The relationship between sea level and bottom pressure in an eddy permitting ocean model

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Introduction

Motivation:

- Clearer understanding on dynamics; Separation of barotropic and baroclinic components
- To what extent can altimetry be used to infer bottom pressure and validate GRACE
- Statistical properties of bottom pressure for assimilation into ocean models

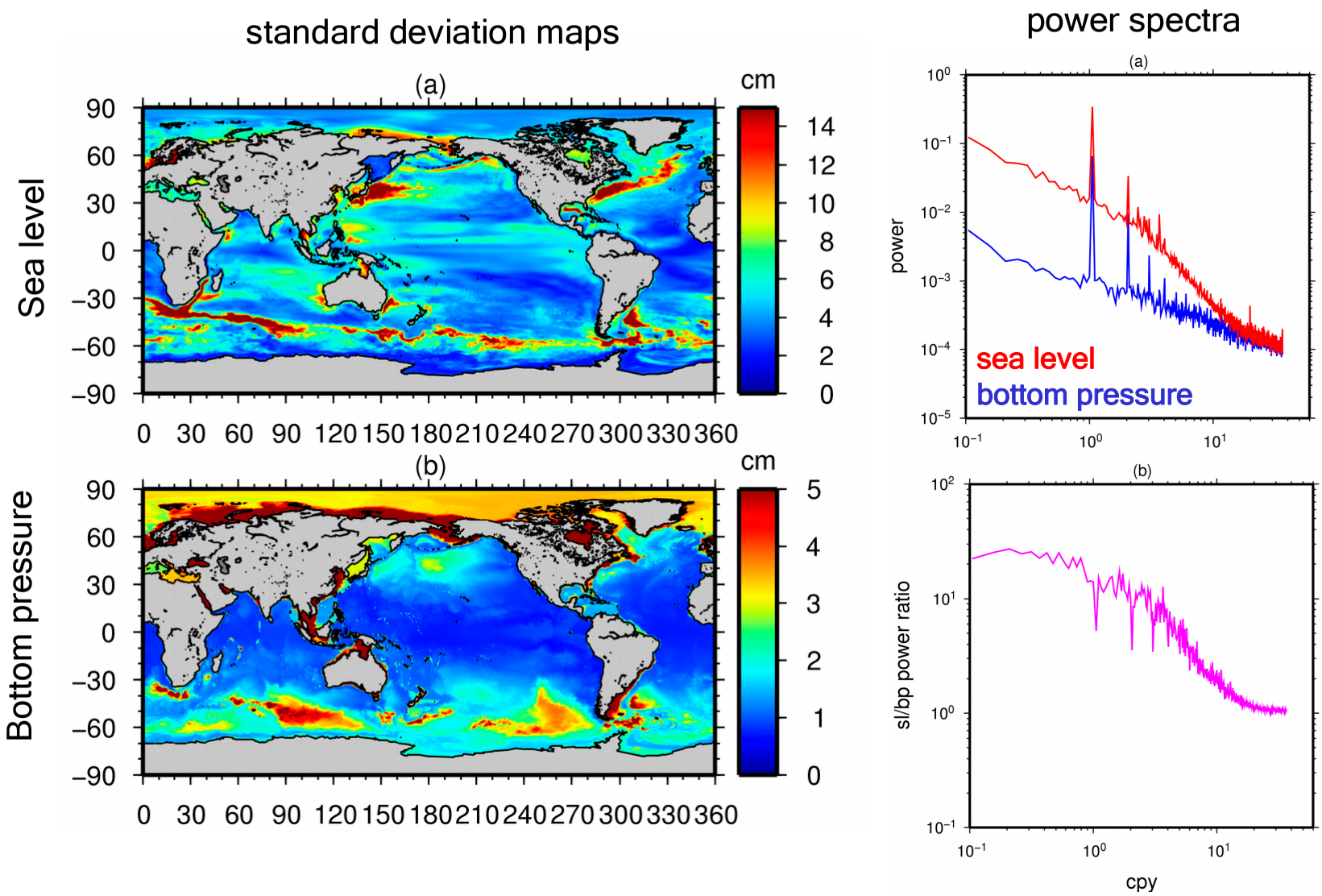
Outline:

- Variability of sea level and bottom pressure
- Co-variability of sea level and bottom pressure: geographic and frequency partitions
- EOF analysis: high and low frequencies, and Arctic Ocean.

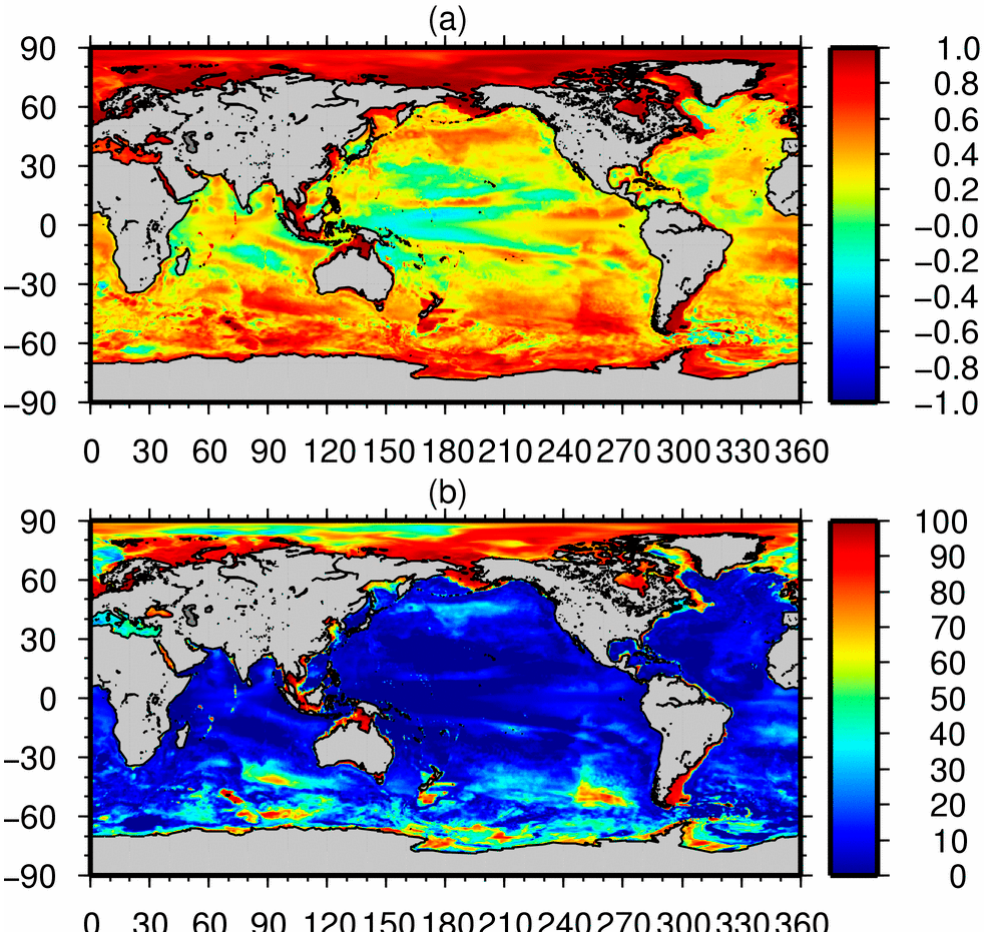
OCCAM:

- 0.25° eddy permitting resolution
- 66 vertical levels
- ECMWF 6hrly forcing
- 5 day mean fields
- 1985-2003 period after spin up

The variability of bottom pressure and sea level



The co-variability of bottom pressure and sea level: all frequencies



Correlation of sea level and bottom pressure

Percent of total sea level variance "appearing" as bottom pressure

The co-variability of BP and SL: geographical partitions

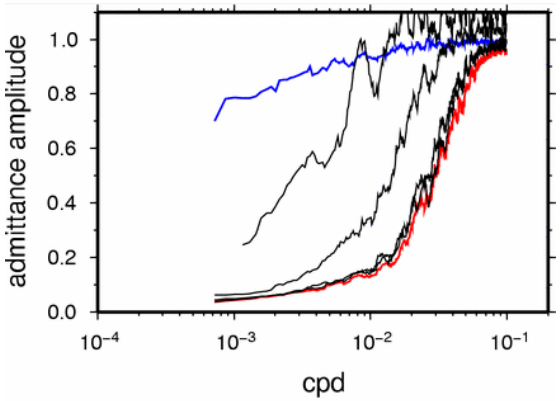
To investigate how the relationship between bottom pressure and sea level depends on frequency for a particular geographical partition we compute the admittance:

$$Z(\omega) = \frac{\sum \hat{h} \cdot \hat{p}^*}{\sum \hat{h} \cdot \hat{h}^*}$$

h, anomalous sea level
p, anomalous bottom pressure
^ signifies Fourier transform
* signifies the complex conjugate

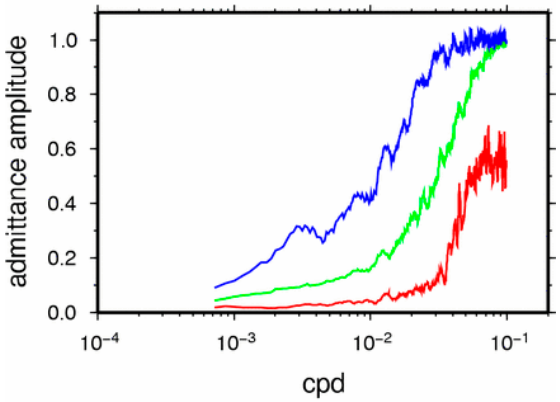
- Summation is performed over some geographic region for each frequency component
- $Z(\omega_0)$=1 implies bottom pressure and sea level variability averaged over region is identical for frequency ω_0

The co-variability of BP and SL: geographical partitions



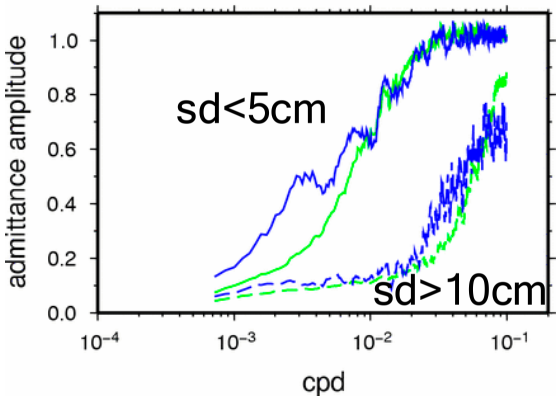
Partition according to depth:

1. Shallow (<1000m)
2. Deep (>1000m)
3. Deep averaged over 1,2,4,8 degree bins



Partition according to latitude:

1. Low (0-15°)
2. Mid (45°-65°)
3. High (65°-80°)



Partition according to latitude and sea level variance:

1. Mid (45°-65°)
2. High (65°-80°)

The co-variability of BP and SL: frequency partitions

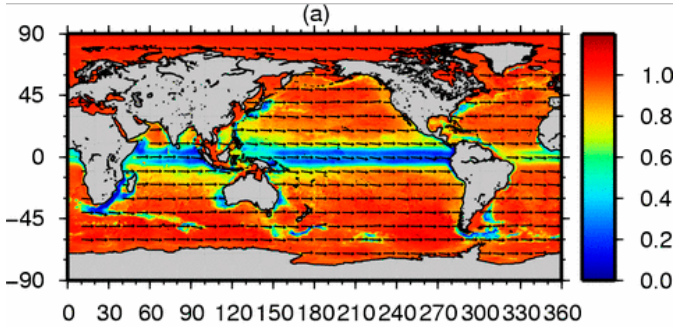
To investigate how the relationship between bottom pressure and sea level depends on geographical location for a particular frequency band we compute the admittance:

$$Z(\theta,\lambda)=\frac{\sum \hat{h}\cdot\sum \hat{p}^{*}}{\sum \hat{h}\cdot\sum \hat{h}^{*}}$$

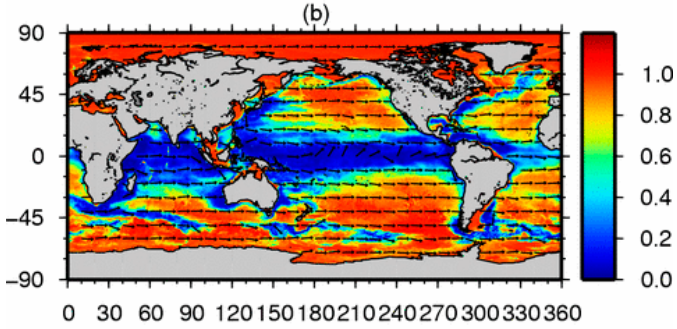
h, anomalous sea level
p, anomalous bottom pressure
^ signifies Fourier transform
* signifies the complex conjugate

- Summation is performed over some frequency band at each location
- $Z(\theta_0,\lambda_0)$=1 implies bottom pressure and sea level variability in frequency band is identical at location θ_0,λ_0

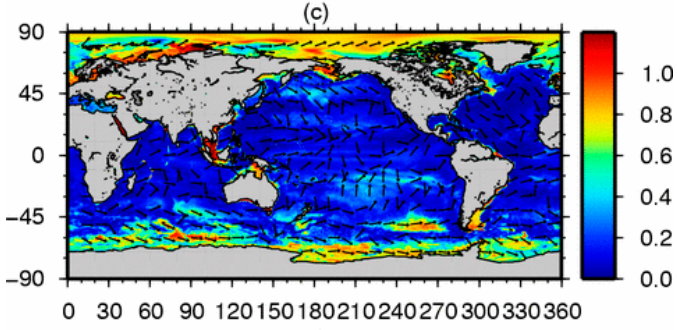
The co-variability of BP and SL: frequency partitions



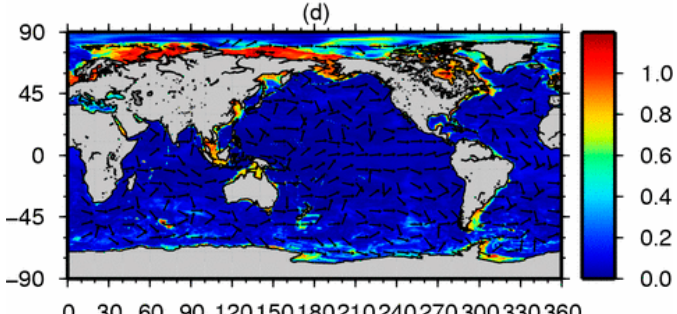
10-20 day period



20-60 day period



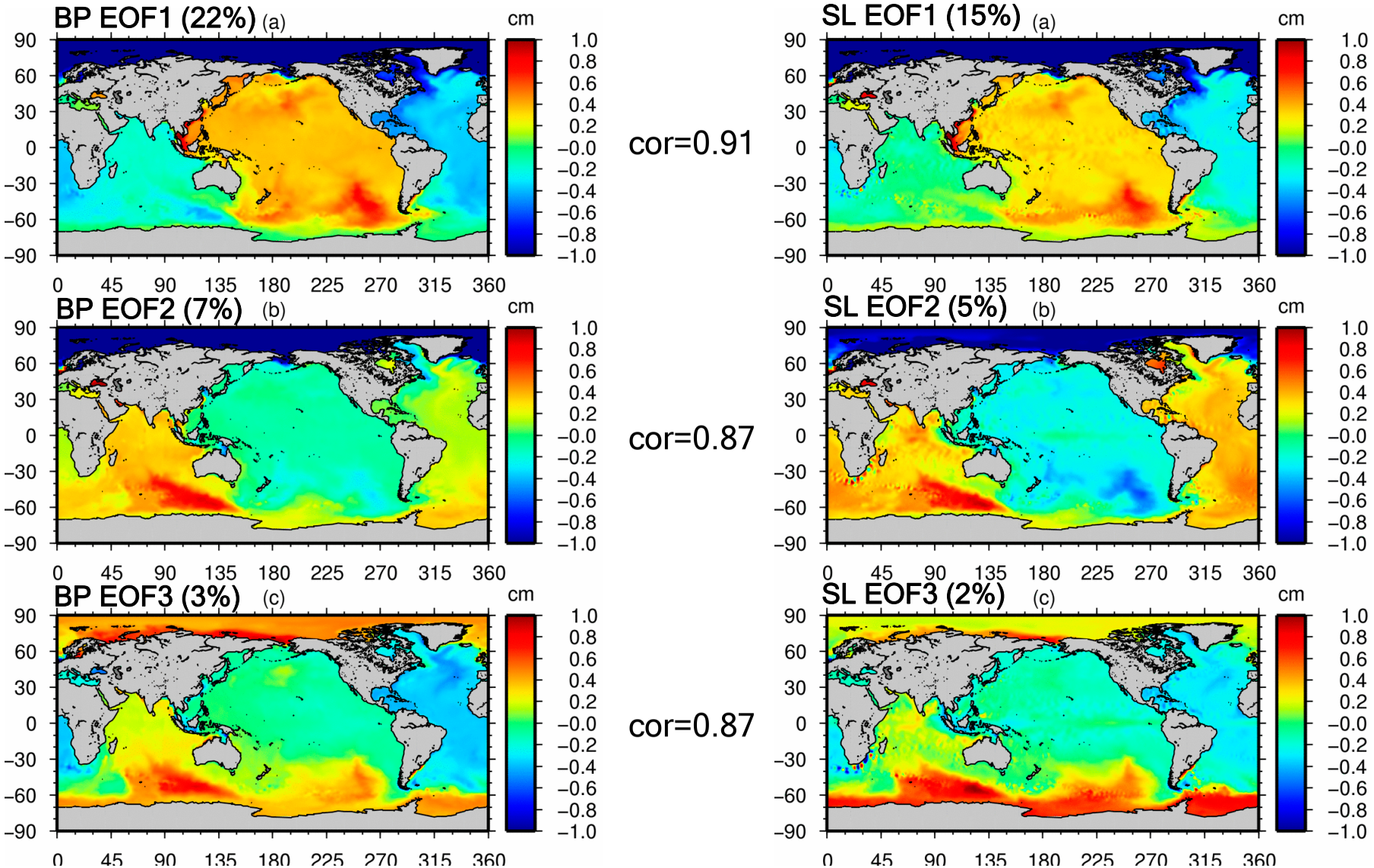
annual



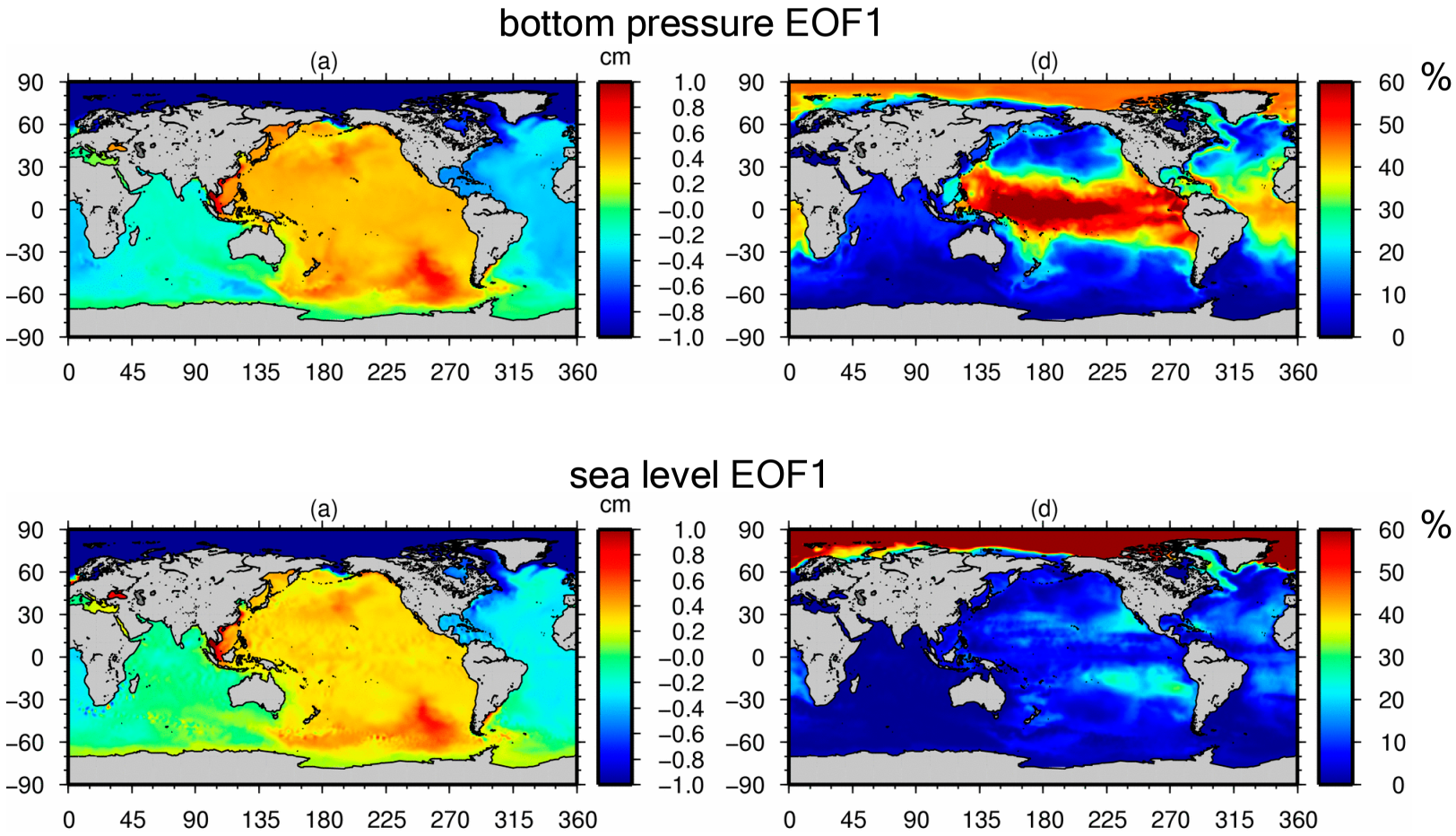
interannual

zero phase difference given by
eastward pointing vector

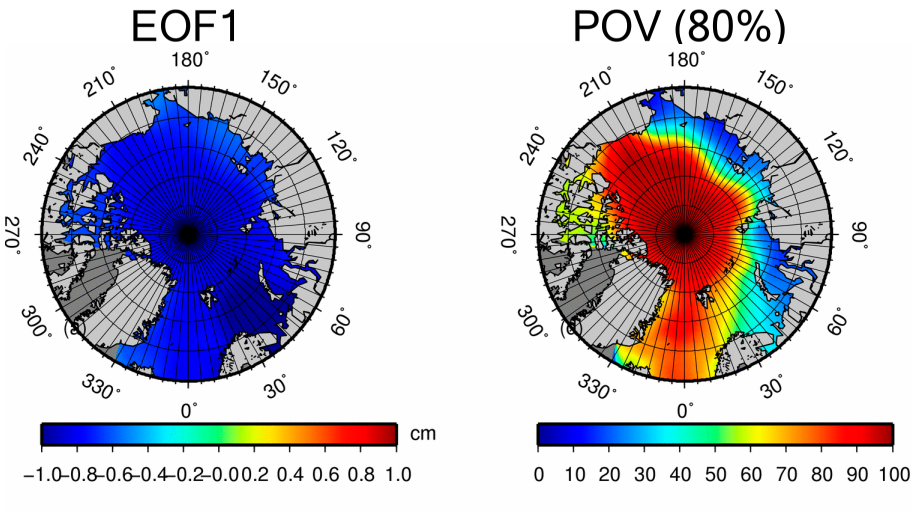
EOFs of high frequency (T<100days) bottom pressure and sea level variability



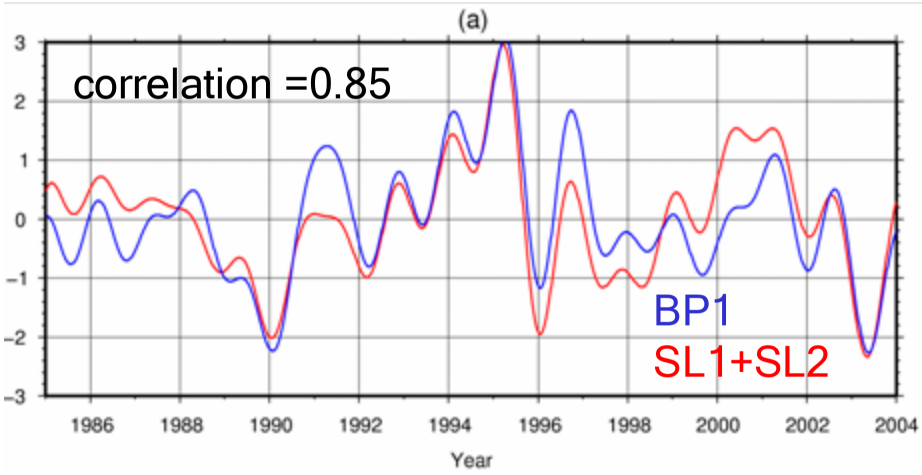
The variance accounted for the leading HF mode

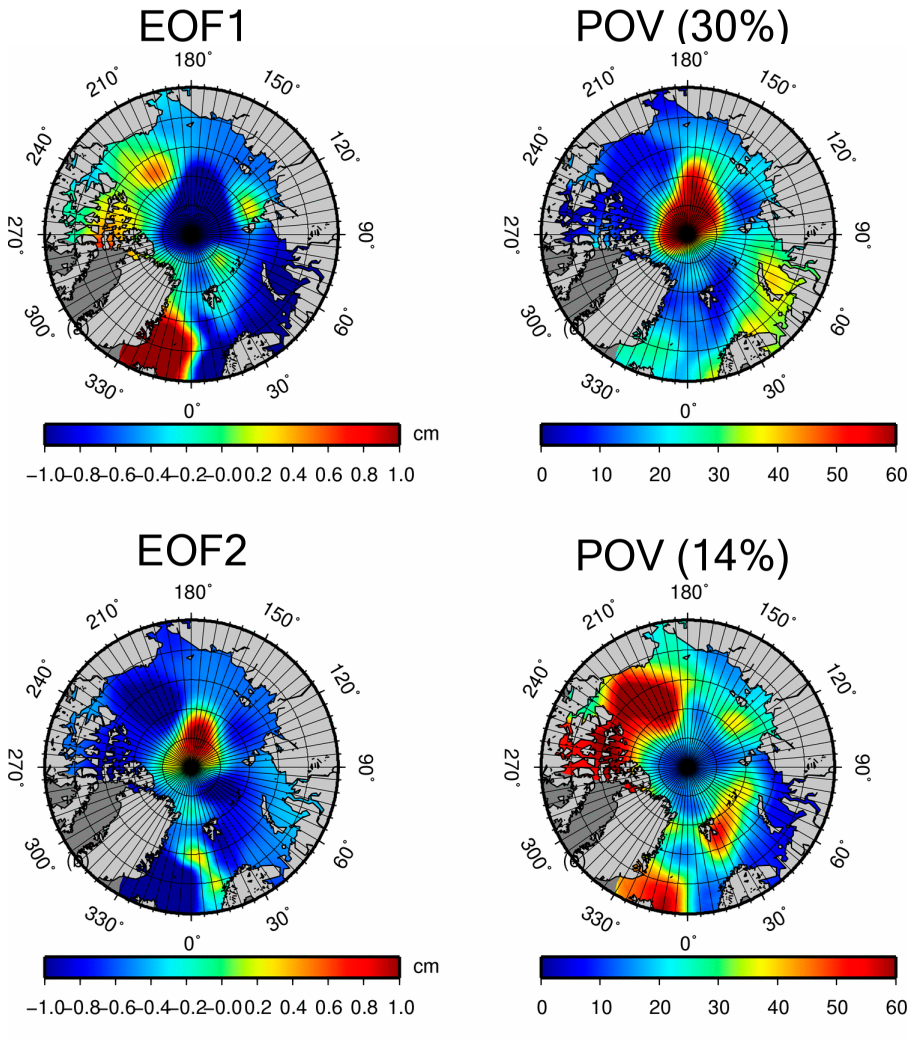


EOFs of interannual (400days< 7) BP and SL variability: Arctic basin



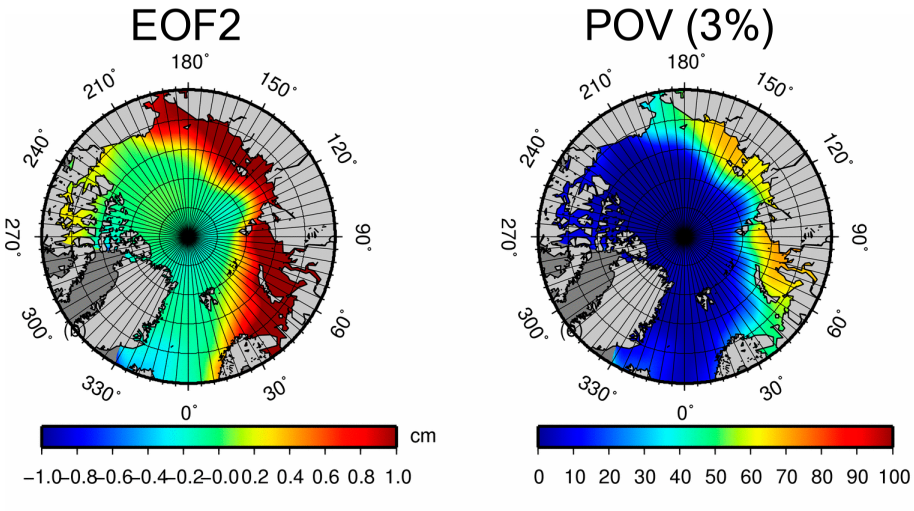
bottom pressure



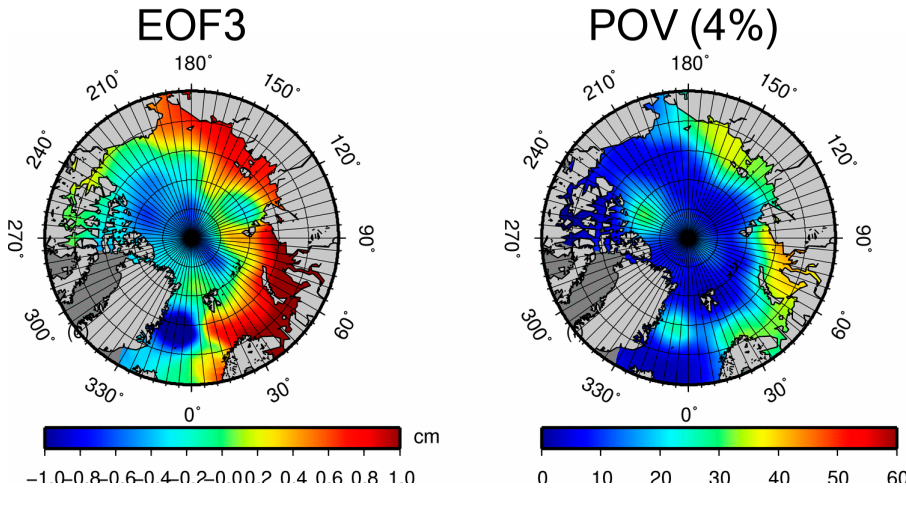


sea level

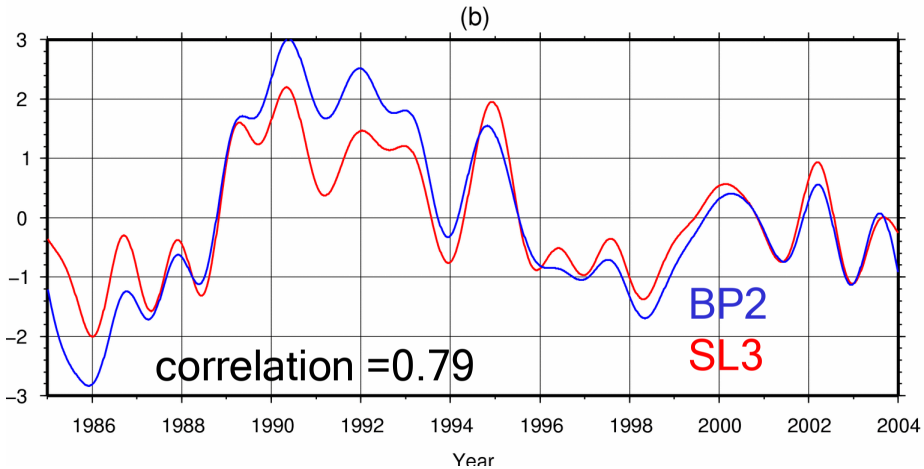
EOFs of interannual (400days< *T*) BP and SL variability: Arctic basin



bottom pressure



sea level



Summary

- Sea level power much greater than bottom pressure
- Sea level and bottom pressure relationship highly dependent on timescale and geography
- Good correspondence at high frequencies where ocean behaves barotropically. Basin scale modes account for most of HF variance globally, but outside tropics smaller scale processes are more important.
- In most of deep ocean correspondence falls off rapidly with increasing timescale so little similarity at annual. Relationship disrupted to the presence of small scale energetic eddies, particularly in boundary currents
- The Arctic is an exception. Single basinwide mode dominants BP and SL at interannual timescales. Interannual relationship also on shelf seas.