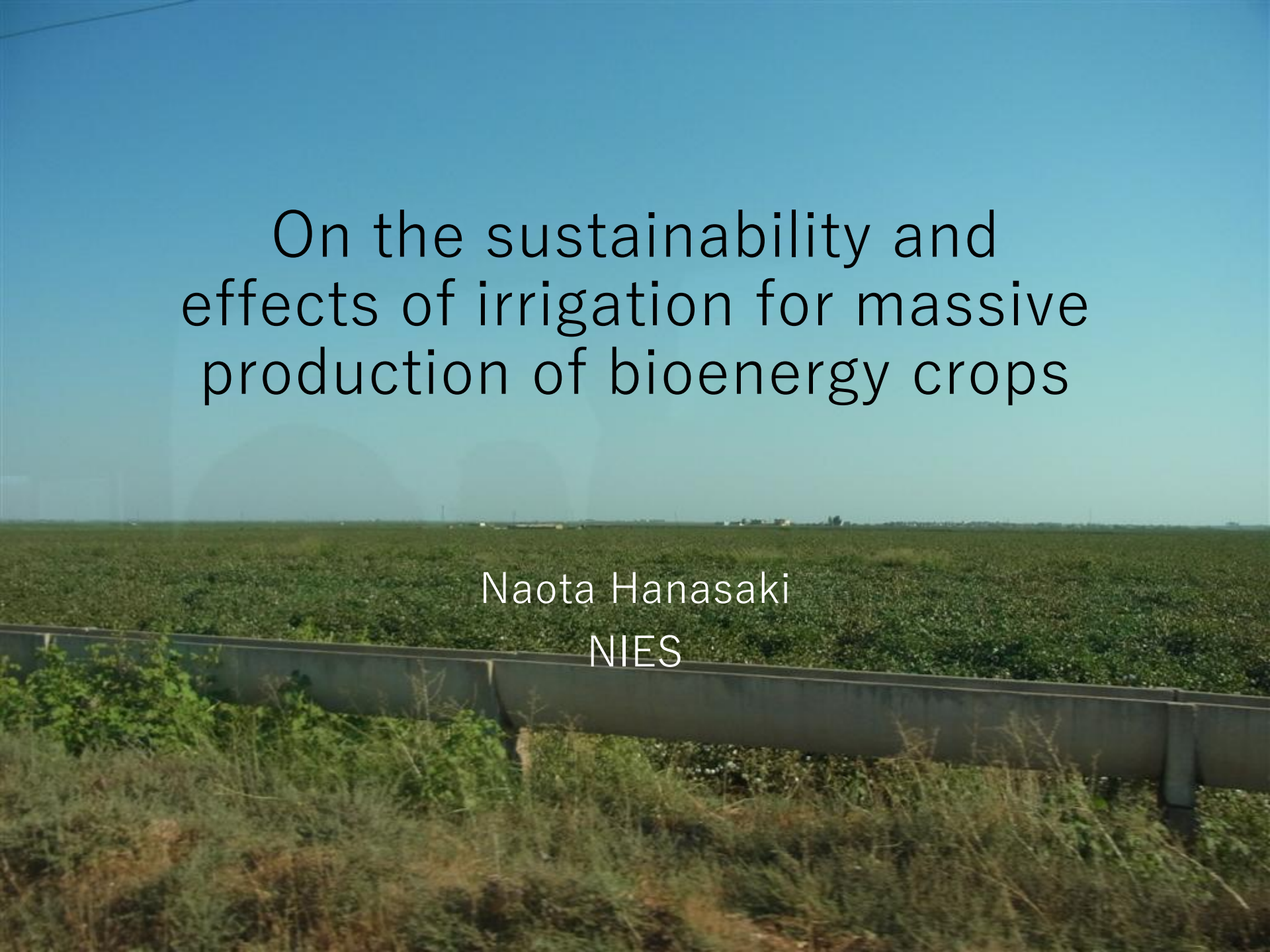
On the sustainability and effects of irrigation for massive production of bioenergy crops



Naota Hanasaki
NIES

Outline

- **Updates of the global water resources model H08**

  H08
  An open source global hydrological model with human activities

  1. Model development
  2. Global impact assessment — Julien-san
  3. Regional impact assessment — Takata-san
  4. Integrated assessment — Zhou-san

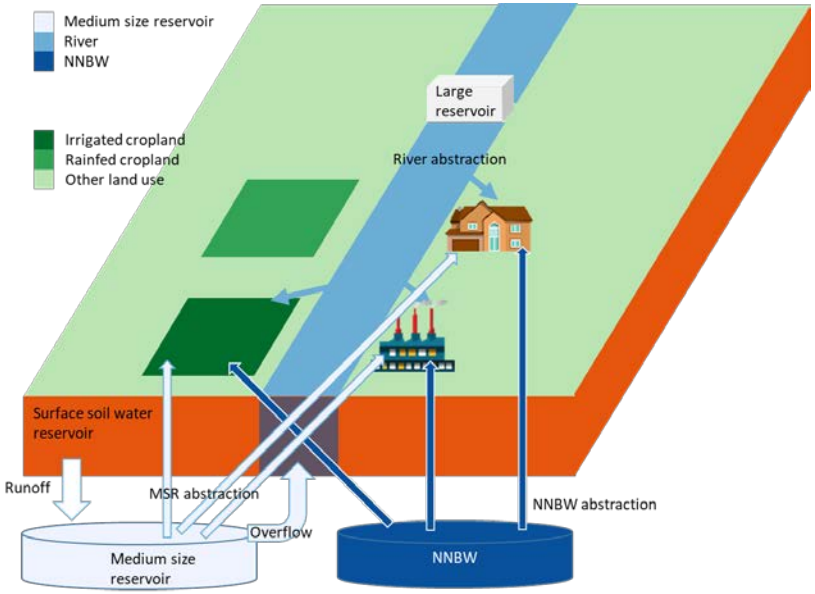


- **Bioenergy crop production and irrigation**

1. Model development

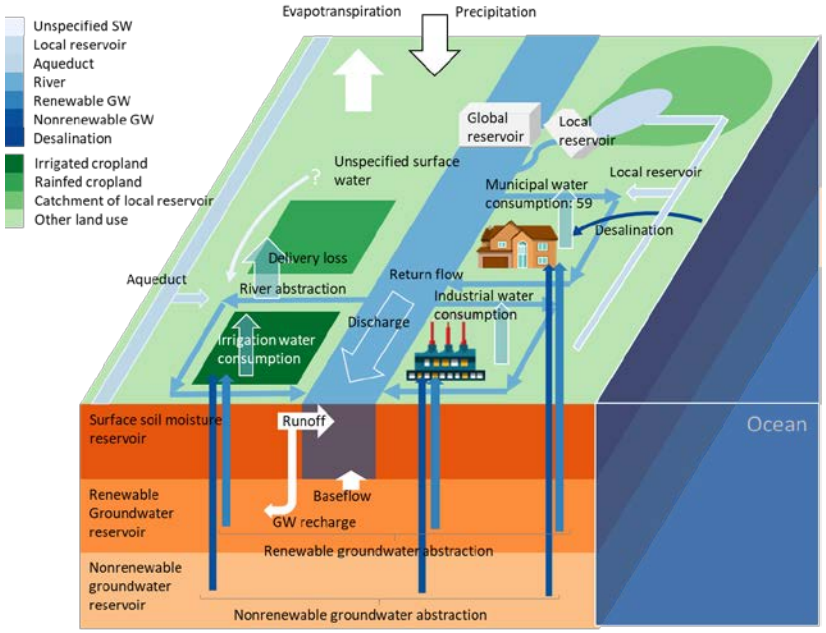
Substantially updated for more “realistic” expressions of water flows

The original H08 model



- Water abstraction from river
- Consumption based

The new H08 model

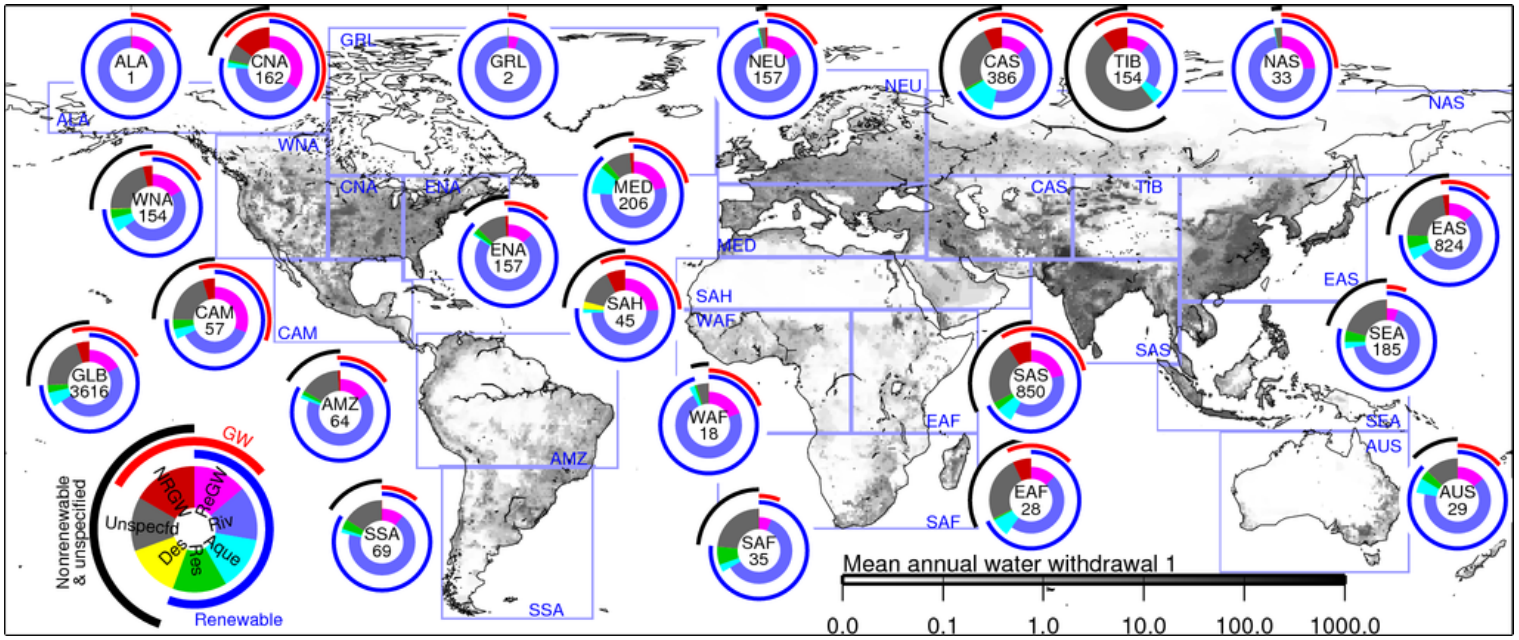


- +Water abstraction from ground-water, canals, & desalination
- Withdrawal based

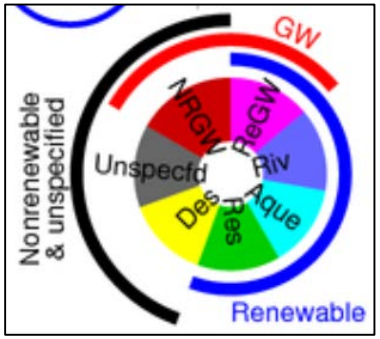
Hanasaki et al. 2016, HESS
Hanasaki et al. (under review; discussion paper available here)

1. Model development > Application

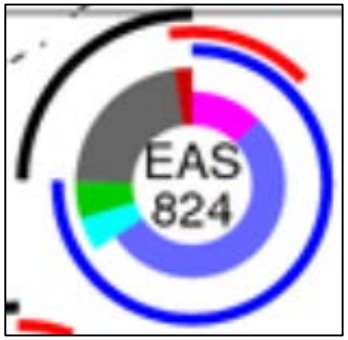
Where do people take water from?



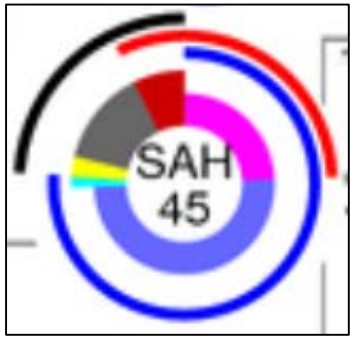
Legend: fraction of water source



East Asia (surface water dominated)



Sahara (groundwater+desalination)

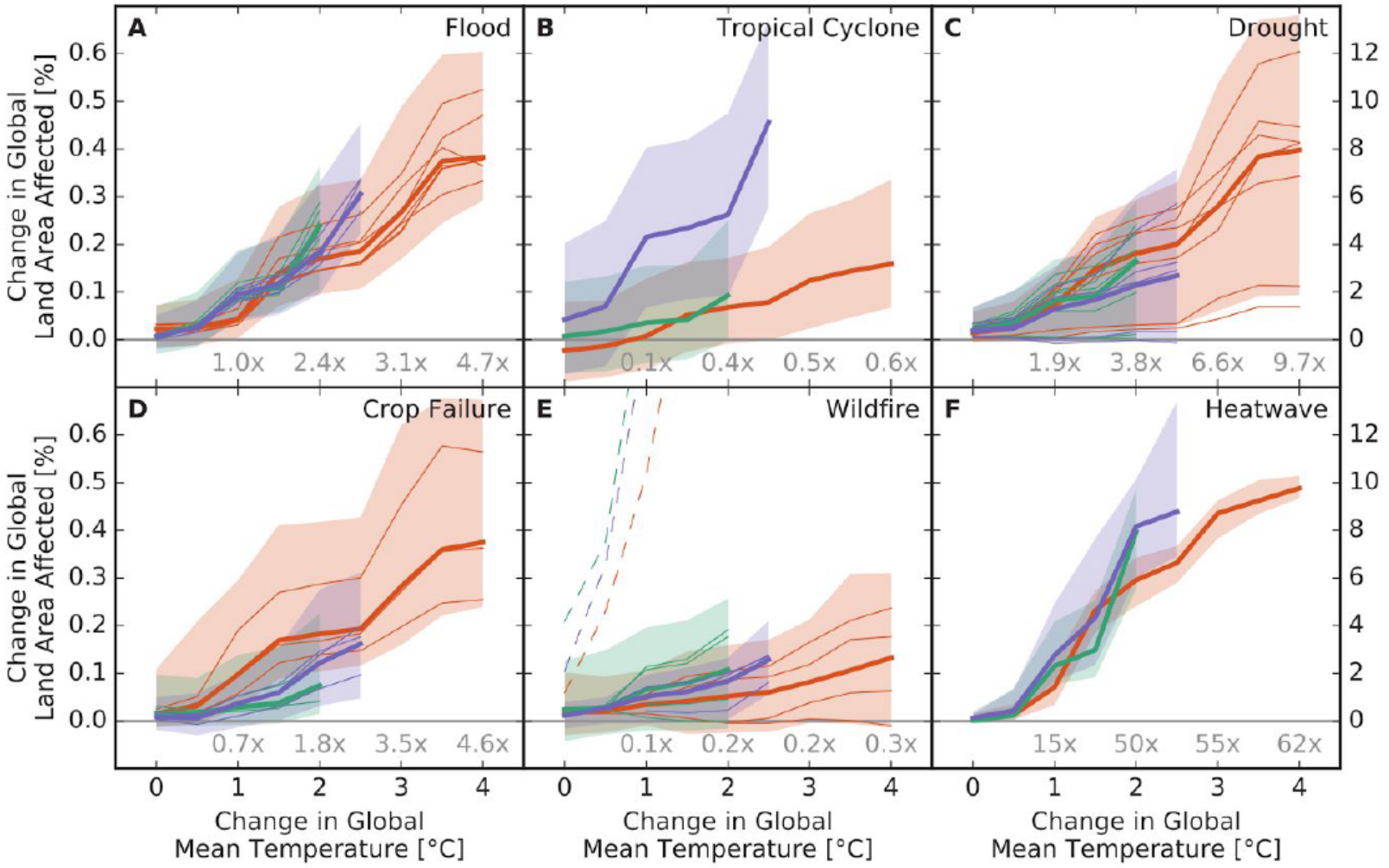


Hanasaki et al. (under review; discussion paper available here)
See also H08 web site

2. Global impact assessment > ISIMIP

Inter Sectoral Impact Model Intercomparison Project Phase 2b (IPCC SR1.5)

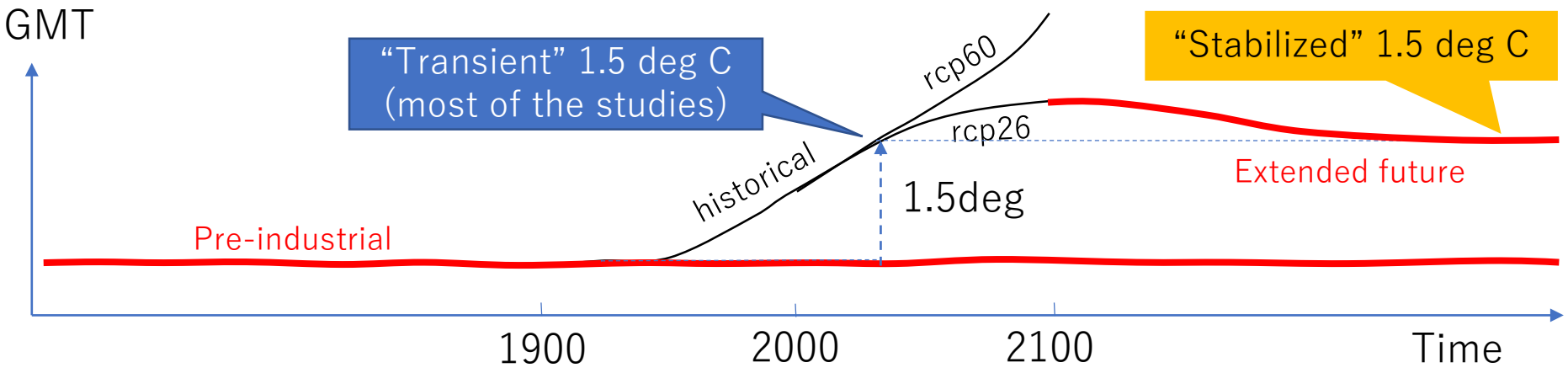
Multi sectoral impact analyses using multiple impact models (>20)

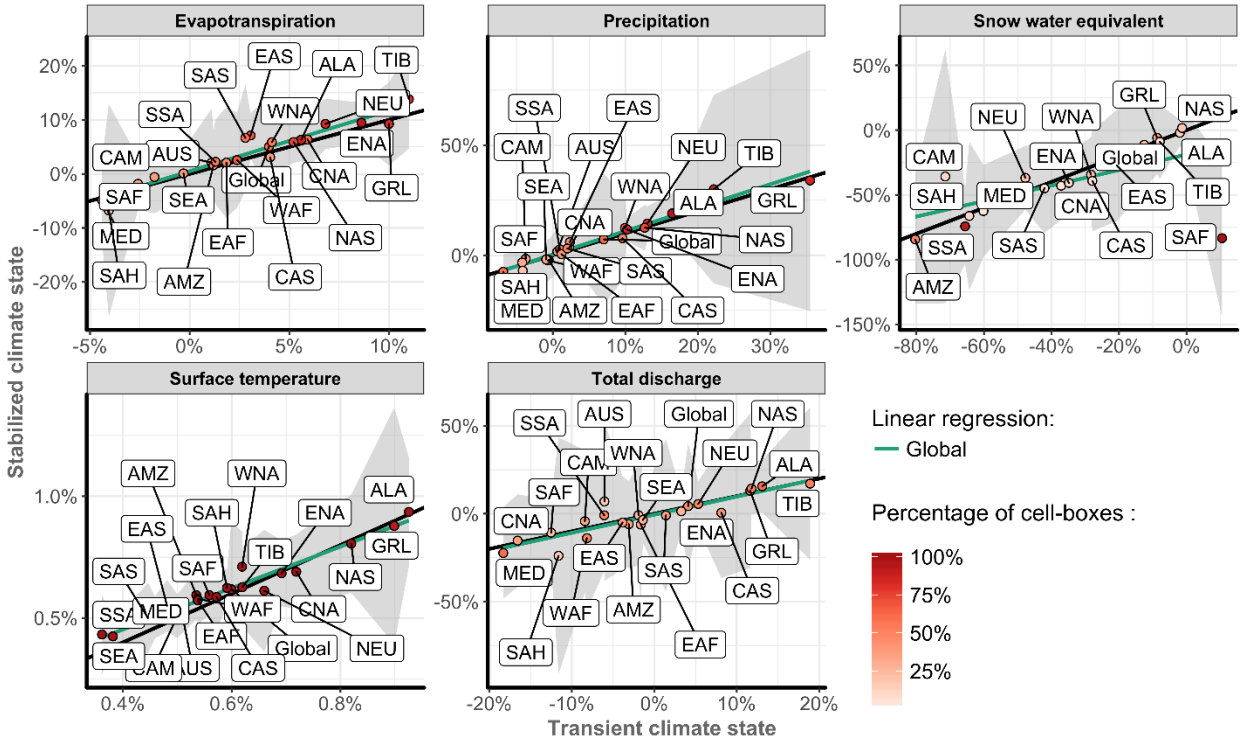


Lange et al. (in prep)
See also [project website]

2. Global impact assessment > ISIMIP

What is the 1.5 degrees warmer world?

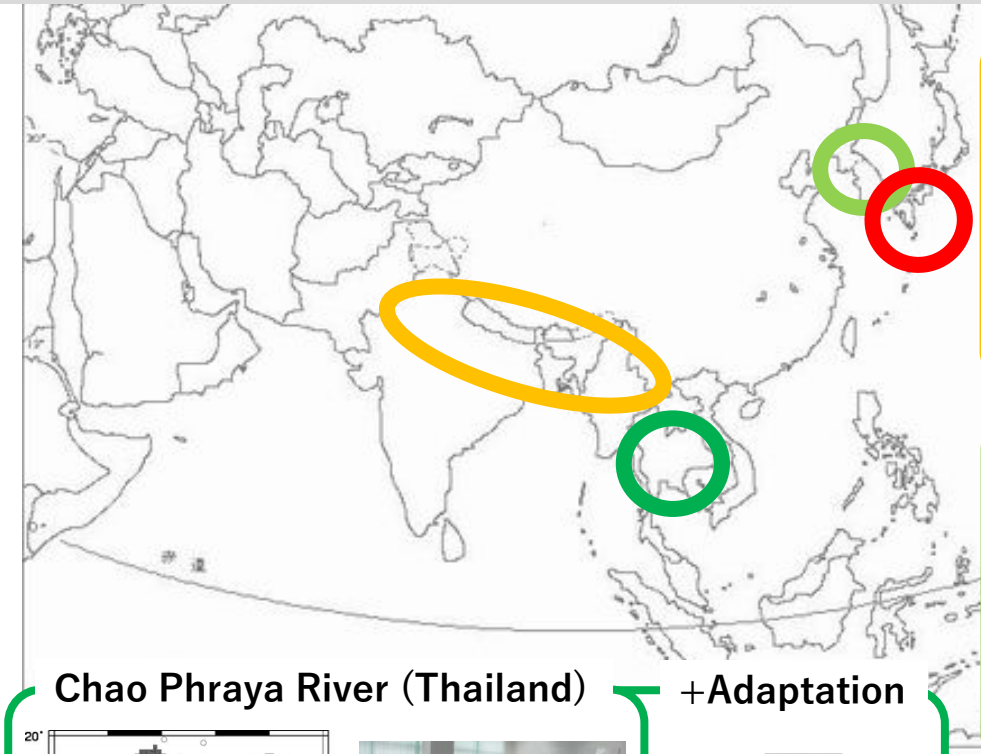




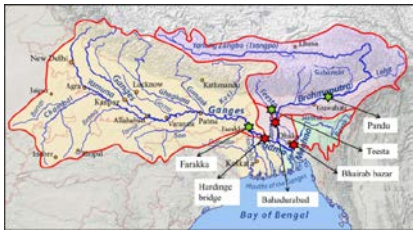
Boulange et al. (submitted)

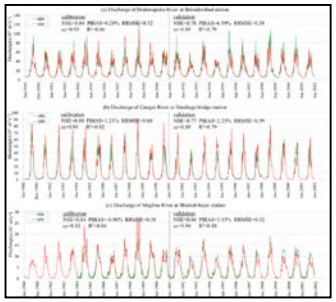
3. Regional impact assessment

Many excellent students have applied H08 to multiple regions



Ganges Brahmaputra Megna

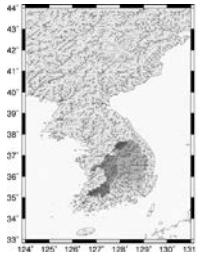


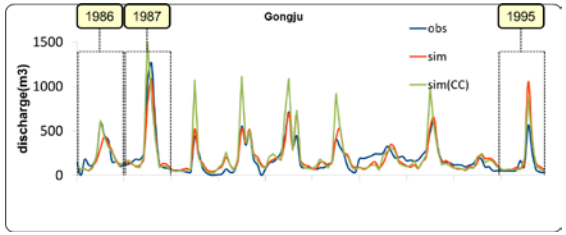


Masood et al. 2015, HESS

ICHARM

Korean Peninsula

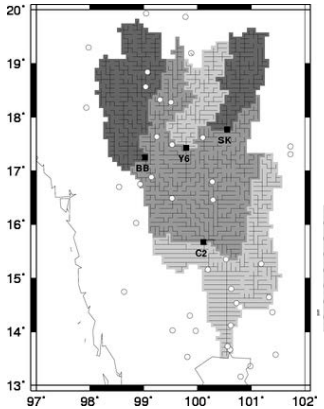


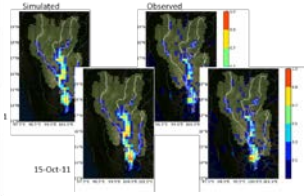


Yoo, 2016, Master thesis

서 울 대 학 교
SEOUL NATIONAL UNIVERSITY

Chao Phraya River (Thailand)

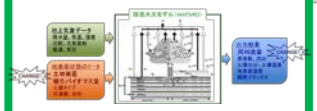


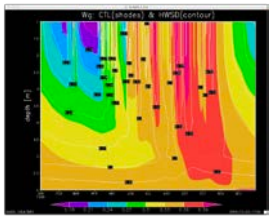


Mateo et al. 2014, WRR;
Hanasaki et al., 2014; HRL

KMUTT

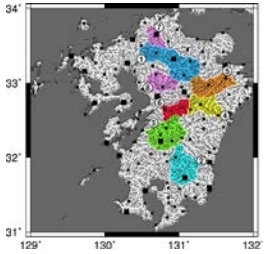
+Adaptation

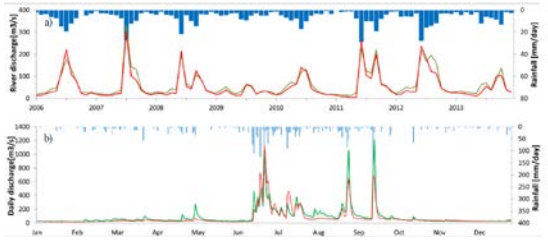




Takata et al.
in prep

Kyushu Island (Japan)



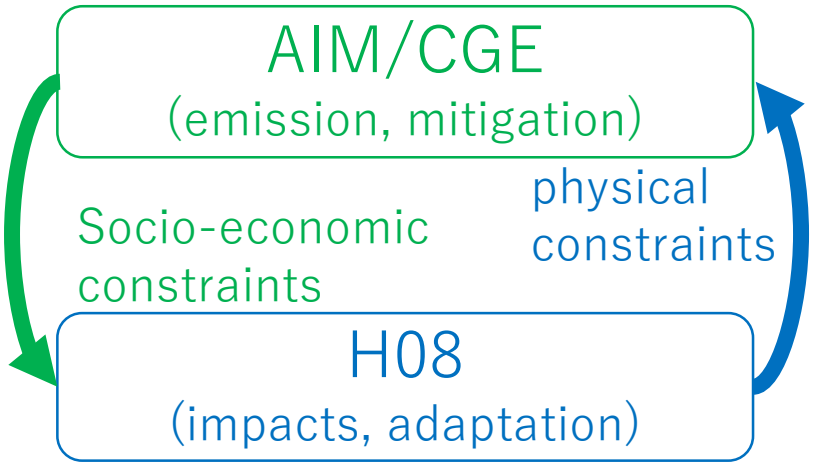


Maji, 2017, Master thesis; Hanasaki et al. subm

Forthcoming: **China**, **India**, **Panama** and **Philippines**

4. Integrated assessment

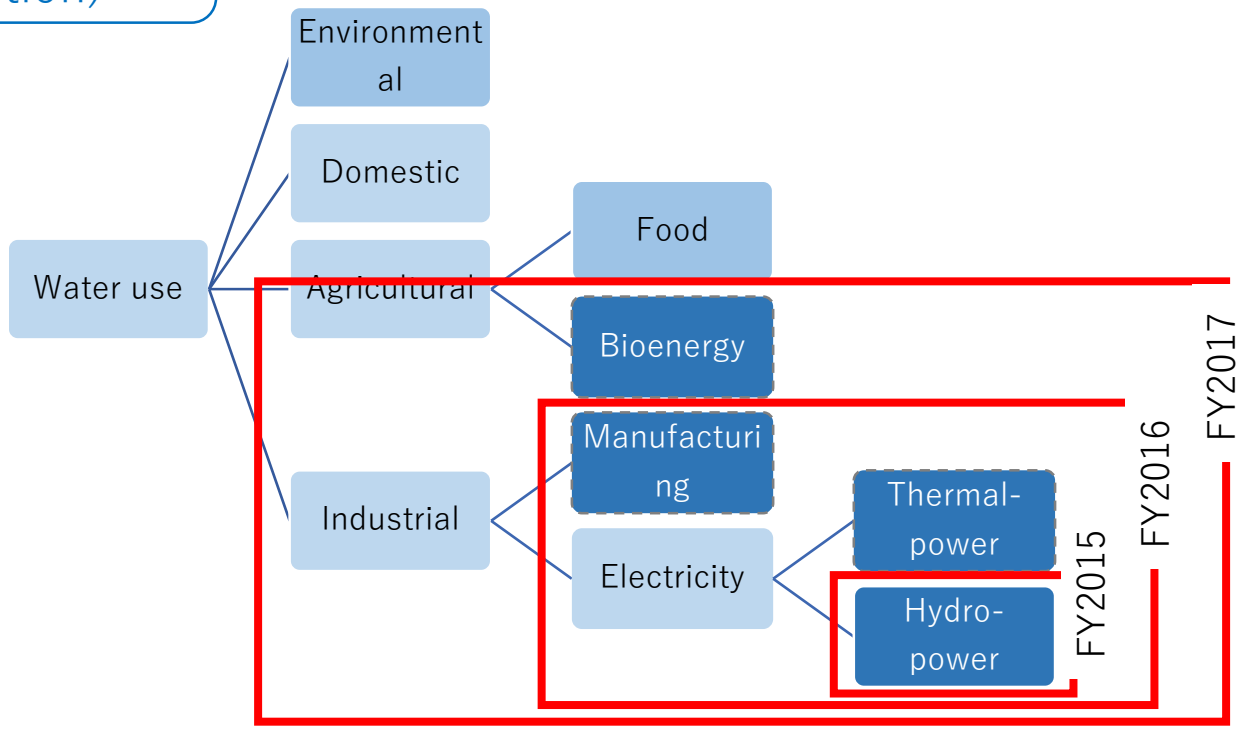
Linking AIM/CGE and H08 for energy-water nexus studies



17 regions, 43 sectors, annual interval

Challenge: Fill the gaps

50km-grid, 3 sectors, daily interval

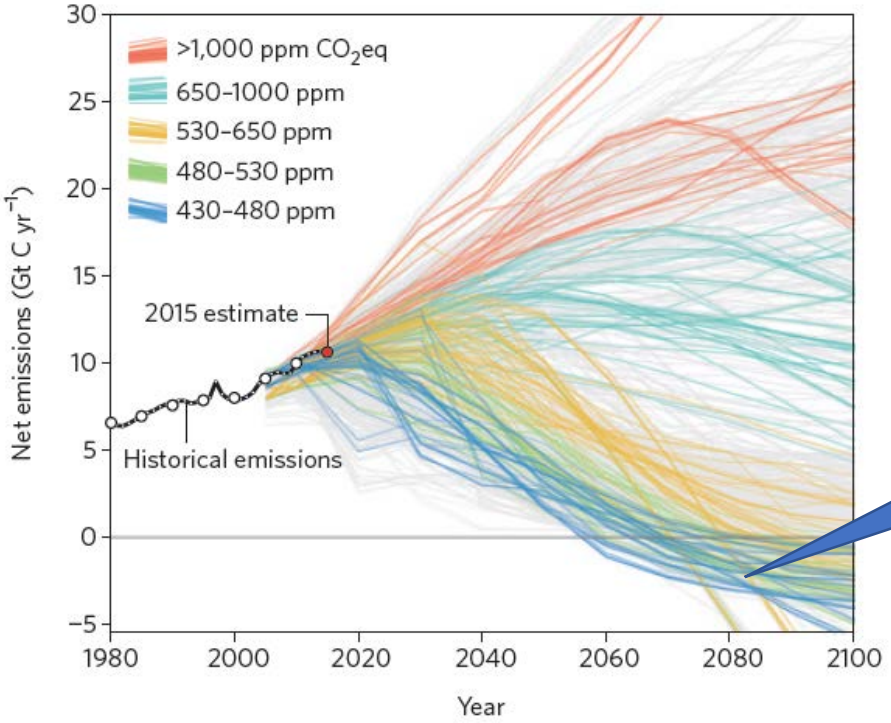


On the sustainability and effects of irrigation for massive production of bioenergy crops

Background

BECCS to achieve 2 (1.5) degrees target

GHG emission paths



2 degrees scenarios (negative emission)

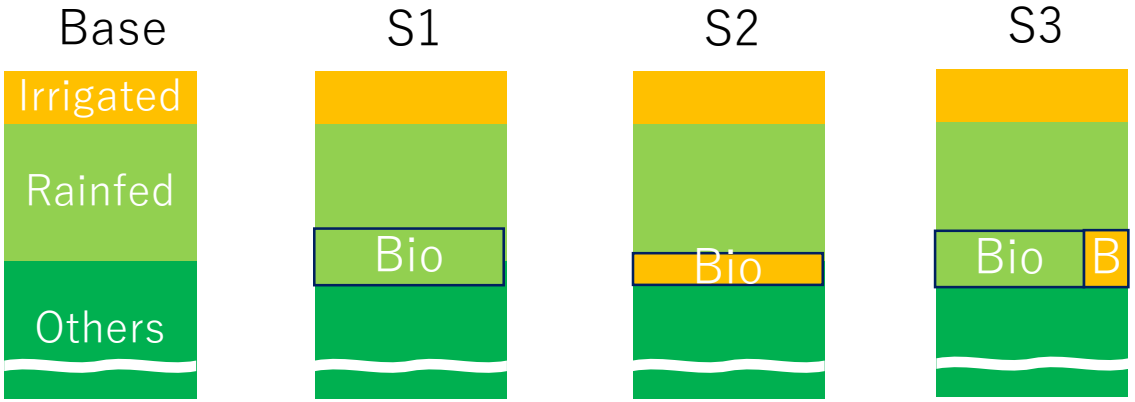
BECCS needed to achieve the 2 degrees target

	C sequestration GtCeq/yr	**Land (Mha)**	**Energy (EJ/yr)**
BECCS	3.3	380-700	170
Present level	Total emission ~10	Total cropland ~1500	Primary energy ~500

Source: Smith et al. 2016

Scenarios

How to produce bioenergy crop?



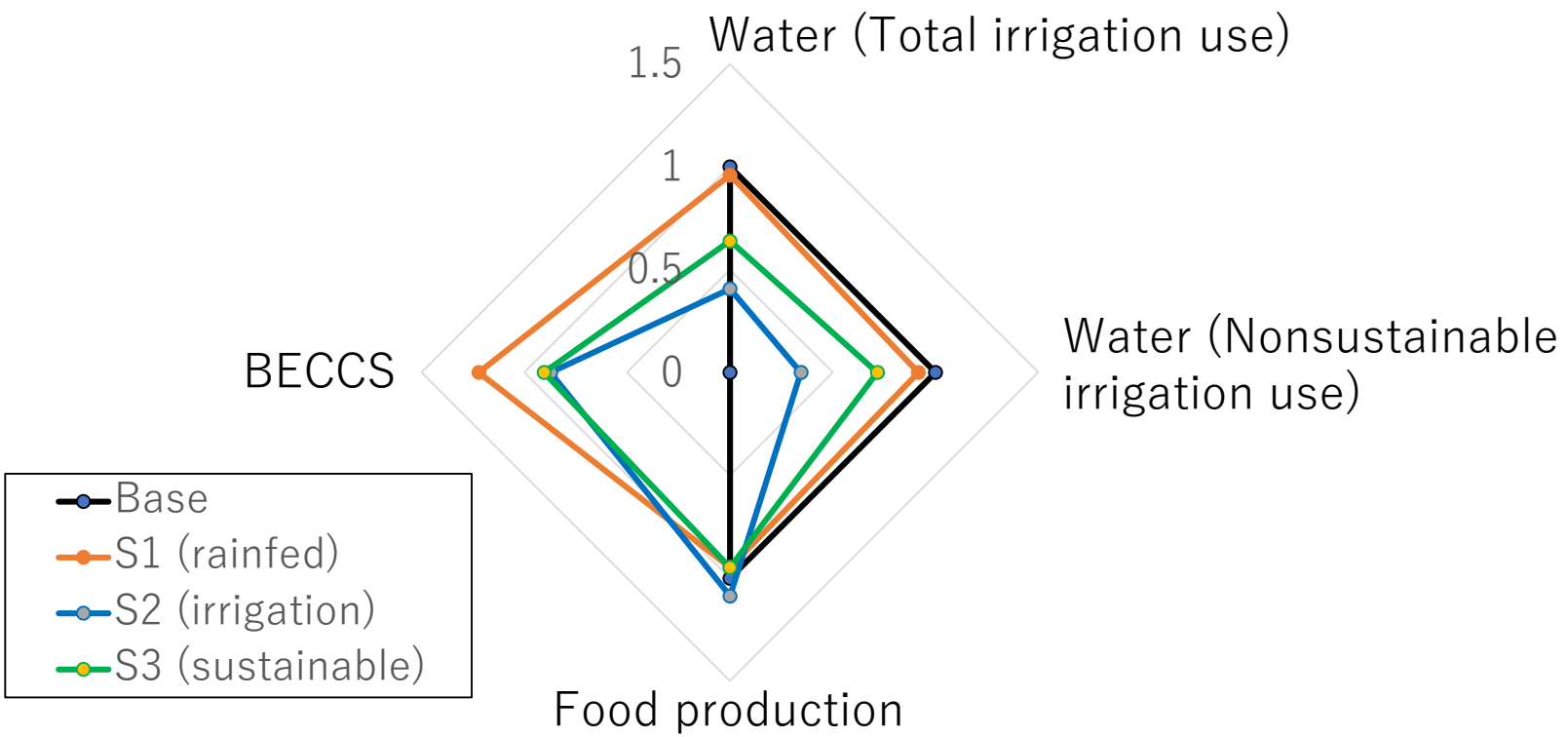
	Base	S1 (rainfed)	S2 (irrigation)	S3 (sustainable)
Year	2000	2100	2100	2100
Total cropland [Mha]	1570	2120	2120	2120
Bioenergy cropland [Mha]	0*	500	250	500
Irrigation for bioenergy crop	No	No	Yes, even if unsustainable	Yes, if sustainable

Yamagata et al. submitted; Hanasaki et al. in prep

Results

Tradeoffs among water, food, and energy.

	Base	S1 (rainfed)	S2 (irrigation)	S3 (sustainable)
Total irrigation use [km3/yr]	1420	1480	3490	2220
Nonsustainable irrigation use	660	720	1910	920
Food production [Mt/yr]	7500	7110	8150	7110
BECCS [GtC/yr]	0	4.03	2.88	3.01



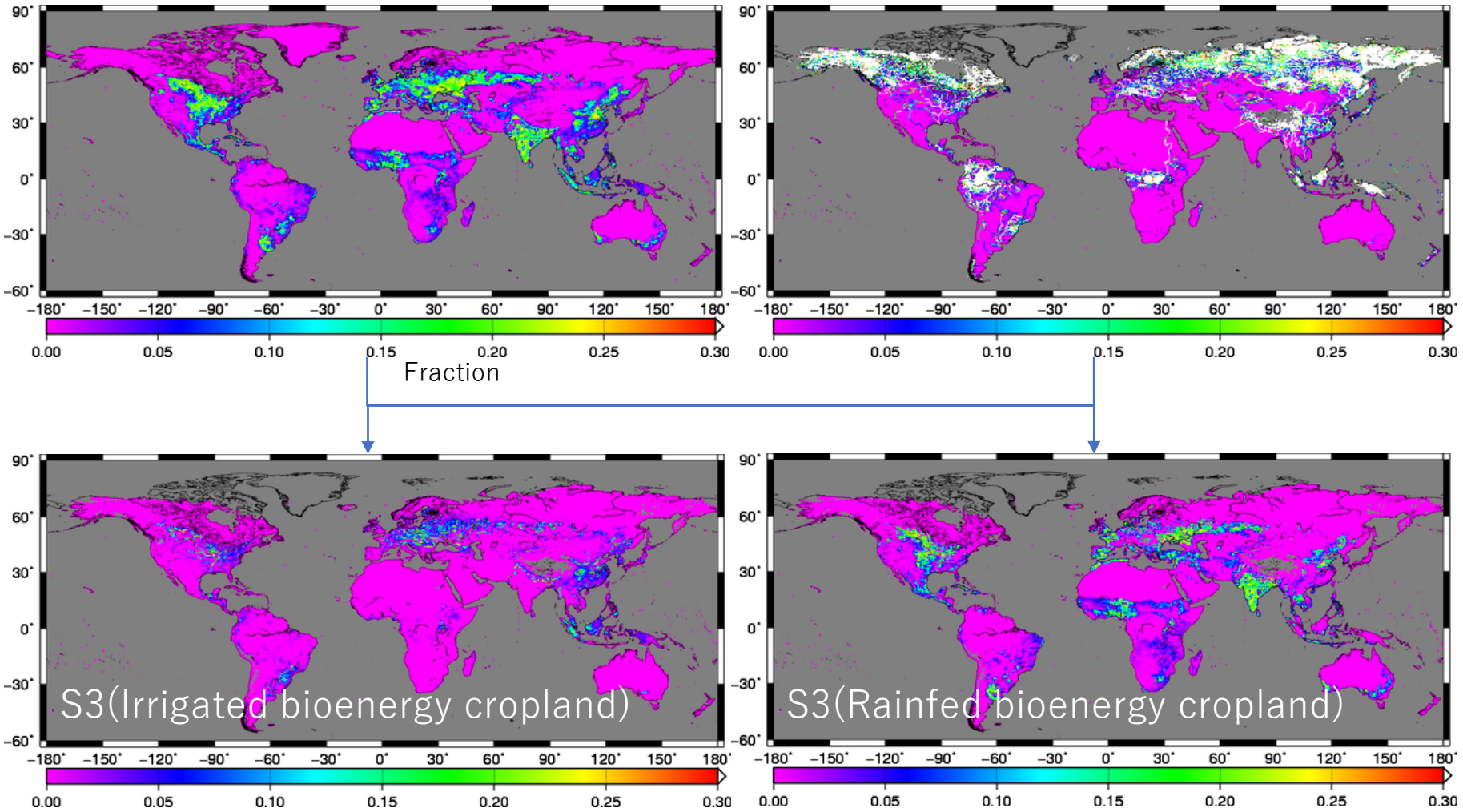
Yamagata et al. submitted; Hanasaki et al. in prep

Discussion

Why S3 was not effective?

Distribution of total cropland

Potential “irrigatable” area



Where irrigation is needed, there is no water available!!

Summary

- Research updates
  - The new model
  - Global impact studies (ISIMIP)→ Julien Boulange
  - Regional impact studies → Kumiko Takata
  - Energy-Water nexus studies
    - Hydropower, Cooling water → Zhou Qian
    - Bioenergy and irrigation

- Bioenergy and irrigation
  - Irrigation enhances bioenergy production
  - Water availability matters. Don't be too much optimistic!