Evaluation of Freshwater Flux over the Ocean

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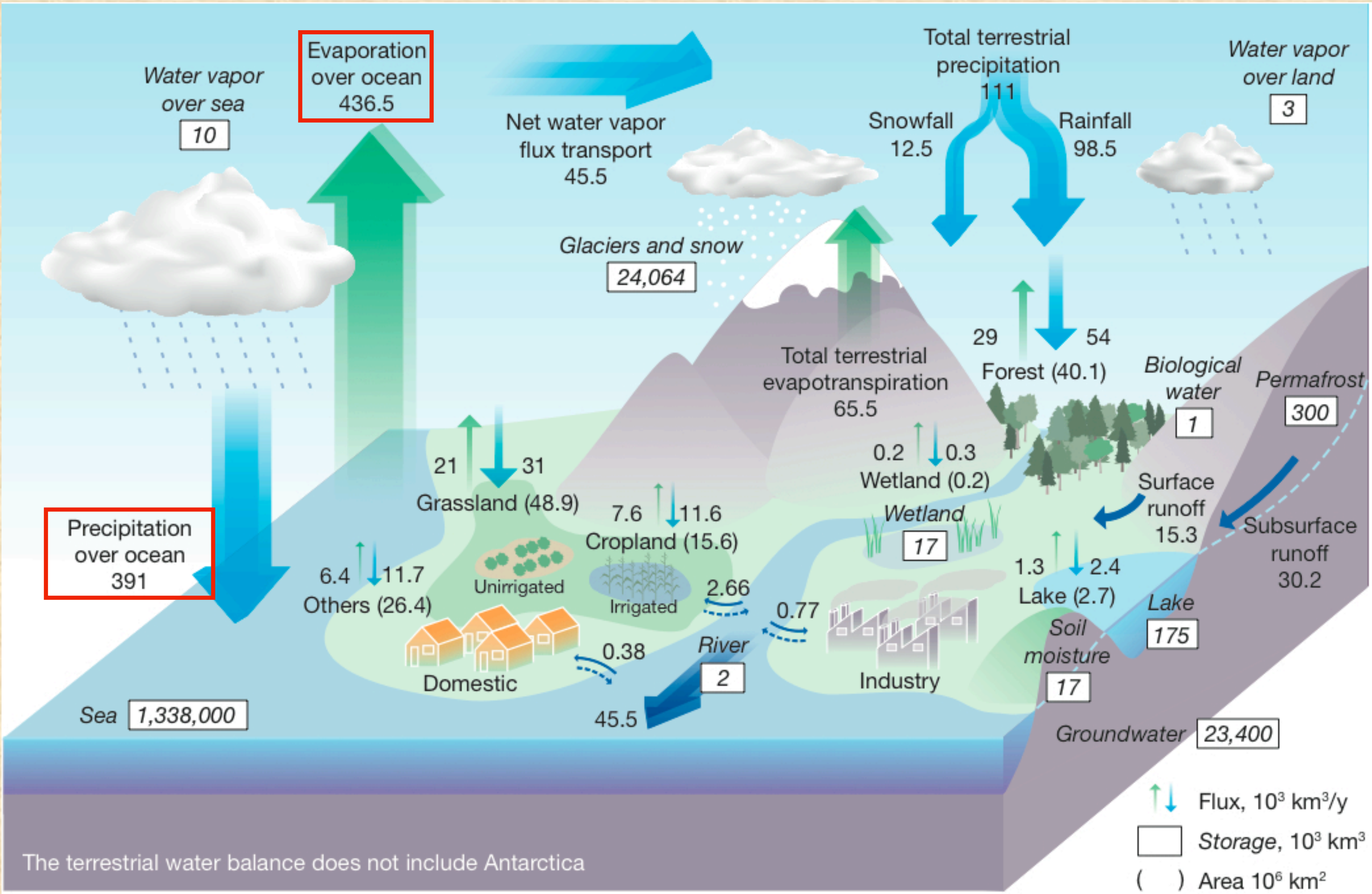


Oki and Kanae(2007)

Outline:

- Intercomparison of global freshwater flux products over the ocean

- Global budget by each product

- Trend of evaporation, precipitation, and freshwater flux

- Contribution of each parameter to the differences between the reference product and other products

Data

(1Satellite and Hybrid evaporation data

Data Set	Japanese-Ocean Flux data sets with Use of Remote sensing Observations Version.2 (J-OFURO2)	Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data 3 (HOAPS3)	Goddard Satellite-Based Surface Turbulent Fluxes 2 (GSSTF2)
Period	1988/1-2006/12	1987/7-2005/12	1987/7-2000/12
Spatial resolution	1°	0.5°	1°
Temporal resolution	Daily	12 hours	Daily

	Objectively Analyzed Air-Sea Fluxes (OAFlux)
Period	1958/1-2008/12
Spatial resolution	1°
Temporal resolution	daily

(2) Precipitaion data

	The Global Precipitation Climatology Project (GPCP) Version.2	Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP)	Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data3 (HOAPS3)
Period	1979/1-present	1979/1-2008/7	1987/7-2005/12
Spatial resolution	1°	1°	1°
Temporal resolution	daily	12 hours	12 hours

(3) Reanalysis data

	NCEP/NCAR Re-analysis (NRA1)	NCEP-DOE Re-analysis (NRA2)	ECMWF Re-analysis 40 (ERA40)	Japanese Re-analysis 25 (JRA25)*
Period	1948/1-present	1979/1-present	1967/9-2002/8	1979/7-present
Spatial resolution	Gaussian grid T62 (180km)	Gaussian grid T62 (180km)	Gaussian grid TL159 (110km)	Gaussian grid T106 (110km)
Temporal resolution	6 hours	6 hours	6 hours	6 hours

* : After Jan. 2005, JMA Climate Data Assimilation System(JCDAS)

Data used in this study

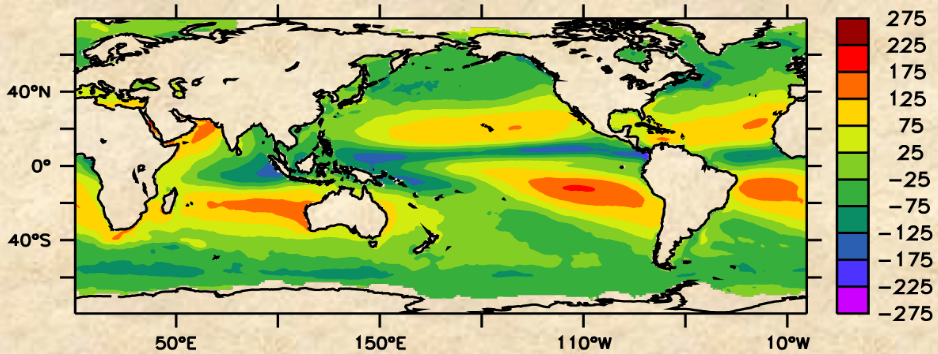
Temporal resolution：Monthly
Spatial resolution：1°
Period：1988-2000

Reference Freshwater Product:
J-OFURO2 evaporation and GPCP precipitation

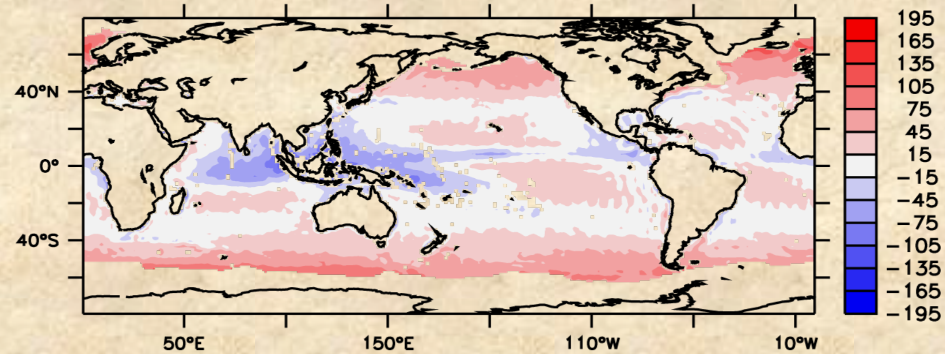
Intercomparisn of freshwater flux over the ocean

J-OFURO2-GPCP ver.2 average field & differences with other products

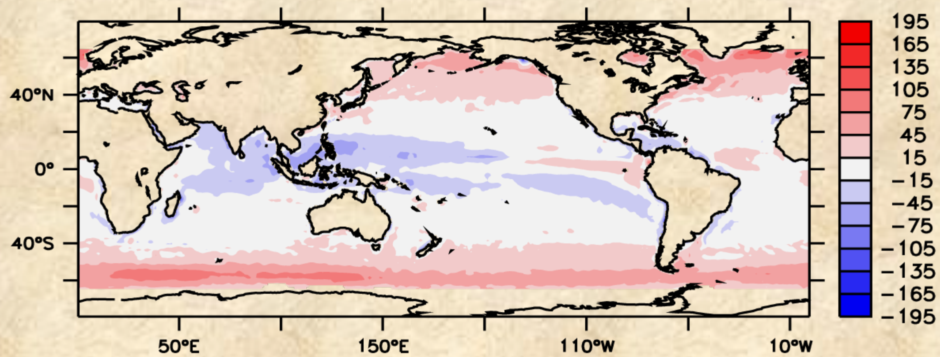
J-OFURO2-GPCP ver.2 average field



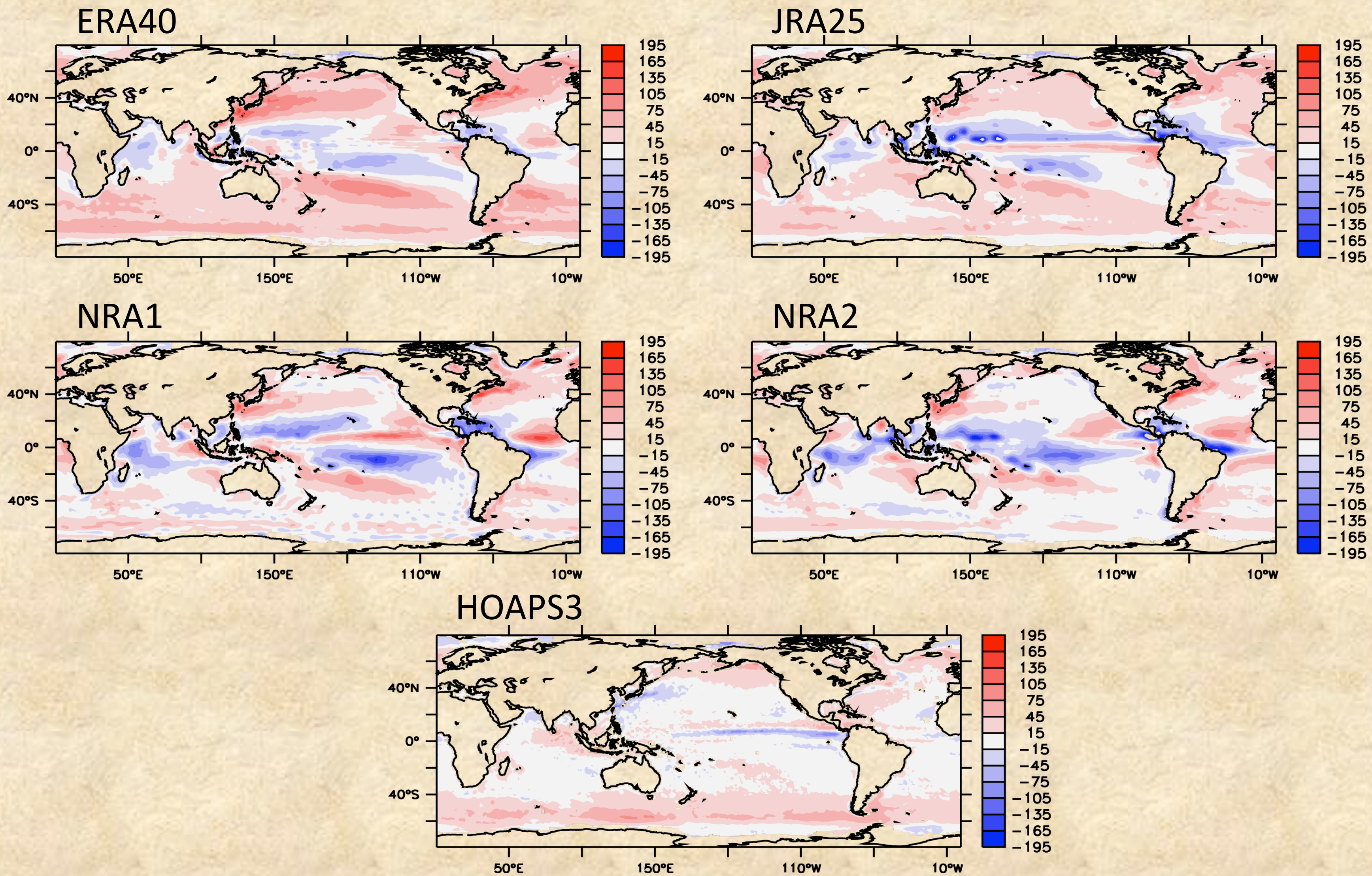
GSSTF2-CMAP



OAFlux-CMAP

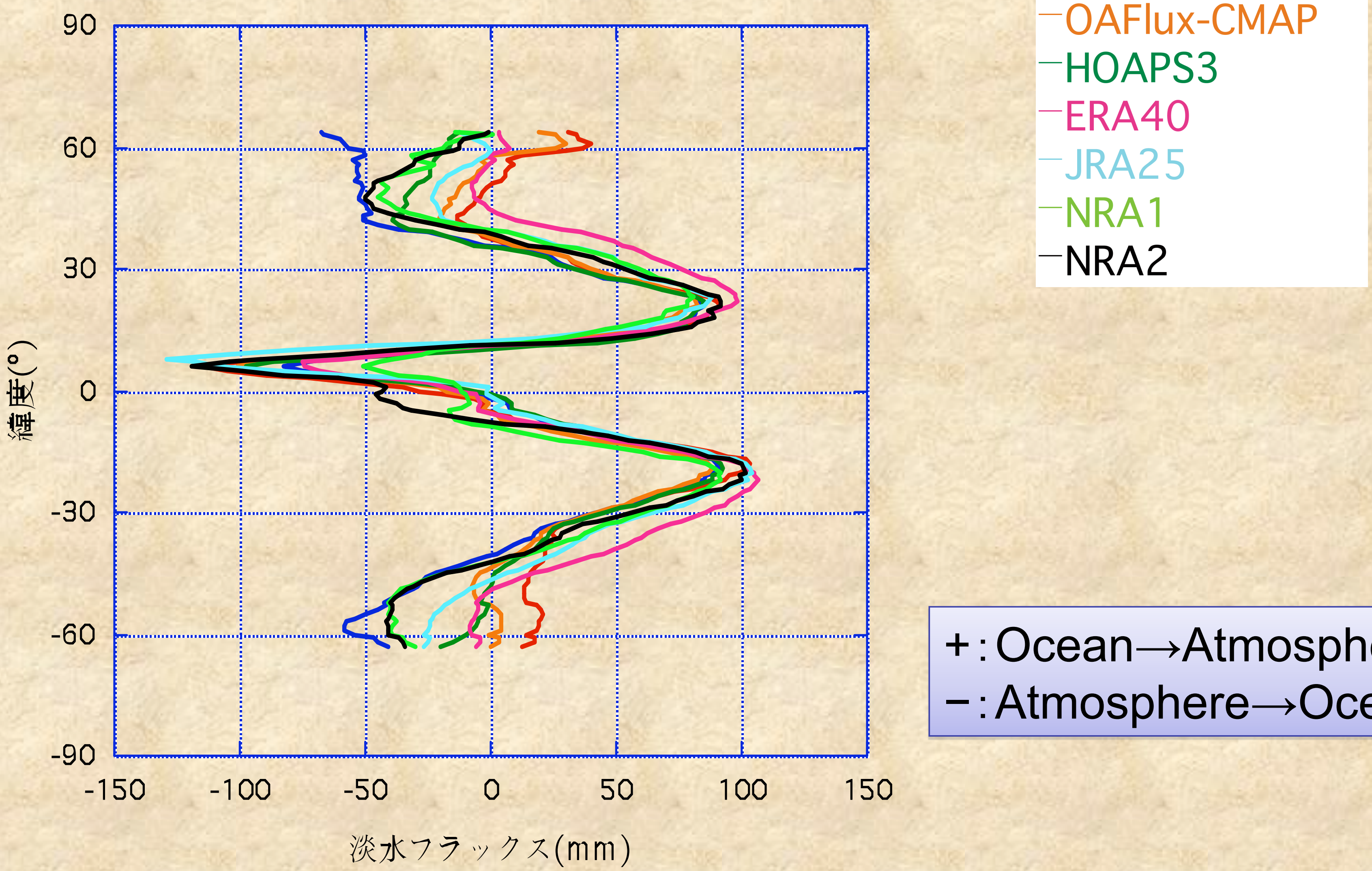


+ : Ocean→Atmosphere
− : Atmosphere→Ocean



ERA40
JRA25
NRA1
NRA2
HOAPS3
40°N
0°
40°S
50°E
150°E
110°W
10°W
195
165
135
105
75
45
15
−15
−45
−75
−105
−135
−165
−195

Meridional Profile



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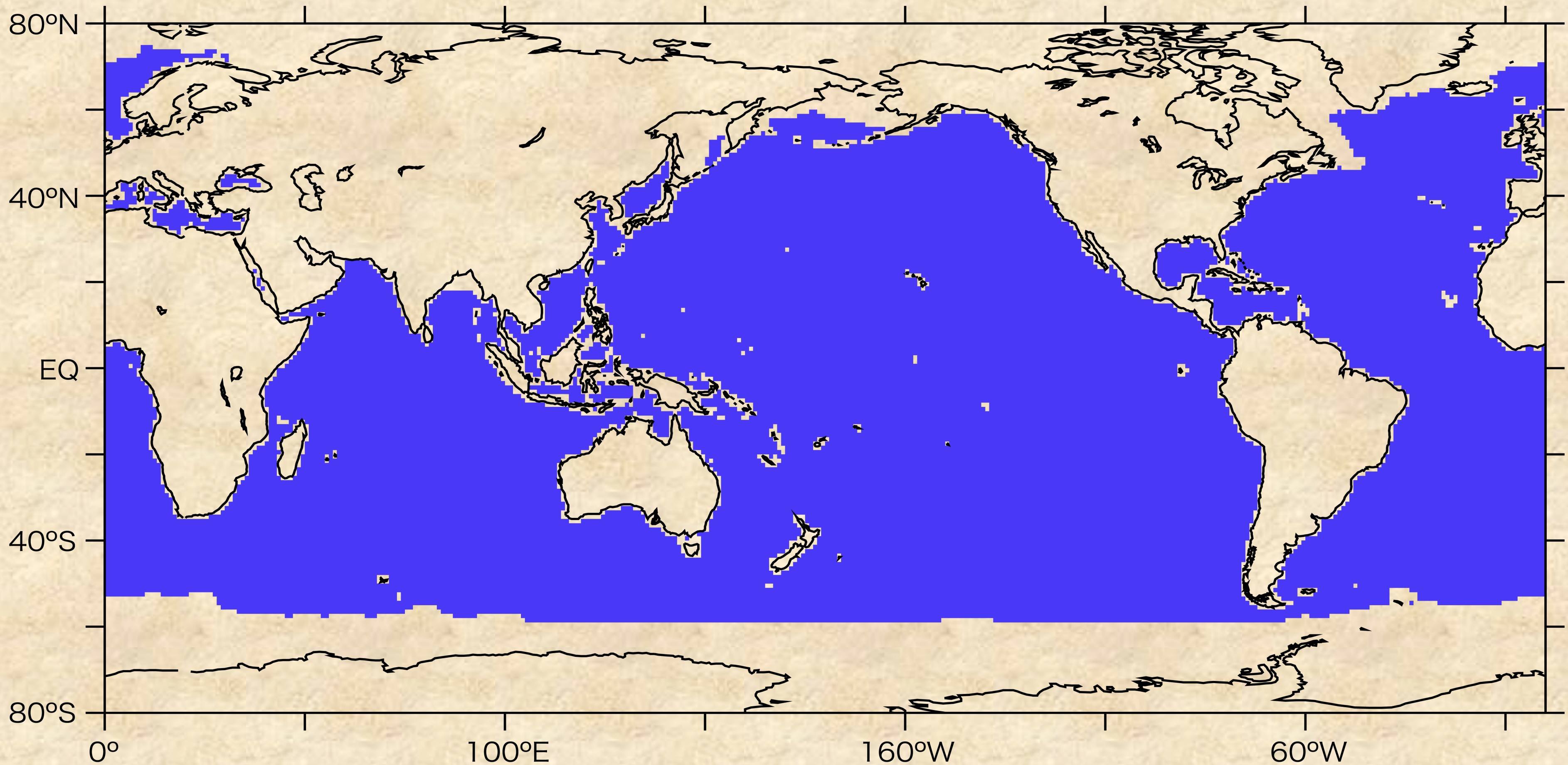
Global Budget by Each Product



Analysis region

Global average evaporation and precipitation (10^{17} kg/year)

Evaporation

J-OFURO2	HOAPS3	OAFlux	ERA40	JRA25	NRA1	NRA2
3.76	3.92	4.45	4.11	6.14	5.38	6.07

Oki, Kanae(2007) $4.37*10^{17}$kg/year

Schlosser and Houser(2007) : GSSTF2 $4.41*10^{17}$kg/year

HOAPS $3.93*10^{17}$kg/year

Precipitation

GPCP ver. 2	CMAP	HOAPS3	ERA40	JRA25	NRA1	NRA2
3.23	3.34	3.15	4.21	3.84	3.43	4.05

Oki, Kanae(2007) $3.91*10^{17}$kg/year

Schlosser and Houser(2007) : GPCP ver.2 $3.80*10^{17}$kg/year

CMAP $3.72*10^{17}$kg/year

Average global freshwater flux over the ocean(10^{16} kg/year)

Evap. / Precip.	J-OFURO2	HOAPS3	OAFlux	ERA40	JRA25	NRA1	NRA2
GPCP ver.2	5.47	7.00	12.31	8.98	29.21	21.66	28.55
CMAP	4.22	5.76	11.06	7.72	27.96	20.40	27.30
HOAPS3	6.23	7.76	13.07	9.73	29.98	22.42	29.30
ERA40	-4.32	-2.77	2.53	-0.82	19.43	1.98	18.77
JRA25	-0.62	0.91	6.22	2.87	23.11	15.55	22.45
NRA1	3.47	5.00	10.31	6.97	27.22	19.66	26.54
NRA2	-2.78	-1.24	4.08	0.73	20.98	13.42	20.32

Oki, Kanae(2007): 4.73*10^{16}kg/year

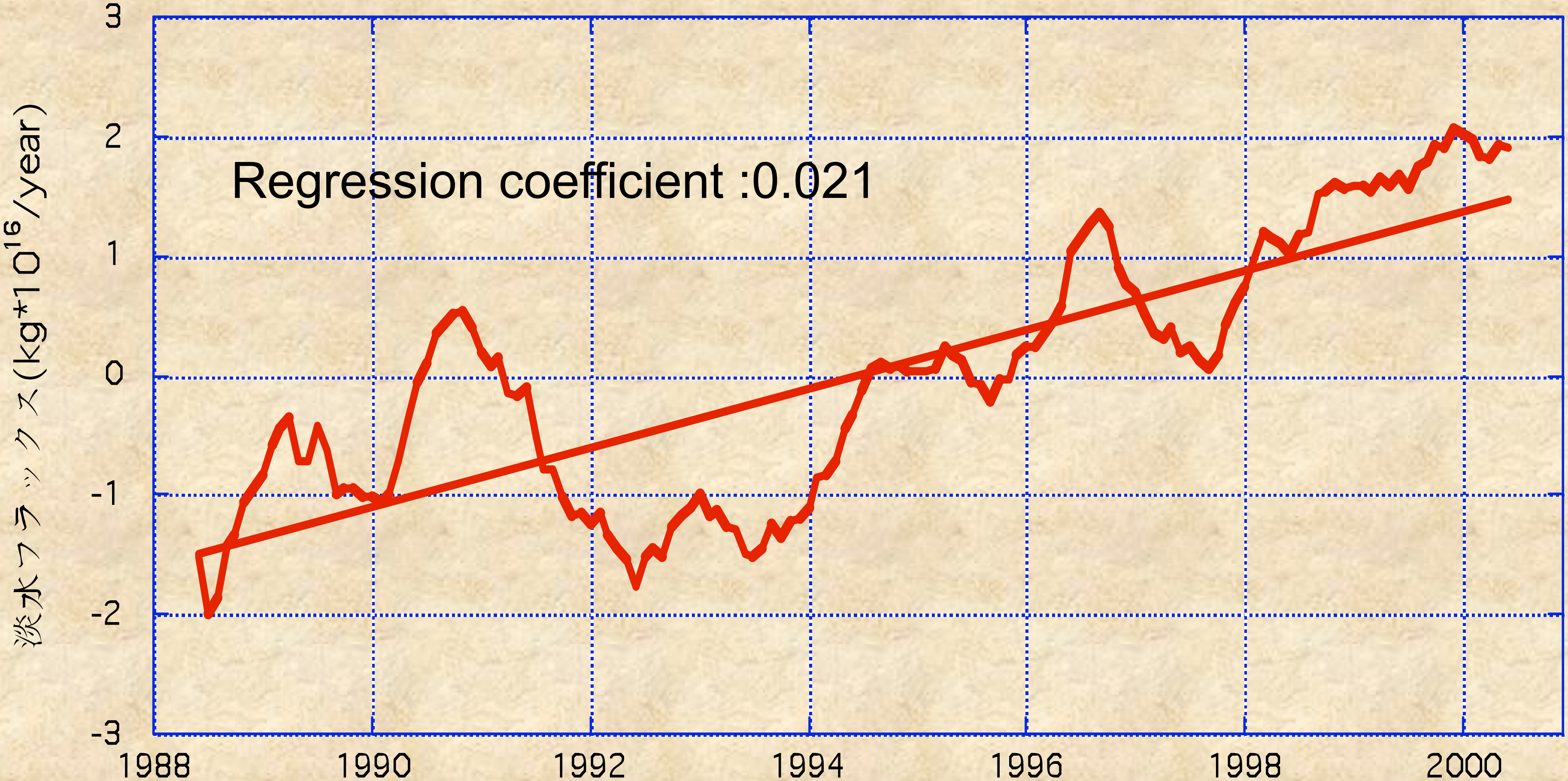
Schlosser and Houser(2007) :

GSSTF-GPCP 6.1*10^{16}kg/year, HOAPS-GPCP 1.3*10^{16}kg/year

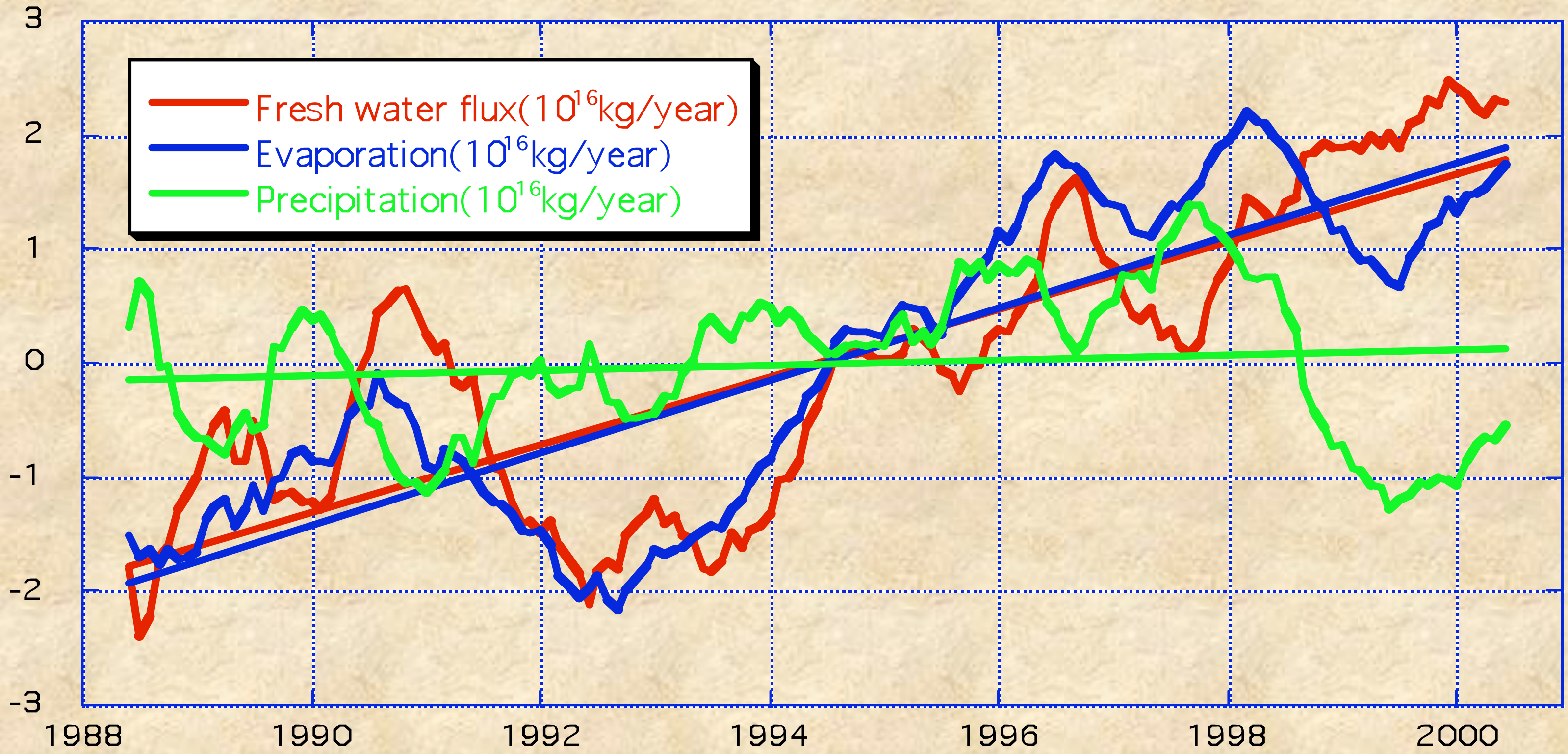
GSSTF-CMAP 6.9*10^{16}kg/year, HOAPS-CMAP 2.1*10^{16}kg/year

Trend of evaporation, precipitation, and freshwater flux

Annual time series of global freshwater flux over the ocean by J-OFURO2-GPCP ver.2



Increase of freshwater tranport from the ocean to the atmosphere



Time Series of Freshwater Flux(J-OFURO2-GPCP ver.2)、
Evapolation(J-OFURO2)、
Precipitation (GPCP ver.2)

Regression Coefficients for global evaporation and precipitation (10^{15} kg/month)

Evaporatiom

J-OFURO2	HOAPS3	OAFlux	ERA40	JRA25	NRA1	NRA2
0.02	**0.03**	**0.02**	0.00	0.00	**0.02**	**0.03**

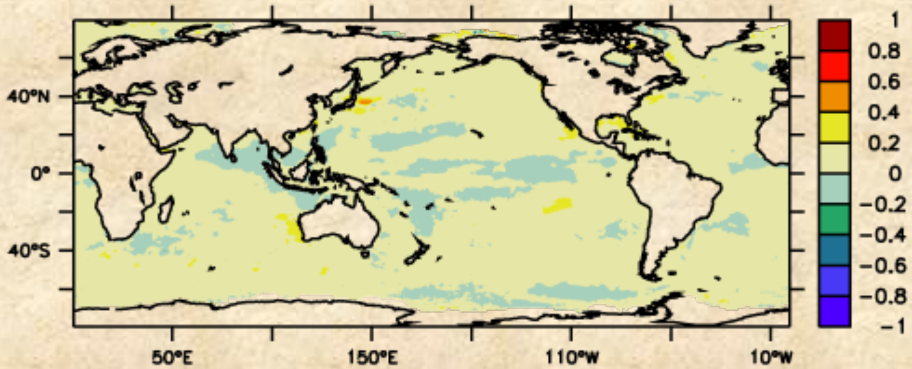
Precipitation

GPCP ver.2	CMAP	HOAPS3	ERA40	JRA25	NRA1	NRA2
0.00	-0.02	-0.01	**0.07**	0.02	0.02	**0.04**

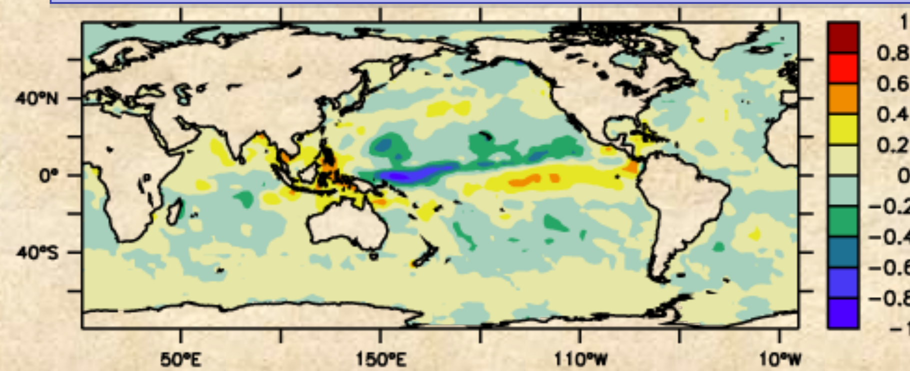
Regression Coefficients for Freshwater Flux ((10^{15}kg/month)

Evap. / Precip.	J-OFURO2	HOAPS3	OAFlux	ERA40	JRA25	NRA1	NRA2
GPCP ver.2	0.02	0.02	0.02	0.00	0.00	0.02	0.02
CMAP	0.03	0.04	0.03	0.01	0.01	0.03	0.04
HOAPS3	0.03	0.04	0.03	0.01	0.01	0.03	0.04
ERA40	-0.03	-0.03	-0.03	-0.05	-0.05	-0.03	-0.03
JRA25	0.01	0.01	0.00	-0.01	-0.01	0.01	0.02
NRA1	0.01	0.01	0.00	-0.01	-0.02	0.01	0.01
NRA2	-0.01	-0.01	-0.01	-0.03	-0.03	-0.01	0.00

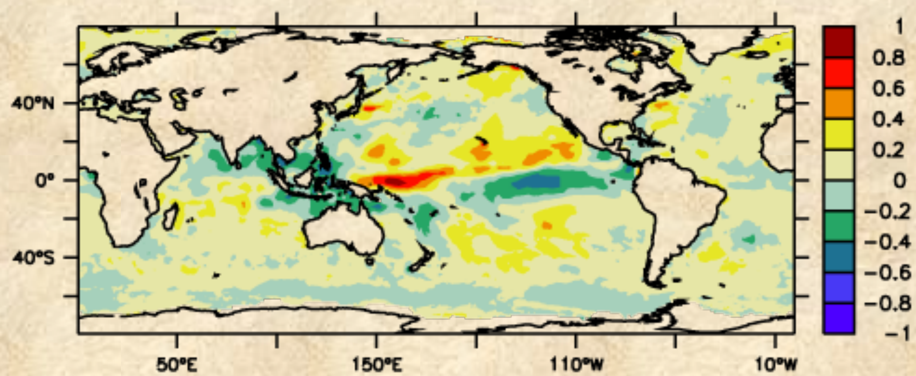
Evaporation(J-OFURO2)(mm)



Precipitation(GPCP ver.2)(mm)



Freshwater Flux(mm)



Regression Map

Contribution of each parameter to the differences between the reference product and other products

Analysis of discrepancies between various products in terms of precipitation and bulk variables

(Bourras,2006)

$$dFWF = dPRECIP^* (-1) + \frac{\partial EVAP}{\partial U_a} dU_a + \frac{\partial EVAP}{\partial Q_a} dQ_a + \frac{\partial EVAP}{\partial Q_s} dQ_s$$

$$\frac{\partial EVAP}{\partial U_a} = L\rho_a C_E (Q_s - Q_a)$$

$$\frac{\partial EVAP}{\partial Q_a} = -L\rho_a C_E U_a$$

$$\frac{\partial EVAP}{\partial Q_s} = L\rho_a C_E U_a$$

$$dFWF = FWF(other) - FWF(J-OFURO2-GPCPver.2) \sum_{i=1}^{n} X_i$$

$$dPRECIP = PRECIP(other) - PRECIP(GPCPver.2)$$

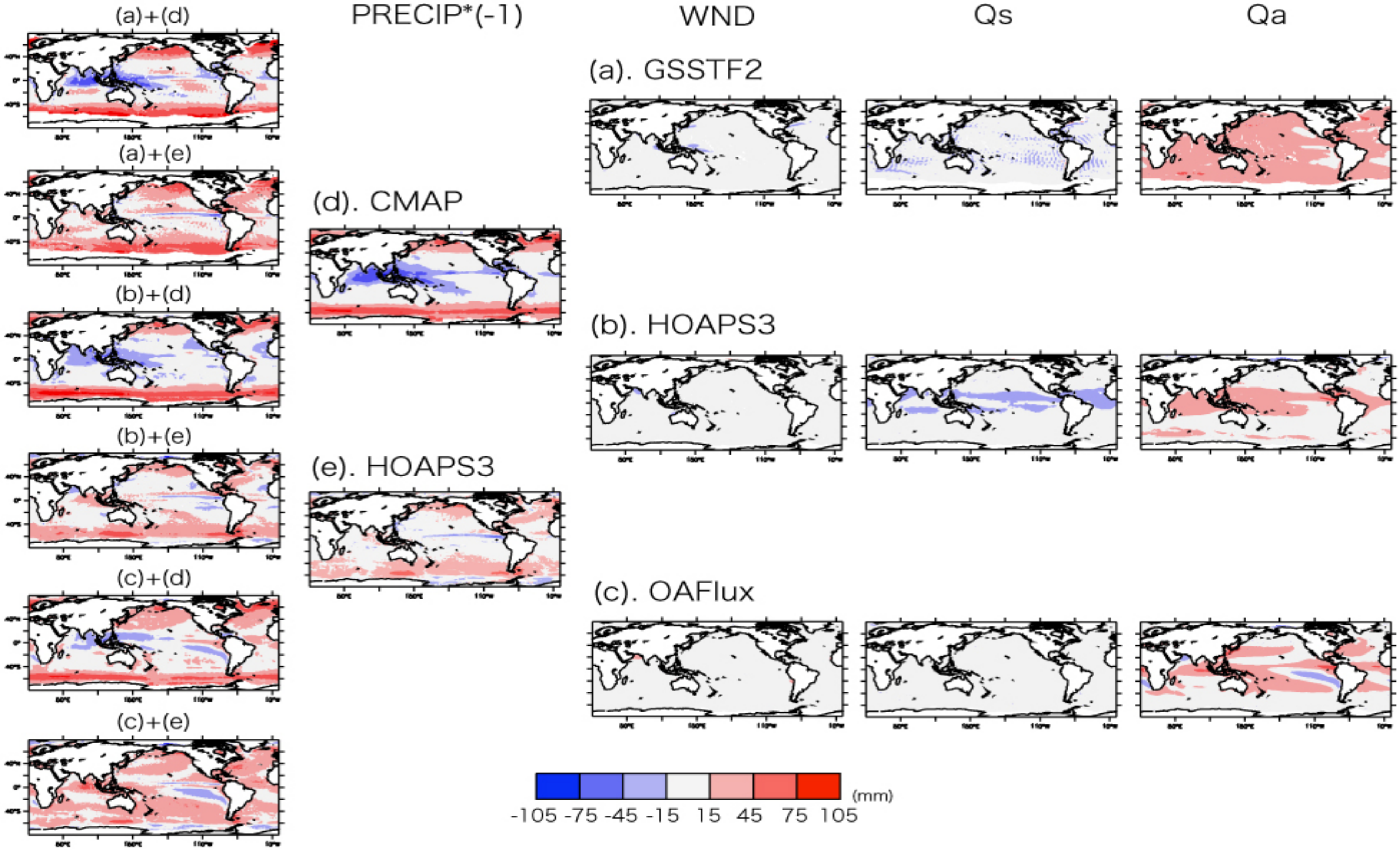
$$dU_a = U_a(other) - U_a(J-OFURO2)$$

$$dQ_a = Q_a(other) - Q_a(J-OFURO2)$$

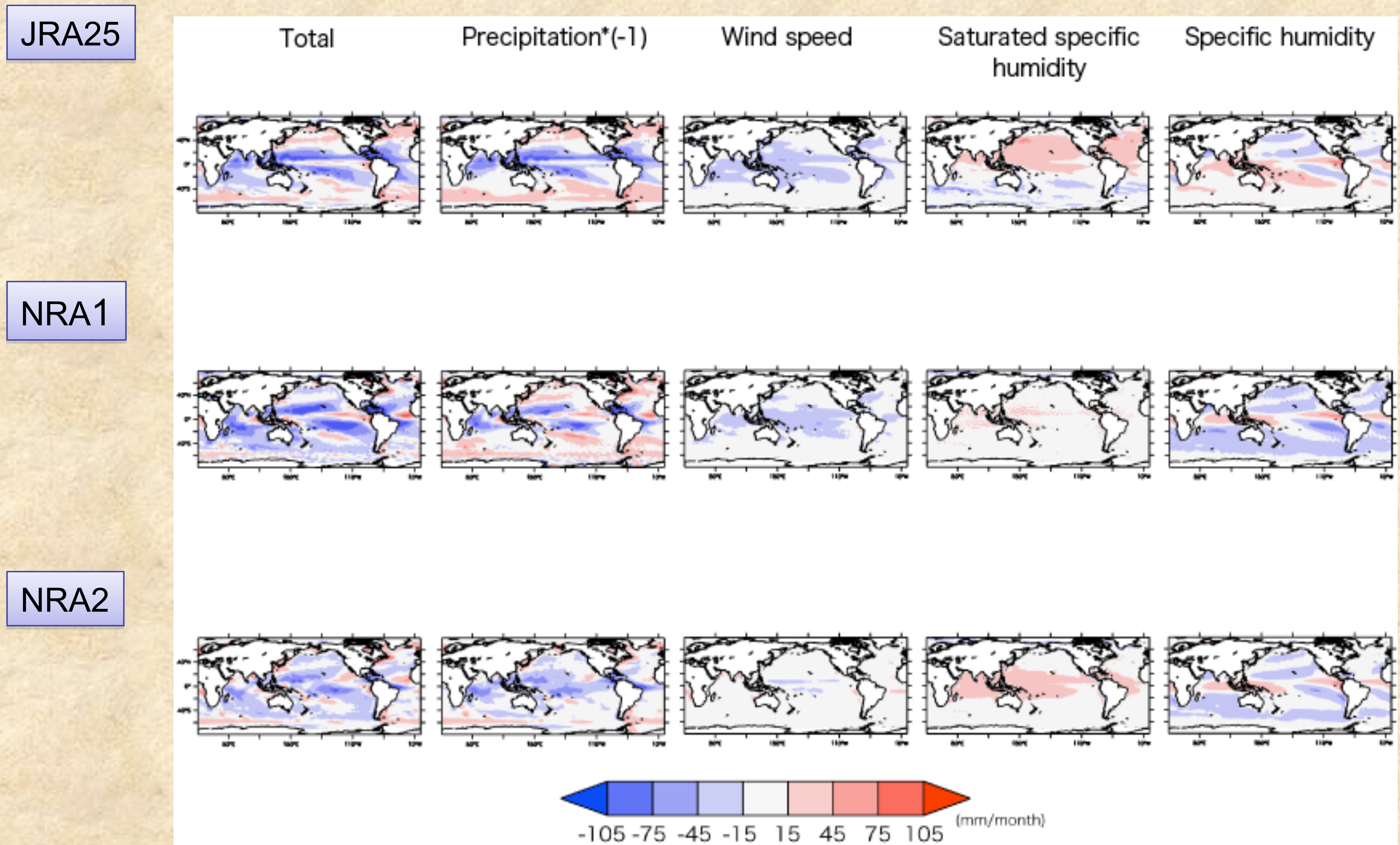
$$dQ_s = Q_s(other) - Q_s(J-OFURO2)$$

U_a:wind speed、Q_a:specific humidity、Q_s:saturated specific humidity

Contributions to the deviation between J-OFURO2-GPCP ver.2 freshwater flux and other freshwater products



Contributions to the deviation between J-OFURO2-GPCP ver.2 freshwater flux and other freshwater reanalysis products



Summary

We carried out intercomparison of various ocean-surface freshwater flux products. such as J-OFURO2, HOAPS3, GSSTF2, OAFlux, GPCP, CMAP, JRA25, ERA40, NRA1, and NRA2. We assume fershwater flux derived from J-OFURO2(evaporatiuon) and GPCP as a reference product.

1. Intercompariosn of average fields

   All products can reproduce general common features.

   However, Most of products overestimate in the high-latitudes and underestimate in the tropical regions compared with the reference product.

2. Global budget

We investigate global budget of evaporation, precipitation and freshwater flux. J-OFURO2 gives the minimum evaporation and NRA2 gives the maximum value. Also HOAPS gives minimum precipitation and ERA40 gives the maximum precipitation. Reanalysis products except ERA40 gives large freshwater fluxes compared with satellite-products because of large evaporation.

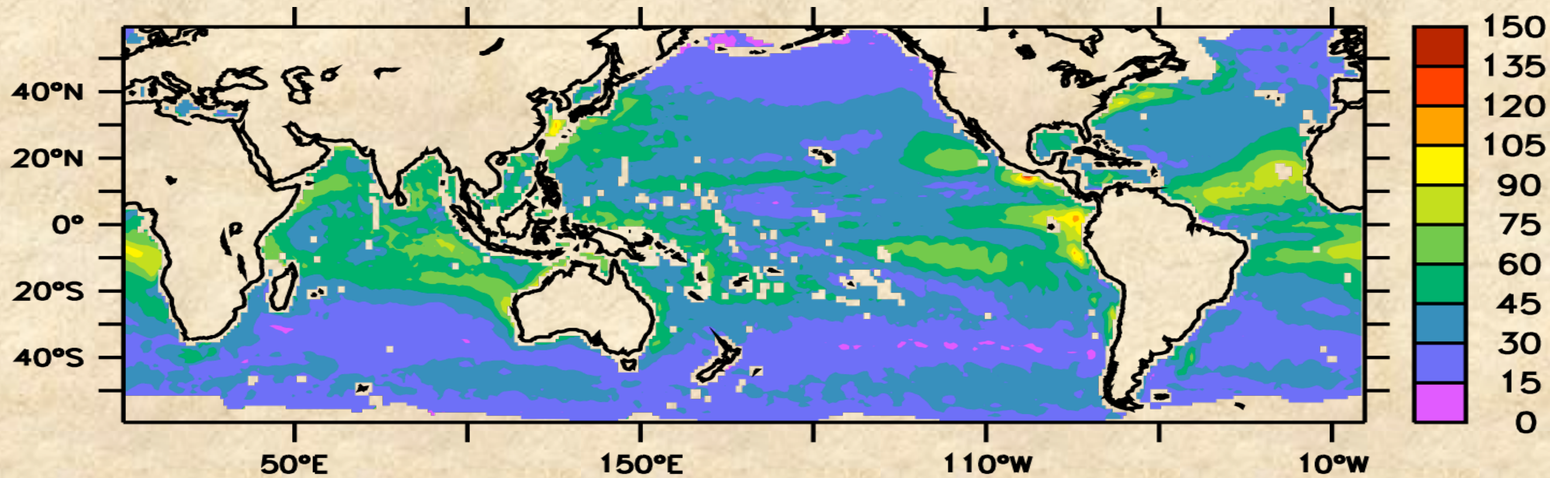
3. Trend

The reference product gives remarkable positive trend because evaporation by J-OFURO2 has a positive trend and precipitation by GPCP has no trend. Most products show positive trend except products related to ERA40 and NRA2. The positive trend suggests increase of precipitation over land and river discharge. Both of positive and negative large trends of freshwater flux exist in the tropical regions, similar to precipitation.

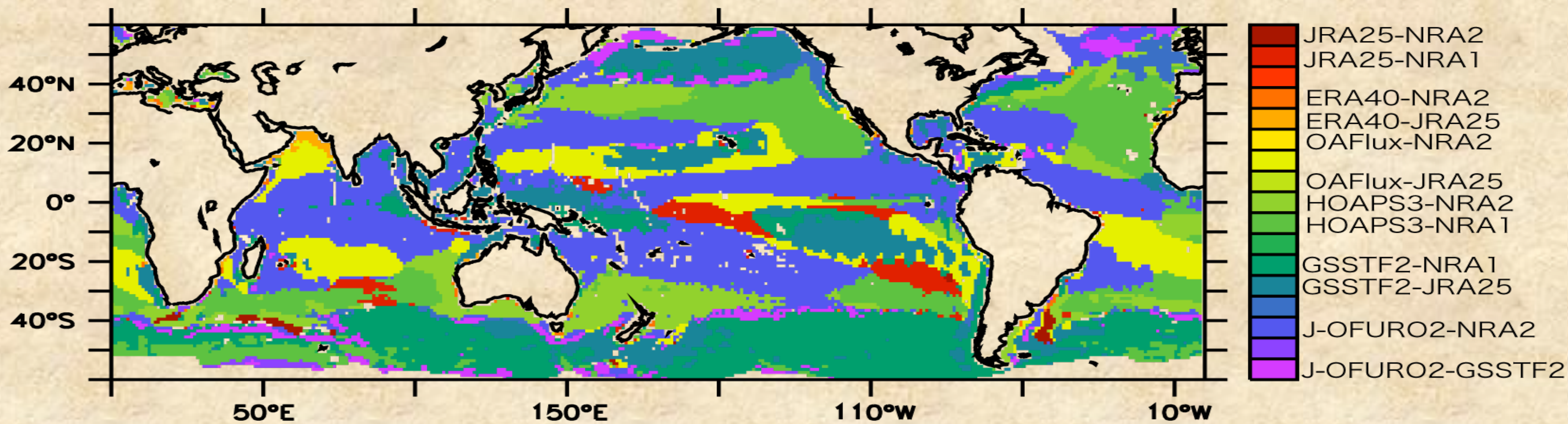
4. Contribution of each parameter to the differences between the reference product and other products

For the satellite products the deviation is mostly related to precipitation and air specific humidity. However, for the reanalysis products the deviation is related to all parameters. Wind speed and Qa contribute to the underestimation and Qs contributes to the weak overestimation of freshwater flux.

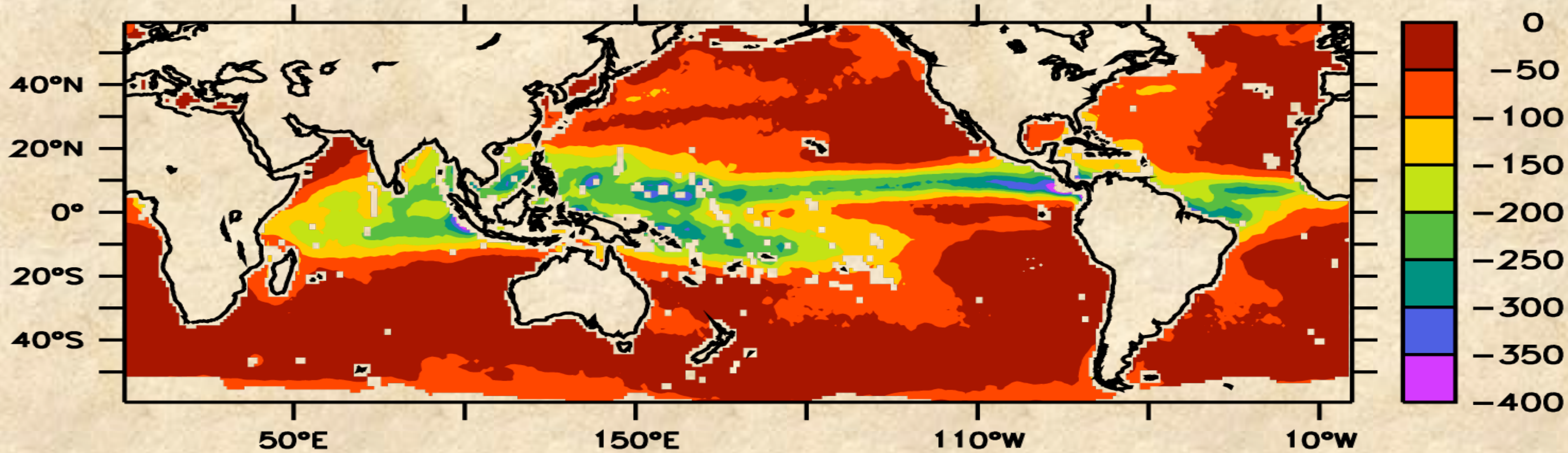
Maximum differences among evaporation products



The combination



Maximum differences among precipitation products



The combination