Ocean and Continental Water Balance from Space

W. Timothy Liu and Xiaosu Xie

HYDROLOGIC BALANCE

$$\frac{\partial W}{\partial t} + \nabla \bullet \Theta = E - P$$

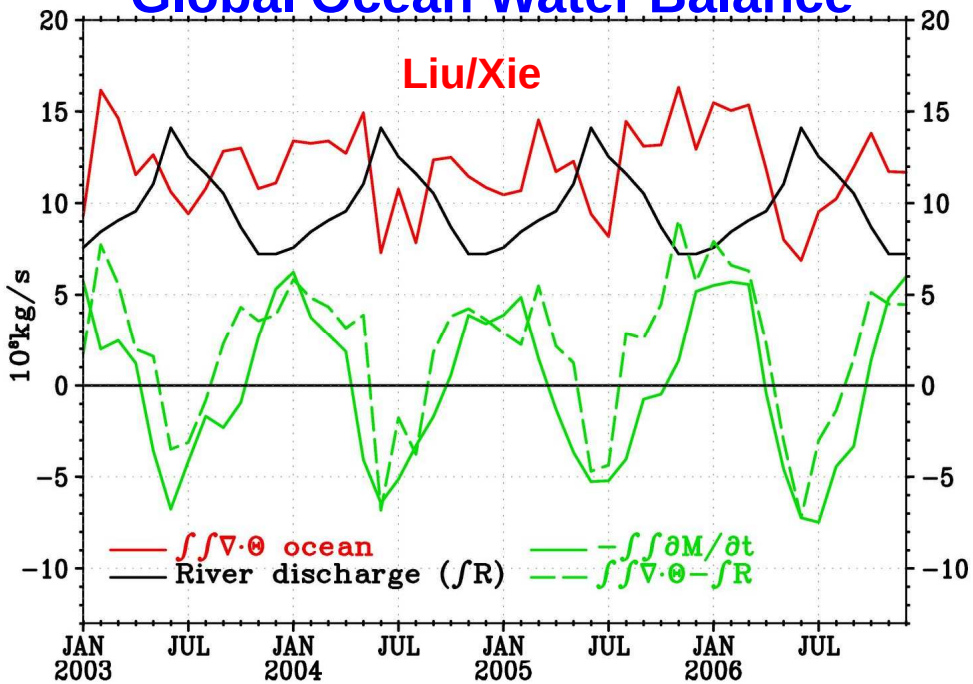
$$\Theta = \frac{1}{g}\int_0^{p0} qU\mathbf{d}p$$

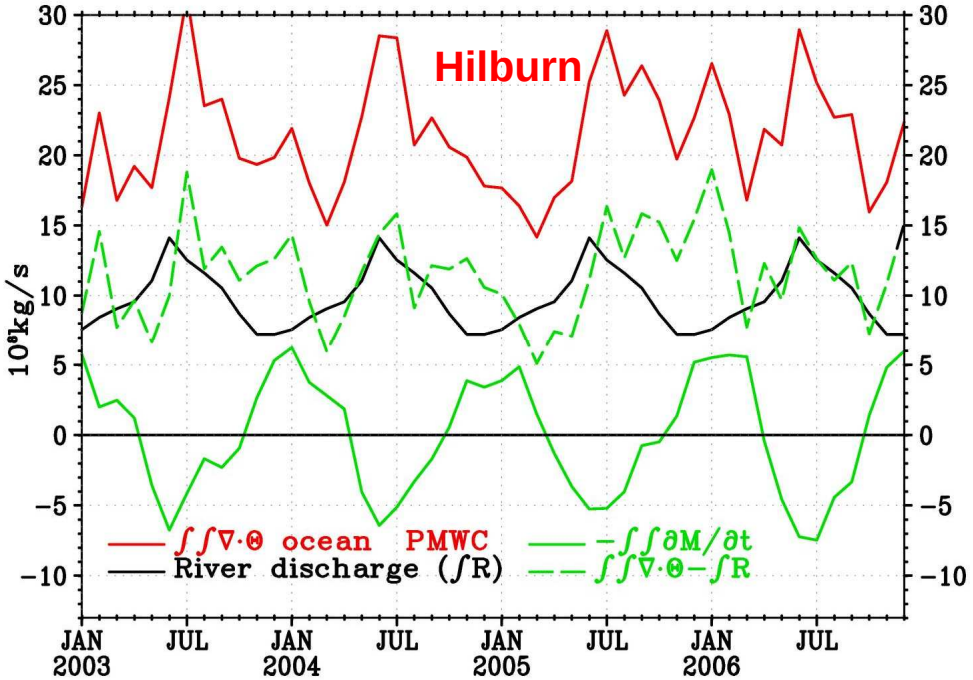
$$W = \frac{1}{g}\int_0^{p0} q\mathbf{d}p$$

$$\Theta = \mathbf{U}\mathbf{e}\ W$$

Θ is equivalent to column water vapor W advected by Ue.
Ue is the depth-averaged wind weighted by humidity
We use SVR to relate Ue to wind at two levels:
1. U_N: scatterometer surface wind stress
2. U_{850mb}: cloud drift wind (free-stream wind)

Global Ocean Water Balance





$$\iint \frac{\partial M}{\partial t} = \int R - \iint \nabla \cdot \Theta$$

GRACE Dai/Trenberth Liu/Xie

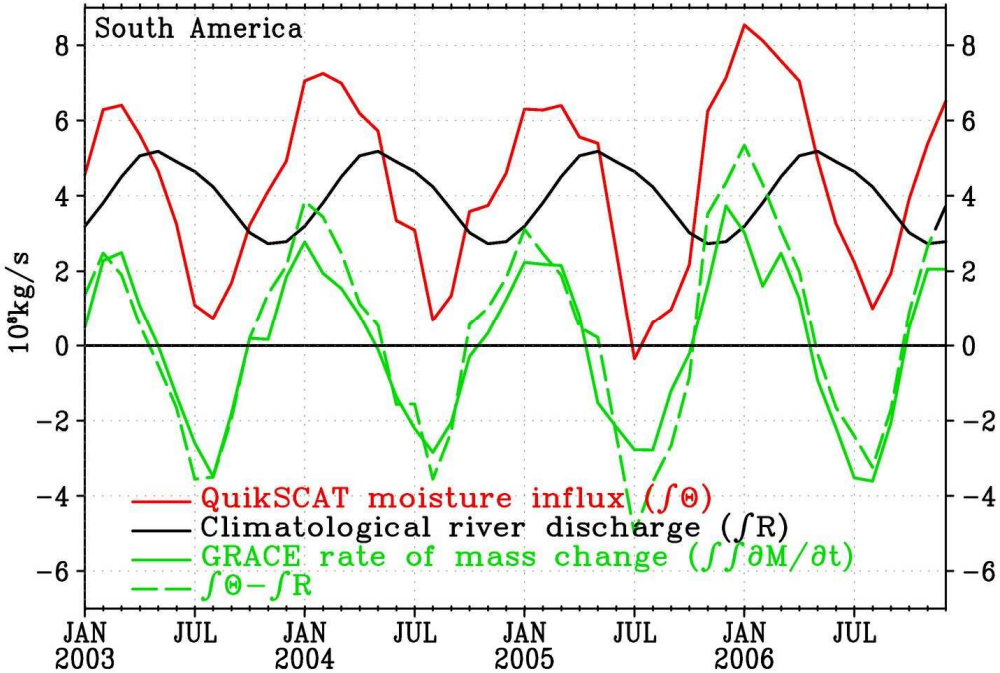
$$\iint (E-P) = \int \Theta = \iint \nabla \cdot \Theta$$

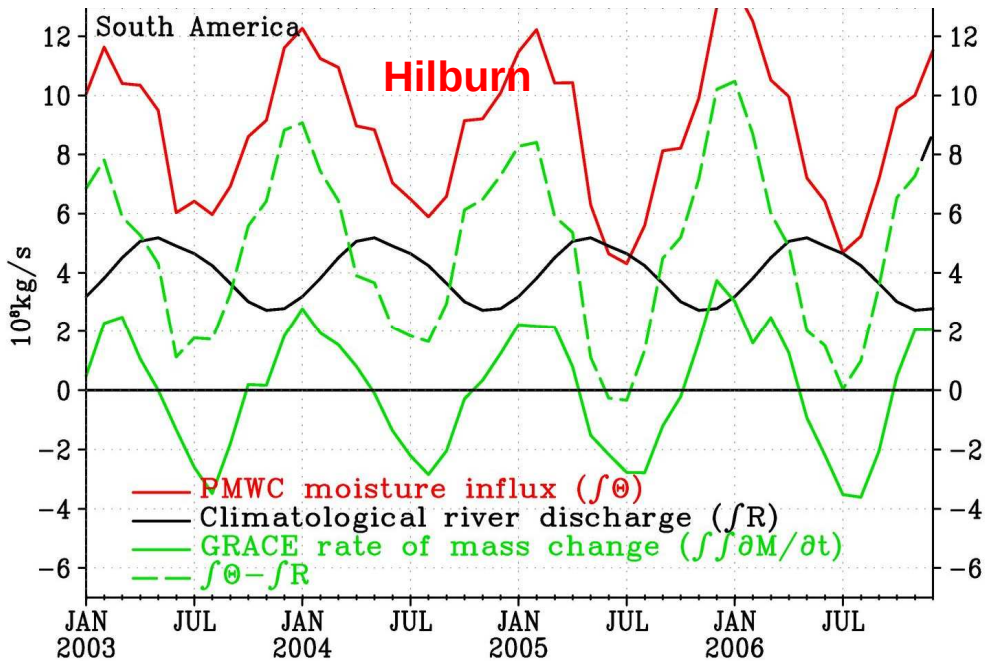
Four-year means in cm/yr

div of water transport

Liu	10.6
Hilburn	21.9
E-P	
Merra	10.6
NEWS	10
River discharge	
Dai	8.6

Water Balance over South America





$$\iint \frac{\partial M}{\partial t} = \int \Theta - \int R$$

GRACE Liu/Xie Dai/Trenberth

$$\iint (P-E) = \int \Theta$$

Four-year means in cm/yr

Moisture into continent

Liu 76.1

Hilburn 154.5

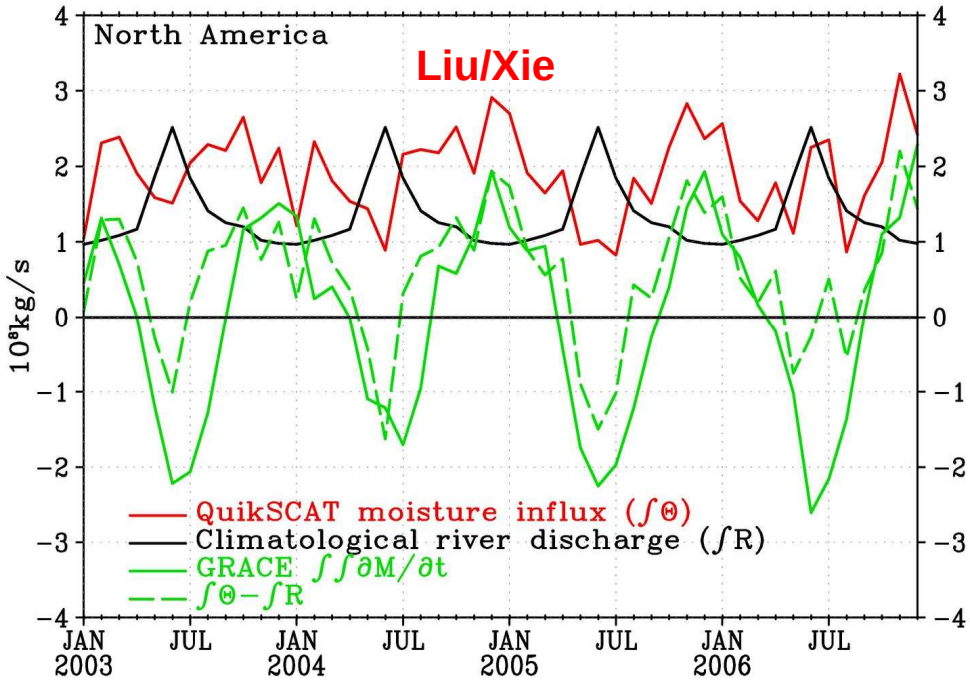
P-E

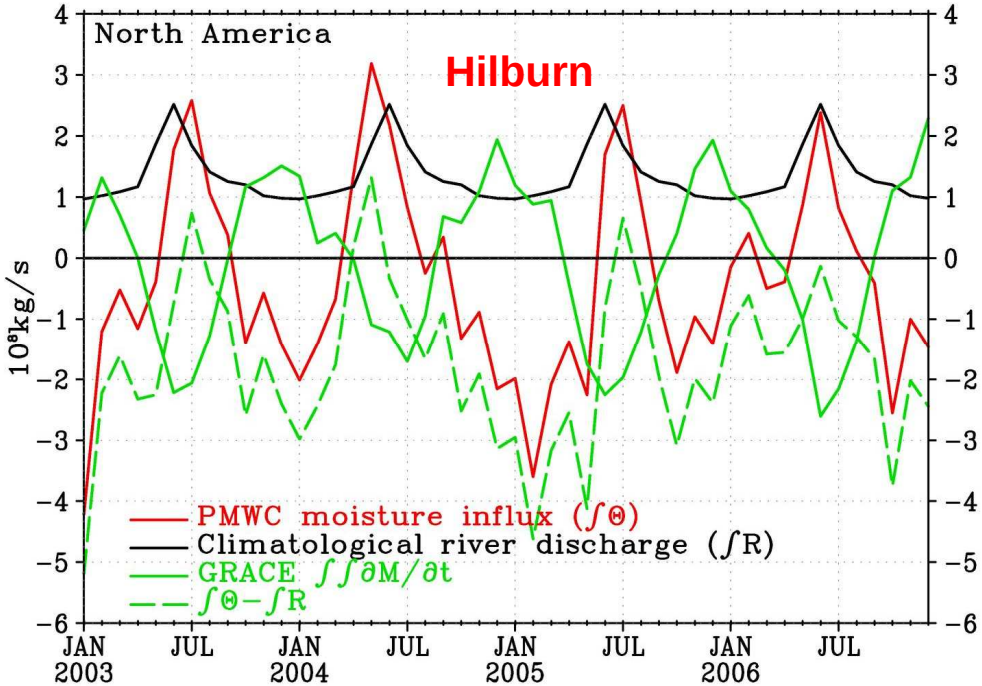
NEWS 61.3

River discharge

Dai 69.2

Water Balance over North America





$$\iint \frac{\partial M}{\partial t} = \int \Theta - \int R$$

GRACE Liu/Xie Dai/Trenberth

$$\iint (P-E) = \int \Theta$$

Four-year Means in cm/yr

Moisture into continent

Liu 28.9

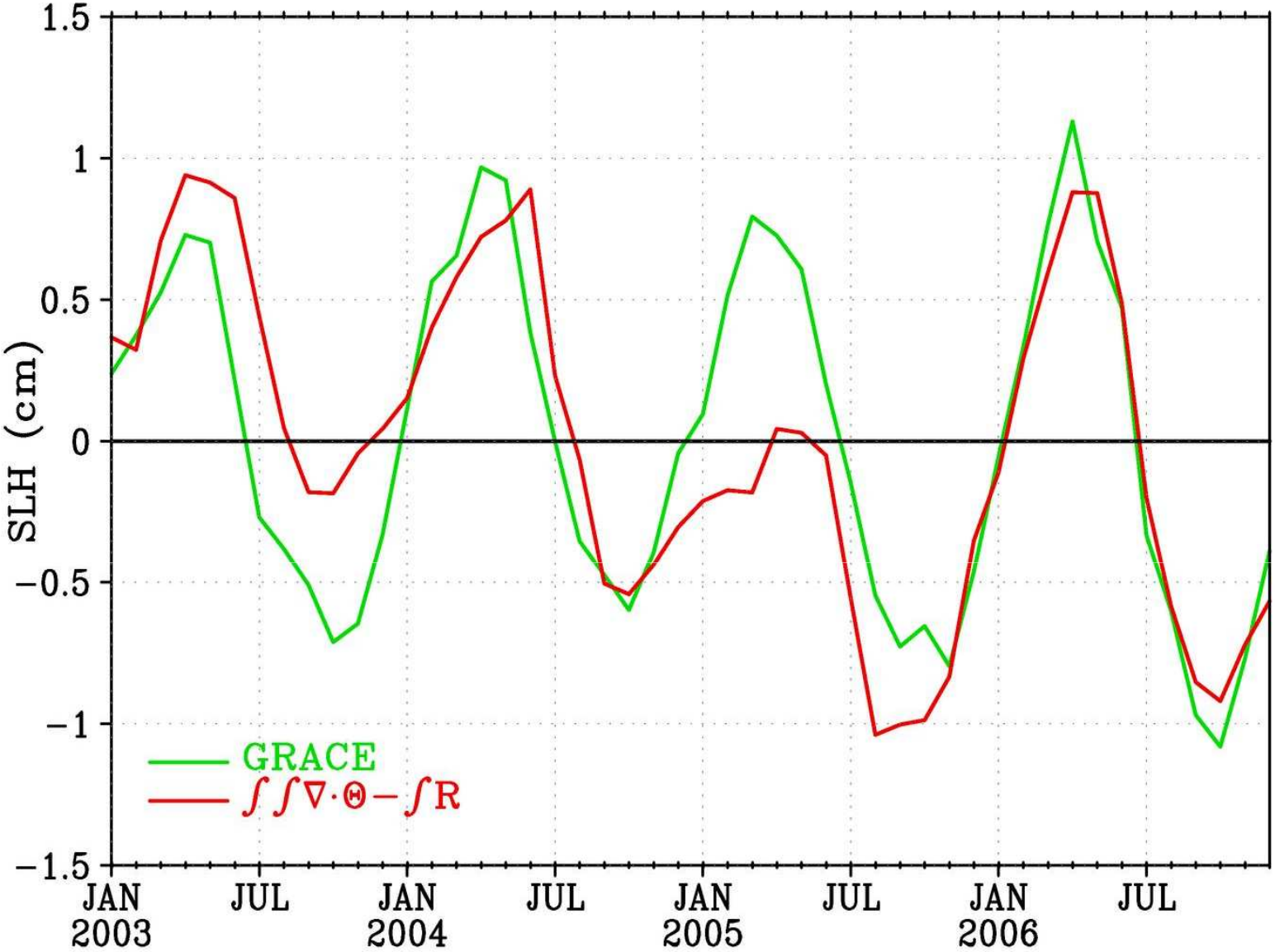
Hilburn -5.9

P-E

NEWS 20.9

River Discharge

Dai 20.5



Sea level variation calculated from GRACE & moisture transport