

Emerging instability in global terrestrial water storage since 2010

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Time series of global land water storage change, glacierized zone excluded

Reading flow:

(Title)

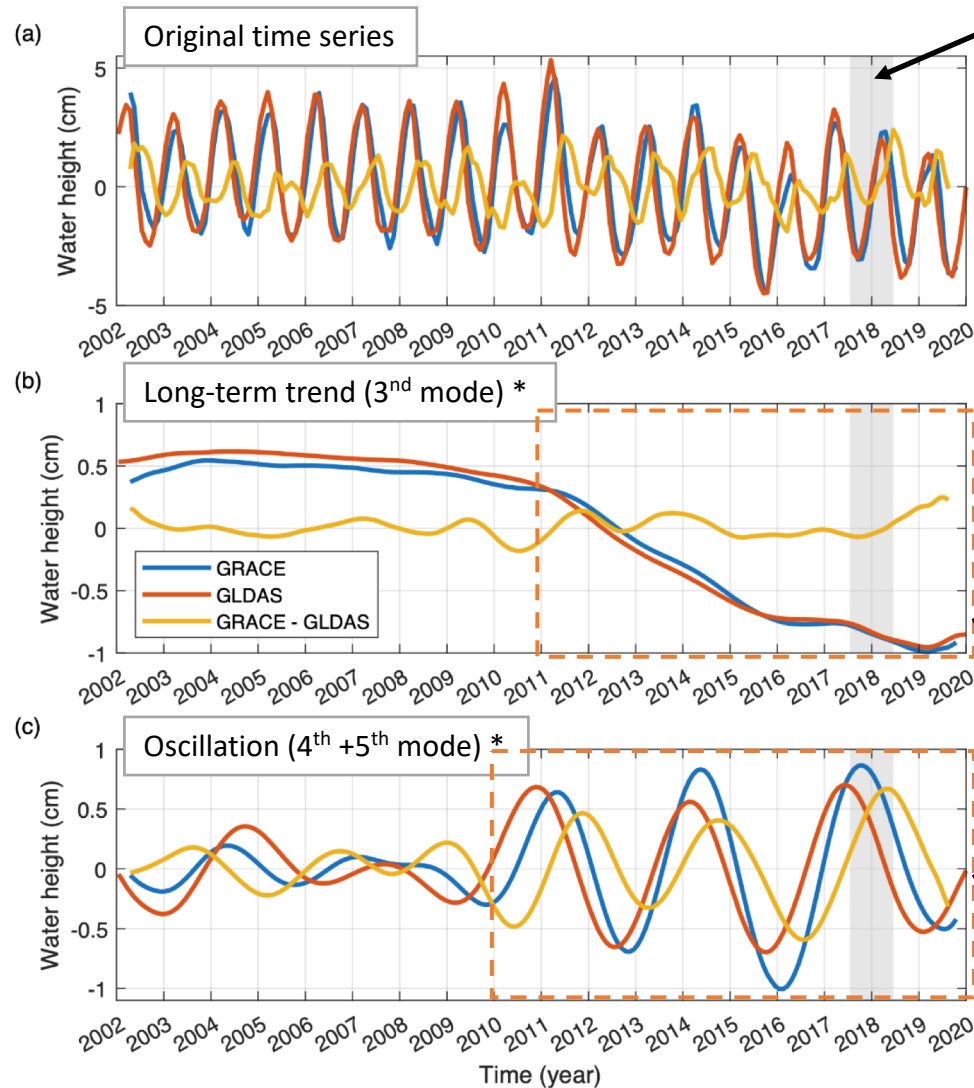
Explanation

(Figure)

Focus/conclusion

If necessary:

Sidenote



Data gap filled by Singular Spectrum Analysis (SSA)

GRACE: Total land water storage
= Soil moisture + snow +
surface water + groundwater

GLDAS: Soil moisture + snow

GRACE-GLDAS: surface water + groundwater

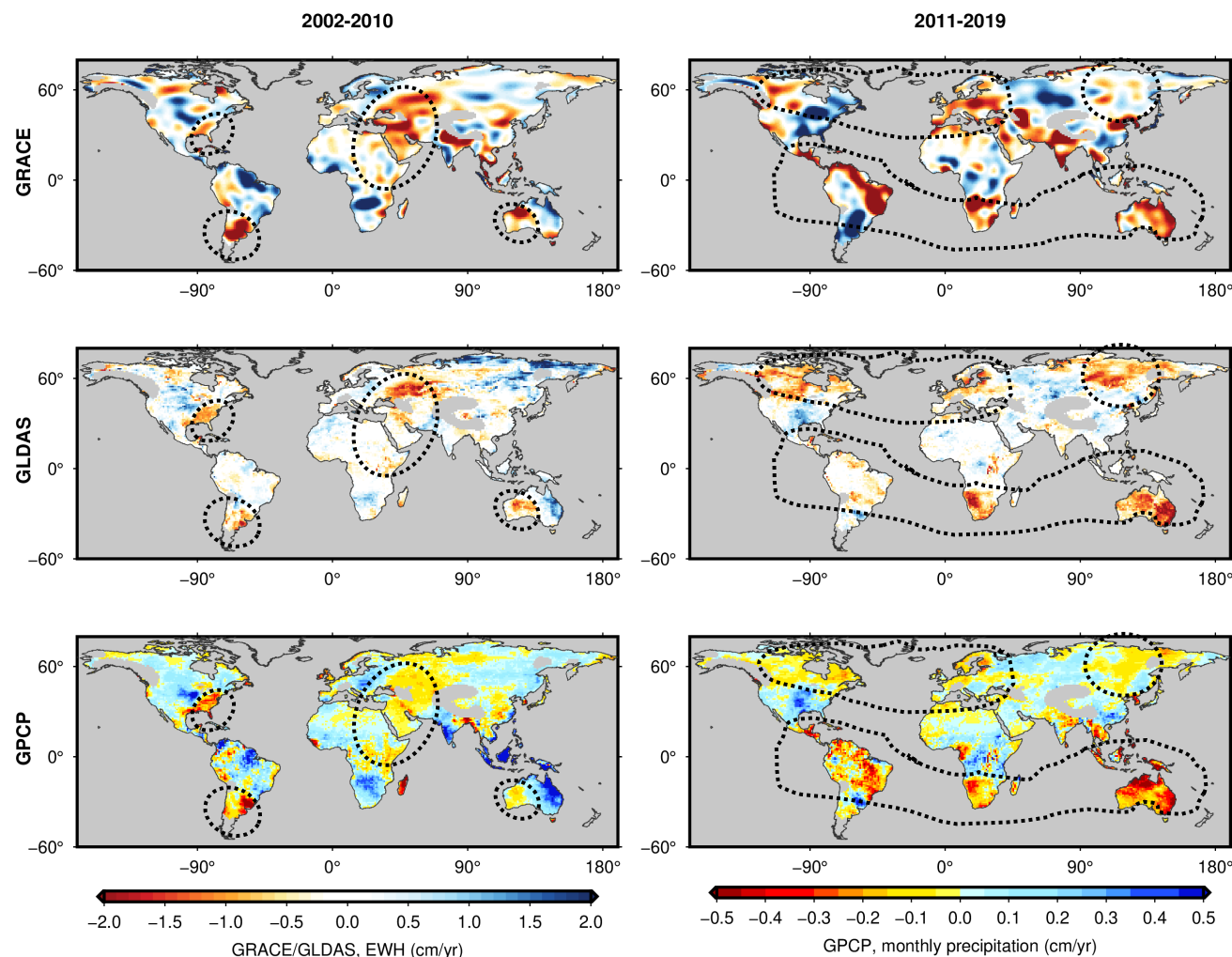
a. There is little trend in GRACE-GLDAS

b. Significant decline in GRACE and GLDAS
since 2011

c. Increasing amplitude in oscillation
in all series since 2010

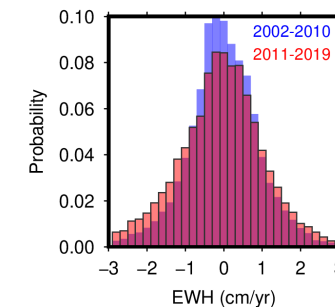
(*Component decomposed from the original time series by using SSA; 1st + 2nd modes represent the annual variation)

Map of trends over two intervals

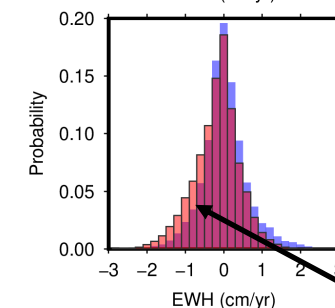


Trend in precipitation

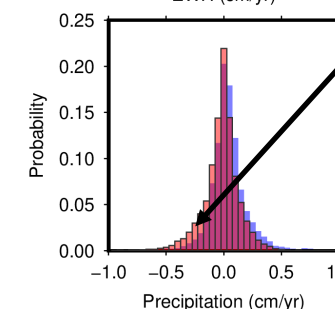
Comparison of the distribution of trends



Large increase in negative trends; moderate increase in positive trends



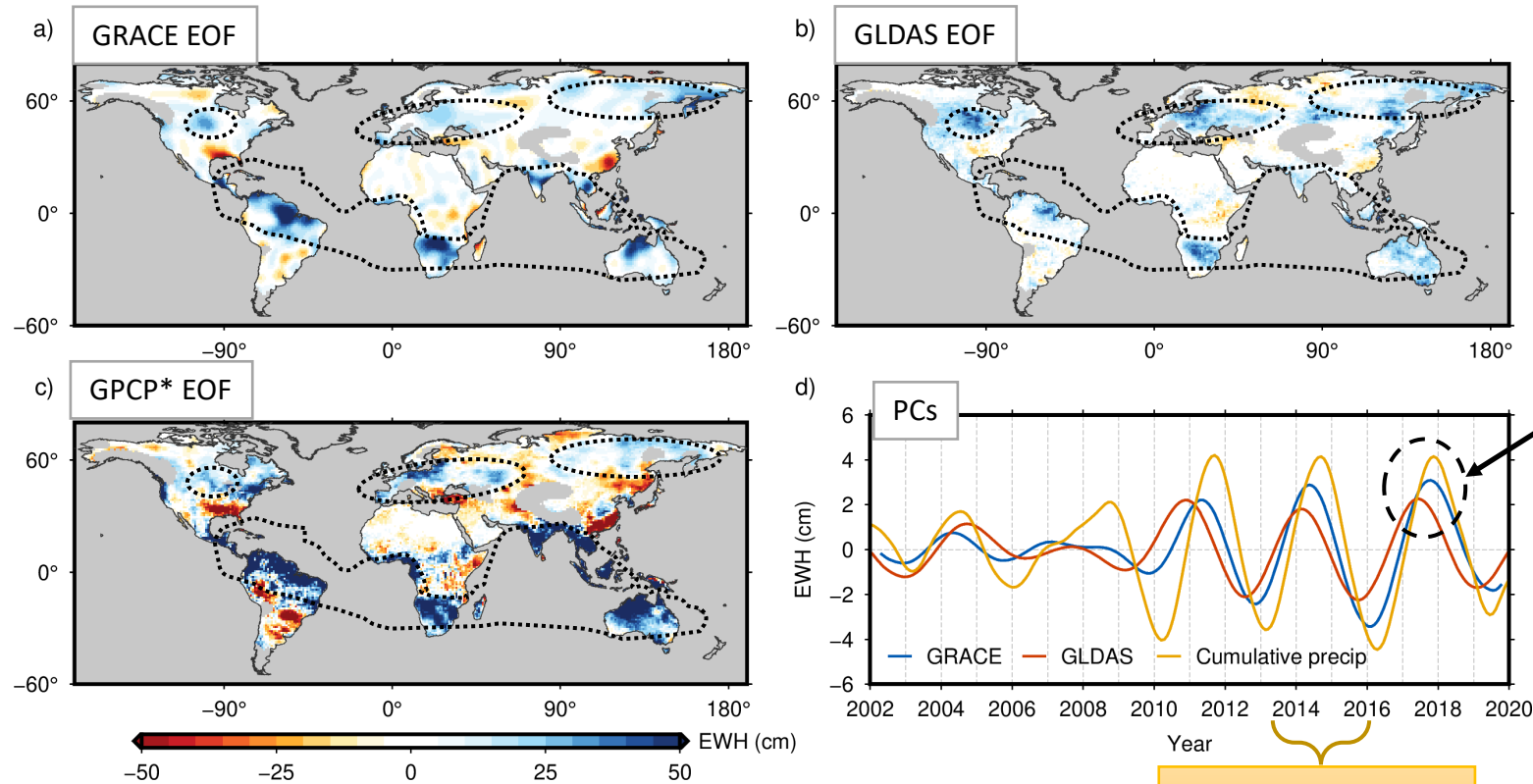
Increased intensity in negative trends



- Regions with less precipitation increased globally;
- Precipitation is responsible for most of the change;
- GRACE shows enhanced trends in both mass increase and decrease.

Explanation of the emerging oscillation since 2010

Spatial distribution (EOF) of the temporal evolution (PC)



EOF = observation matrix \times normalized PC

PCs are from SSA; the oscillation component shown here is only weaker than the seasonal and long-term components.

Why there is a lag in the oscillation phase of cumulative precipitation?

$$m = C_p - C_{ET + RO}$$

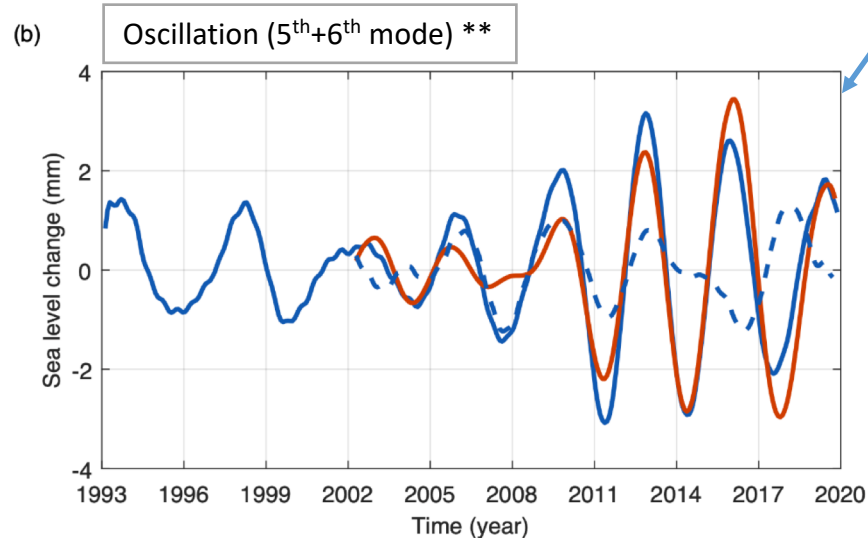
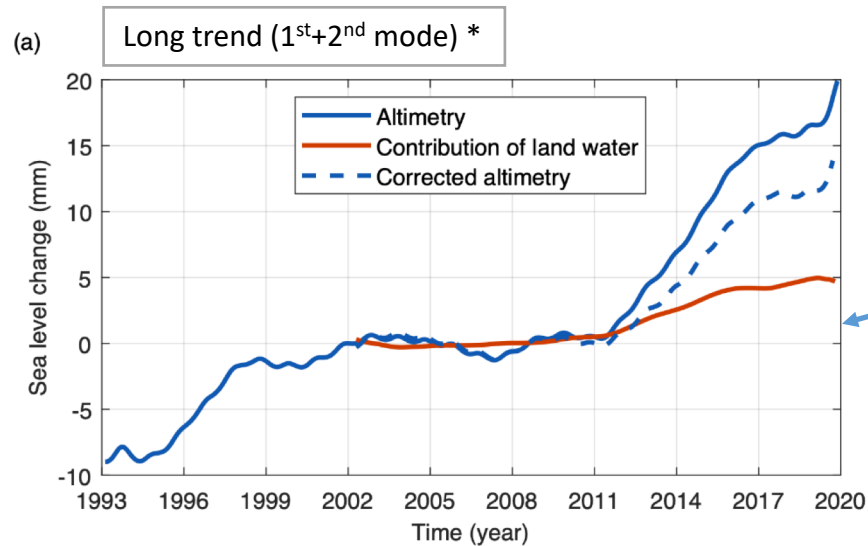
Where, C: cumulative; m: water storage;
ET: evapotranspiration; RO: runoff

- Only a fraction of C_p turns into m ;
- The phase difference between C_p and $C_{ET + RO}$ brings forward the phase in m .

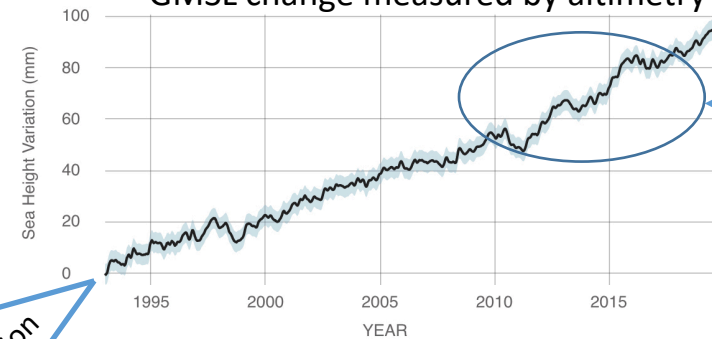
- The 3-year oscillation occurred globally;
- Generally precipitation is responsible for its occurrence.

*Cumulative precipitation is used; $C_p(t) = \sum_{i=1}^t (P_i - \bar{P})$, with \bar{P} to be the average

Implication of the instability in global land water storage: one example in global mean sea level (GMSL)



GMSL change measured by altimetry



Visible fluctuation in the GMSL records in recent years

Image: <https://climate.nasa.gov/vital-signs/sea-level/>

SSA decomposition

$\Delta \text{GMSL (altimetry)} =$

$\Delta \text{ water density} + \Delta \text{ land water storage} + \Delta \text{ land ice mass}$

$\Delta \text{ Corrected altimetry} = \Delta \text{ water density} + \Delta \text{ land ice mass}$

a. Land water storage accounts for $\frac{1}{4}$ of the increase in the trend of GMSL since 2011;

b. Land water storage accounts for $> 50\%$ of the intensified fluctuation in GMSL since 2010.

Outlook: is its influence evident in the earth rotation parameters?

* Component decomposed by using SSA; A line with a slope of 2.7 mm/yr (the trend between 2002 and 2010) is removed in the altimetry result.

** 3rd + 4th modes represent the annual variation.