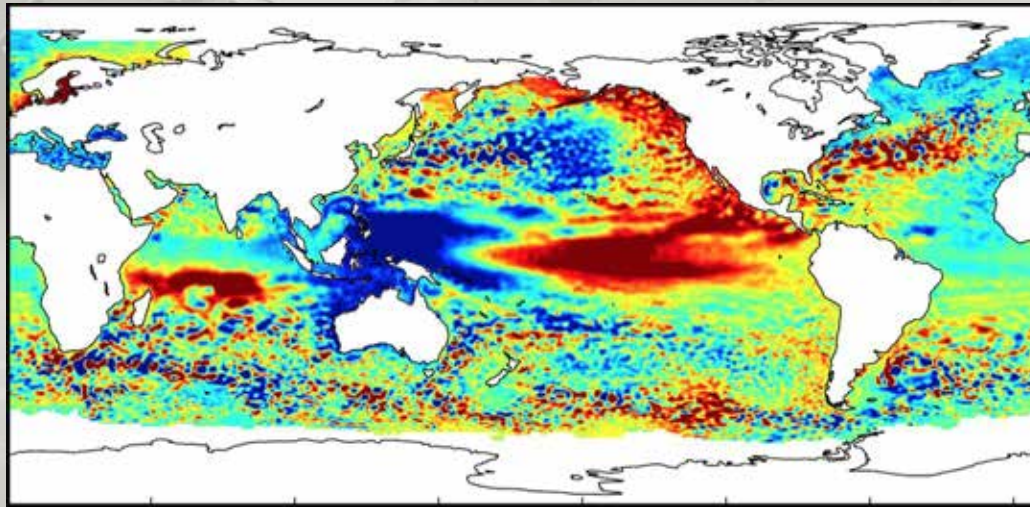# Impact of Pacific Ocean Variability on Global Mean Sea Level

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Robert R. Leben (University of Colorado at Boulder, USA)
**John T. Reager (NASA JPL, USA)**

Previous Studies

❖ Inter-annual and decadal variability on GMSL

➢ Boening et al., (2011)
  ▪ AVISO and GRACE
  ▪ La Nina (2010/2011) - 5 mm sea level

➢ Fasullo et al., (2013)
  ▪ Explained 5 mm GMSL drop between 2010 and 2011.

➢ Cazenave et al., (2014)
  ▪ Removing ENSO effect from the GMSL

➢ Hamlington et al. (2016)
  ▪ PDO impact on sea level using AVISO, CSEOF analysis

➢ Piecuch and Quinn (2016)
  ▪ Water budget of ENSO
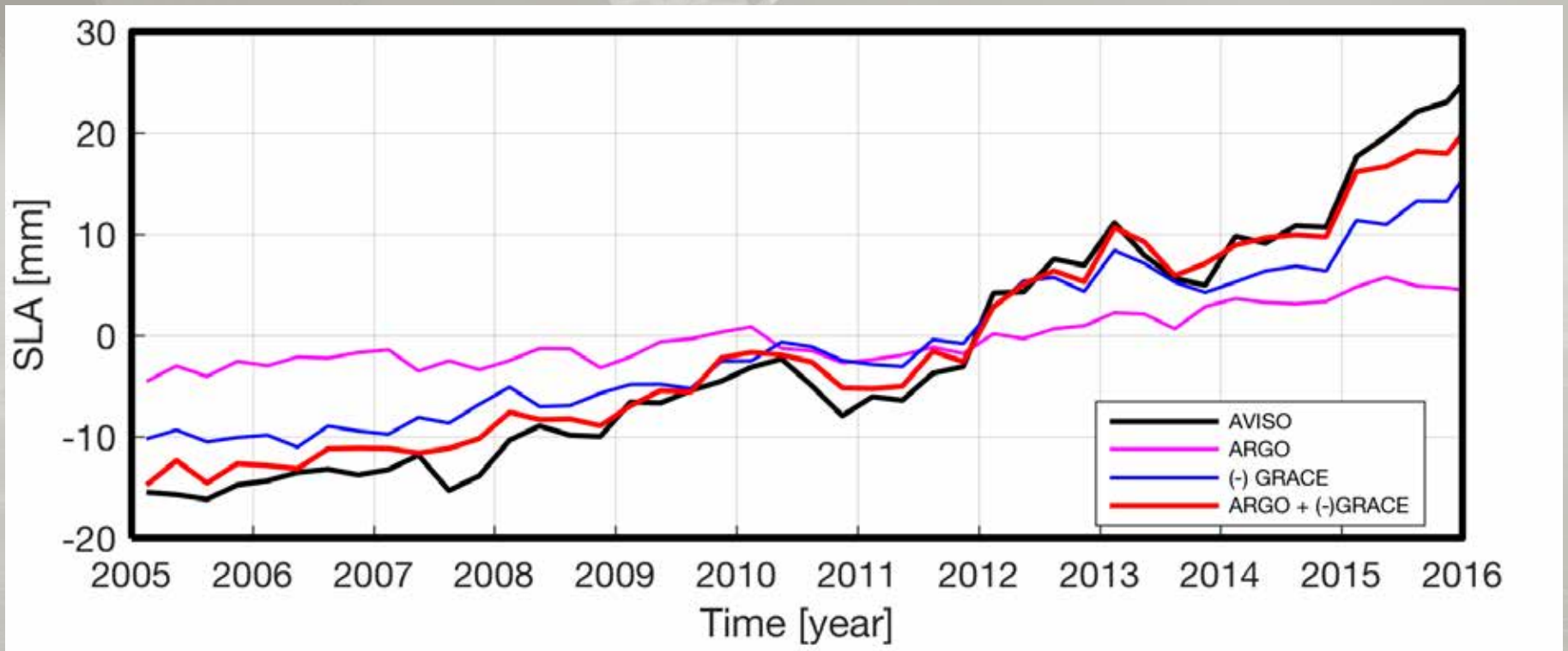   using GRACE, ARGO, AVISO and Various GMSLs.

Problems of Index approach

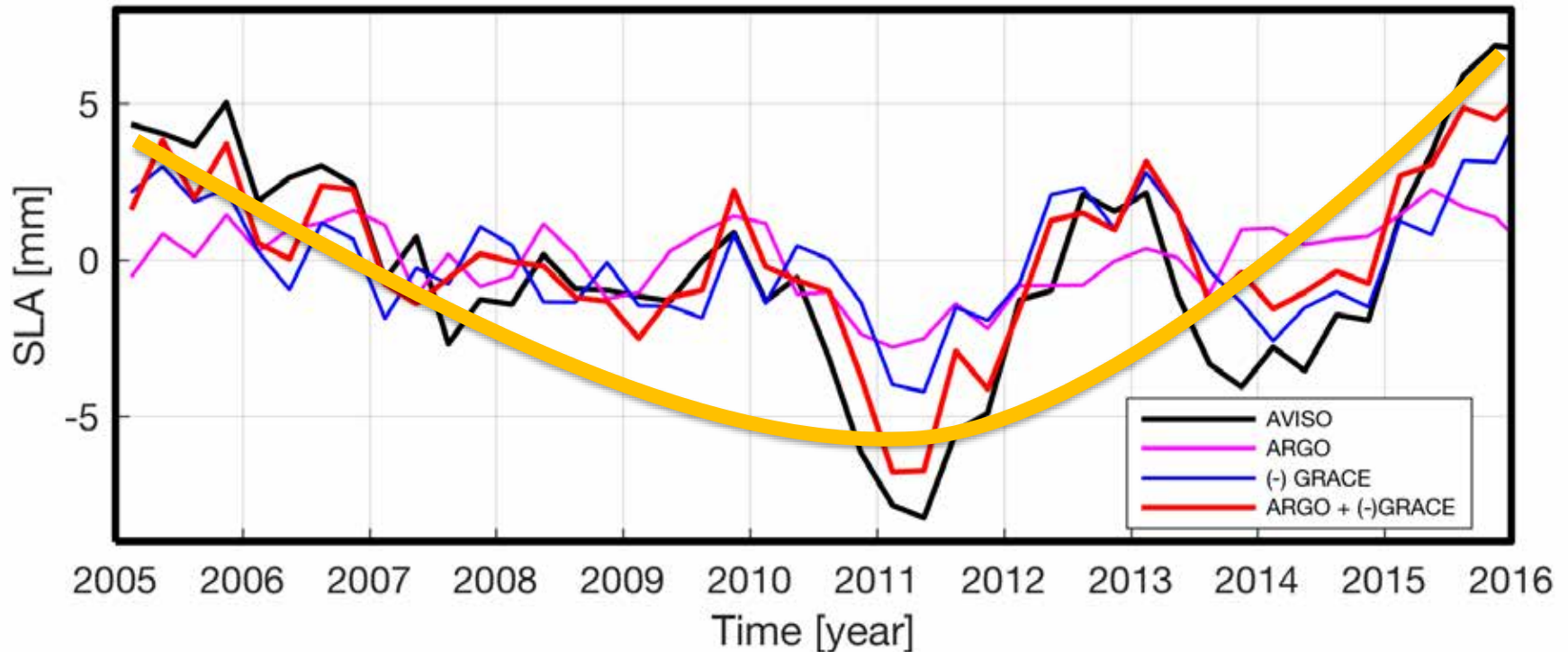❖ No stationary explanations using a single index

❖ Can not explain the lags
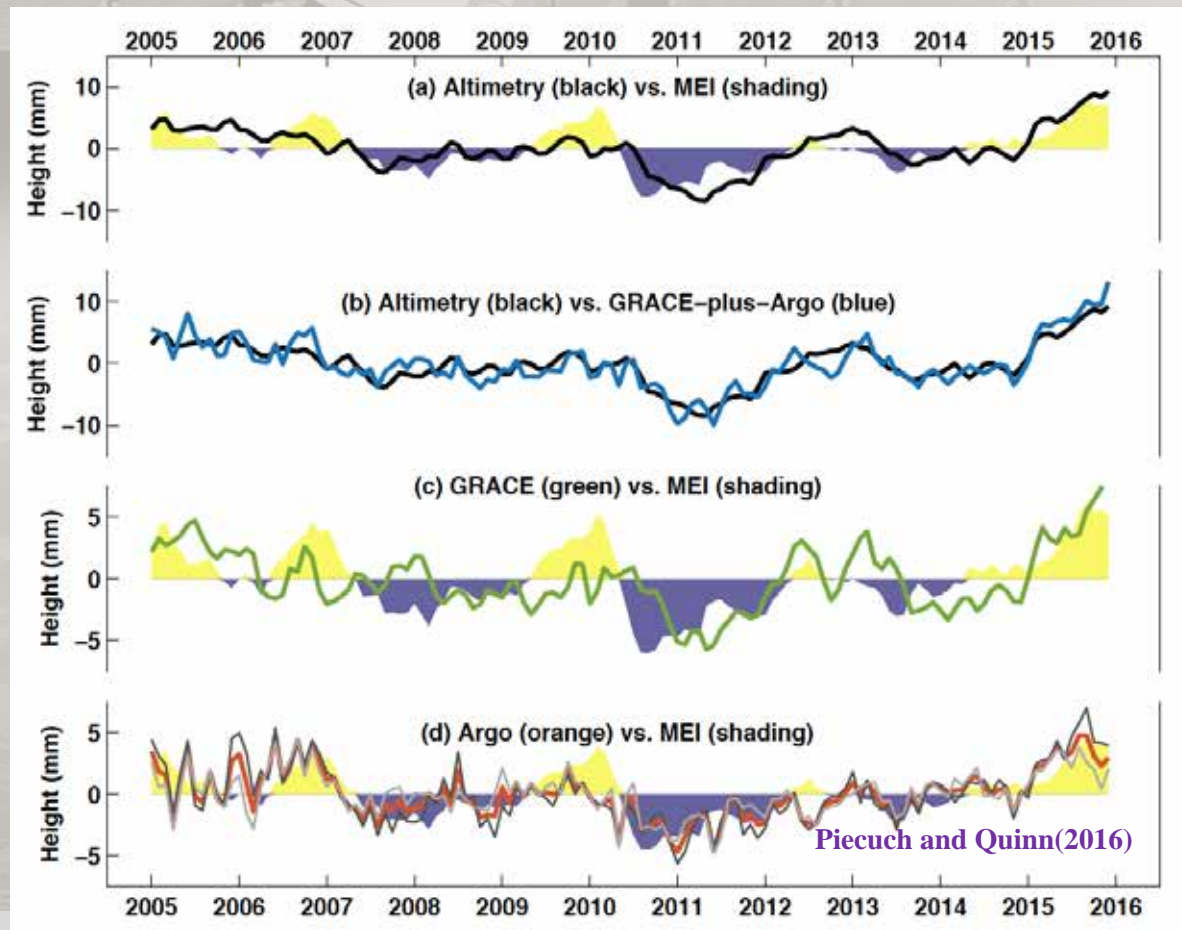
Piecuch and Quinn(2016)

Data

- ➢ SLA: AVISO (0.25 × 0.25, 1993-2016, month, [m])
- ➢ TWS: GRACE (0.5 × 0.5, 2003-2016, month, [cm])
- ➢ Steric SLA: ARGO (1.0 × 1.0, 2005-2016, season, [mm])

Data

➢ SLA: AVISO (0.25×0.25, 1993-2016, month, [m])

➢ TWS: GRACE (0.5×0.5, 2003-2016, month, [cm])

➢ Steric SLA: ARGO (1.0×1.0, 2005-2016, season, [mm])

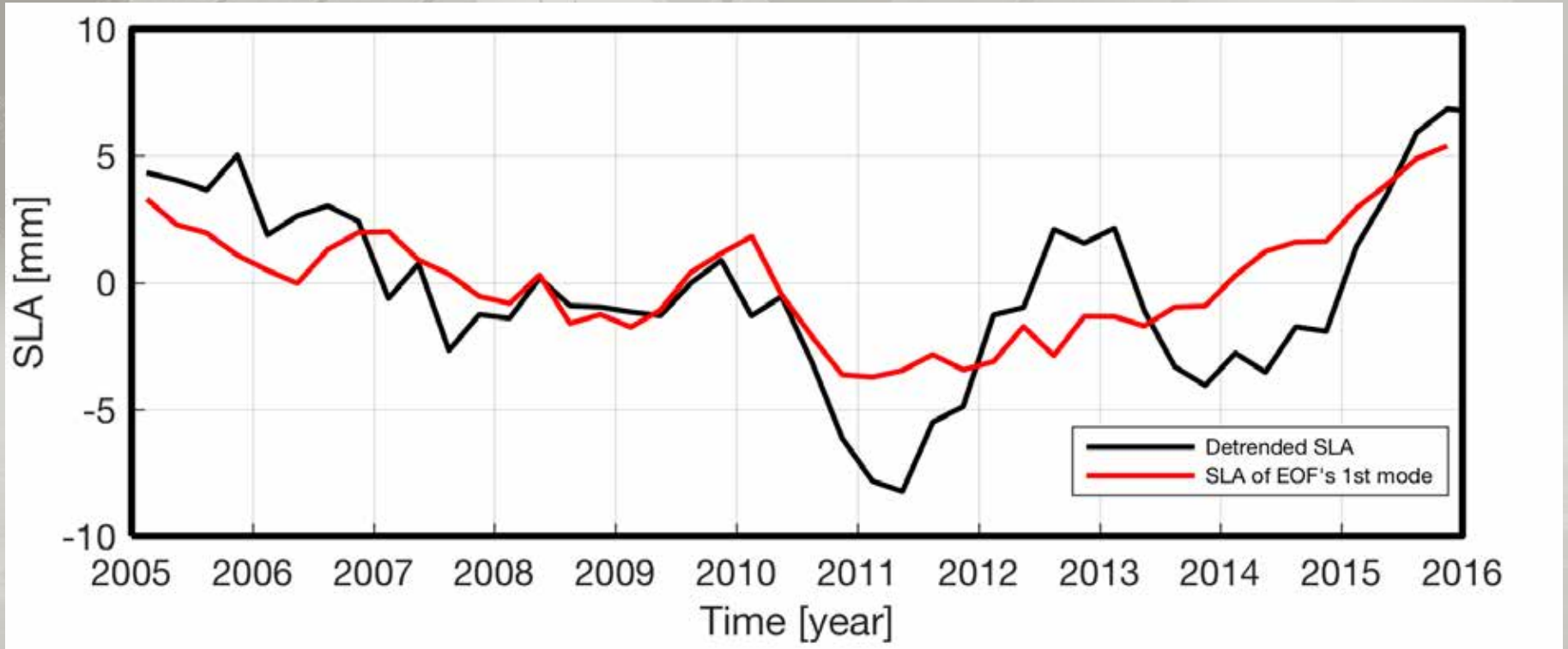➢ Combining the datasets over 2005-2016

Combined EOF Analysis

❖ EOF analysis (Combined AVISO, ARGO, GRACE)

$$T(x, y, t) = \sum_i LV_i(x, y) \cdot PCT_i(t)$$
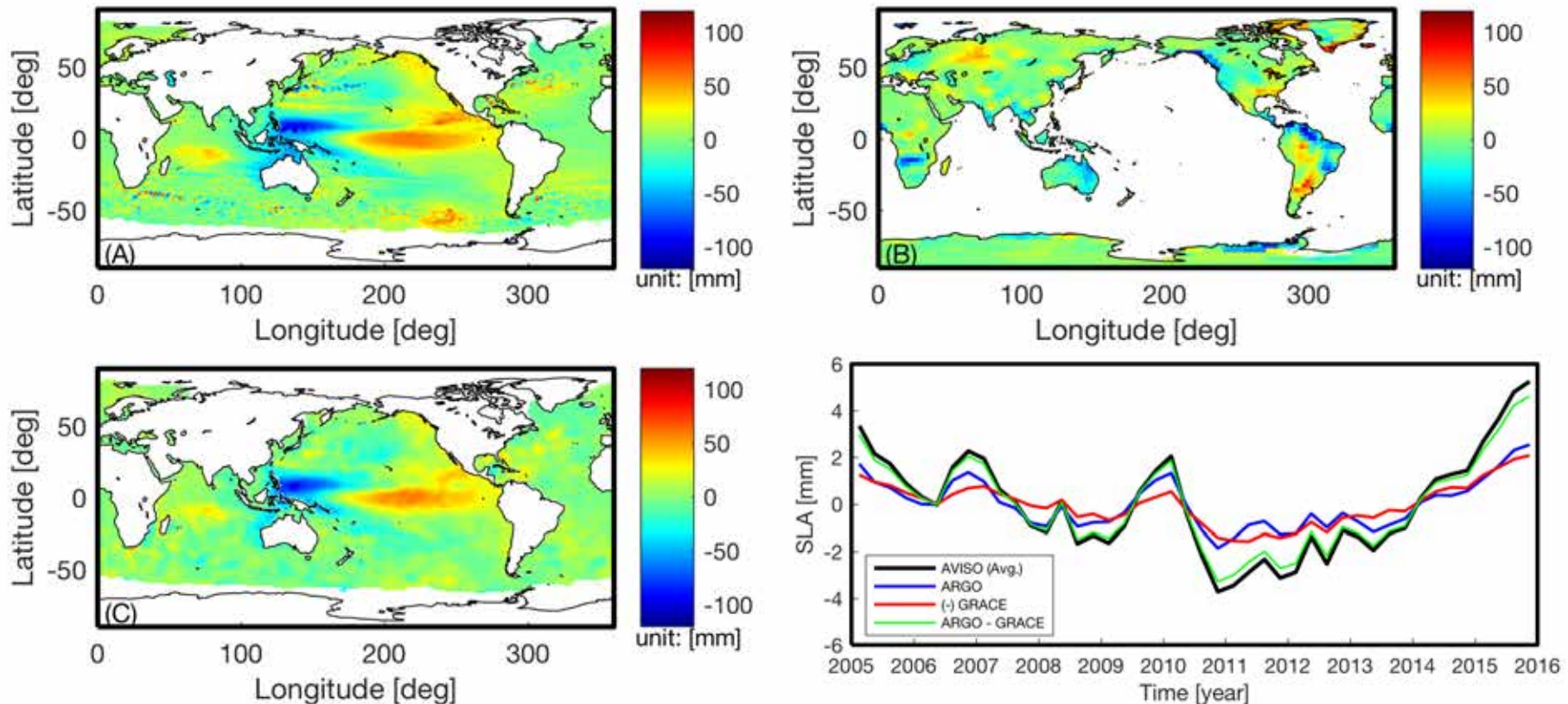
Combined EOF Analysis

❖ Effect on GMSL

Combined CSEOF Analysis
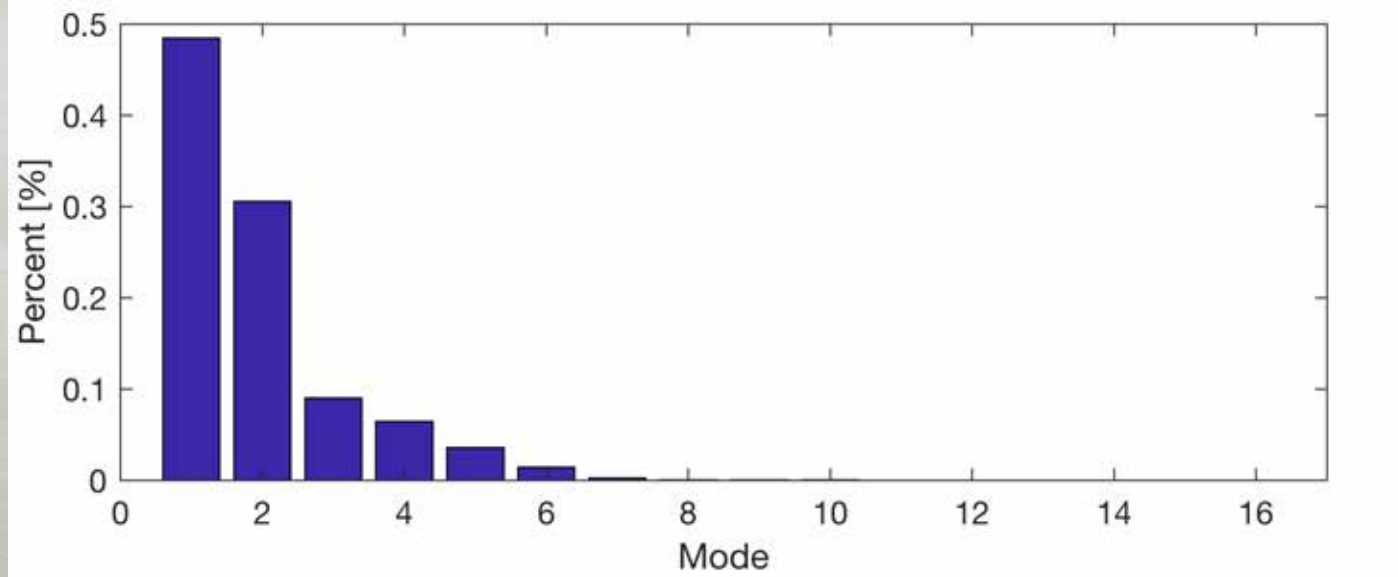
EOF

$$T(x, y, t) = \sum_i LV_i(x, y) \cdot PCT_i(t)$$

CSEOF (Cyclo-Stationary EOF)

$$T(x, y, t) = \sum_i LV_i(x, y, t) \cdot PCT_i(t)$$

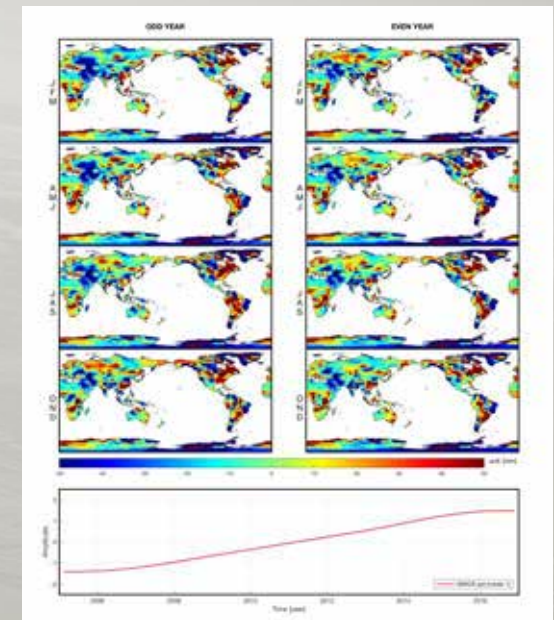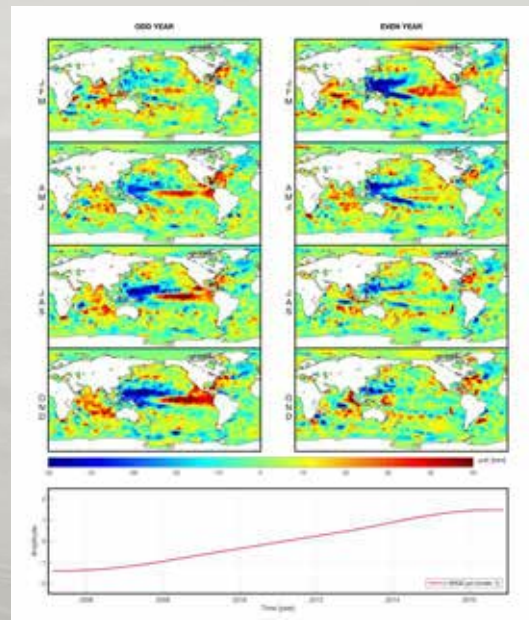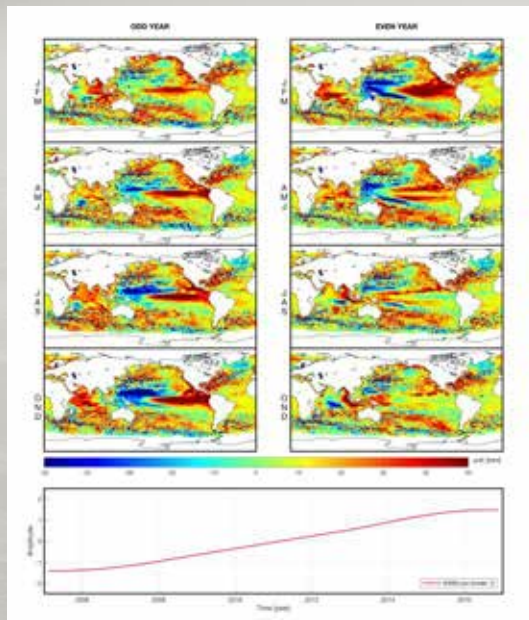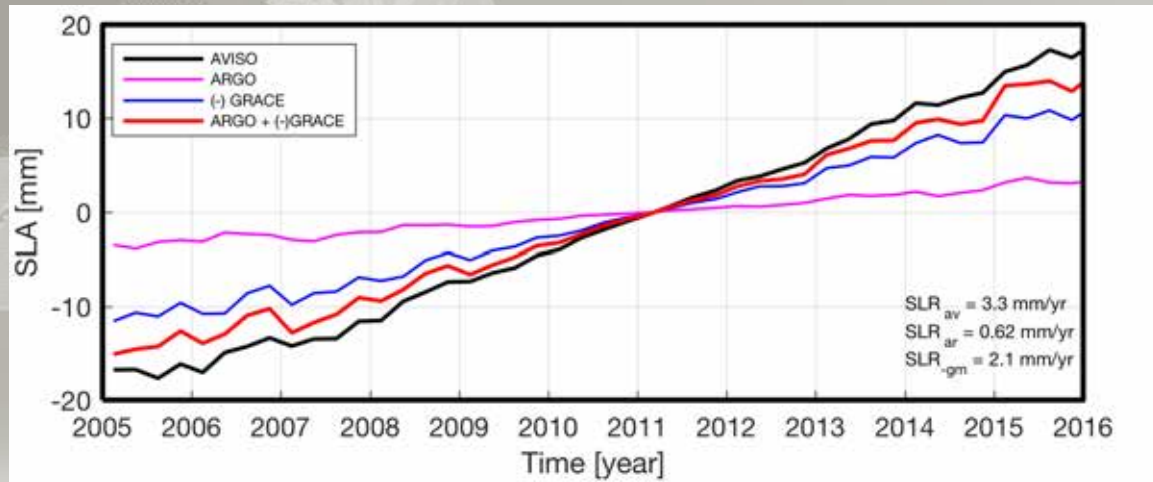$$LV(x, y, t) = LV(x, y, t + d), \text{ where } d = \text{nested period}$$
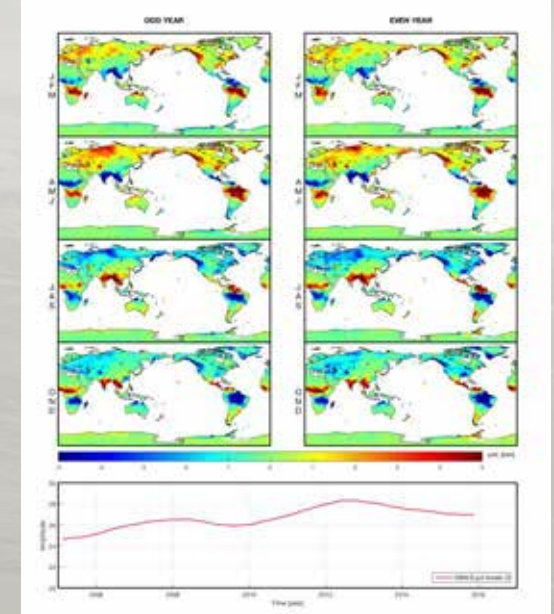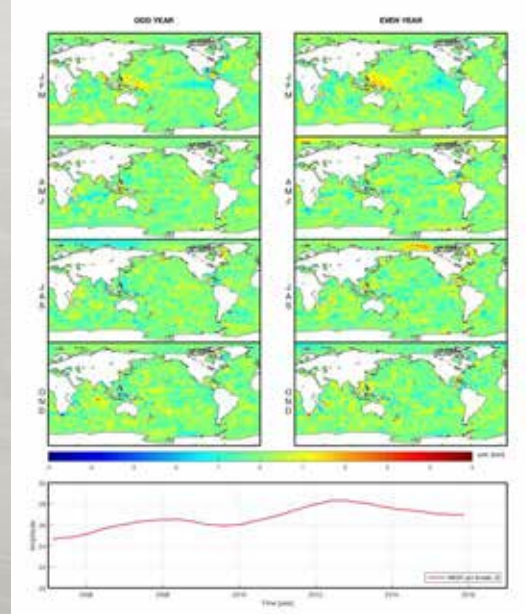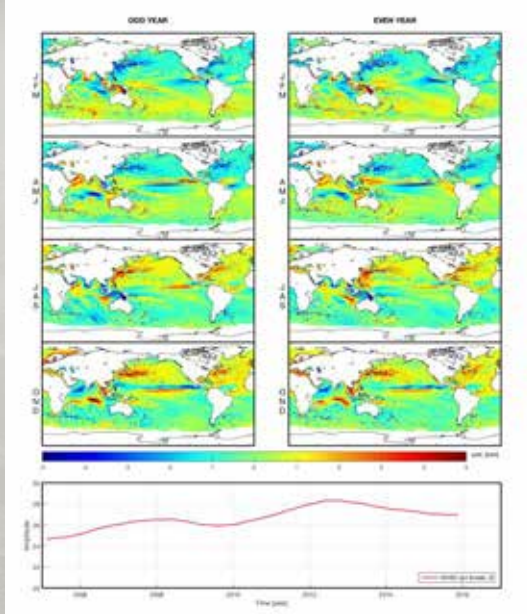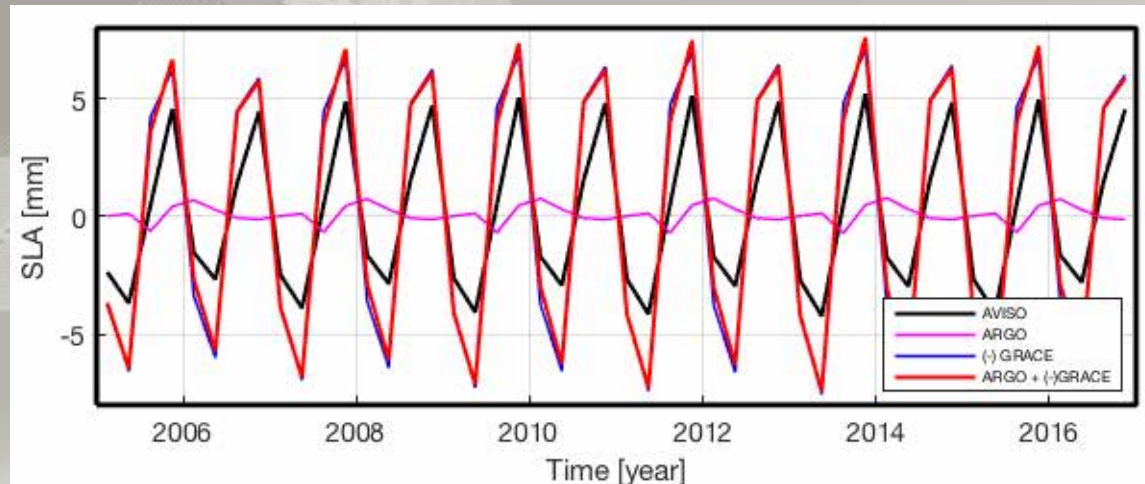
Combined CSEOF Analysis

❖ Conditions

➢ Data: combined data (360,180,3,48)

➢ Nested Period: 24 month (8 seasons)

➢ Time: 2005 – 2016 (seasonally averaged data)

➢ Removed mean values of each grid point
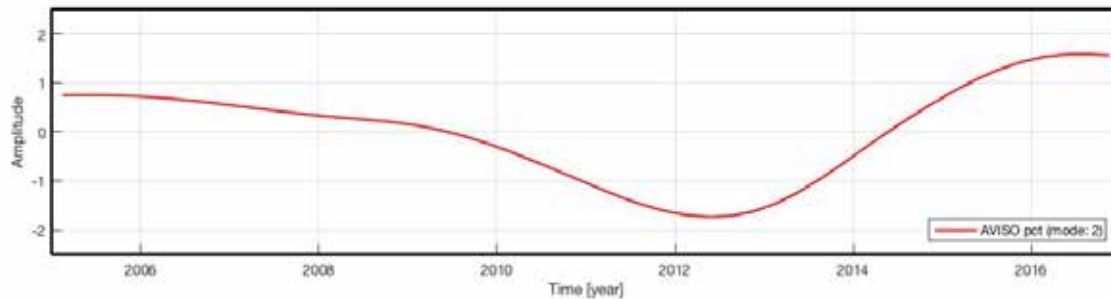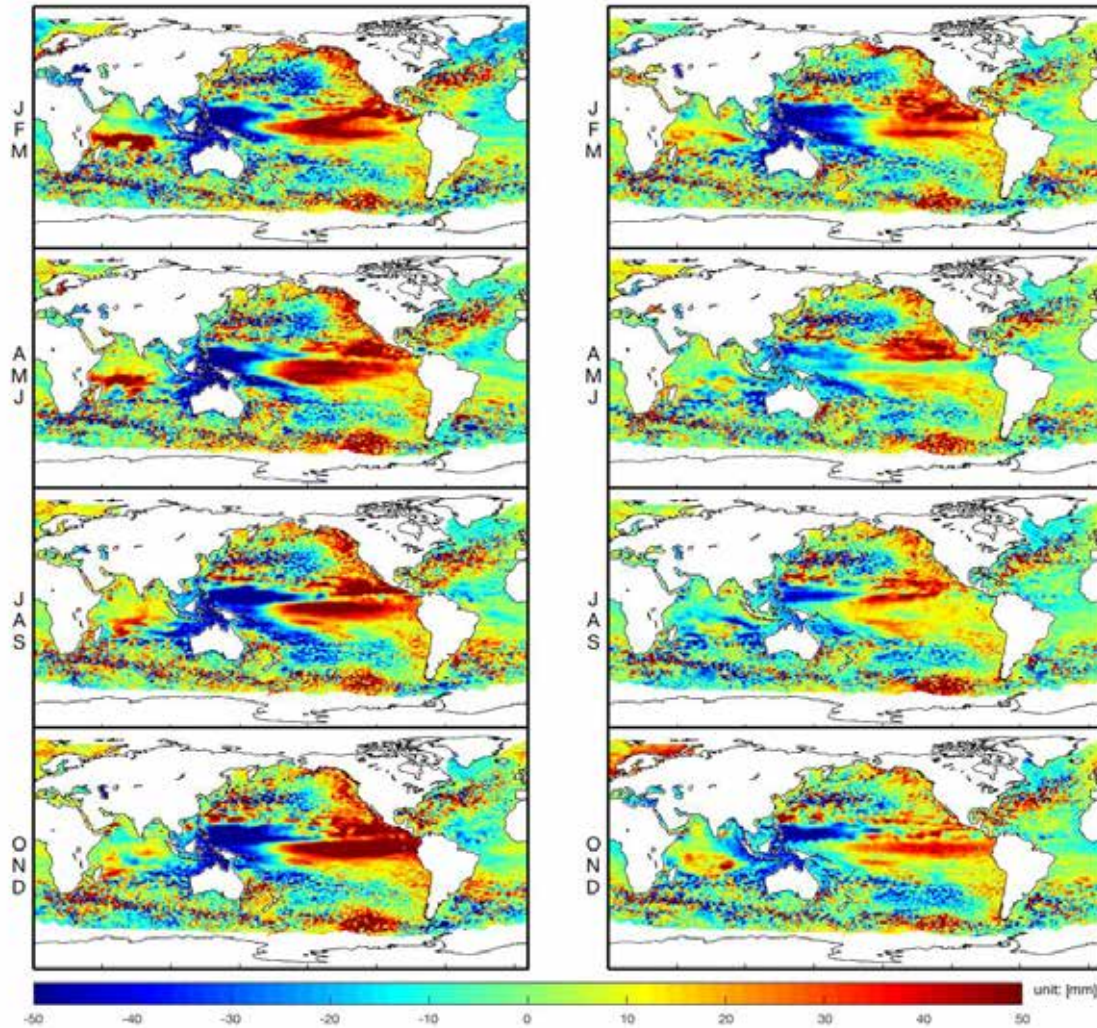
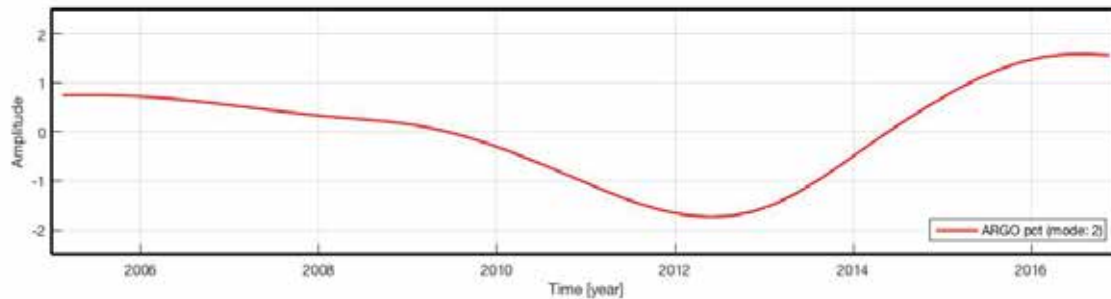# Effect of Mode 1 on Sea Level

Effect of Mode 2 on Sea Level

OSTST 2017

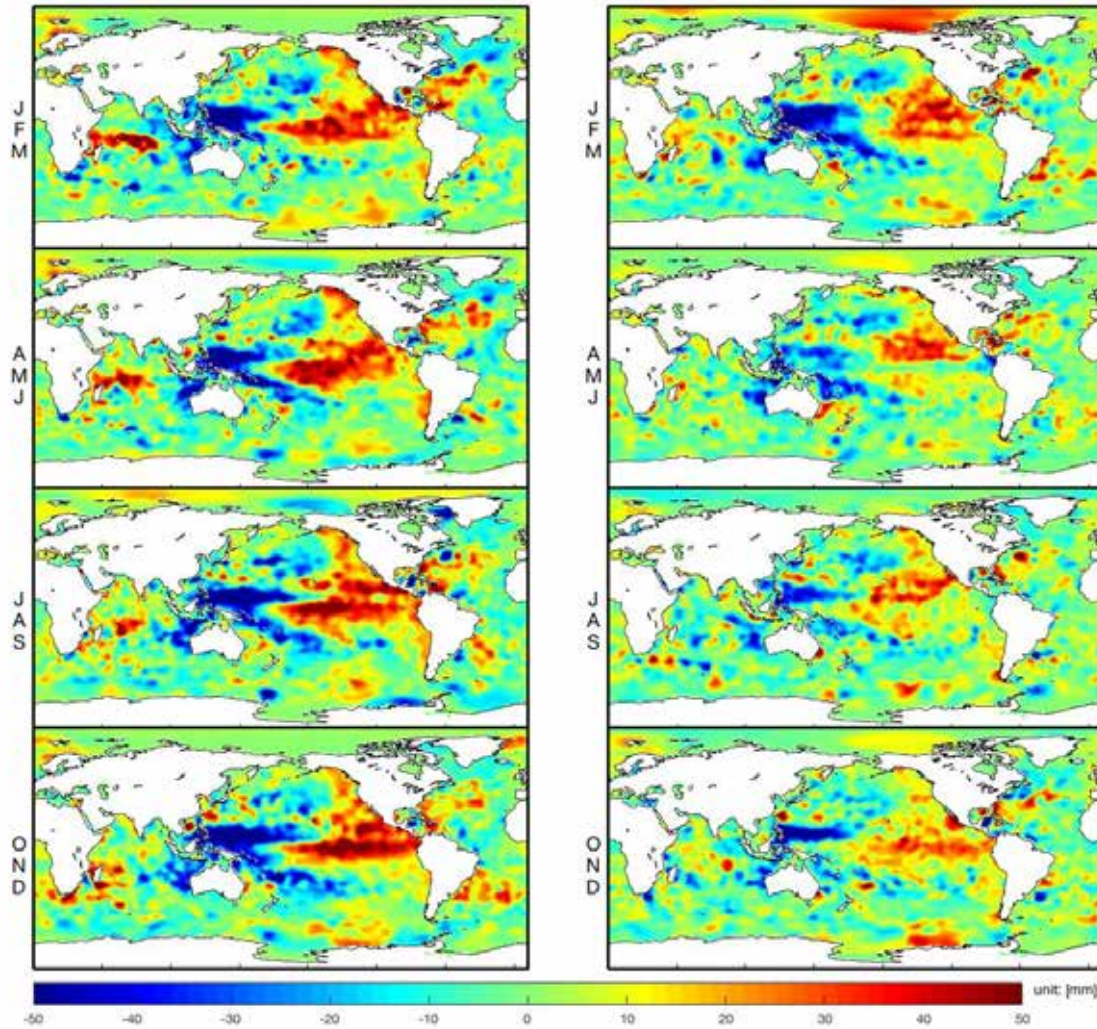# Mode: 3 (AVISO)

- Low Frequency Mode
- Explaining 9.0% of Total Variance
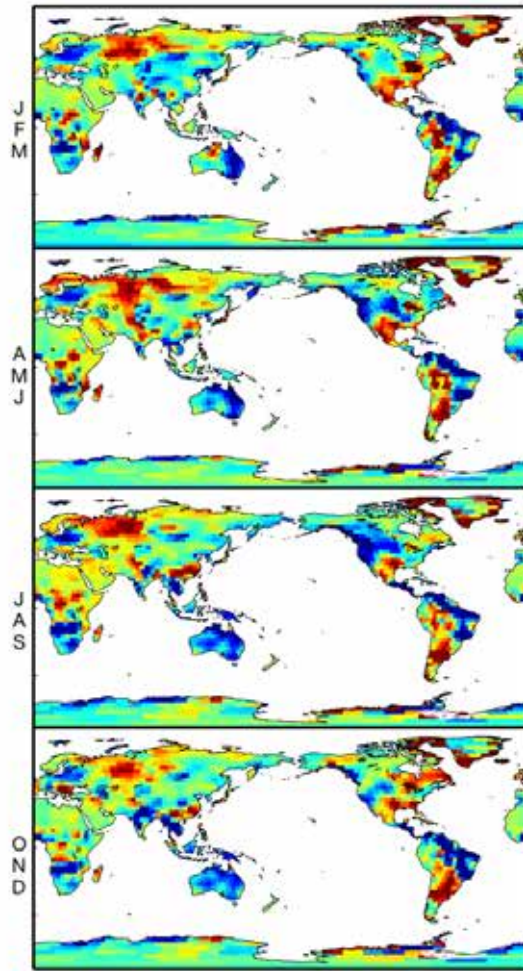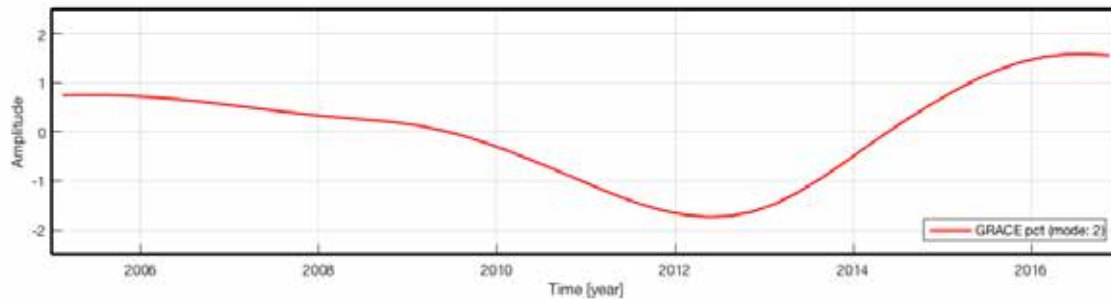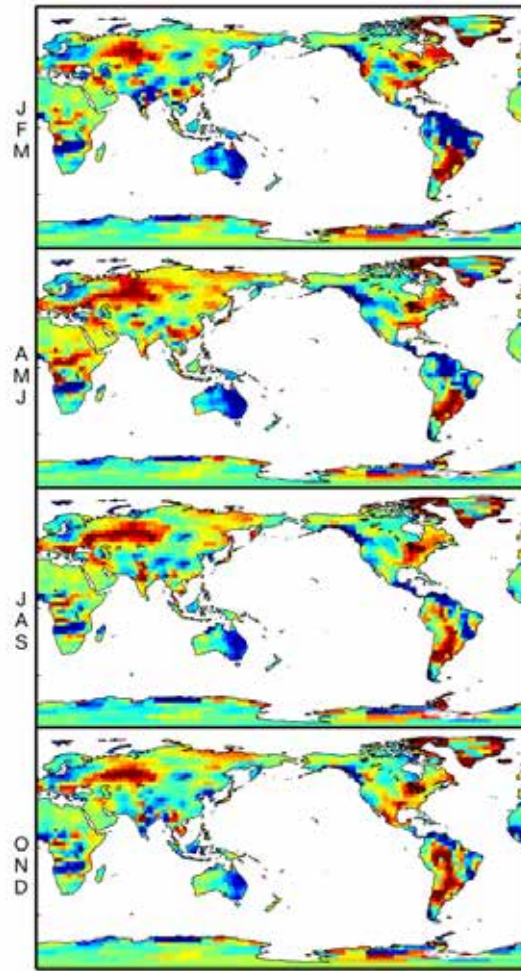
Mode: 3 (ARGO)

- Low Frequency Mode
- Explaining 9.0% of Total Variance

Mode: 3 (GRACE)
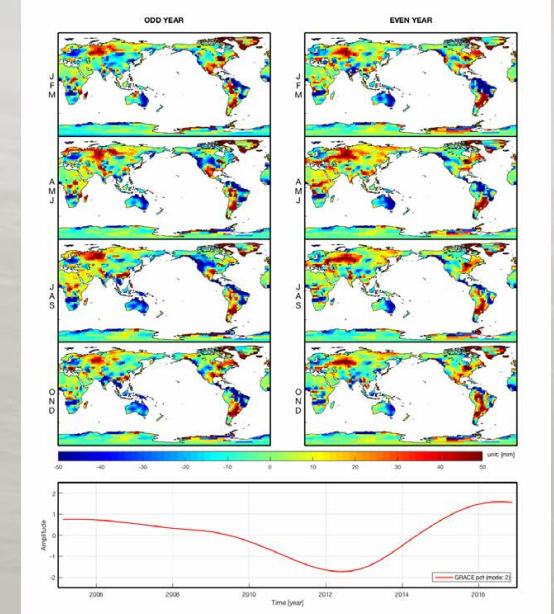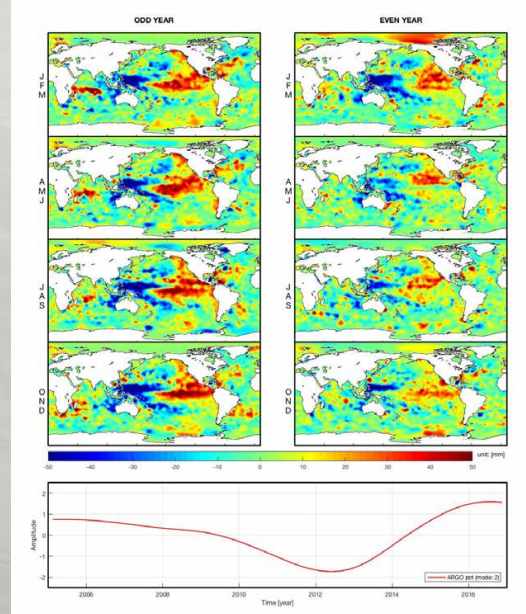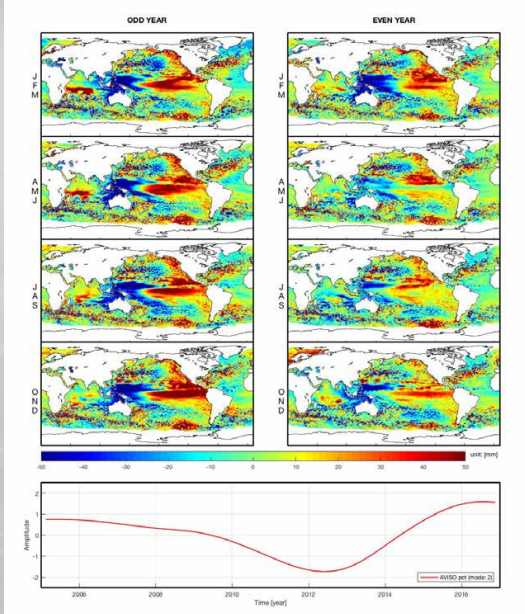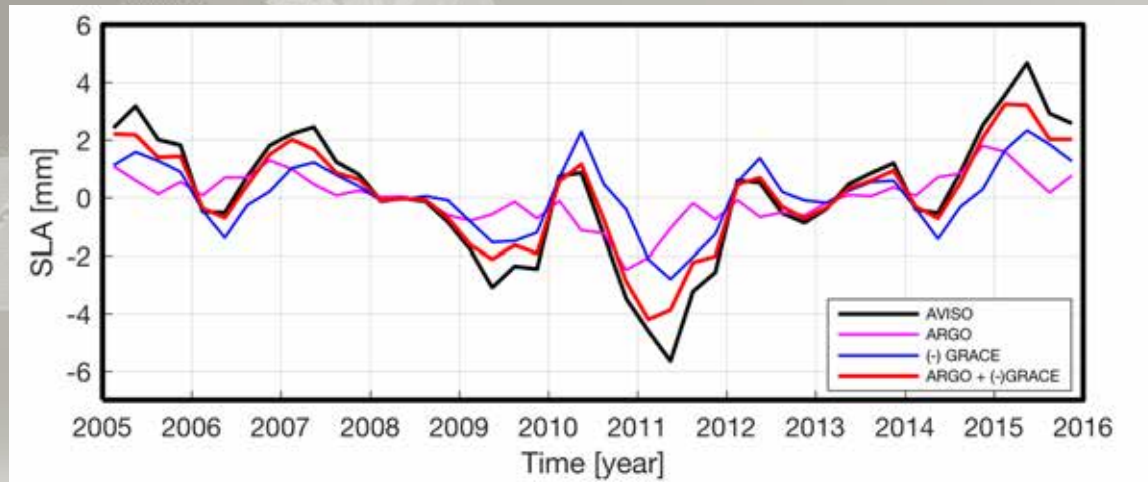
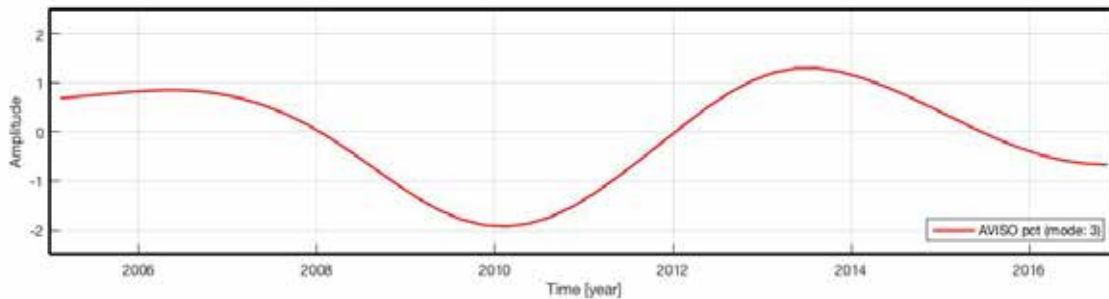- Low Frequency Mode
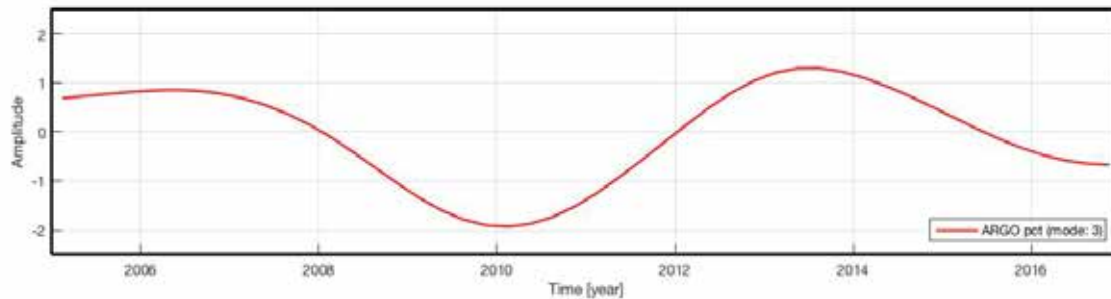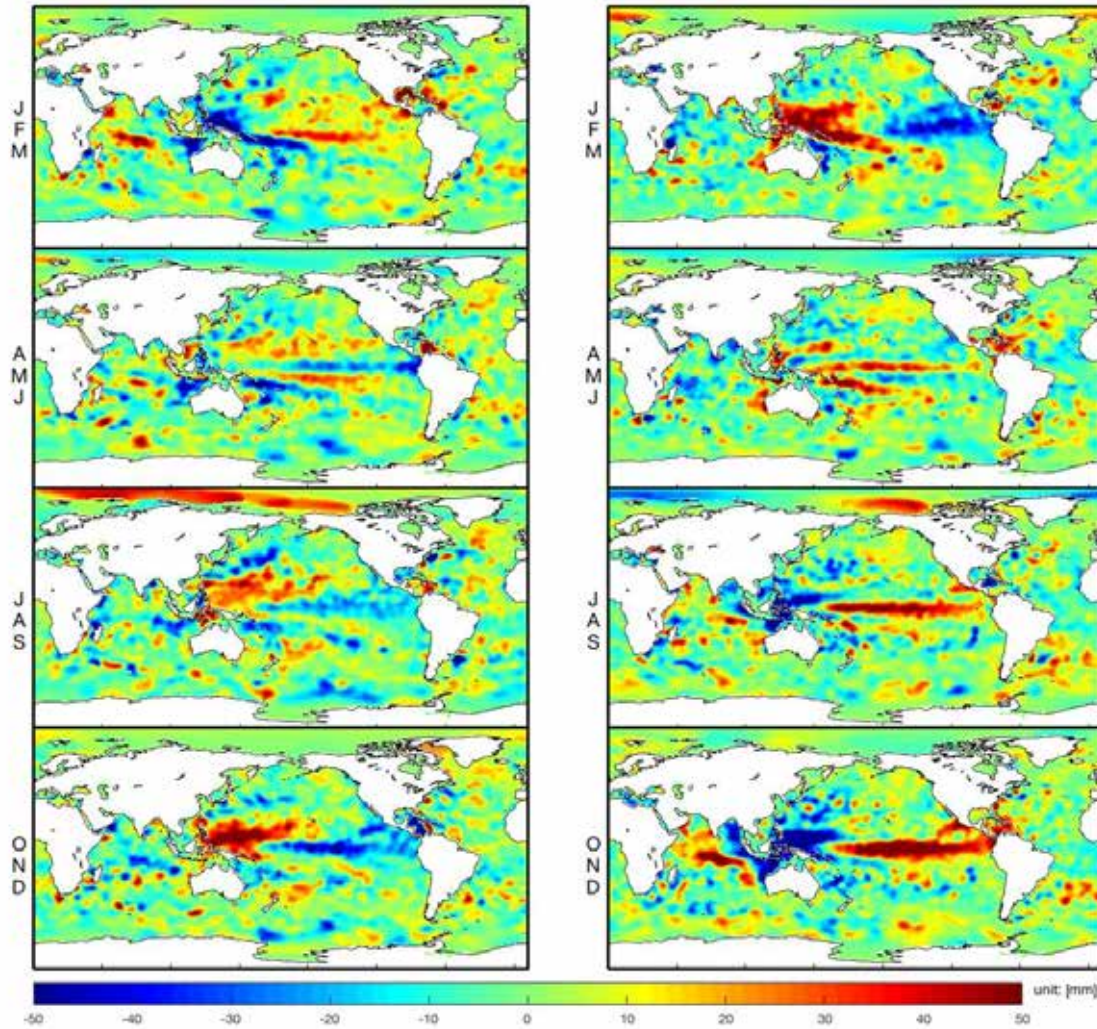- Explaining 9.0% of Total Variance

Effect of Mode 3 on Sea Level
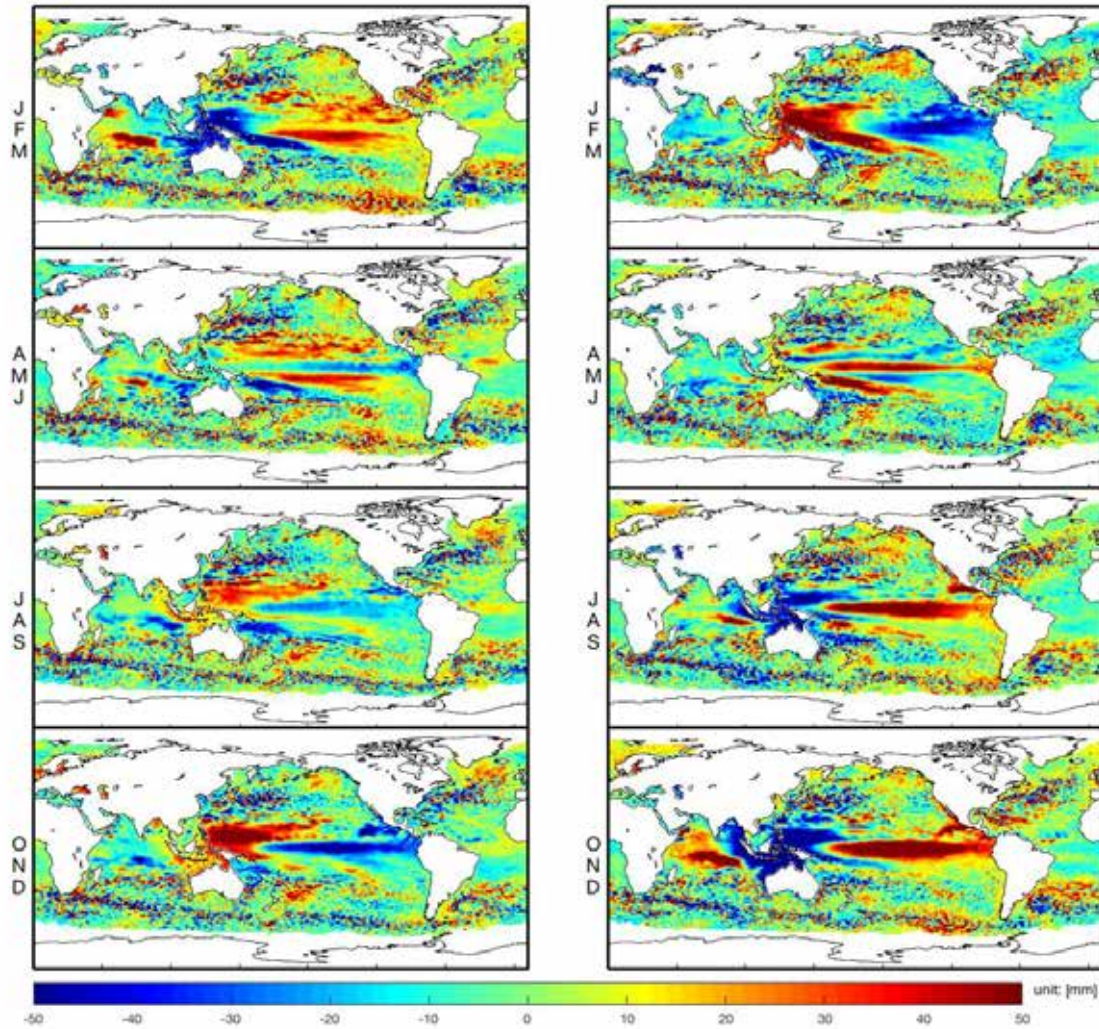
Mode: 4 (AVISO)
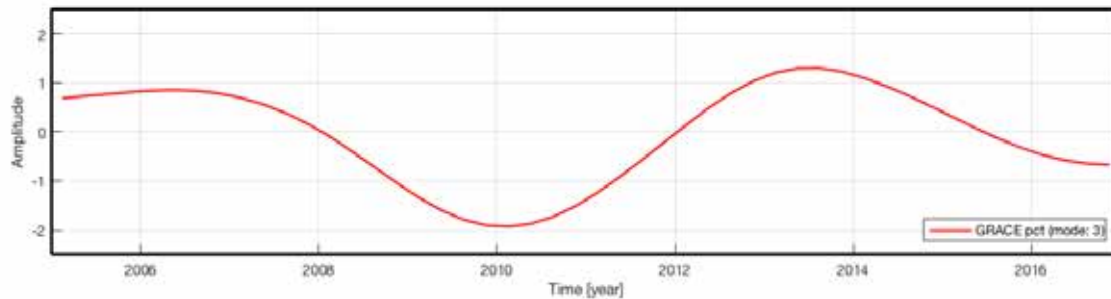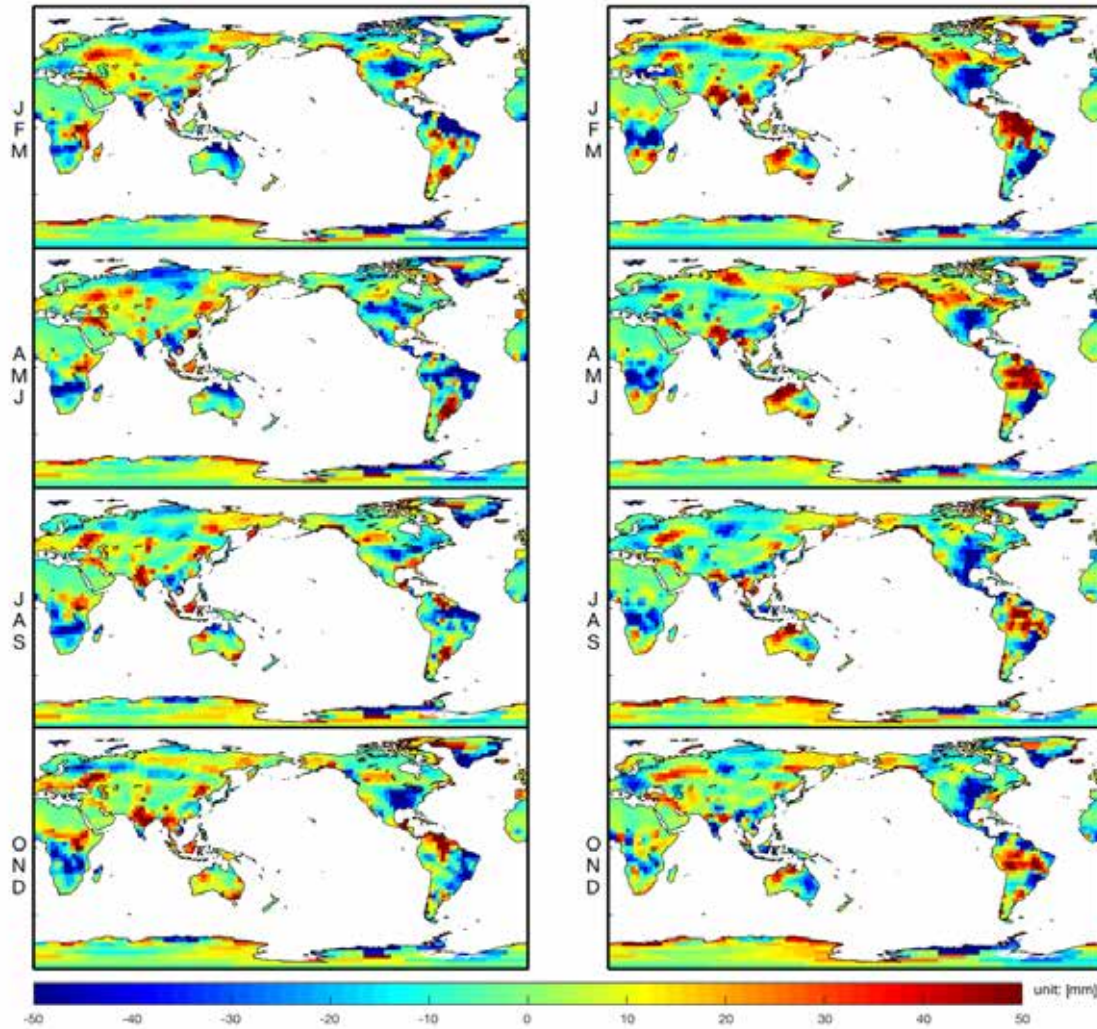
- Biennial Mode
- Explaining 6.5% of Total Variance

Mode: 4 (ARGO)

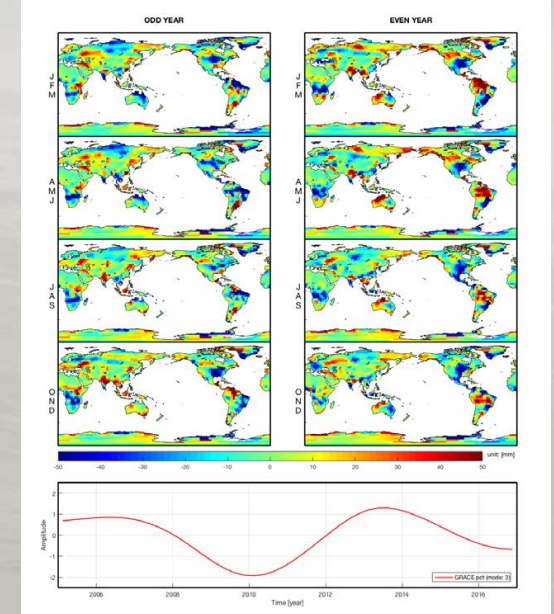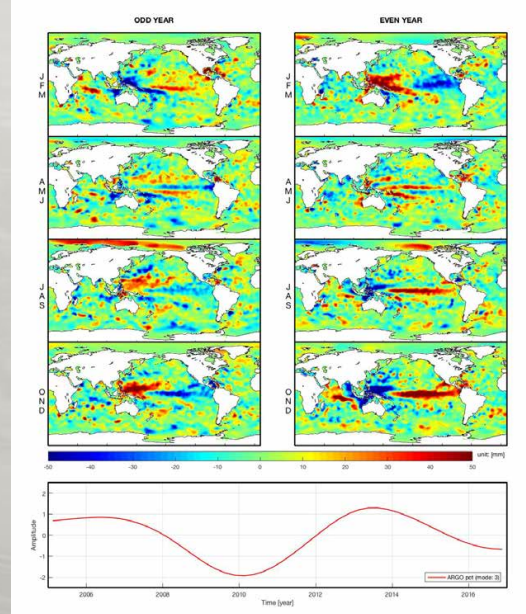- Biennial Mode
- Explaining 6.5% of Total Variance
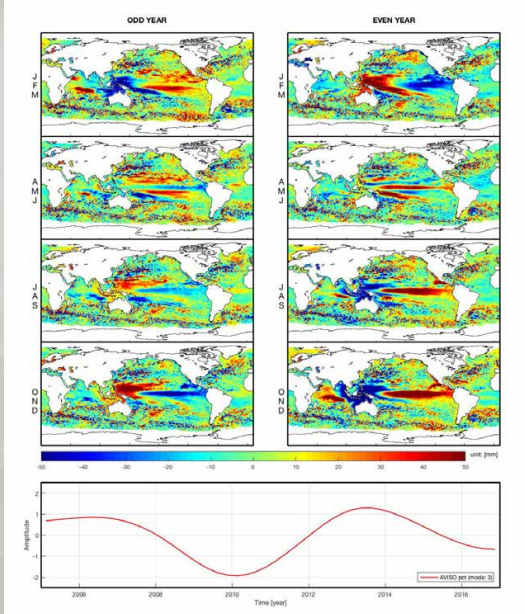
Mode: 4 (GRACE)

- Biennial Mode
- Explaining 6.5% of Total Variance

Effect of Mode 4 on Sea Level
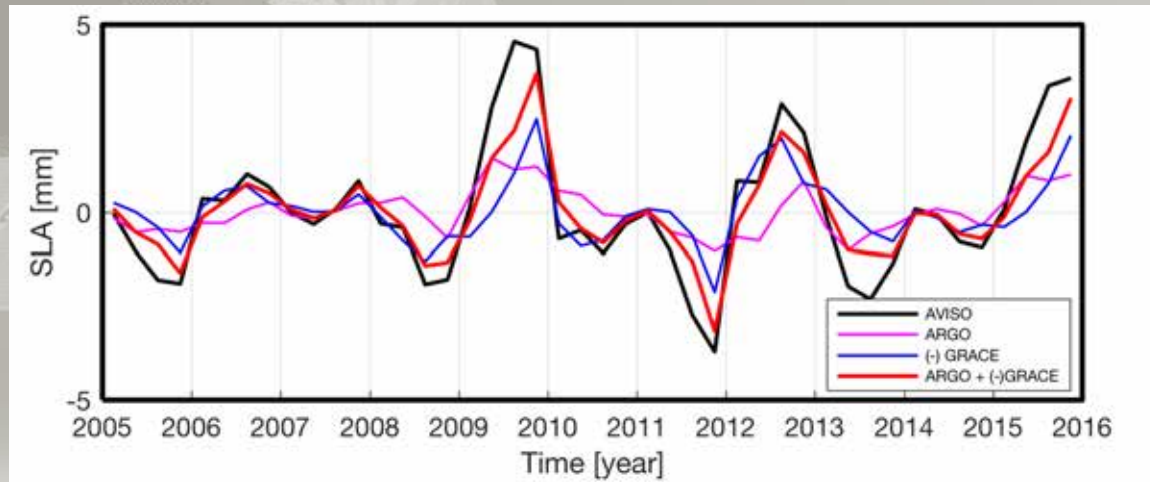
Effect of Mode 3 and 4 on Sea Level
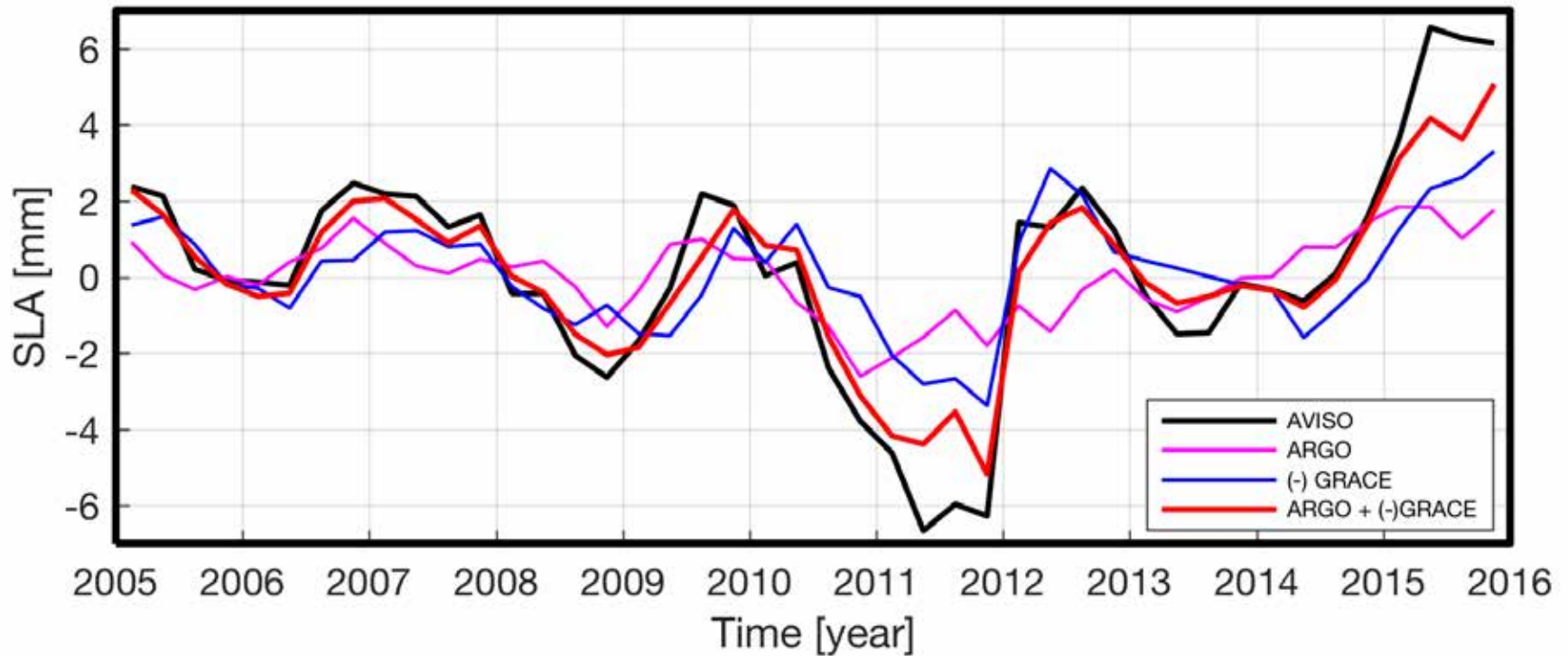
Combined CSEOF Analysis

❖ Effect on GMSL
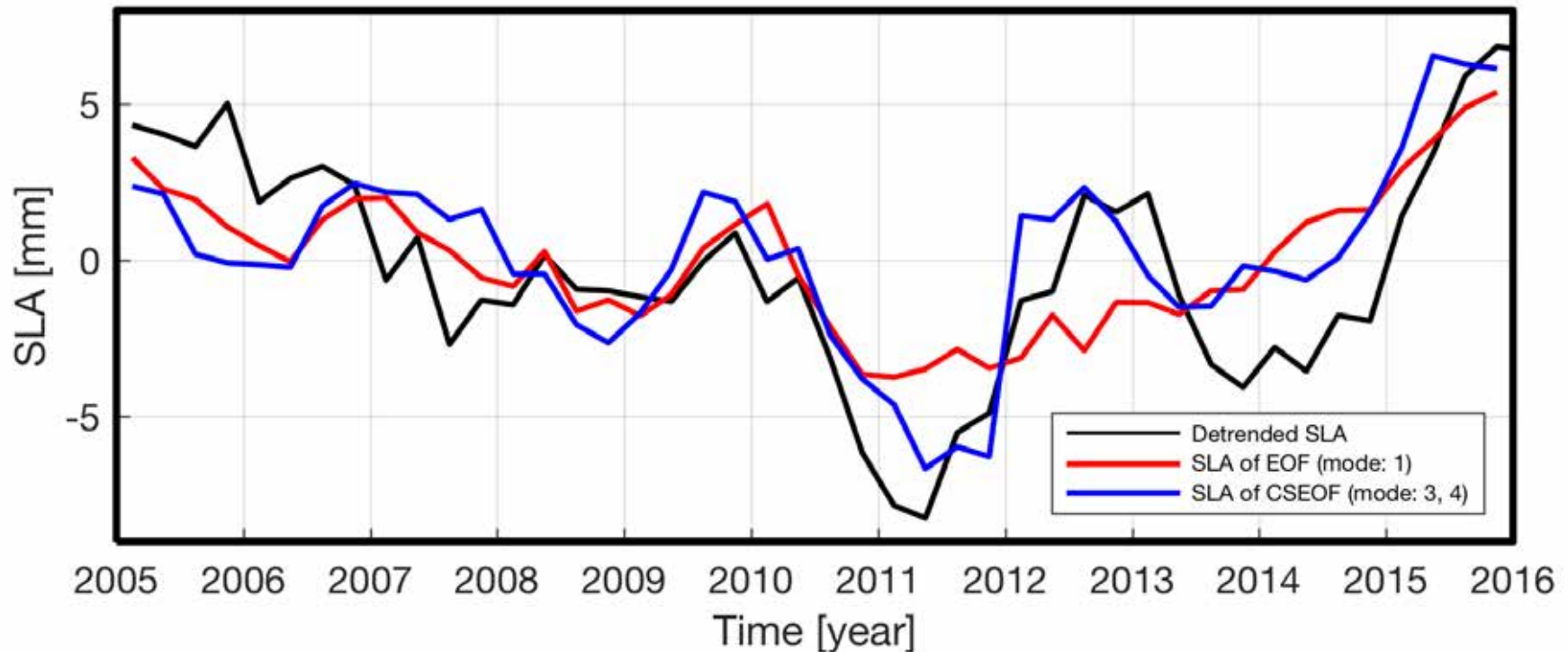
Summary

❖ To have better understand of internal variabilities in GMSL than index based analysis, we applied Combined EOF and CSEOF Analysis

❖ Combined CSEOF Analysis (AVISO, GRACE, ARGO) can isolate the inter-annual and decadal variability and trend

❖ Better indication of steric vs. mass driven internal variabilities.

❖ Isolated signals showed good balance b/w different datasets.

❖ Need to improve physical understanding/attribution of CSEOF mode

  ➢ Including additional dataset (precipitation?)
  ➢ CSEOF provides additional spatial and temporal information allowing for better interpretation

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THANK YOU