Strategic Workshop on "Accounting for water scarcity and pollution in the rules of international trade"
NEMO Science Centre, Amsterdam, the Netherlands,
25-26 November 2010

How virtual water trade and water footprint can be beneficial, practical, and useful?

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special thanks to
Dr. Naota Hanasaki (NIES) and Takeshi Kondo

How to Assess

Climate Model
River Map (TRIP)

Water Resources Q

Country Statistics
Grid Data

W Water Withdrawal

Balance (Water Scarcity Index)

$R_{ws} = (W-S)/Q$

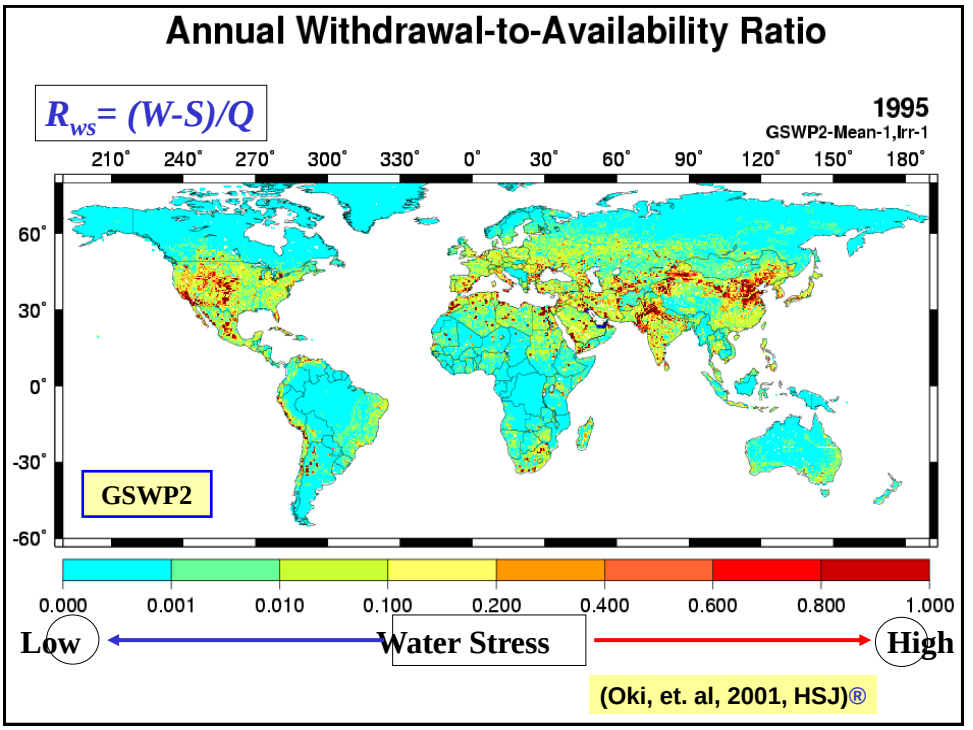
<0.1 : No Stress
0.1—0.2 : Low Stress
0.2—0.4 : Moderate St.
0.4< : High Stress

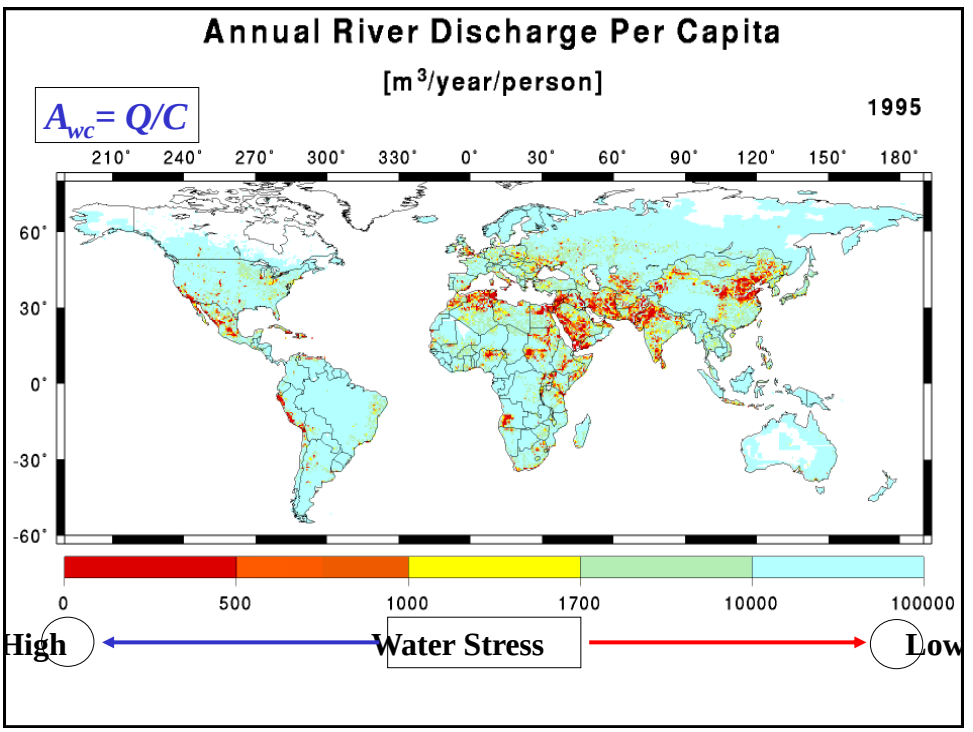
$A_{wc} = Q/C$ $(m^3/y/c)$

>1700 : No Stress
1700-1000 : Low Stress
1000-500 : Moderate St.
500> : High Stress

Water Res. Assessment

(Oki, et. al, 2001, HSJ)

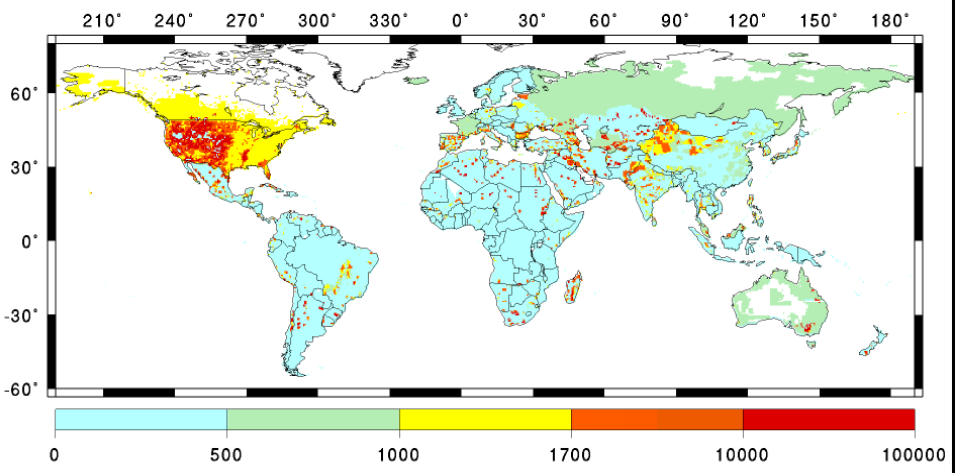

Annual Withdrawal-to-Availability Ratio
R_{ws}= (W-S)/Q
1995
GSWP2-Mean-1,Irr-1
210° 240° 270° 300° 330° 0° 30° 60° 90° 120° 150° 180°
60°
30°
0°
-30°
-60°
GSWP2
0.000 0.001 0.010 0.100 0.200 0.400 0.600 0.800 1.000
Low
Water Stress
High
(Oki, et. al, 2001, HSJ)®


Annual River Discharge Per Capita
[m³/year/person]
A_{wc}= Q/C
1995
210° 240° 270° 300° 330° 0° 30° 60° 90° 120° 150° 180°
60°
30°
0°
-30°
-60°
0 500 1000 1700 10000 100000
High
Water Stress
Low

Annual Water Usage per capita

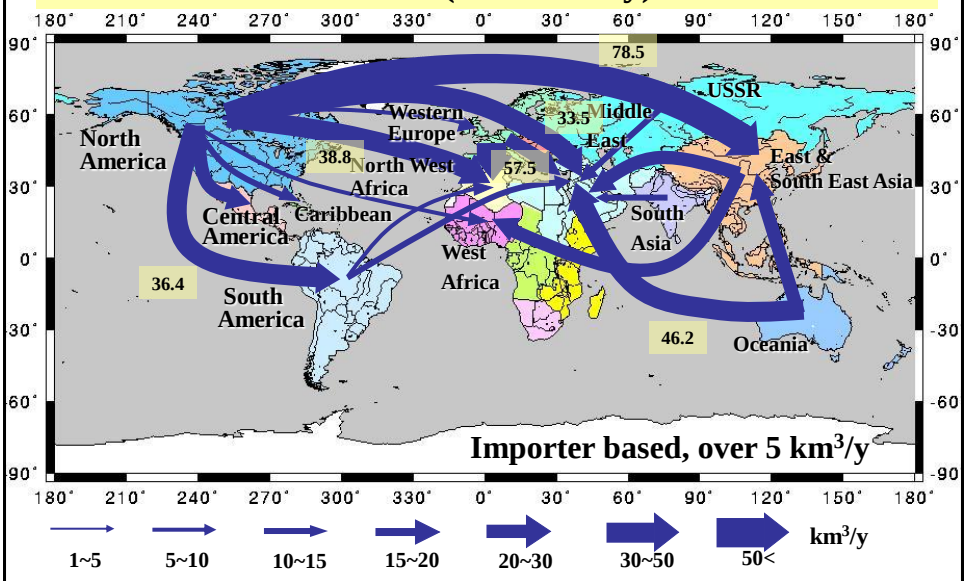
(W - S) / population [m^3 / year / person]

1995



R_{ws}= *(W-S)/Q* and A_{wc}= *Q/C(m³/y/c)* have similar global distribution → Is *(W-S)/C* uniform globally?

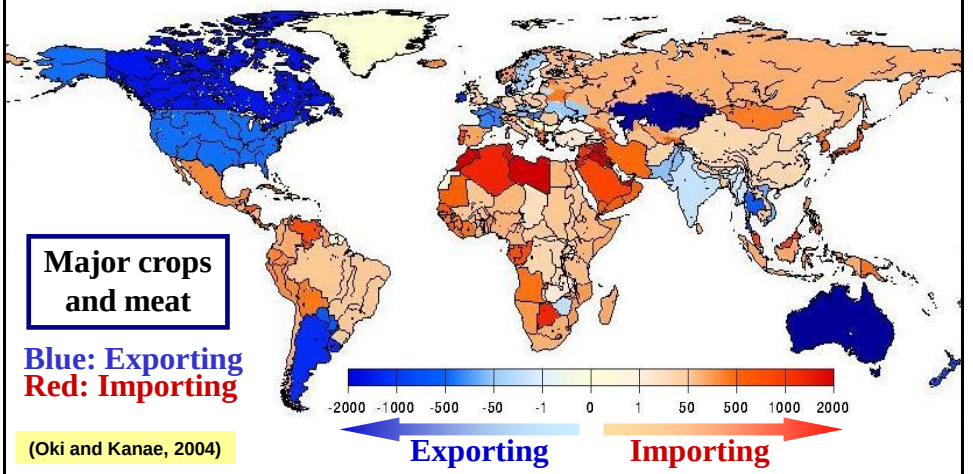
"Virtually Required Water" Trade between Regions in 2000 (cereals only)



(Oki and Kanae, 2004)

(Based on Statistics from FAO etc., for 2000)

Virtual Water Balance in Countries (m^3/c/y) in 2000

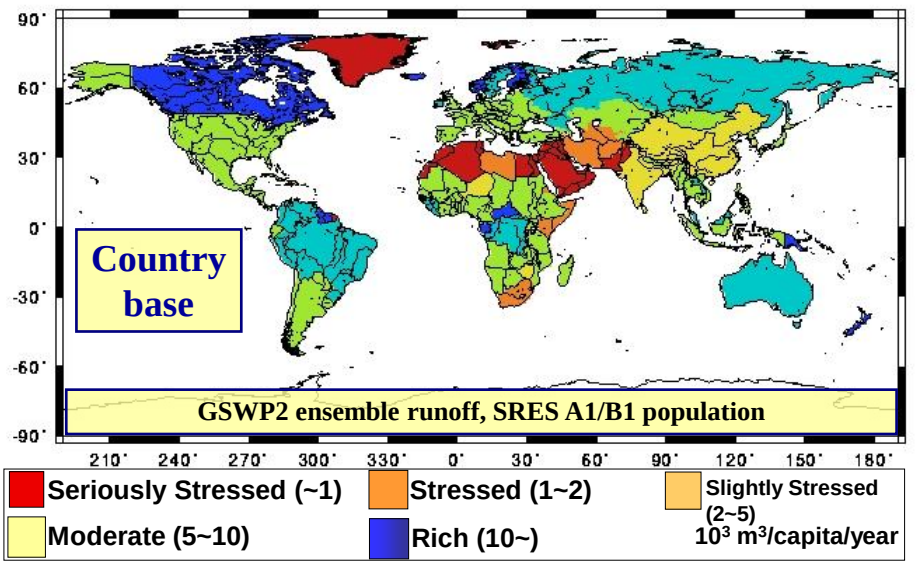


(Oki and Kanae, 2004)

- 7 out of top 10 importing countries are seriously poor in water resources.
- 7 out of top 10 exporting countries are rich in water resources.
- Denmark (10) and India (18) are water stressed but exporting *RW* in net.

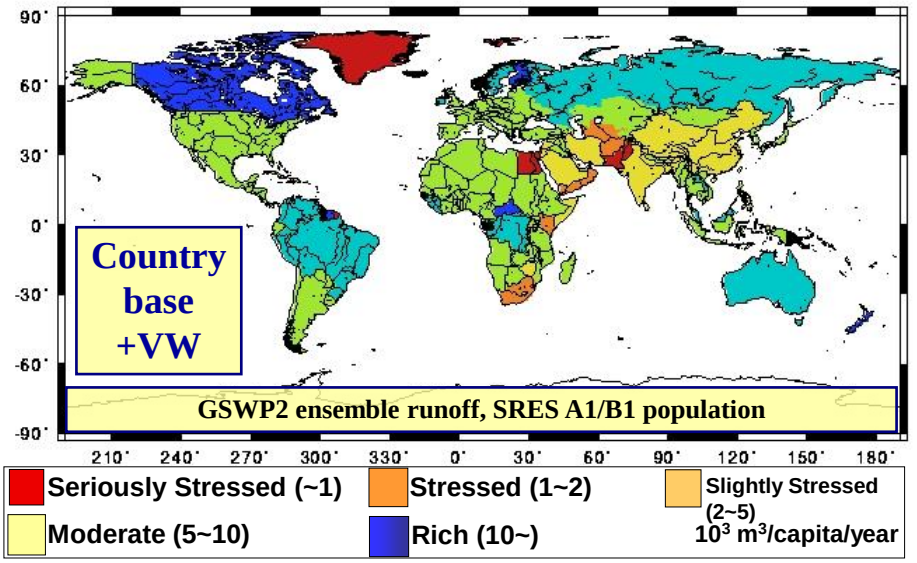
Conventional Water Resources Assessment

Potentially Available Water Resources per Capita in 2000



World Water Resources Considering Virtual Water Trade

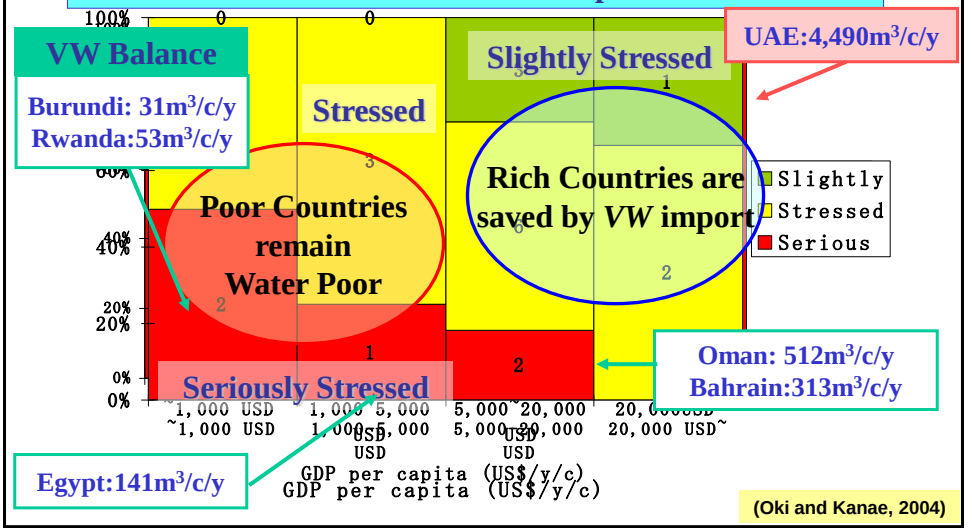
Potentially Available Water Resources per Capita in 2000



Water Resources Assesment Considering VW trade

22 Countries were classified into "seriously stressed" in 2000 by conventional water resources assessment.

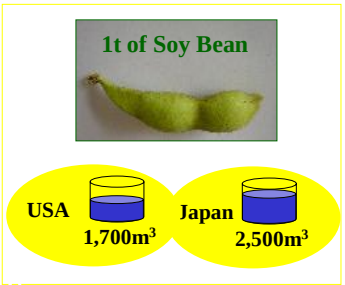
➔ +Virtual Water Import



(Oki and Kanae, 2004)

How Virtual Water Trade Saves the Water Resources Globally?

Comparing the required water to produce 1 ton of soy bean in USA and Japan



Exporting 1t of Soy bean from USA to Japan

Real Water: Really required water in USA

Virtual Water: Virtually required water in Japan

USA Export 1,700m^3 — Trade (1t of Soybean) — Japan Import 2,500m^3

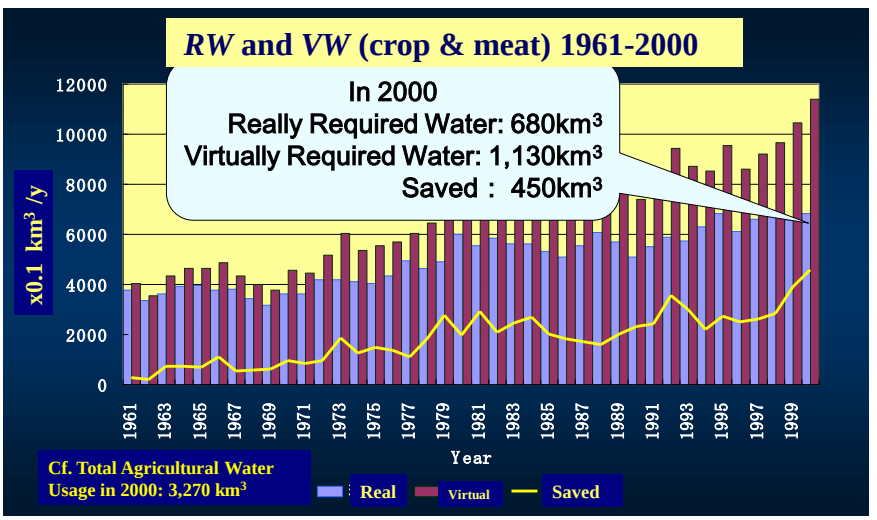
2,500-1,700 = 800m^3

Water Resources is saved by the *VW* trade!

←Comparative advantage of water efficiency

(Oki and Kanae, 2004)

Virtually Saved Water Resources in the World



Virtually Requied Water = Sum of Importing *VW* in each country (1),
Really Requied Water = Sum of Exporting *RW* in each country (2),
Saved = (1)-(2)

(Oki and Kanae, 2004)

More water usage, much worse?

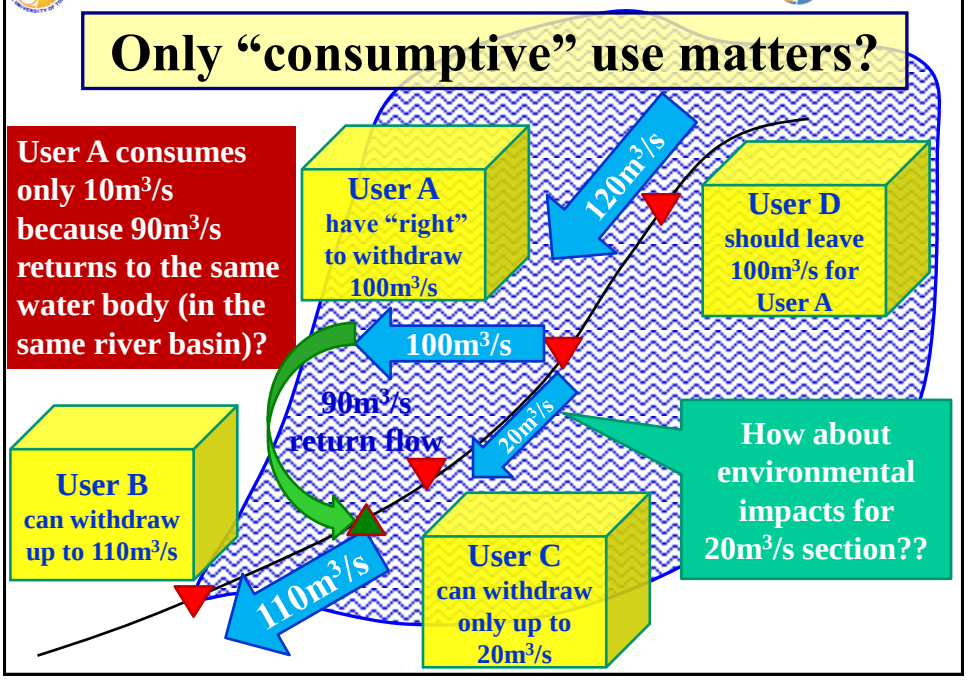
	Product A	Product B
Manufactured in …	Alaska with abundant water	Sub-Saharan Africa
Timing and origin of water	Spring snow melt water	End of dry season ground water
Discharge	Well treated	At the regulation level
Water footprint	Total 200 liter	Total 150 liter

Which has less impacts on environment?

A (New) Water Index Needed

- which reflects the impacts on environment (internal & external costs) and the opportunity cost for other competing users of water usages:
  - Larger value of the index should mean larger environmental impacts and higher opportunity cost.
  - Should consider region, timing, water source, …
- which can reflect the investments of water-saving efforts and water quality improvements.
- …yet other boundaries, such as energy, land use, etc., should be considered to assess the sustainability of the water usage.

Only "consumptive" use matters?



http://hydro.iis.u-tokyo.ac.jp/ 東京大学 THE UNIVERSITY OF TOKYO

Can we quantify water withdrawals by sources?

- **The source of evapotranspiration**
  - ❄ **Precipitation**
  - ❄ **Irrigation water**
    - ➢ **Stream flow**
    - ➢ **Reservoirs and ponds**
    - ➢ **Renewable groundwater**
    - ➢ **Fossil groundwater**

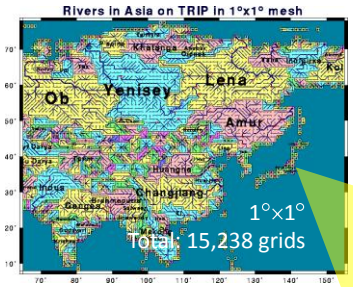
Low environmental impact
Sustainable
Low opportunity cost

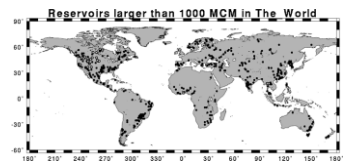
High environmental impact
Less-sustainable
High opportunity cost



Hanasaki et al., 2006, *J. of Hydrol.*
Hanasaki et al. ,2008a,b, *Hydrol. Earth Sys. Sci.*

Global water resources model H08





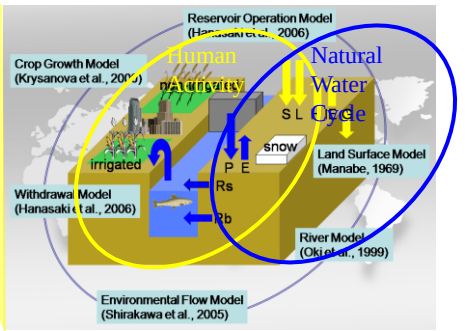
452 reservoirs, 4140 km^3

•Requirements

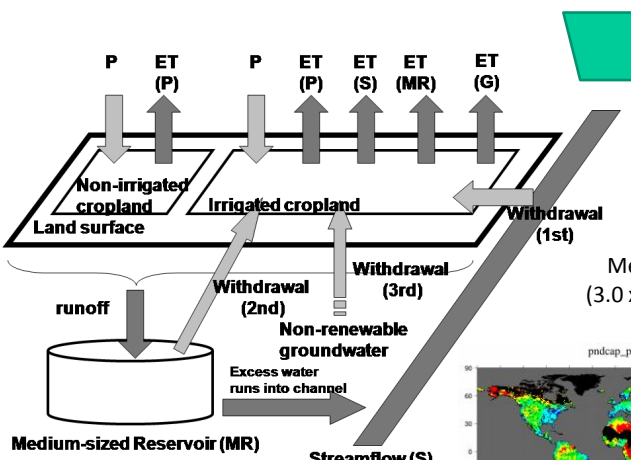
1.Simulate both water availability (streamflow) and water use at daily-basis

2.Deal with interaction between natural hydrological cycle and anthropogenic activities

3.Applicable for future climate change simulation

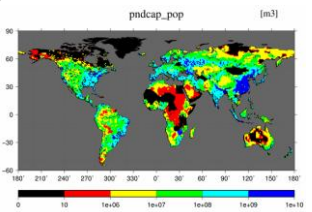


Enhancement of the H08 model



Large reservoirs
(1.0 x 10^{9}m^3 ≤S)
4140km^3

Medium-sized reservoirs
(3.0 x 10^{6}m^3≤S< 1.0 x 10^{9}m^3)
3280km^3



(Hanasaki et. al, *J. Hydrol.* , 2010)

Results 1: Green water*

(*evapotranspiration originates from precipitation in cropland)

Unit：km^3/yr	This study	Molden (2007)	Falkenmark and Rockstrom (2004)
ET from cropland	7650	7130	6800
ET from non-irrigated cropland (green)	5080	4910	5000
ET from irrigated cropland (green)	1220	650	
ET from irrigated cropland (blue)	1350	1570	1800

Direct simulation of ET

Yield per area / Water use efficiency = ET

(Hanasaki et. al, *J. Hydrol.* , 2010)

Groundwater withdrawal

Groundwater withdrawal in major countries

Unit: km^3/yr	This study	WRI (2007)
India	129.3	169.1
USA	78.8	68.4
Pakistan	47.3	54.0
Mexico	12.3	16.0
Bangladesh	6.6	9.4
Saudi Arabia	6.0	13.0

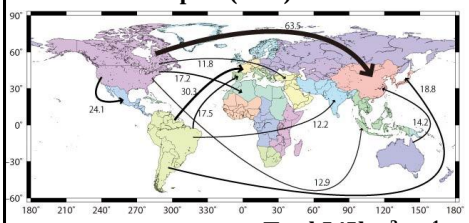
Ground water withdrawal in the Ogallala aquifer

Unit: mm/yr	This study	USDA (2002)	Area km^2
Maize	369	331	36.02
Wheat	408	247	6.33
Cotton	434	255	5.55

(Hanasaki et. al, *J. Hydrol.* , 2010)

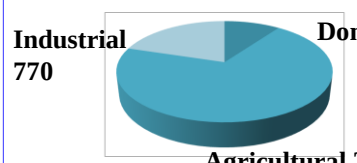
Global flows of virtual water export

Virtual water export (total)



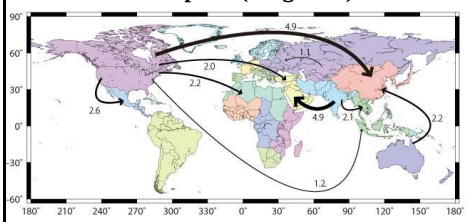
Total 545km^3 yr^{-1}

Total water withdrawal：3,800km^{3}yr^{-1}



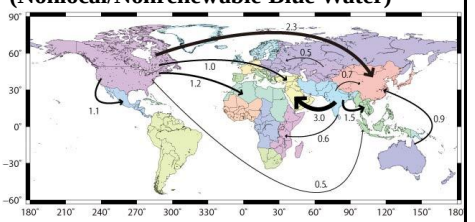
Shiklomanov, 2000

Virtual water export (irrigation)



Total 61km^3 yr^{-1}

Virtual water export
(Nonlocal/Nonrenewable Blue Water)

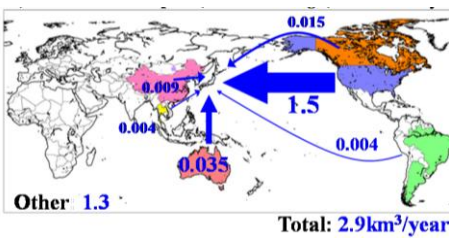


Total 26km^3 yr^{-1}

(Hanasaki et. al, *J. Hydrol.* , 2010)

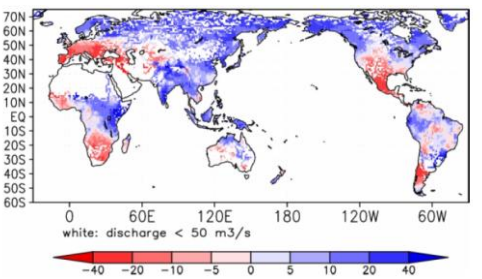
Water Footprint --- Beyond Labeling

- Critical information for risk management of entities, such as a nation or an enterprise, even for a person: how much water from what water source in which area one's activities rely on? How sustainable is the water use?



Total: 2.9km^3/year

Virtual Water Import to Japan through through Major Crops and Meat Products



Changes in freshwater resources under CC


飲水思源
When you drink water,
think its origin.
飲食思水
When you eat,
think about water.
饮水区，禁止污染!
Drinking water part
No pollution !
Thank You!