Intercomparison of regulated river discharge among multiple global hydrological models under multiple forcings

Yoshimitsu MASAKI

Now: Hirosaki University (contracted employee)

Note: Today's talk was done during my working days at NIES

1. Introduction

Introduction

- Dams (>60000 in the world)
  - Most large rivers are regulated = We cannot neglect dam effects
  - No intercomparison on flow regulation has been performed

- Aims of this paper

  We examined the characteristics of river discharge regulated by dams using multiple global hydrological models (GHMs) under multiple meteorological forcings

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Two-parted papers were written with co-authors:

- **Paper I (multiple forcings)**

  Masaki, Y., N. Hanasaki, K. Takahashi and Y. Hijioka

- **Paper II (multiple models)** [*this talk*]

  Masaki, Y., N. Hanasaki, H. Biemans (LPJmL), H. Müller Schmied (WaterGAP), Q. Tang (DBH), Y. Wada (PCR-GLOBWB), S. N. Gosling (GHM-Coordinator), K. Takahashi and Y. Hijioka

ISI-MIP

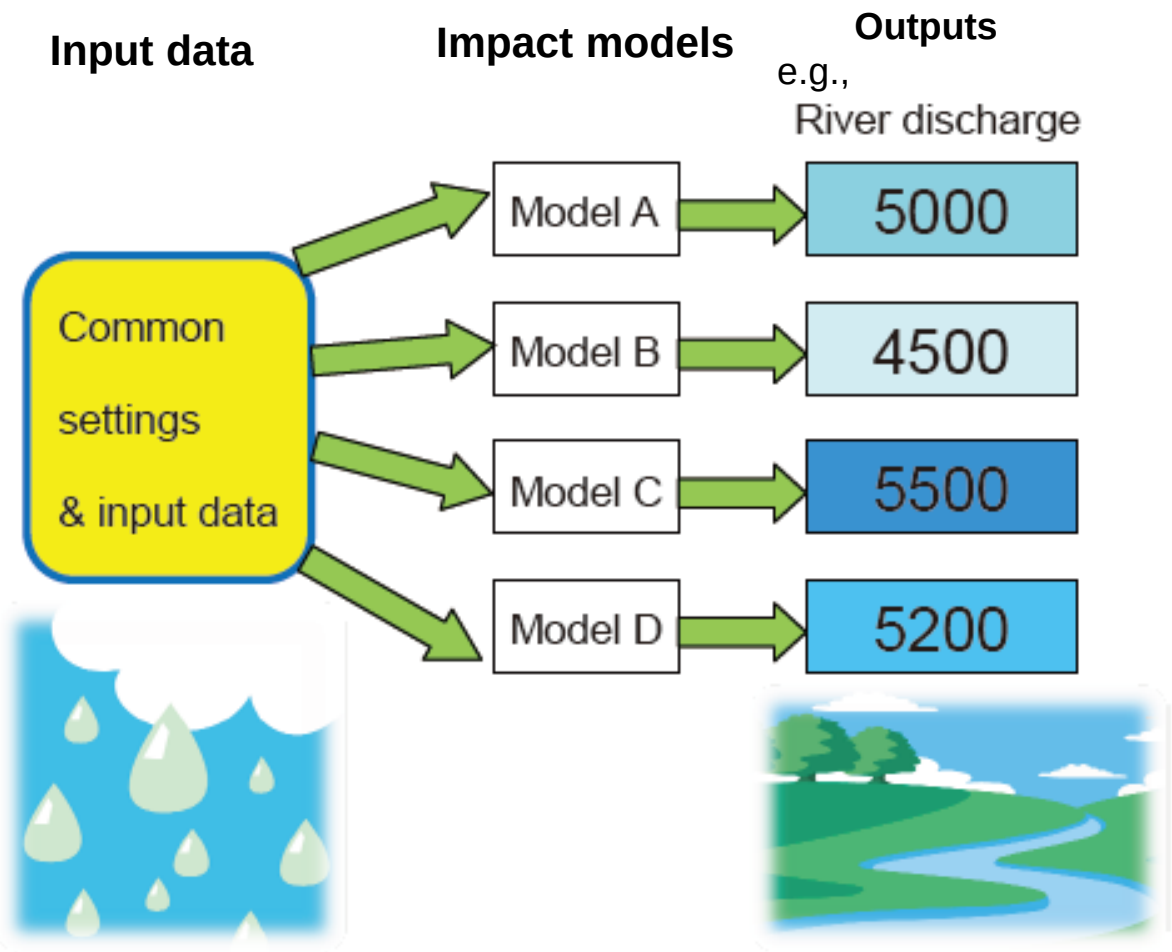
- This study was done in the framework of ISI-MIP 2a
  - ISI-MIP: Inter-Sectoral Impact Model Intercomparison Project
  - Headed by PIK (Potsdam Institute for Climate Impact Research, Germany)
  - ISI-MIP2a: Validation for impact analysis
  - See details: https://www.isimip.org/

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

Phase	Main tasks & target outcomes (IPCC reports)
Fast track (finished)	Future climate change impacts using CMIP5 (using 5GCMs × 4RCPs) IPCC AR5
2a (finished)	Historical validation (including extreme events) [*Today's talk*]
2b (now-2017?)	Future climate change impacts, esp. in terms of "1.5 degree target" +land-use change + projection till 2300 IPCC Special Report on 1.5degree target
3	? (Future climate change impacts at high spatial resolutions using CORDEX)

Intercomparison of impact models

- Using common meteorological inputs and settings
  - ISI-MIP Coordinator provides these data sets
- Details are defined in the protocol



2. Methods and Analysis

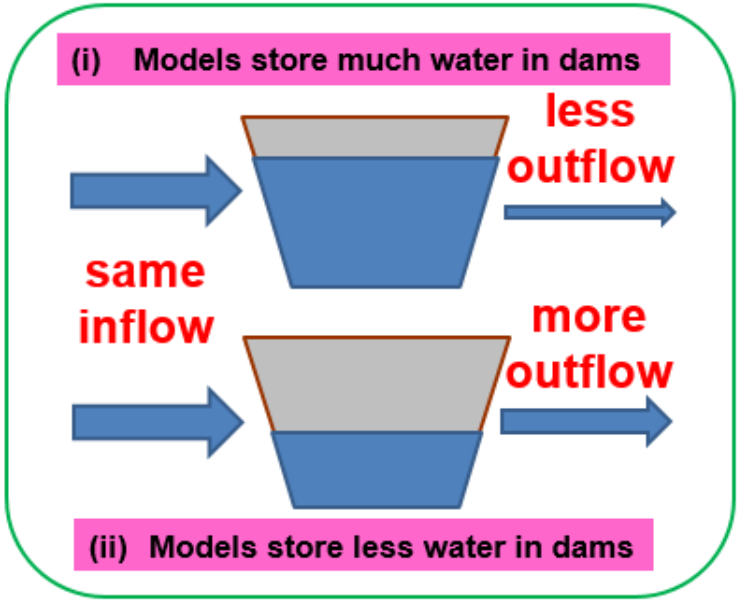
Method

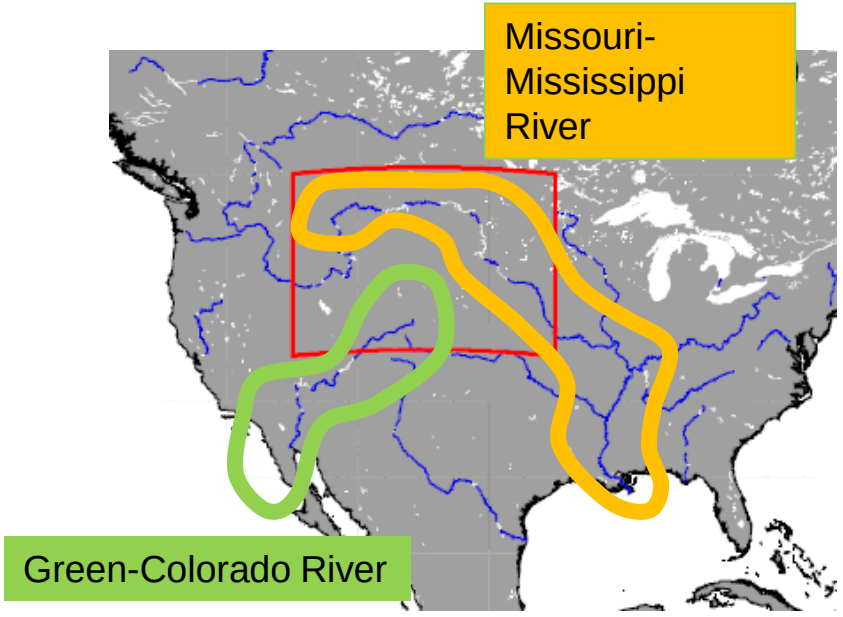
- ISI-MIP2.1A (Water Sector)
  - Multimodel intercomparison: 5 global hydrological models
    DBH, H08, LPJmL, PCR-GLOBWB, WaterGAP
  - Multiforcing intercomparison: 4 meteorological forcings
    GSWP3, Princeton, WFDEI, WATCH
    * Today, we'll mainly talk GSWP3 results
  - Varsoc runs: Time-varying human interventions
    (dams, water withdrawal, change in land use)
  - Nosoc runs: No human interventions
  - Historical simulations (1971-2000/2010)

Method

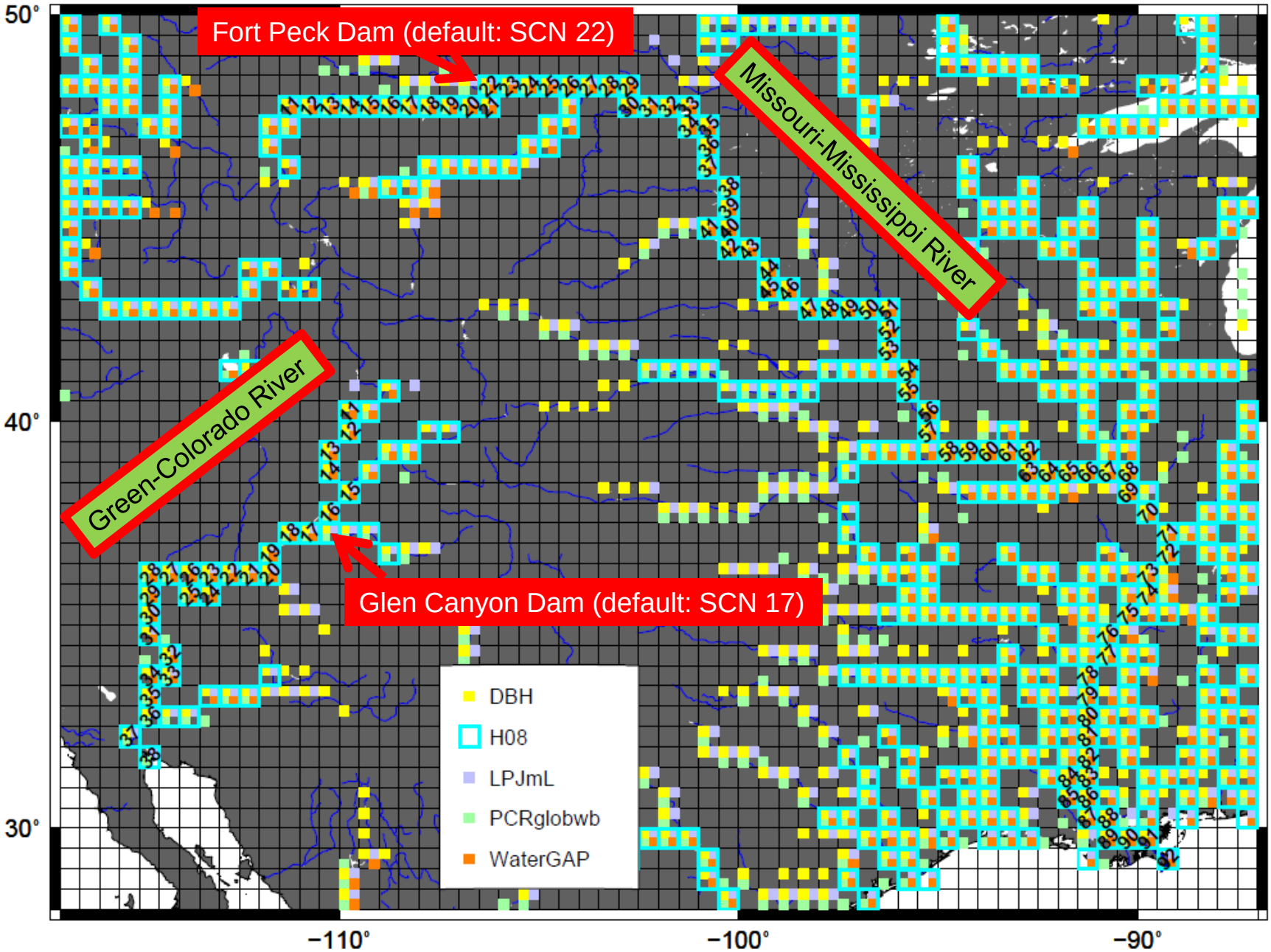
- Two case-study river basins in US
  - Missouri-Mississippi and Green-Colorado Rivers
  - With large dams on the main channel

- How to examine dam effects?
  - We examined change in river discharge at dam sites
  - Land cells were numbered along the main channel (SCN: sequential cell number)





River Channels and SCNs



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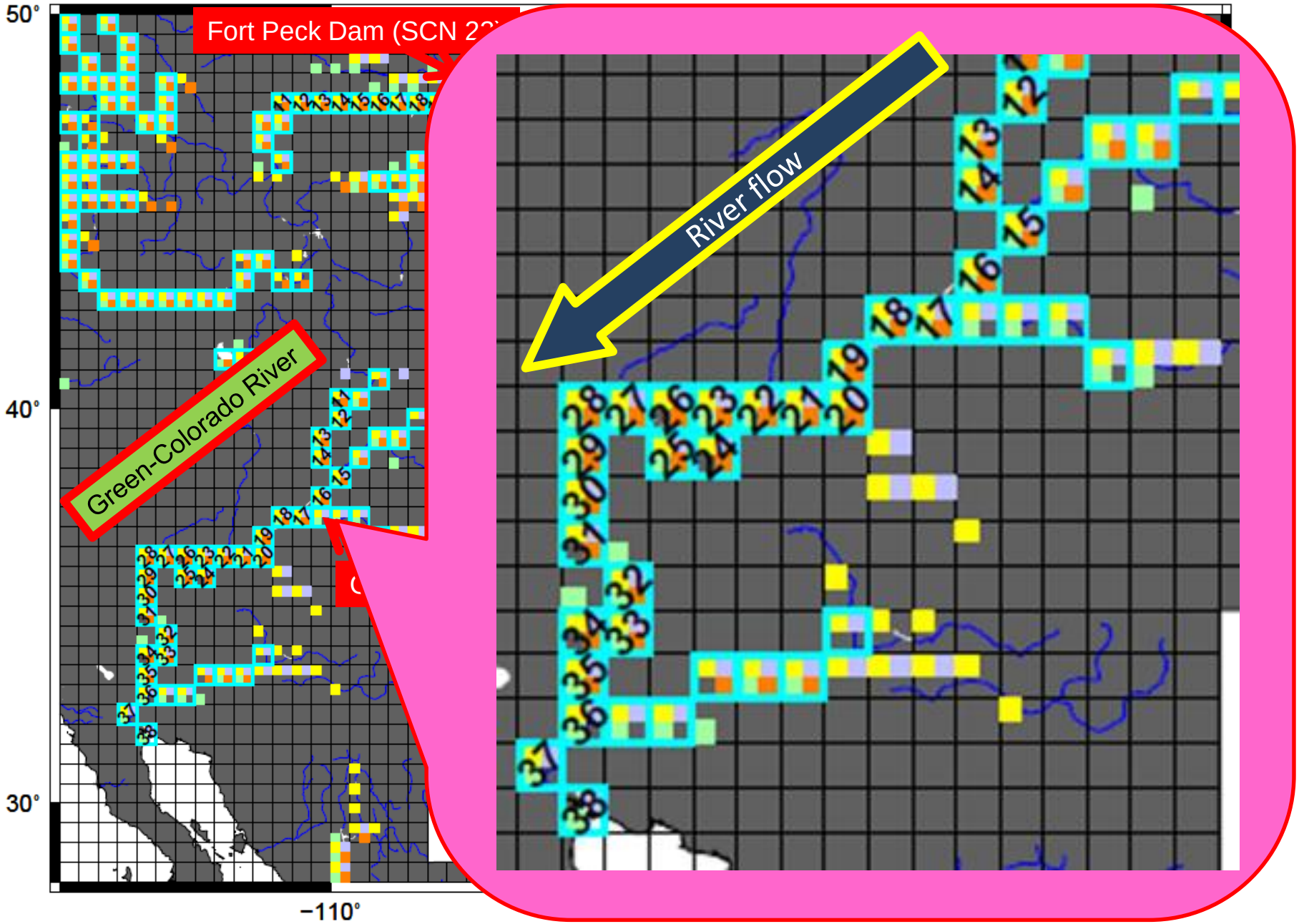
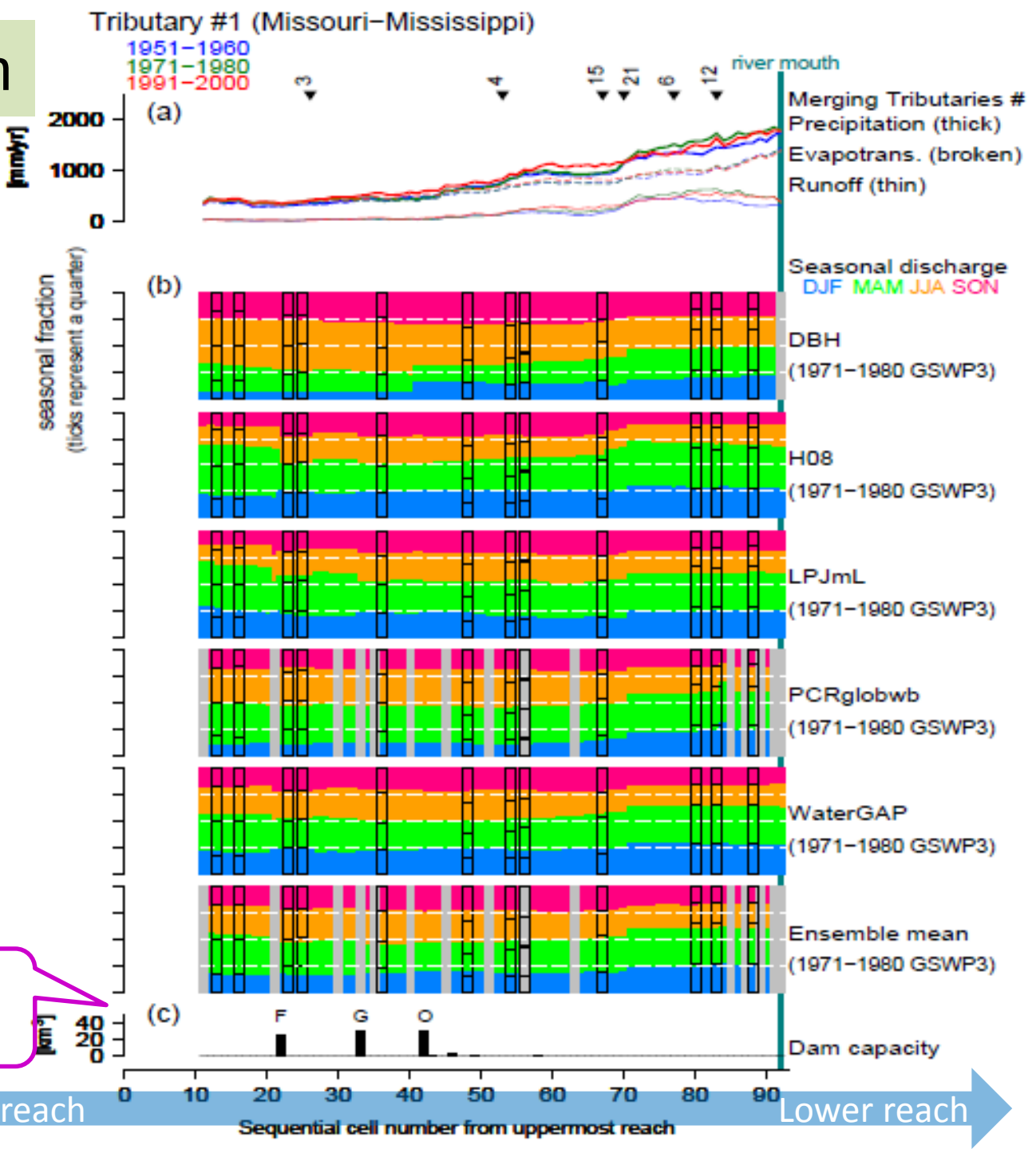


3. Results

Seasonal Fraction

- Larger discrepancies in seasonality in the upper reach
  - Snow melt flow is observed in spring to early summer
  - Discrepancies are attributable to flow regulation, as well as natural flow in each GHMs



Fall
Summer
Spring
Winter

F: Fort Peck Dam
G: Garrison Dam
O: Oahe Dam

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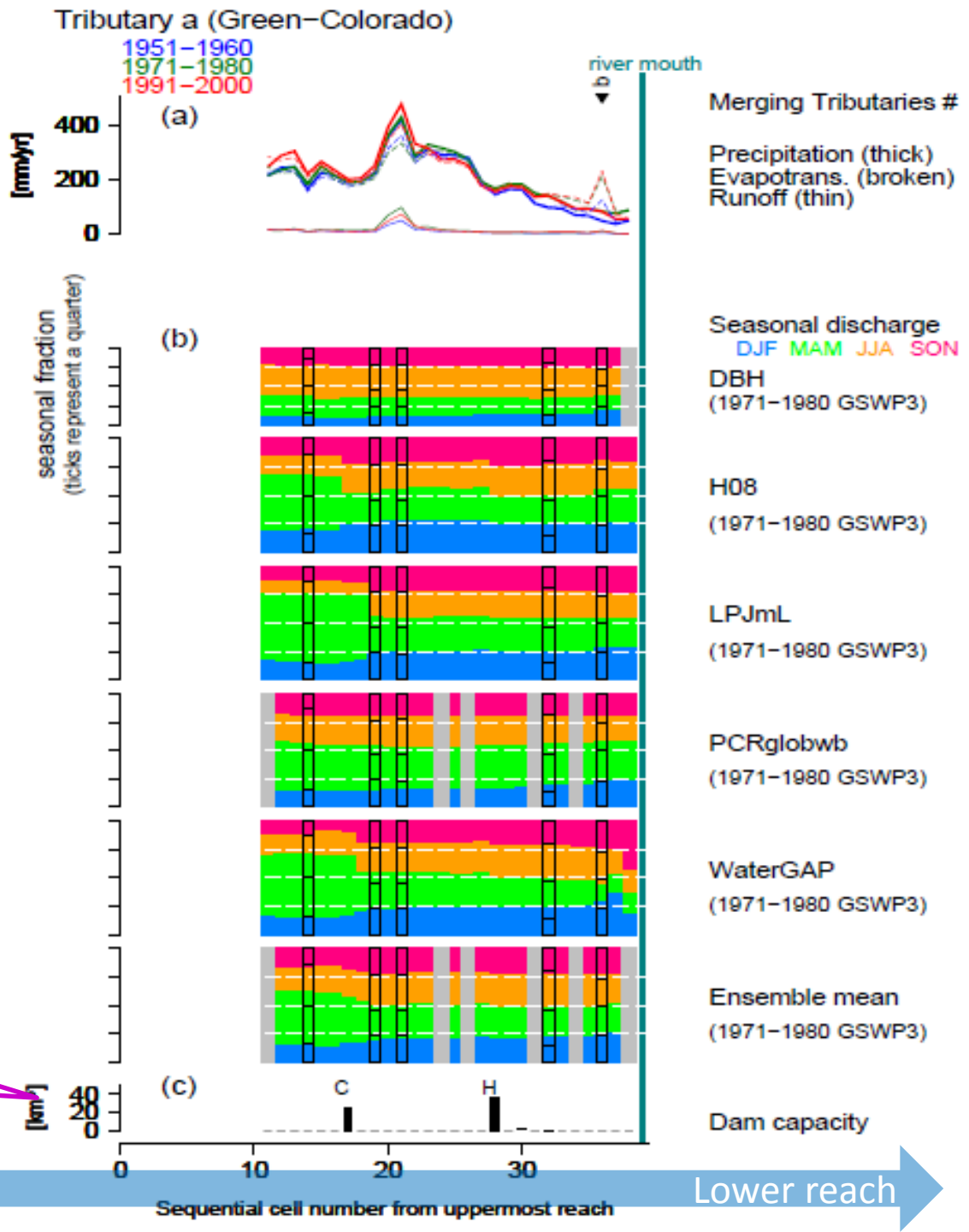
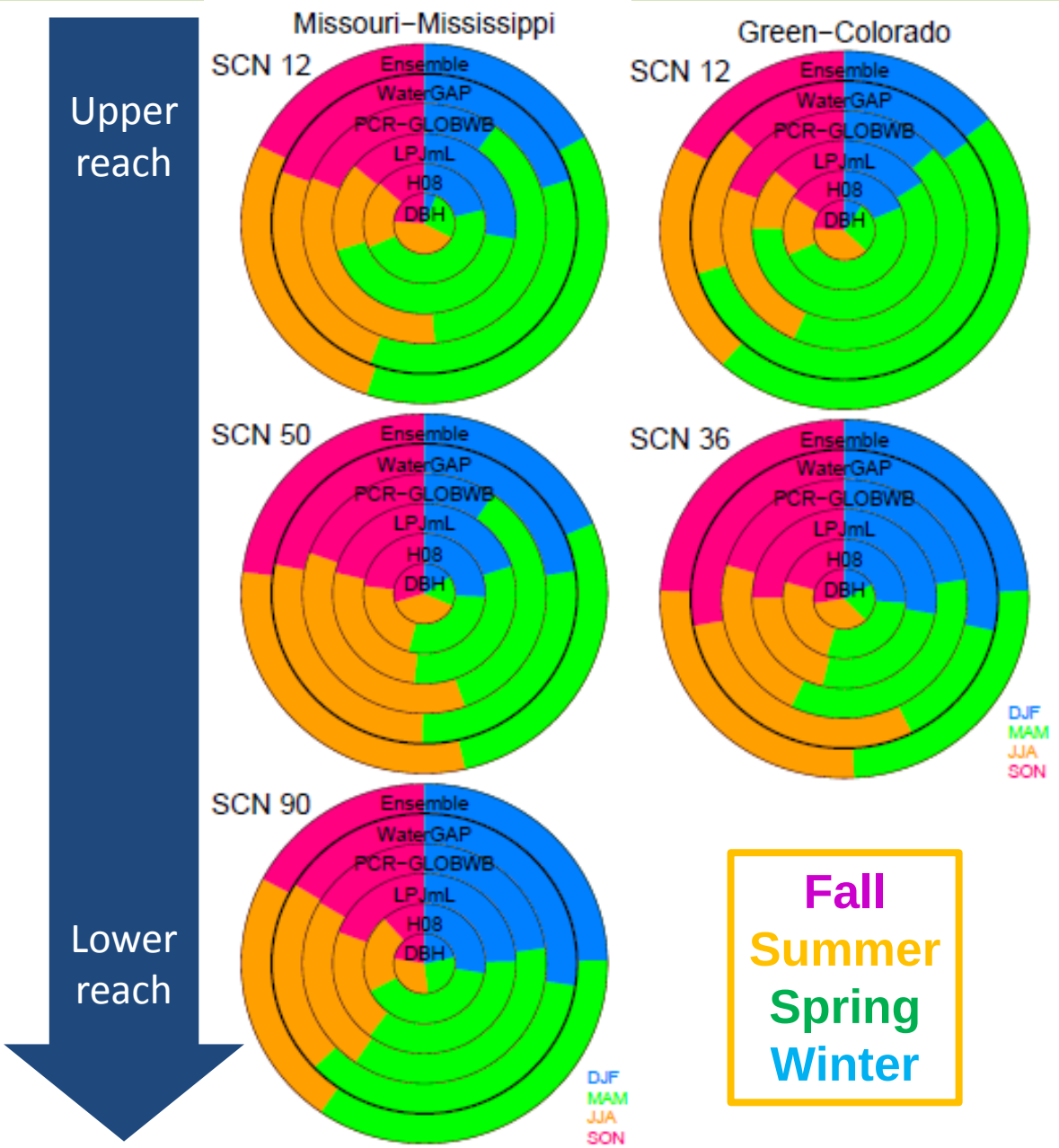


Fall
Summer
Spring
Winter

C: Glen Canyon Dam
H: Hoover Dam

Seasonal discharge (regulated)

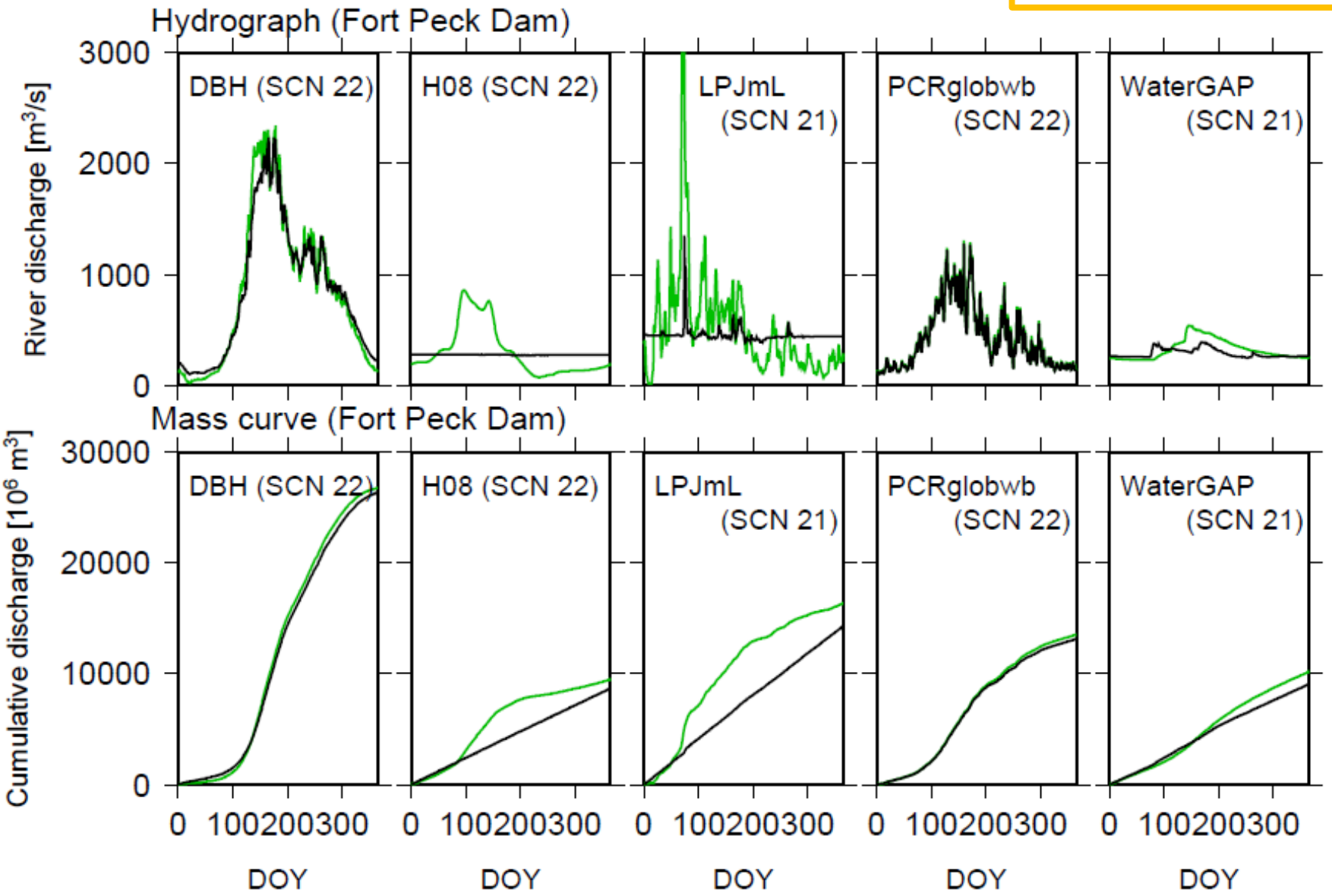
- Larger discrepancies in regulated seasonal discharge are also seen in upper reaches
- If models show good performance at the river mouth, the models do **not** always perform well in other river streches



Changes in hydrograph at dam sites

Fort Peck Dam on the Missouri River

Natural flow (nosoc)
Regulated flow (varsoc)



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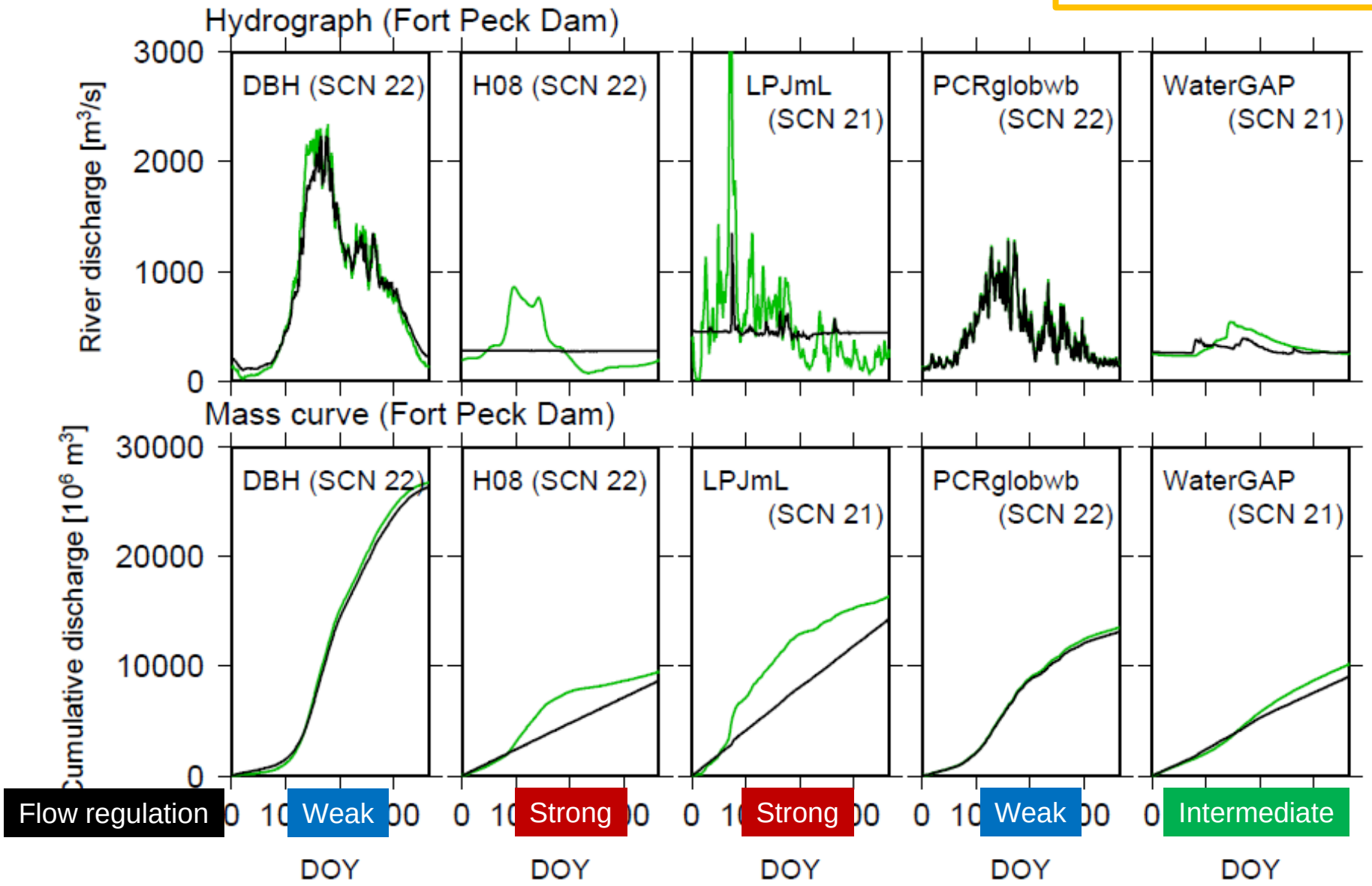
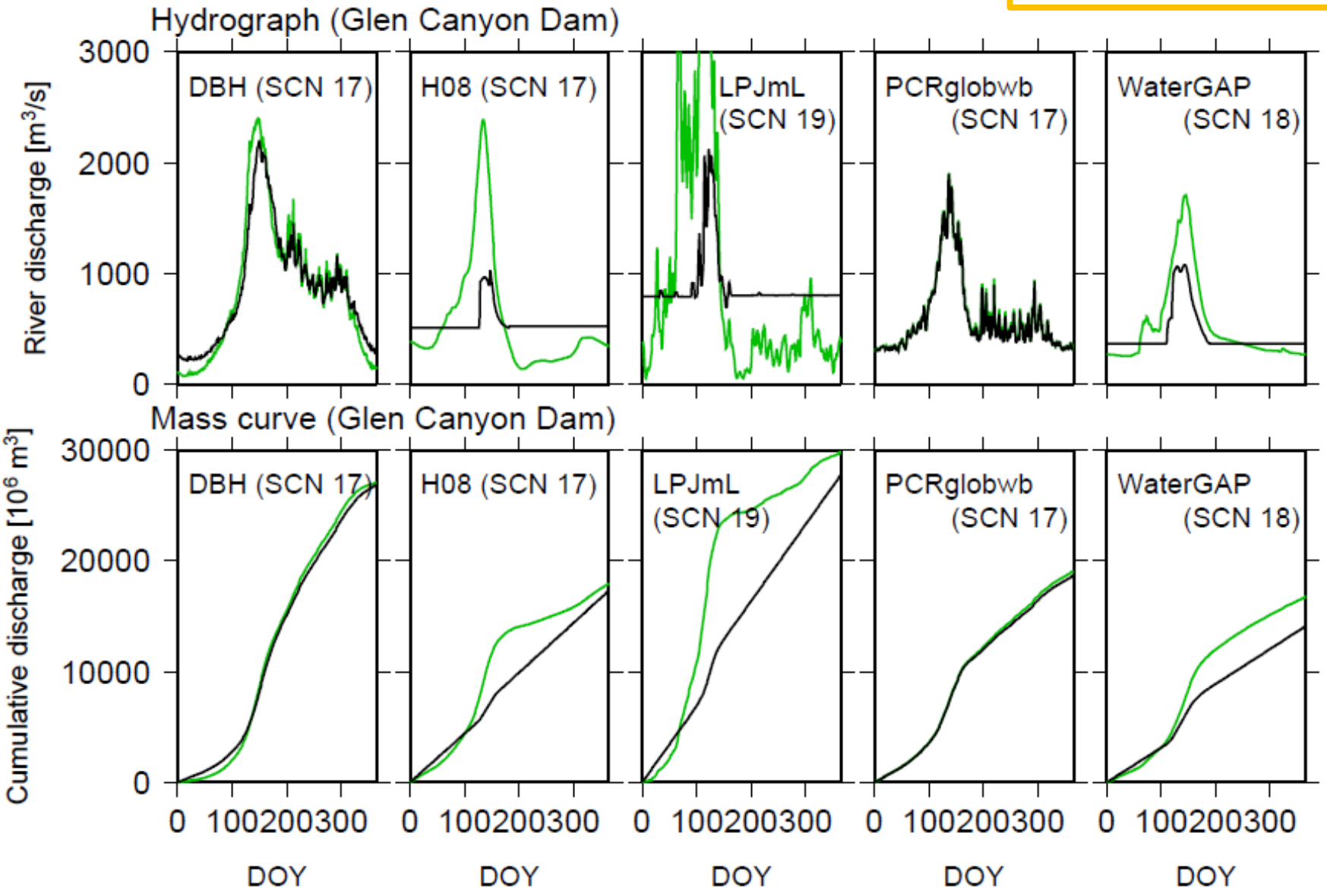


Changes in hydrograph at dam sites

Glen Canyon Dam on the Colorado River

Natural flow (nosoc)
Regulated flow (varsoc)



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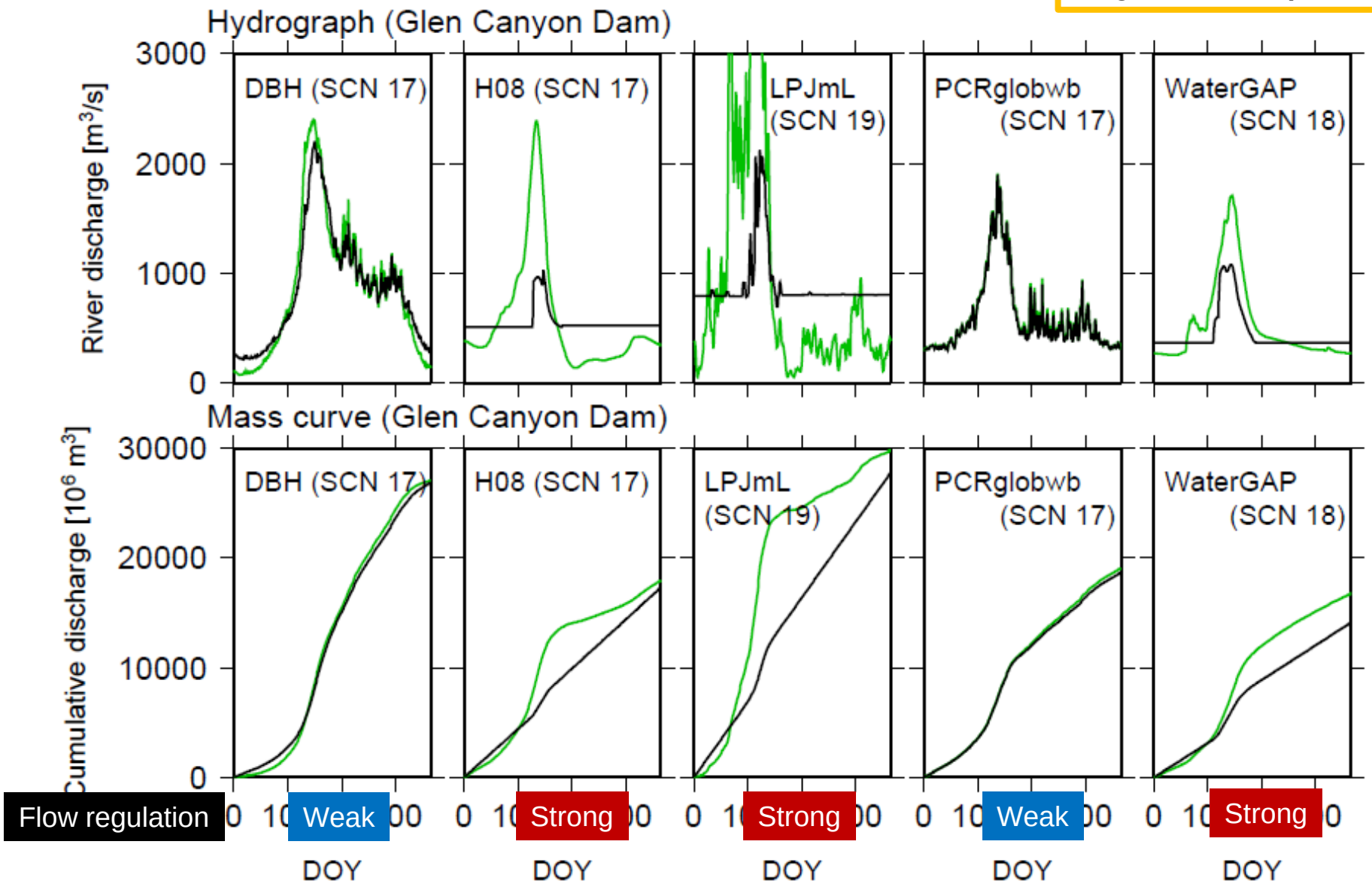
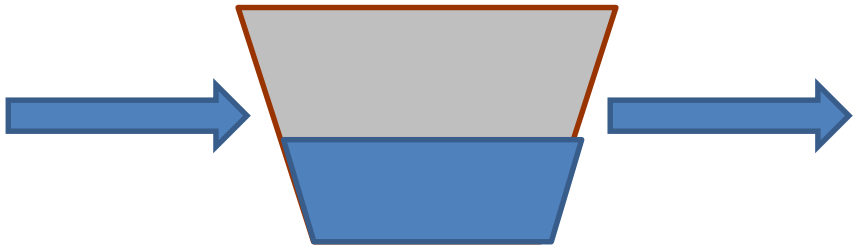


Different magnitude of flow regulation among GHMs

- Strong regulation
  - H08, LPJmL, (WaterGAP)
- Weak regulation
  - DBH, PCRglobwb

Possible reasons

- Differences in inflow without human interferences
  - reflecting land model characteristics (e.g., runoff)
- Differences in dam operation schemes
  - generally are a function of inflow, requirement and storage
  - most models adopted Hanasaki et al. (2006)'s scheme
- Differences in initial storage (at the beginning of a hydrological year)



Conclusion

- The magnitude of dam regulation differs considerably among GHMs
  - The differences are attributable not only to dam operation schemes but also to the natural inflow to dams
- Intermodel discrepancies are less significant toward the lower reach
  - Intermodel comparison should be made in the upper reach, as well as in the lower reach

Problems to be solved for future model comparisons

- Dam location
  - Inconsistency in dam location among GHMs

Thank you for your attention

ymasaki@hirosaki-u.ac.jp