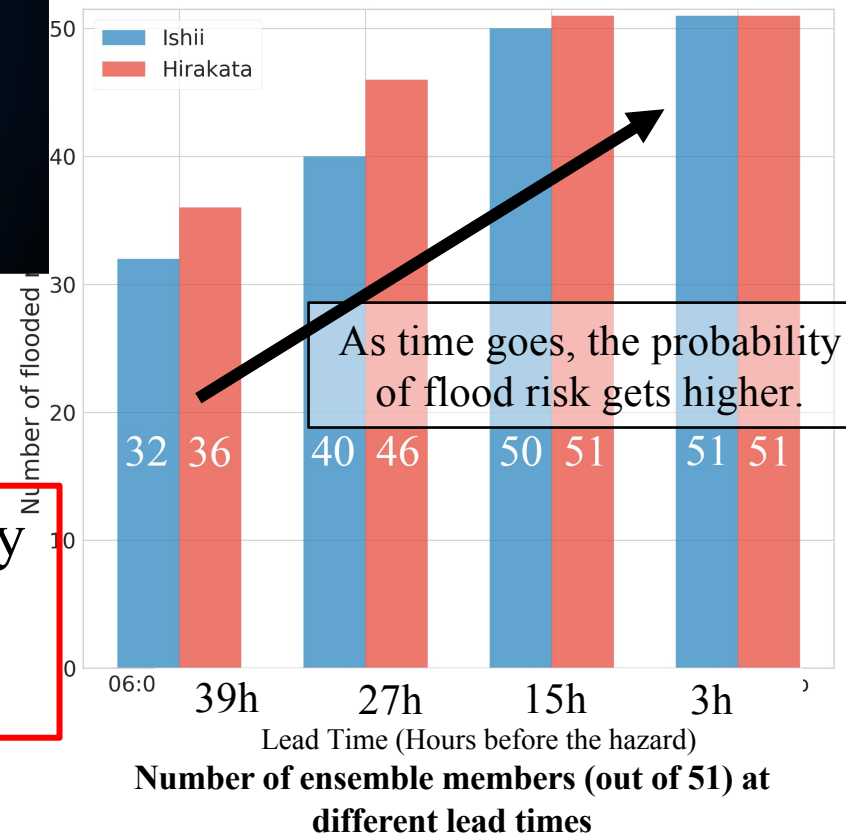
Accumulated Precip.
08-10, Sep. 2015

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.



As time goes, the probability of flood risk gets higher.

Thank you for your attention!