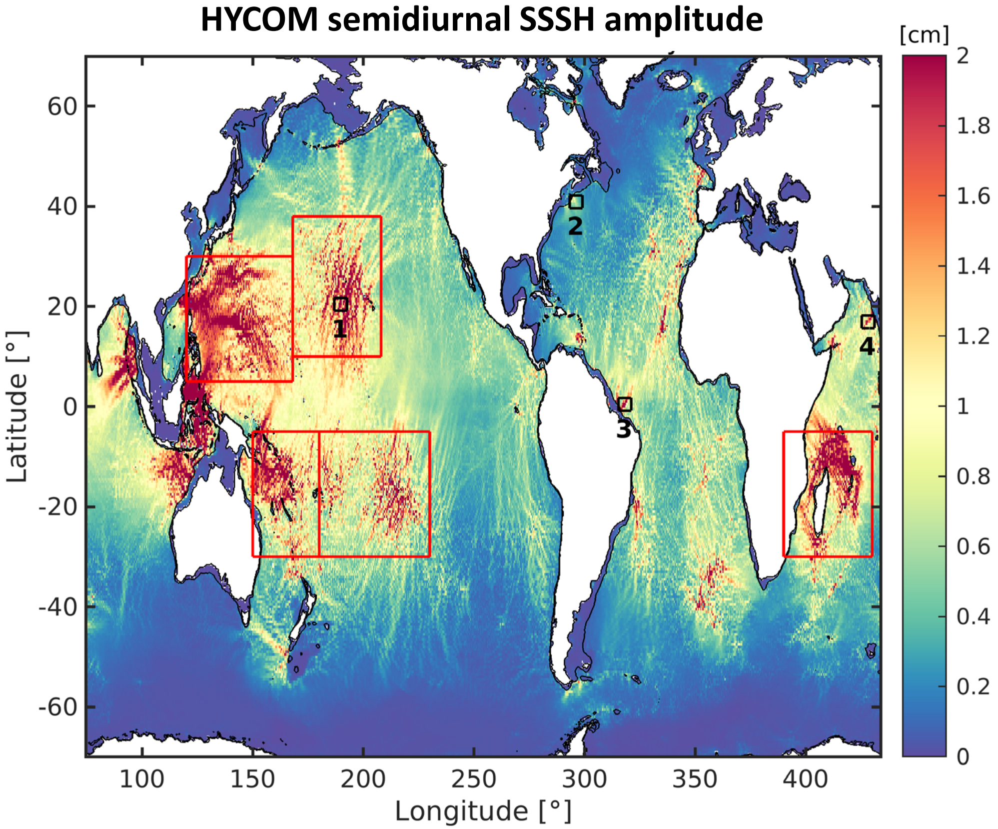
Internal tides in global HYCOM

1) *Oladeji Siyanbola - graduate student*
   Impact of remote internal tides on coastal dynamics

2) *Harpreet Kaur - graduate student*
   Semidiurnal internal tide variability: differences between SSSH and energetics



Maarten Buijsman, Harpreet Kaur, Oladeji Siyanbola, Brian Arbic, Jay Shriver, Roy Barkan, Audrey Delpech, Zhongxiang Zhao, and others

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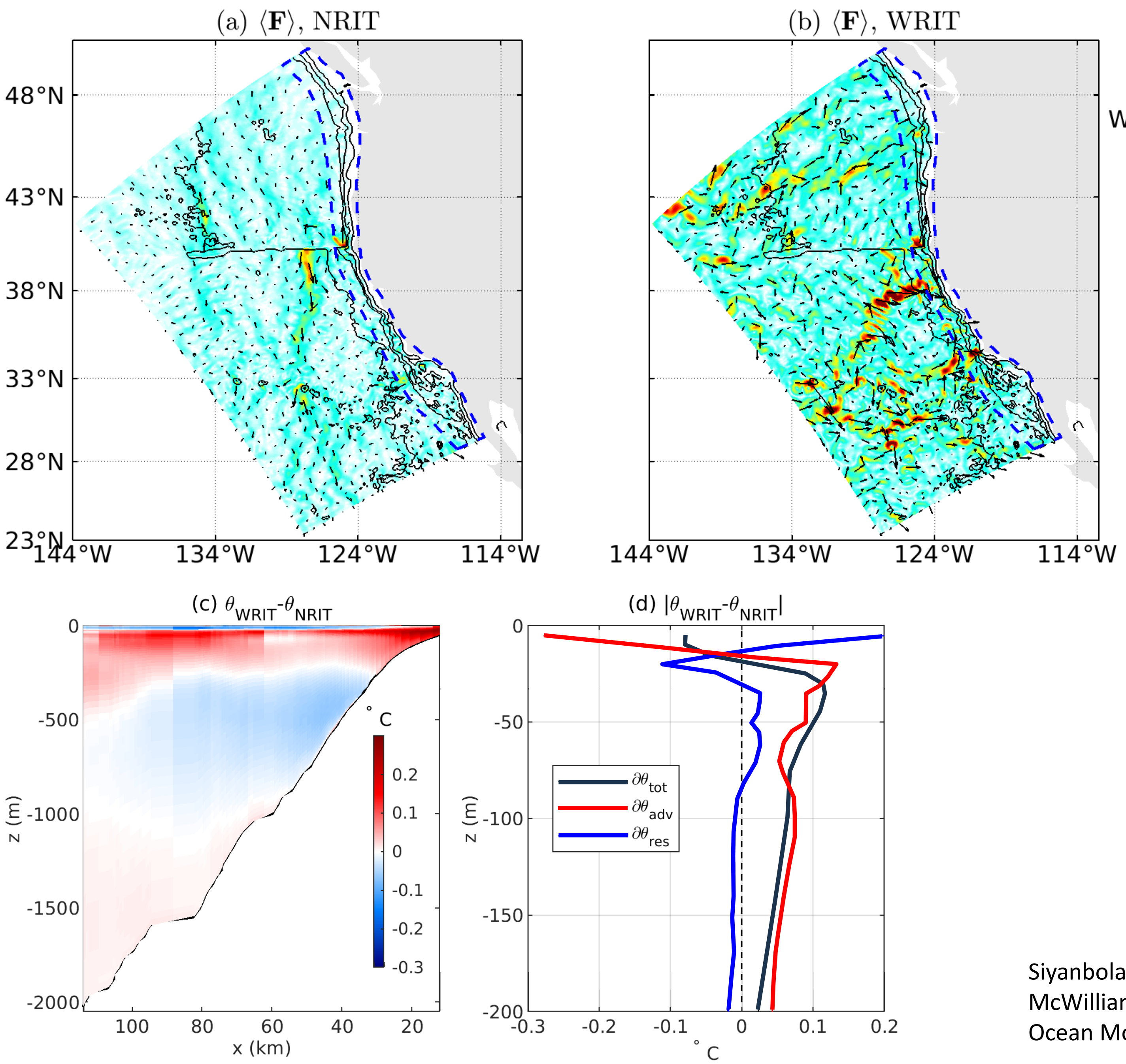
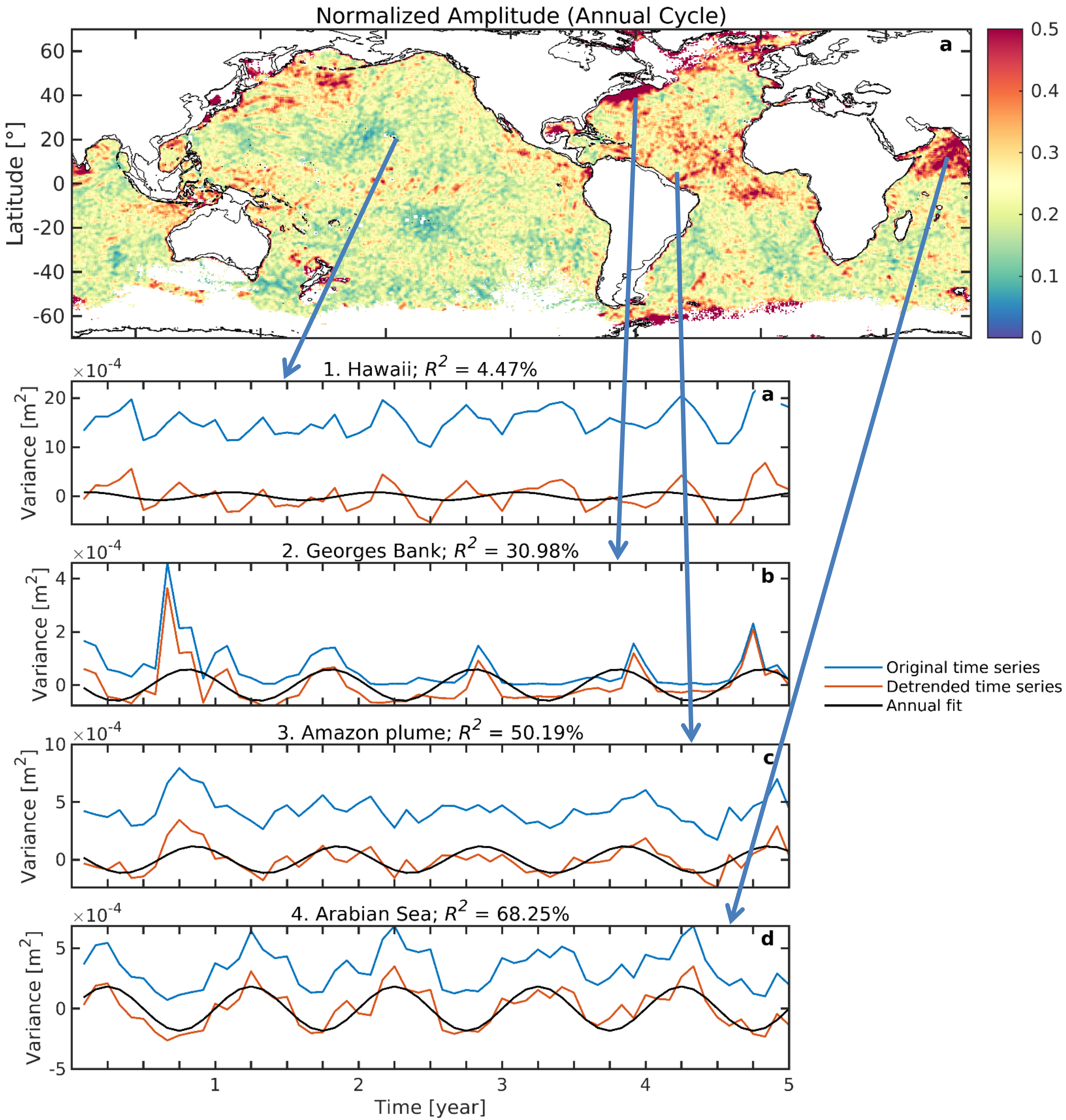
1) Impact of remote internal tides on coastal dynamics



- Regional ROMS simulations of US West coast forced
  - without remote internal tides (**NRIT**)
  - with remote internal tides (**WRIT**) from a global HYCOM simulation
- Remote IT enhance reflections, mode scattering, and water-mass trans-formations (changes in pot. temp θ): surface cooling and warming below
- $\partial\theta_{tot} = \partial\theta_{adv} + \partial\theta_{res}$ is mostly attributed to advection $\partial\theta_{adv}$ and to a lesser extend to mixing θ_{res}, computed as the residual

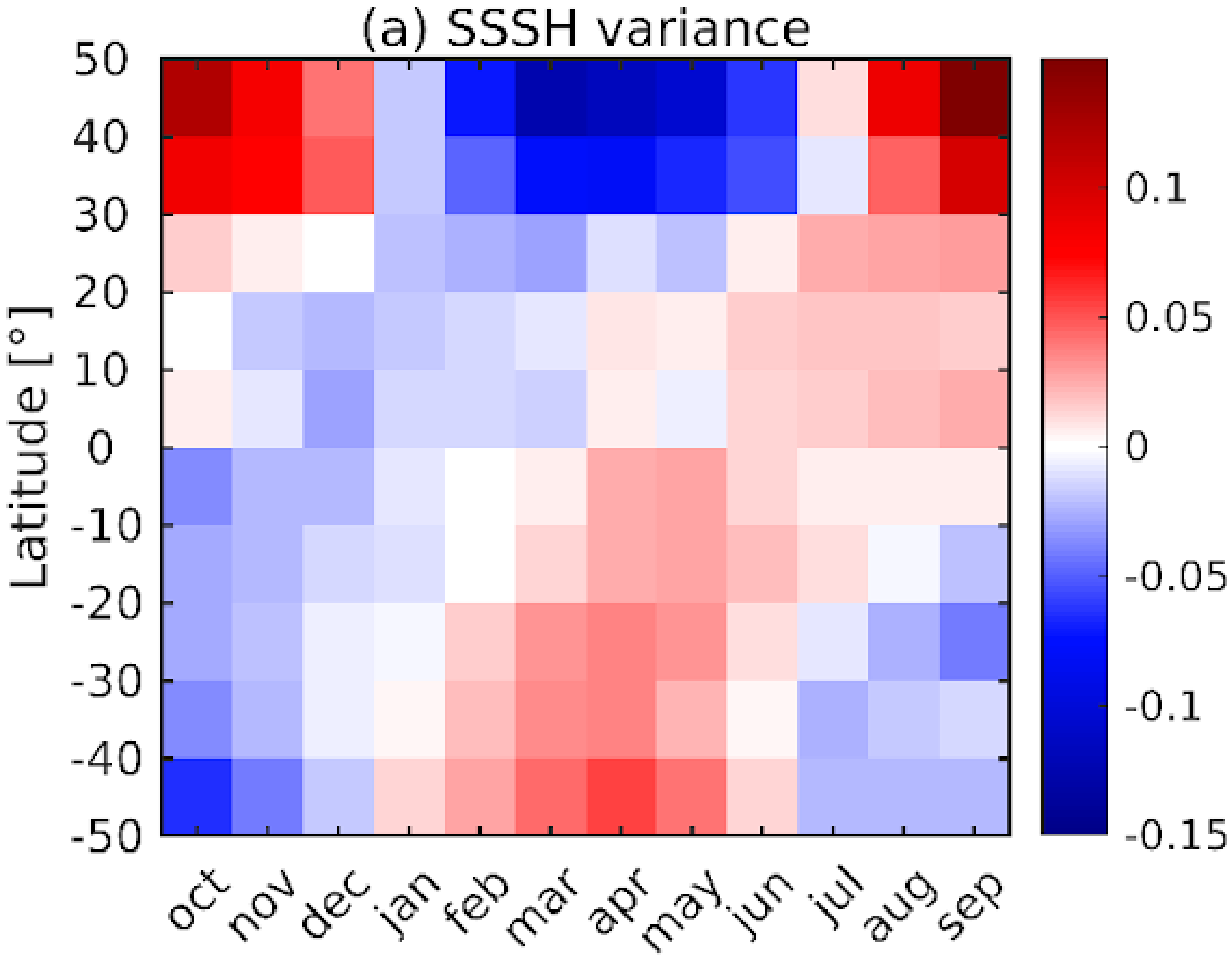
Siyanbola, O. Q., M. C. Buijsman, A. Delpech, L. Renault, R. Barkan, J. F. Shriver, B. K. Arbic, J. C. McWilliams (2023), Remote internal wave forcing of regional ocean simulations near the U.S. West Coast, Ocean Modelling, 181, 102154, https://doi.org/10.1016/j.ocemod.2022.102154

2) Semidiurnal internal tide variability: differences between SSSH and energetics



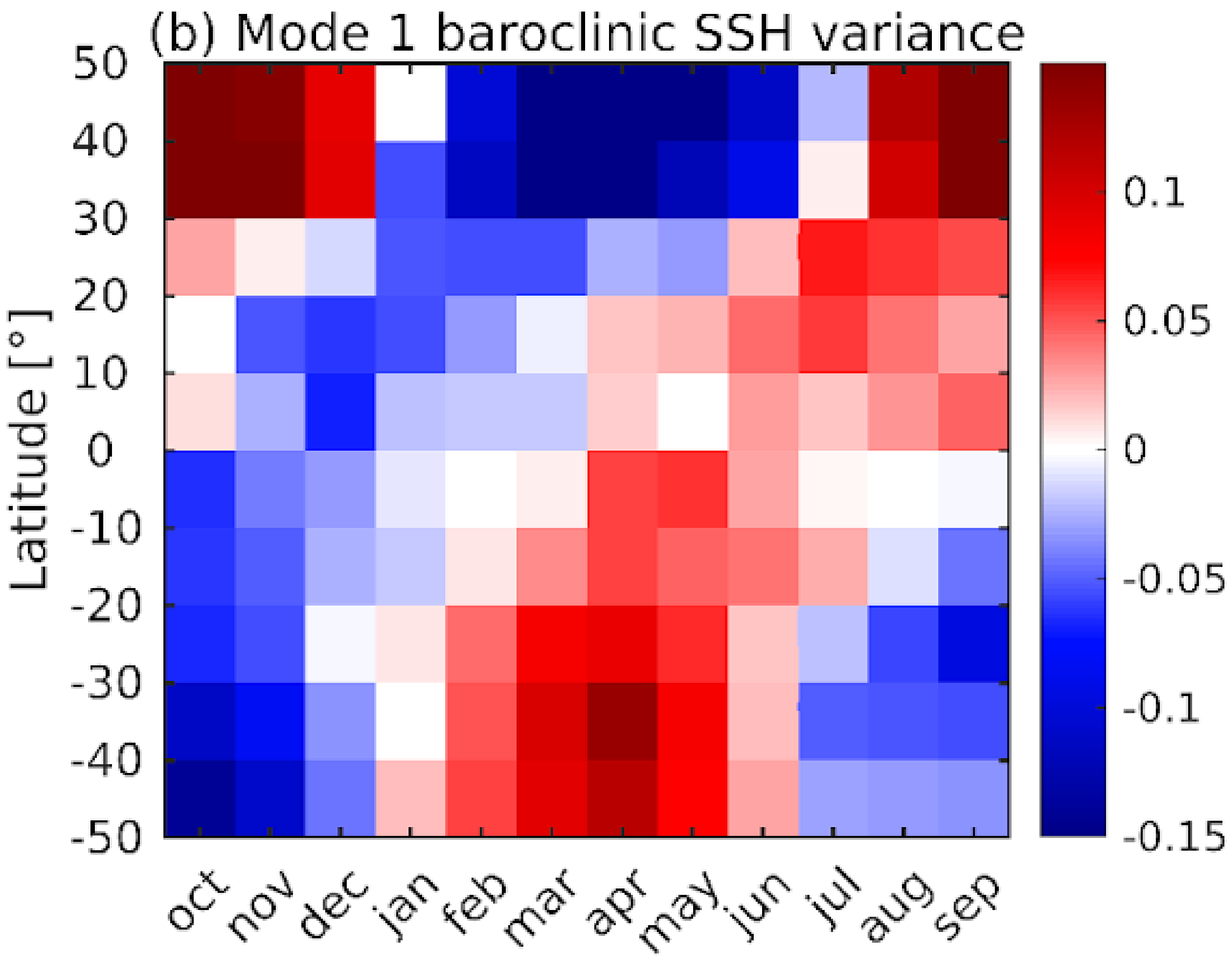
- Extract monthly amplitudes and phases of M_2, S_2, N_2 for 5-year long HYCOM time series of SSSH
- Compute monthly D2 variance σ^2
- Fit annual cycle
- **Georges Bank** and **the Arabian Sea** have the largest seasonal semidiurnal internal tide variability
- Northen hemisphere is 180° out of phase with southern hemisphere

Seasonal SSSH anomalies in the Pacific Ocean



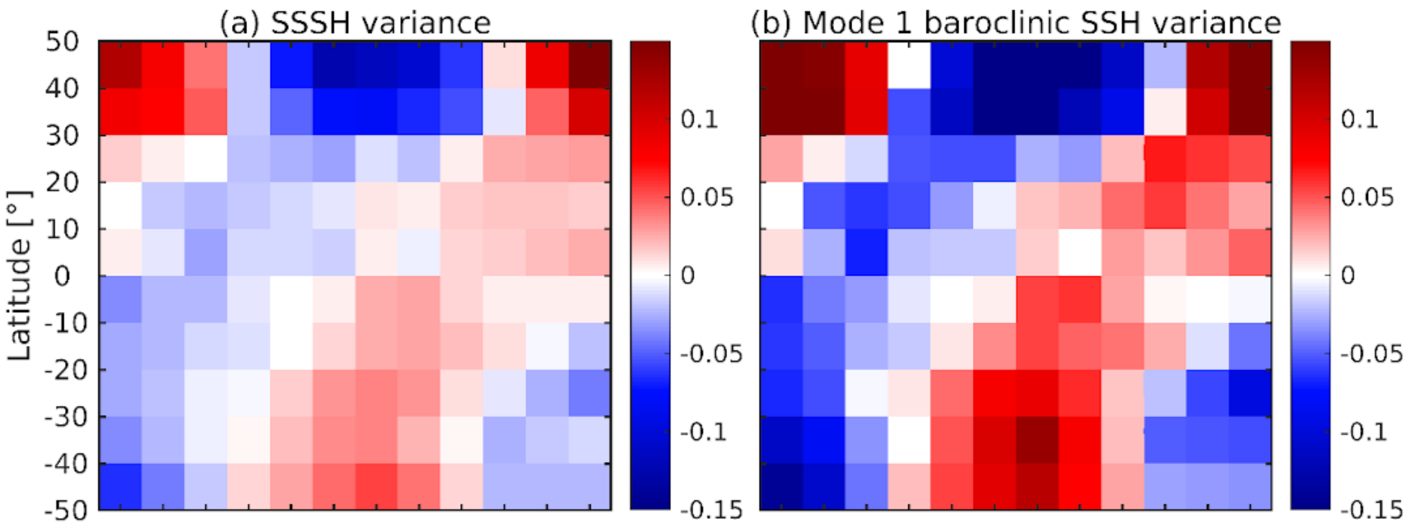
- Monthly D2 variance σ^2 is averaged zonally for each ocean basin and 10° latitude bins
- $anomaly = \frac{\sigma^2 - \overline{\sigma^2}}{\overline{\sigma^2}}$
- Maximum D2 variance occurs at the end of summer
- Seasonal amplitude is 10-15% of mean variance $\overline{\sigma^2}$
- NH and SH are out of phase

Seasonal mode 1 SSH anomalies in the Pacific Ocean



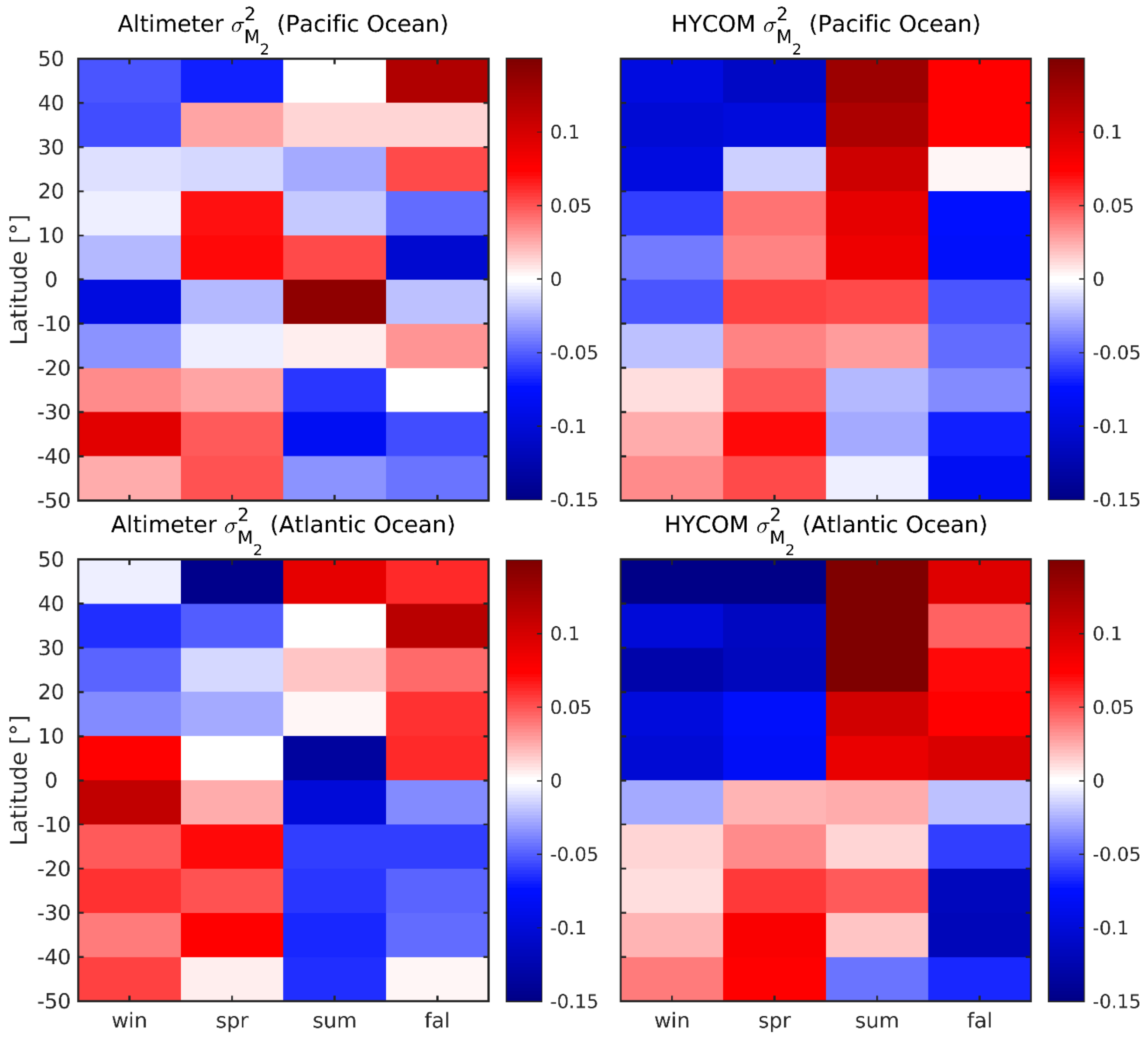
- For a 1-year time series
    1. Compute monthly modal eigen-functions $\mathcal{U}$
    2. Project $\mathcal{U}$ on $\mathbf{u}'$ and p' to extract modal amplitude time series $\hat{\mathbf{u}}_n$ and $\hat{p}_n$
    3. Compute mode-1 SSH variance for $M_2 + S_2 + N_2$ for each month
    4. Compute anomalies
- Results are similar as SSSH
- **Do we see the same trends for the D2 energetics?**

Seasonal mode 1 KE+APE anomalies in the Pacific Ocean



- SSSH and mode 1 SSH
- We compute depth-integrated monthly-mean mode 1 KE and APE
- The seasonal trends in KE and APE are different
- SSH variance computed from mode 1 bottom pressure also shows the same trend as KE and APE

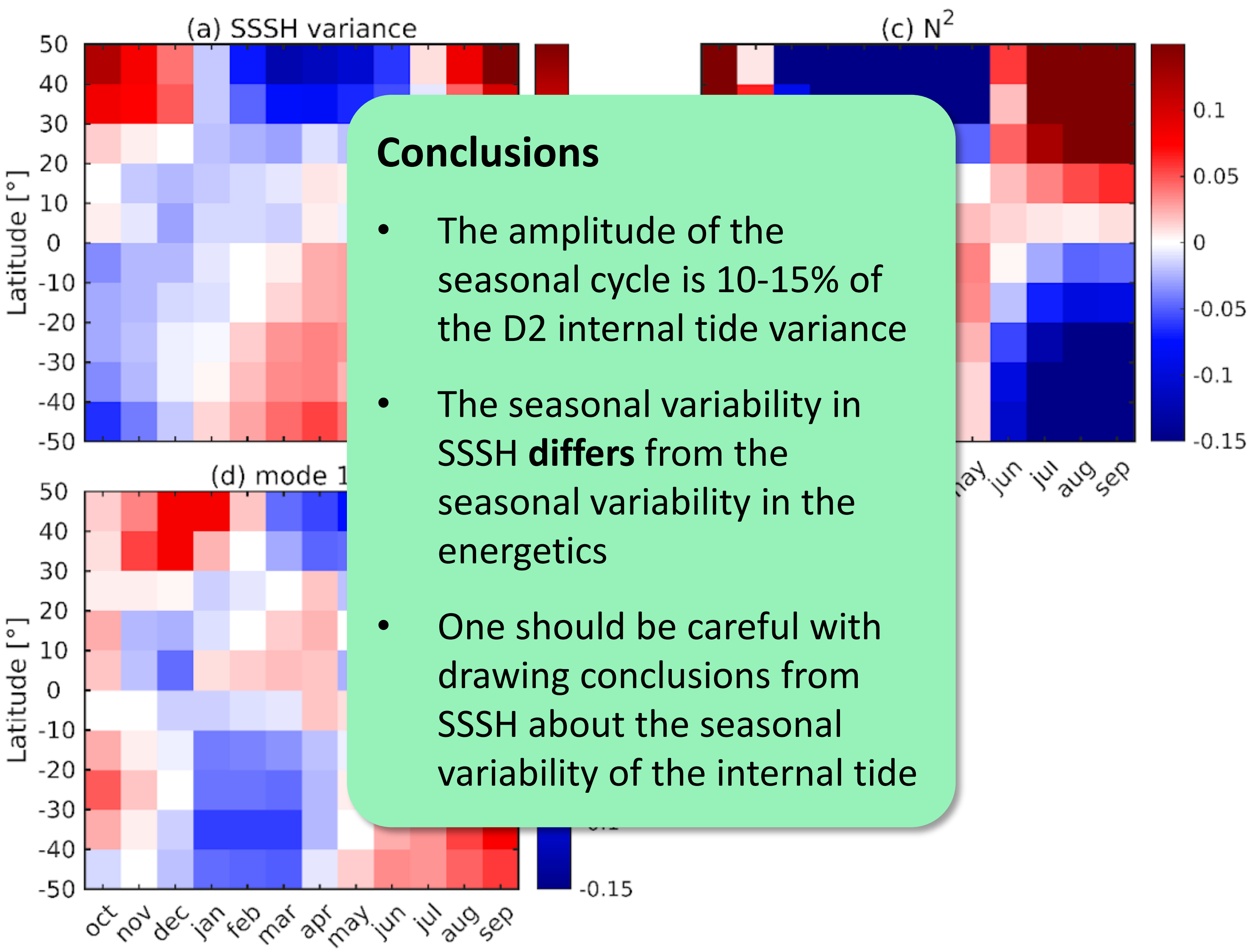
HYCOM SSSH and KE vs. altimetry SSSH anomalies



- Is SSSH variability a model artifact?
- We compare M_2 mode 1 SSH variance from altimetry (Zhao, 2021) with that of HYCOM for 4 seasons
- The trends for HYCOM and altimeter SSH **are similar**
  ⟹ not an artifact!
- However, they differ from the seasonal trends in KE

Zhao (2021), Seasonal Mode-1 M2 Internal Tides from Satellite Altimetry, JPO, https://doi.org/10.1175/JPO-D-21-0001.1

A rough idea that needs to be vetted



Conclusions

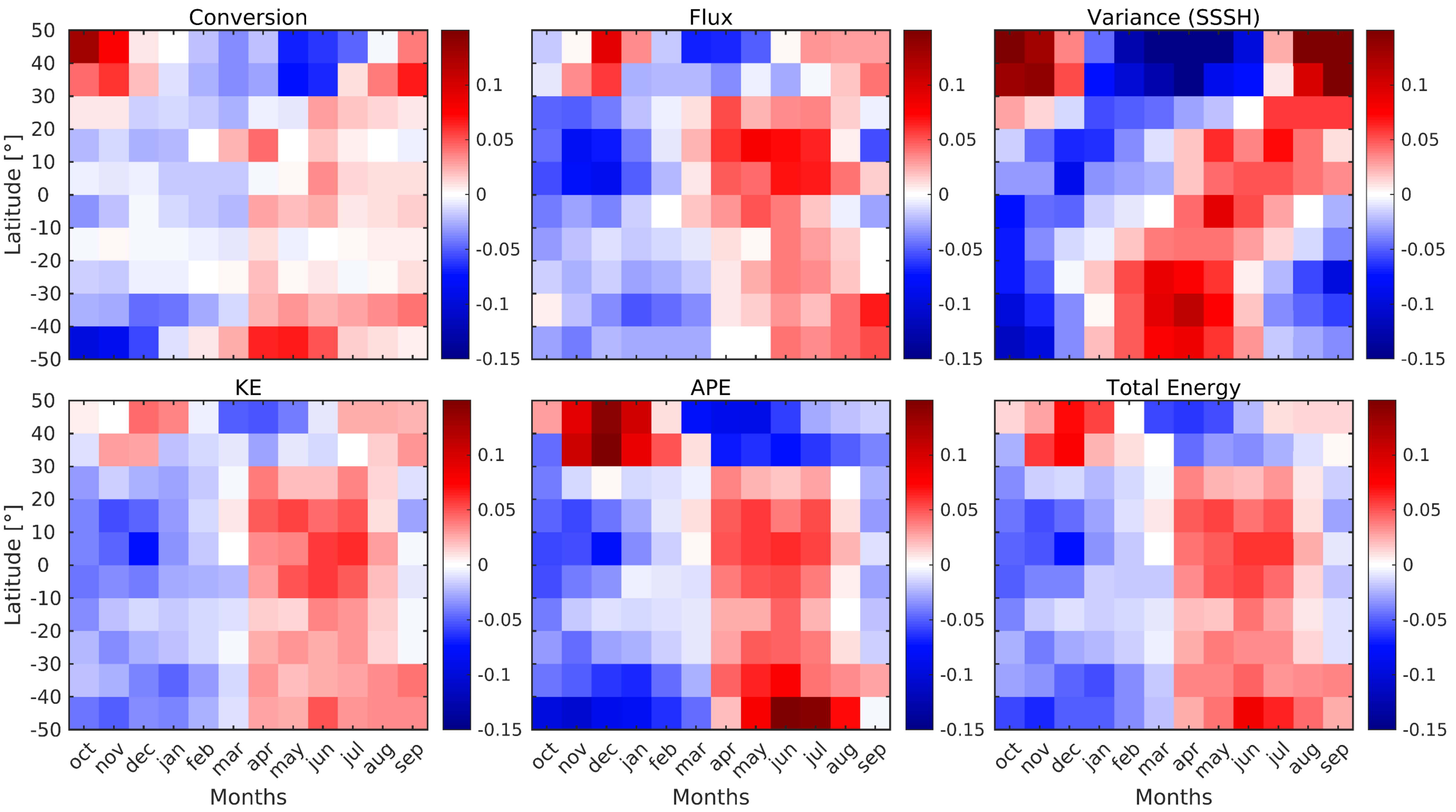
- The amplitude of the seasonal cycle is 10-15% of the D2 internal tide variance
- The seasonal variability in SSSH **differs** from the seasonal variability in the energetics
- One should be careful with drawing conclusions from SSSH about the seasonal variability of the internal tide

- If one assumes the energy input *C* into the internal tide is constant throughout the year, then

  KE = APE $\sim \frac{\rho'^2}{\frac{\partial\bar{\rho}}{\partial z}}$ = constant

- If $\frac{\partial\bar{\rho}}{\partial z}$ is larger in summer, then ρ'^2 needs to also increase for APE to stay constant
- Larger ρ' feeds back to larger p' and SSSH
- However, depth-mean $N^2 = -\frac{g}{\rho_0}\frac{\partial\bar{\rho}}{\partial z}$ is 1-2 months ahead of SSSH ……
- Note, SSH is modulated by both the true energy input *C* and $\frac{\partial\bar{\rho}}{\partial z}$
- To be continued …..

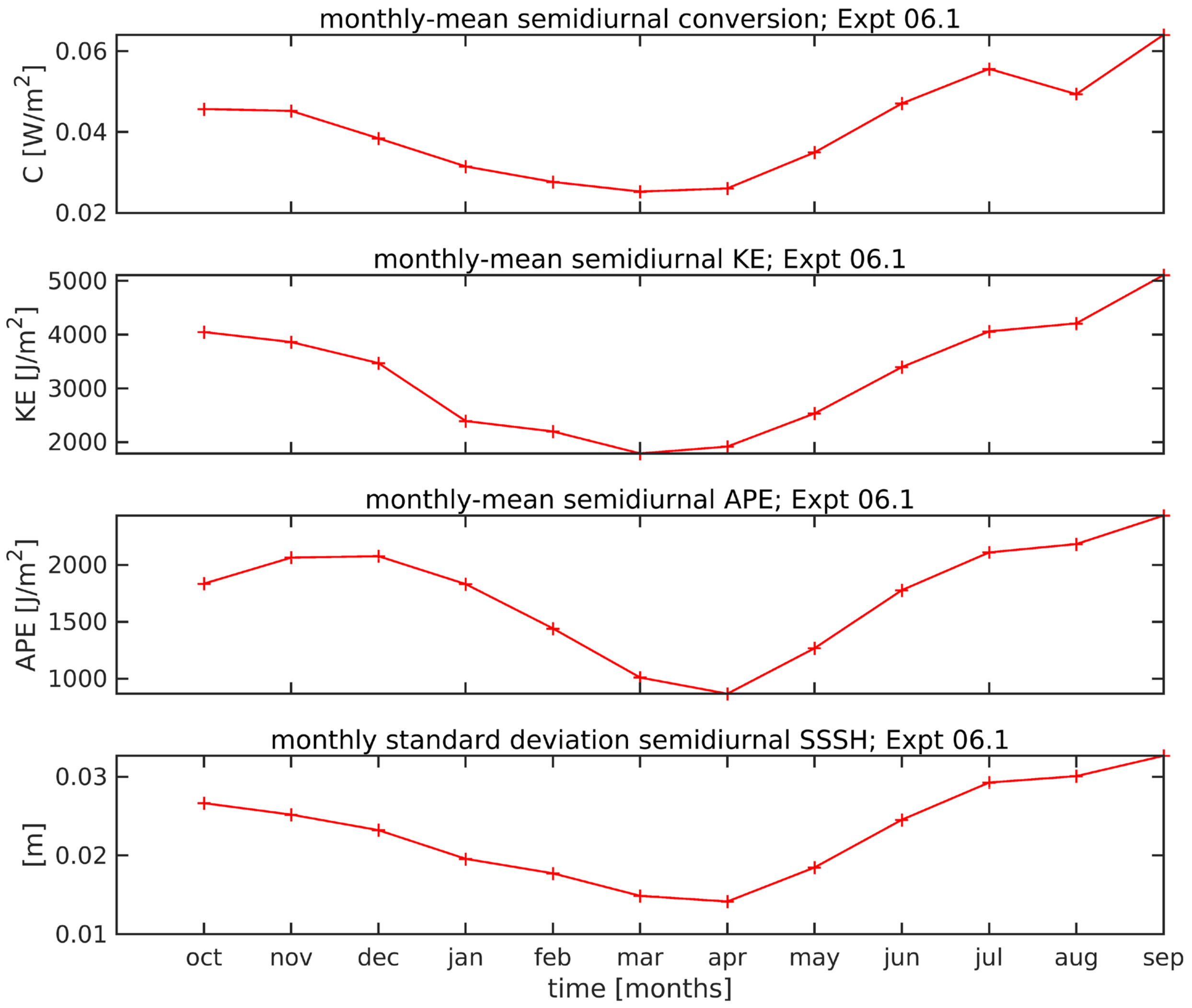
Monthly D2 anomalies Pacific Ocean



SSSH and KE anomalies in IT hotspots

dominated by energy input into internal tide

Georges Bank



Arabian Sea