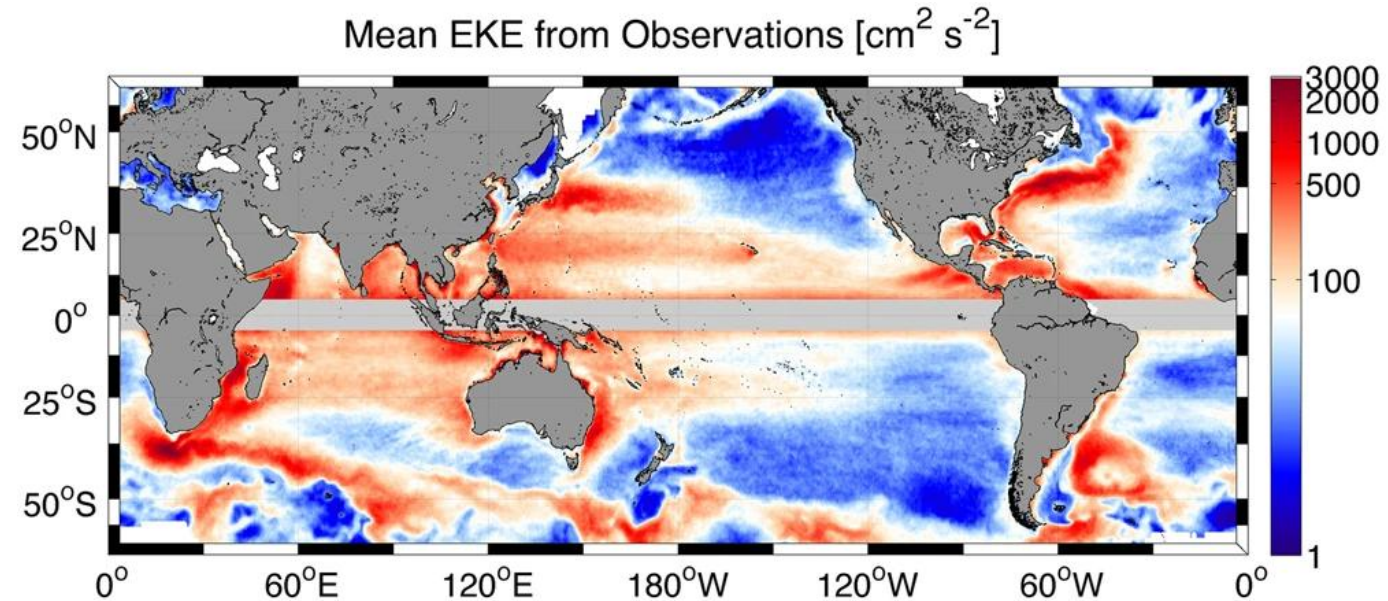


Satellite Altimetry Reveals Intensification of Eddy Kinetic Energy in the Mediterranean Sea

Paul Hargous, Vincent Combes, Bàrbara Barceló-Llull and Ananda Pascual



- **Ocean mesoscale variability** is a key component of the global ocean circulation on spatial scales between **~10-100 km**.
- **Eddy Kinetic Energy (EKE)** is a common metric to determine the intensity of ocean mesoscale variability.
- One way to determine it is using the geostrophic velocities calculated from sea level anomalies from **satellite altimetry**.









Renault et al., 2017

nature
climate change

ARTICLES

<https://doi.org/10.1038/s41558-021-01006-9>

Global changes in oceanic mesoscale currents over the satellite altimetry record

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Navid C. Constantinou ¹, Andrew E. Kiss ¹ and Adele K. Morrison ¹

Satellite data

nature climate change

Long-term evolution of ocean eddy activity in a warming world

[Nathan Beech](#) , [Thomas Rackow](#), [Tido Semmler](#), [Sergey Danilov](#), [Qiang Wang](#) & [Thomas Jung](#)

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Satellite & model data







Positive EKE trends

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Positive EKE trends

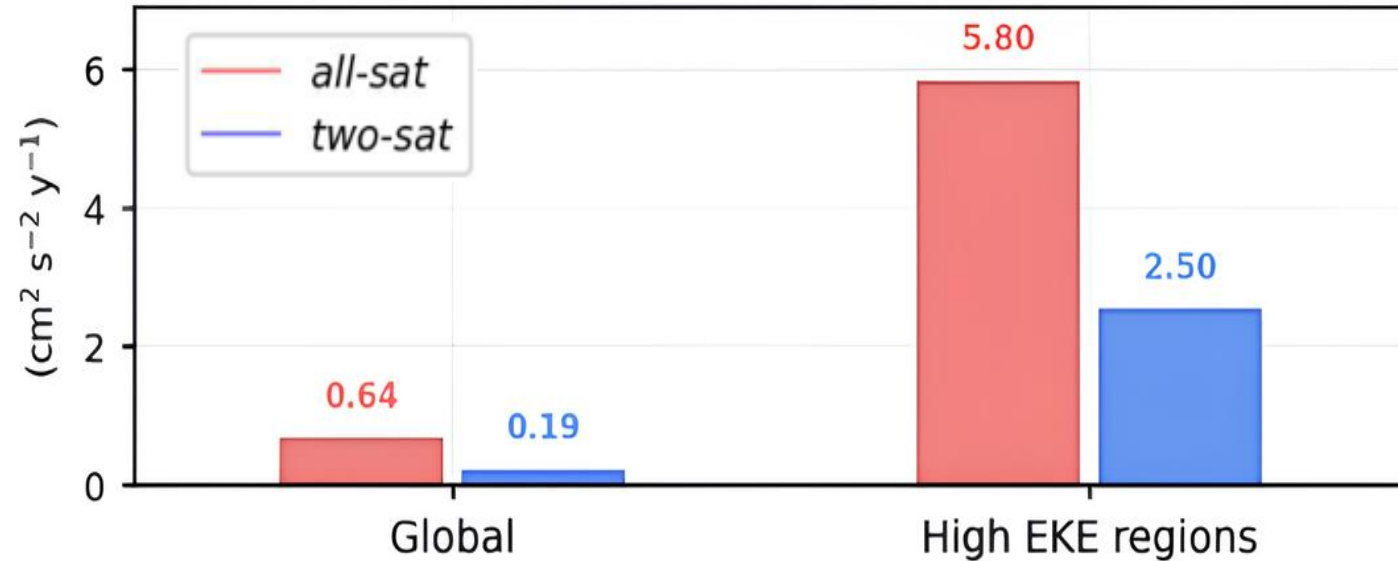
Using all satellites altimetric missions available

Kuroshio Extension and Gulf Stream dominate the Eddy Kinetic Energy intensification observed in the Global Ocean

Bàrbara Barceló-Llull^{1*}, Pere Rosselló¹, Vincent Combes¹, Antonio Sánchez-Román¹, M. Isabelle Pujol² and Ananda Pascual¹

Important differences

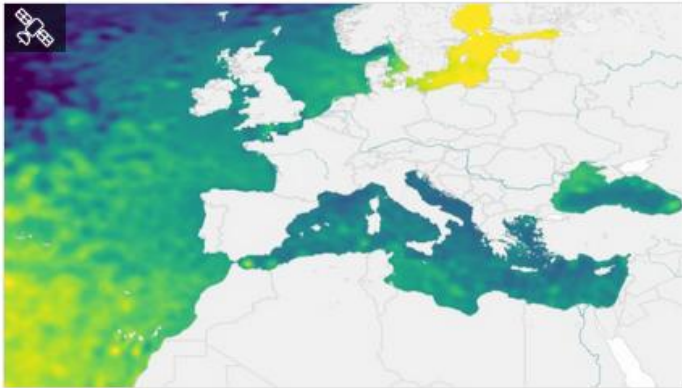
EKE trends (1993-2022)



Barceló-Llull et al., 2025

- **EKE intensity** in the **Mediterranean Sea**
- **EKE trends** during the altimetric record (since 1993)
- **Influence of the dataset product**

“ALL SAT MED”



European Seas Gridded L 4 Sea Surface Heights And Derived...

SEALEVEL_EUR_PHY_L4_MY_008_068

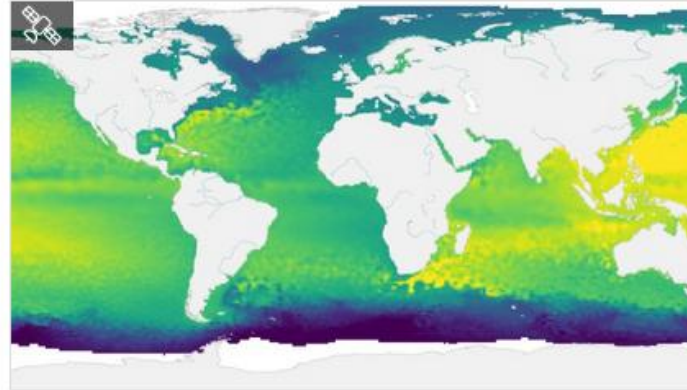
Satellite (L4)

Global, $0.125^\circ \times 0.125^\circ$

1 Jan 1993 to 8 Sep 2023, daily

[Sea surface height](#), velocity

“ALL SAT GLO”



Global Ocean Gridded L 4 Sea Surface Heights And Derived...

SEALEVEL_GLO_PHY_L4_MY_008_047

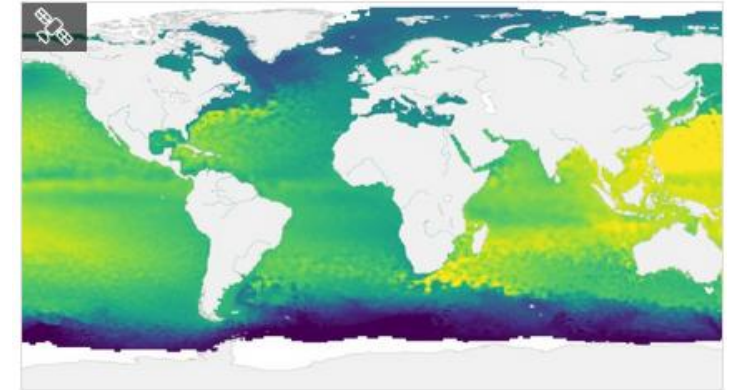
Satellite (L4)

[Global](#), $0.25^\circ \times 0.25^\circ$

1 Jan 1993 to 8 Sep 2023, daily, monthly

[Sea surface height](#), velocity

“TWO SAT GLO”



Global Ocean Gridded L 4 Sea Surface Heights And Derived...

SEALEVEL_GLO_PHY_CLIMATE_L4_MY_008_057

Satellite (L4)

[Global](#), $0.25^\circ \times 0.25^\circ$

1 Jan 1993 to 8 Sep 2023, daily

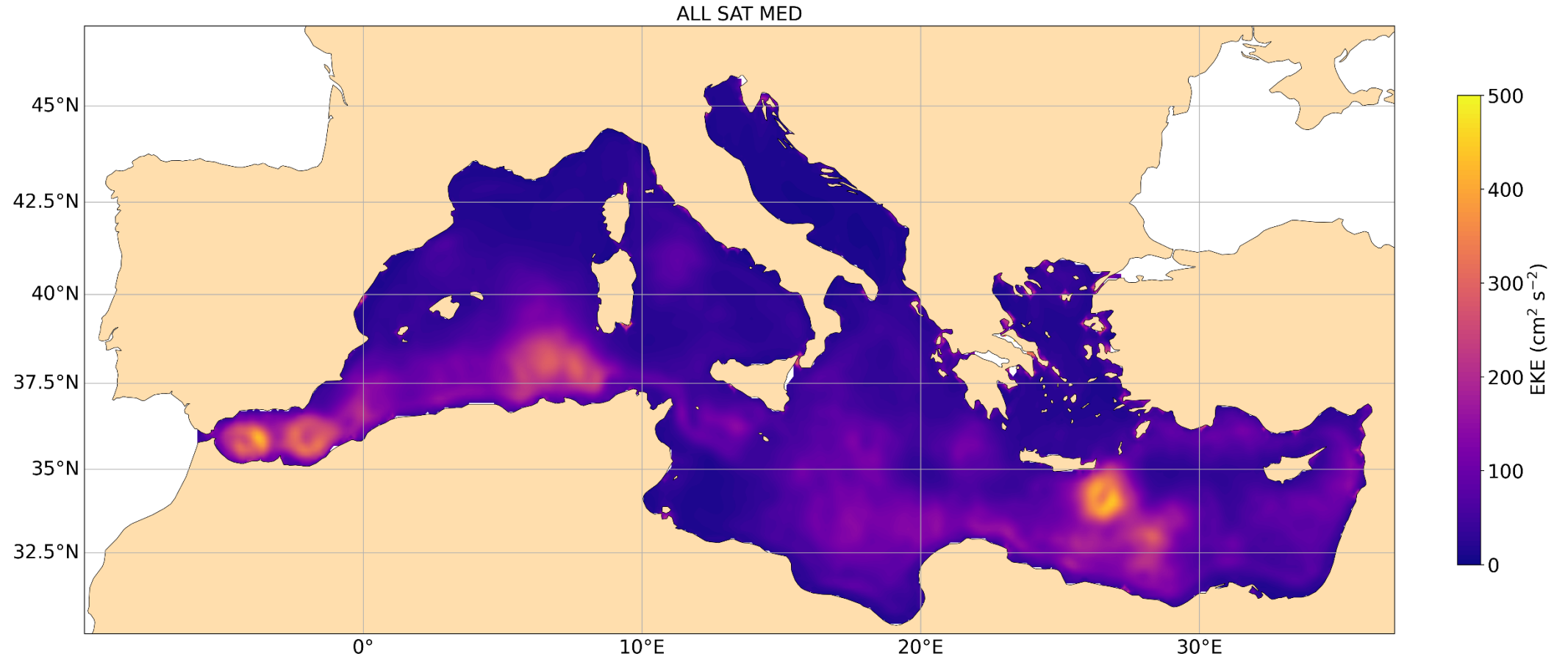
[Sea surface height](#), velocity

- **EKE computation**
- EKE trends: **Mann-Kendall test**

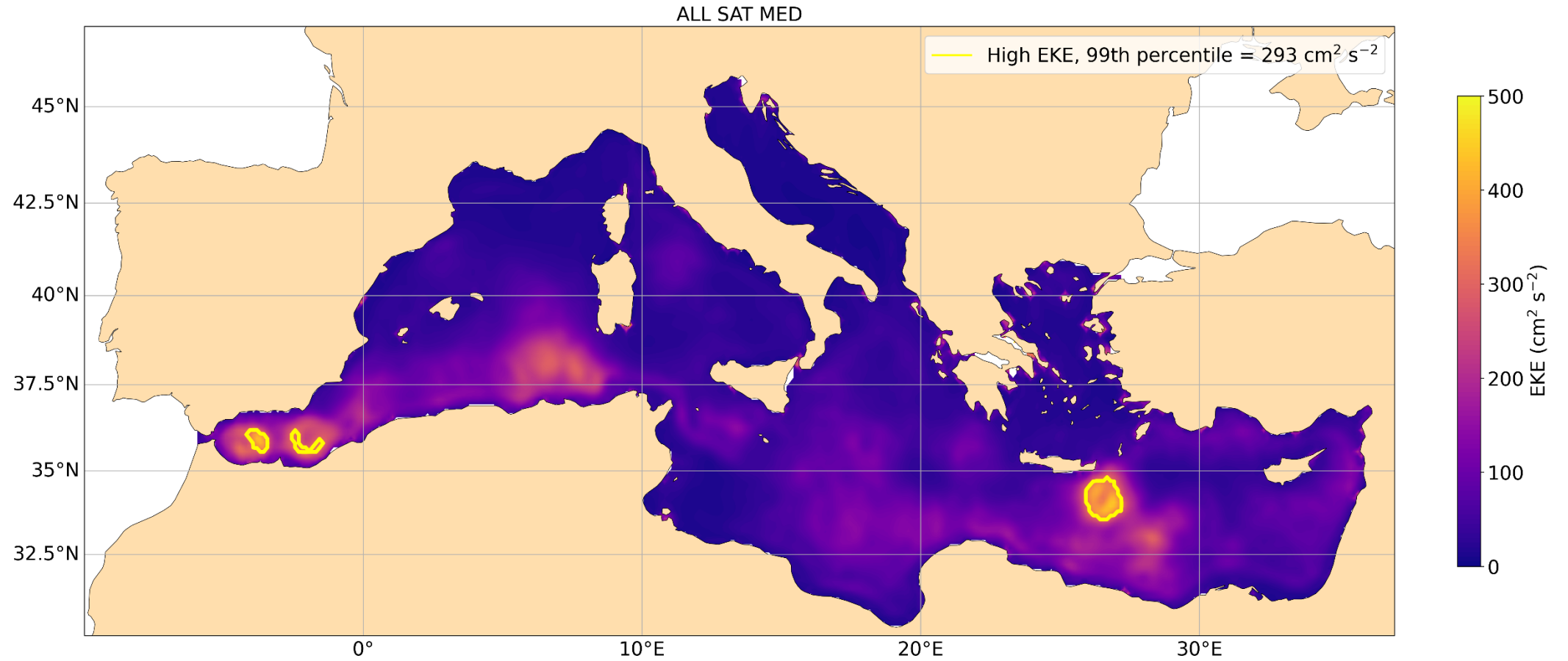
$$EKE = \frac{1}{2} (u_{ga}^2 + v_{ga}^2)$$

Modified MK test by
Yue and Wang, 2004

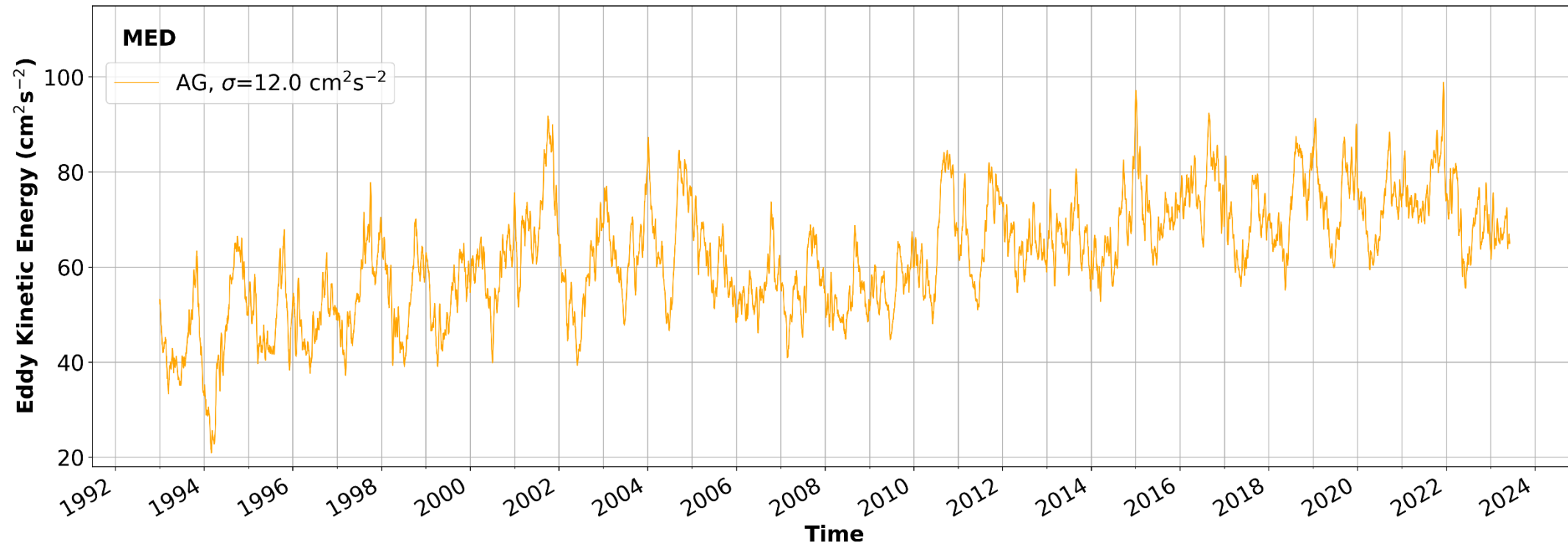
Results - Mean EKE over the Mediterranean Sea (1993-2023)



Results - High EKE regions



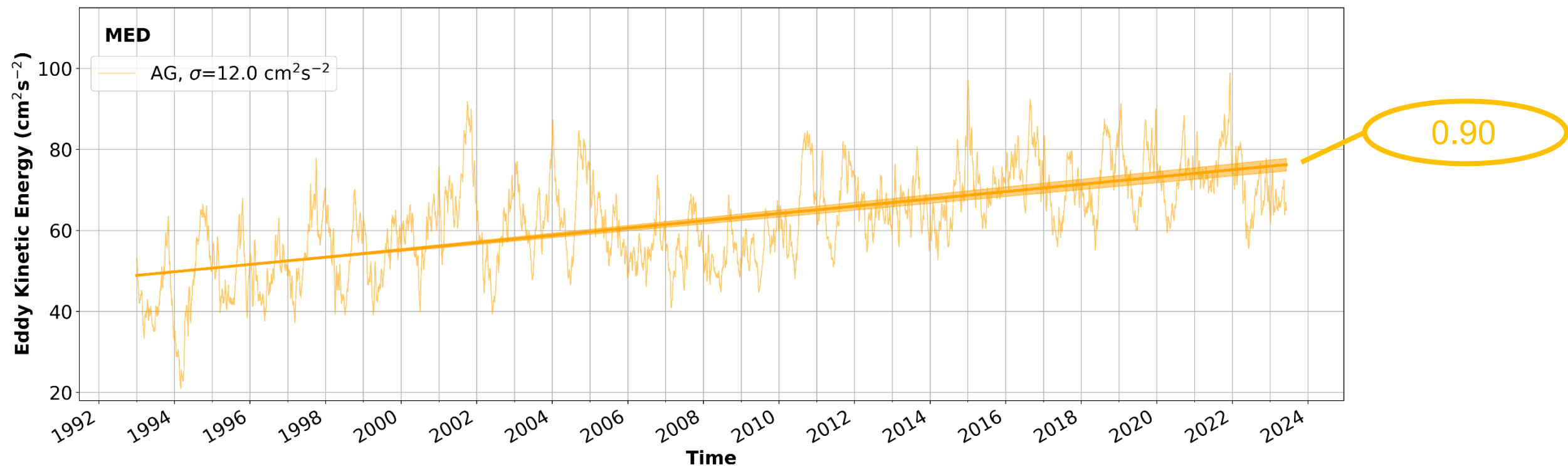
ALL SAT GLO AG



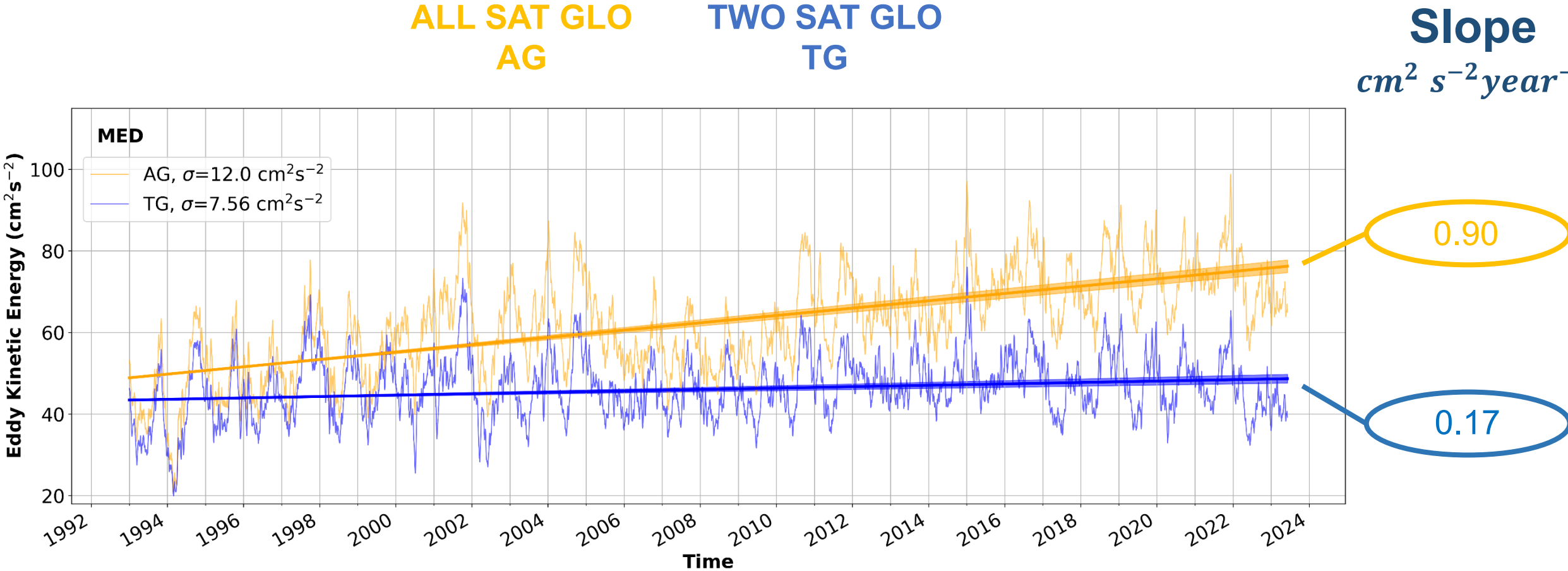
Results - Area weighted mean EKE over the Mediterranean Sea

ALL SAT GLO
AG

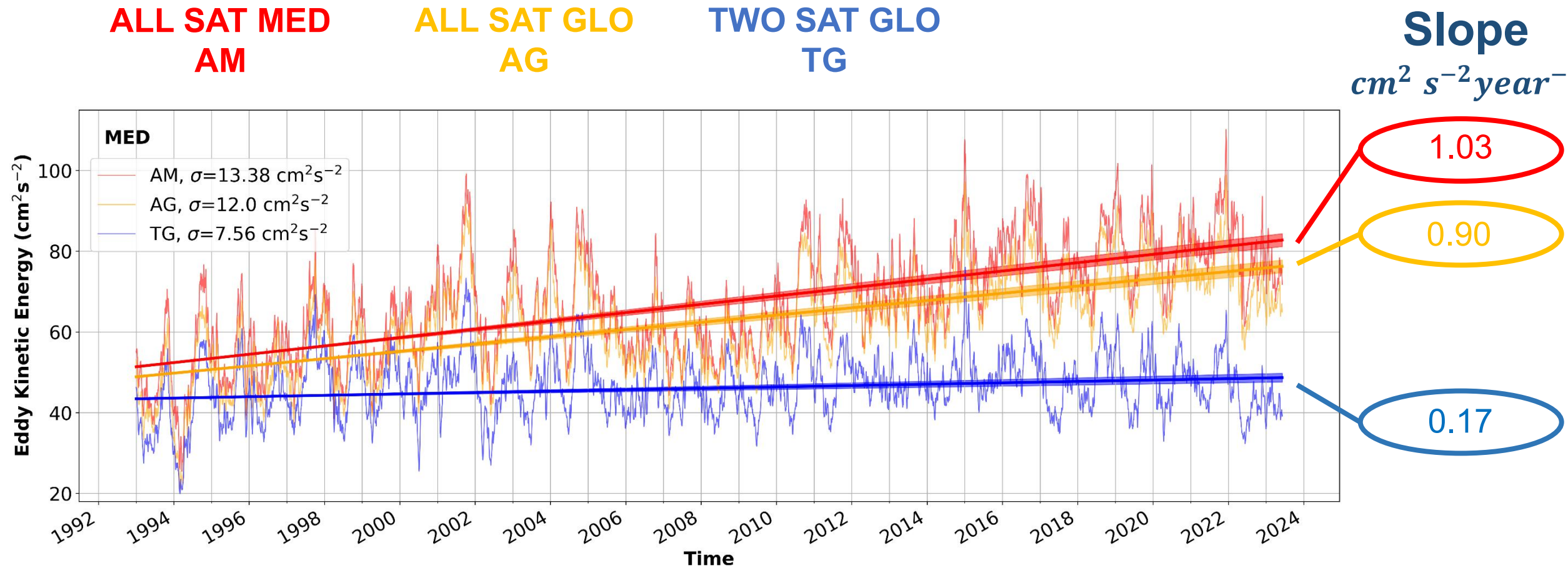
Slope
 $cm^2 s^{-2} year^{-1}$

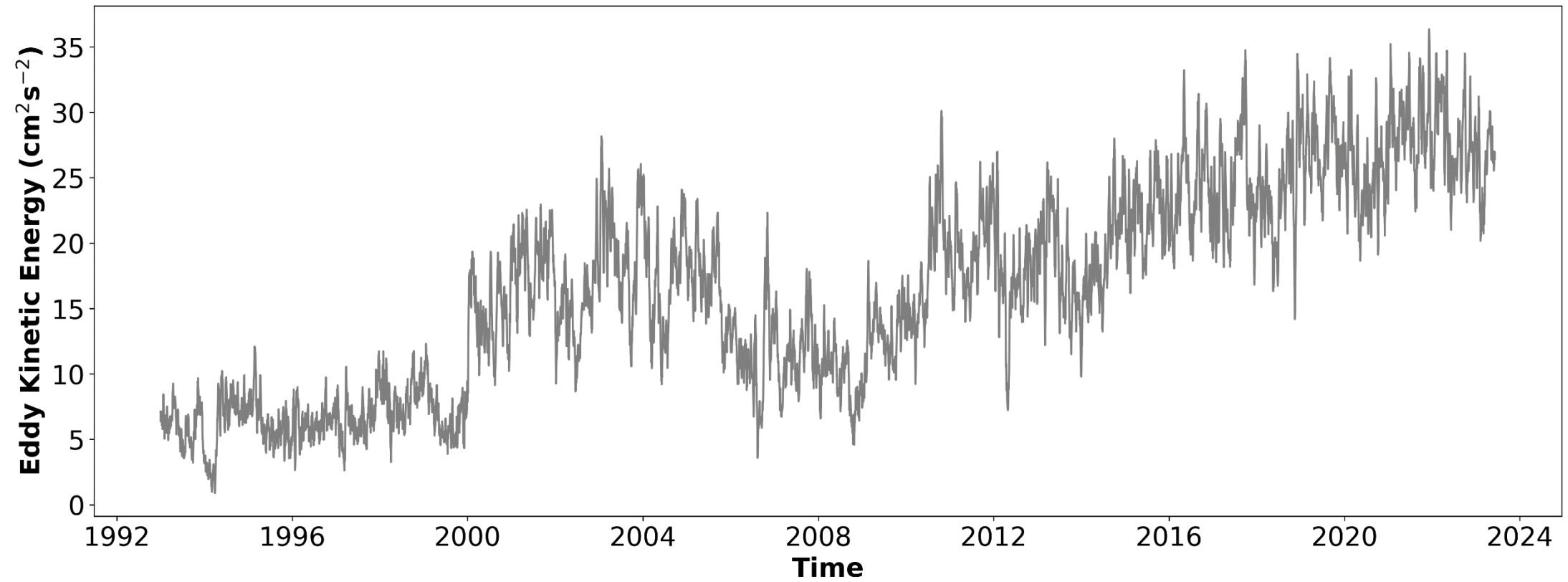


Results - Area weighted mean EKE over the Mediterranean Sea

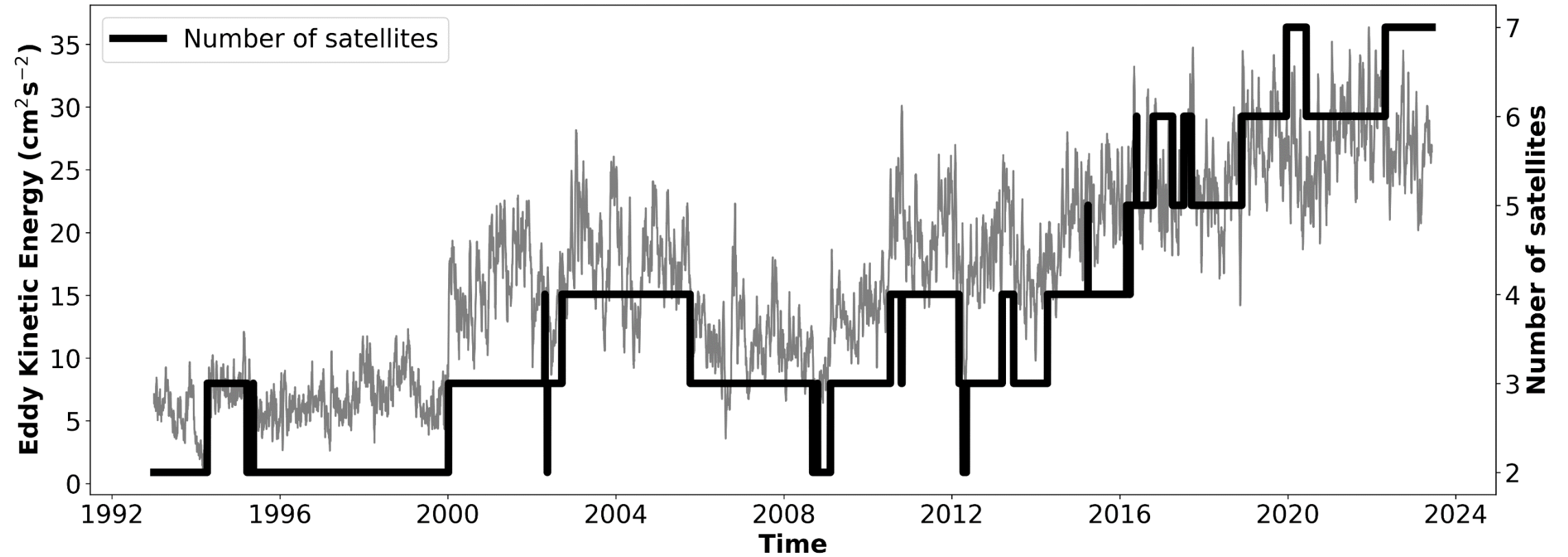


Results - Area weighted mean EKE over the Mediterranean Sea

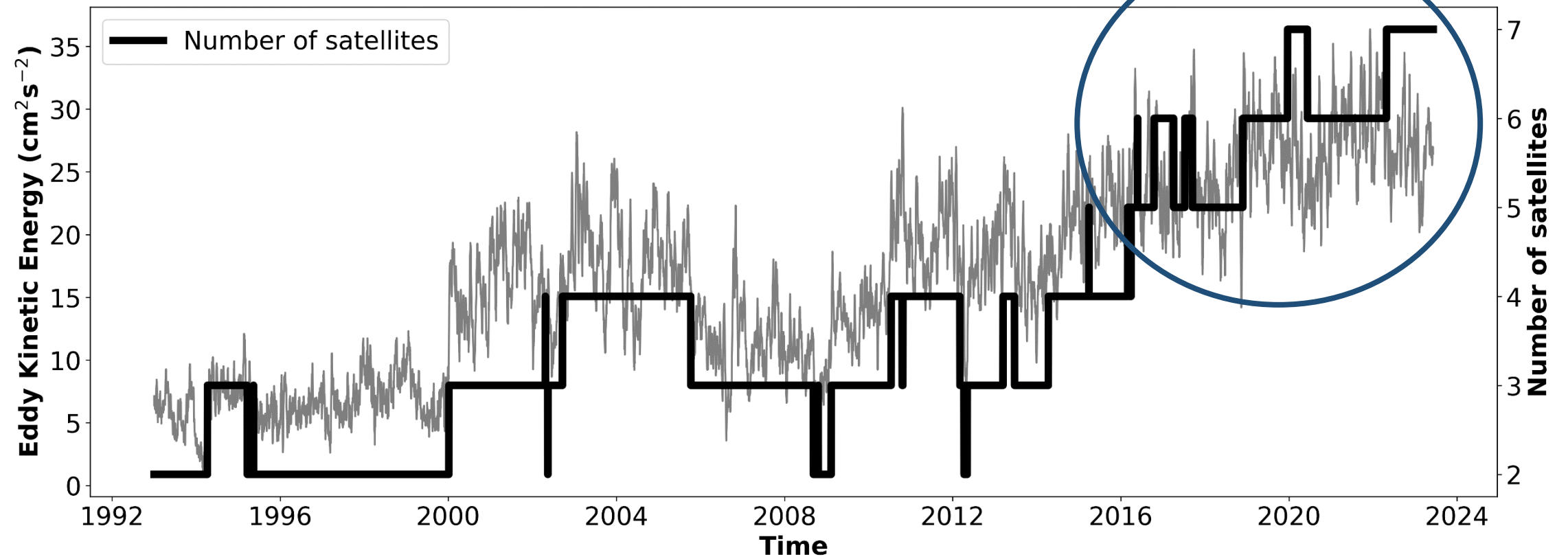




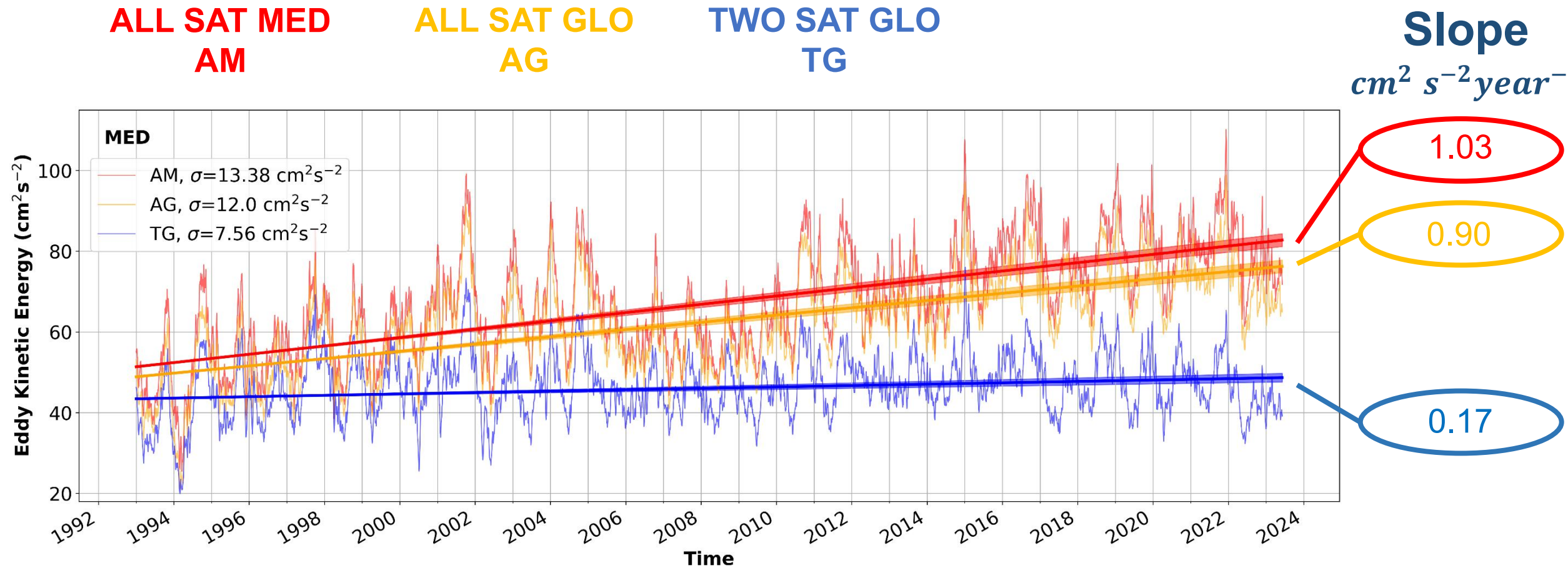
CORRELATION $\rho = 0.87$



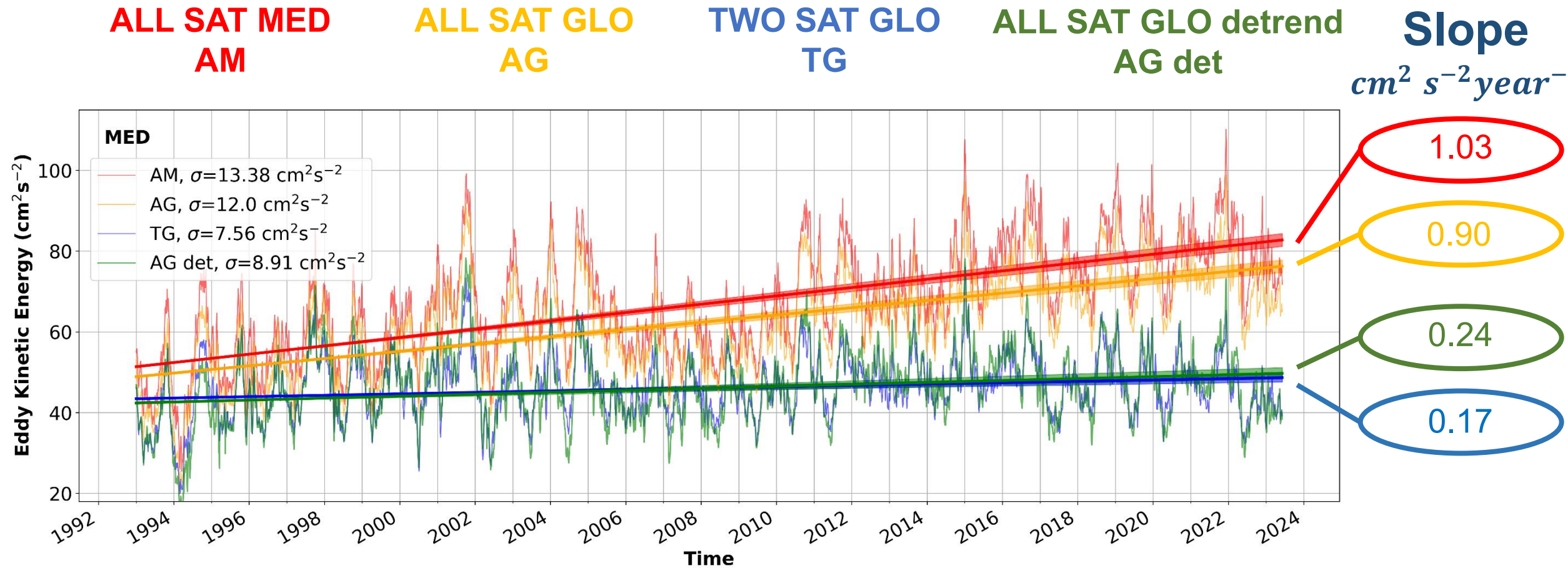
CORRELATION $\rho = 0.87$



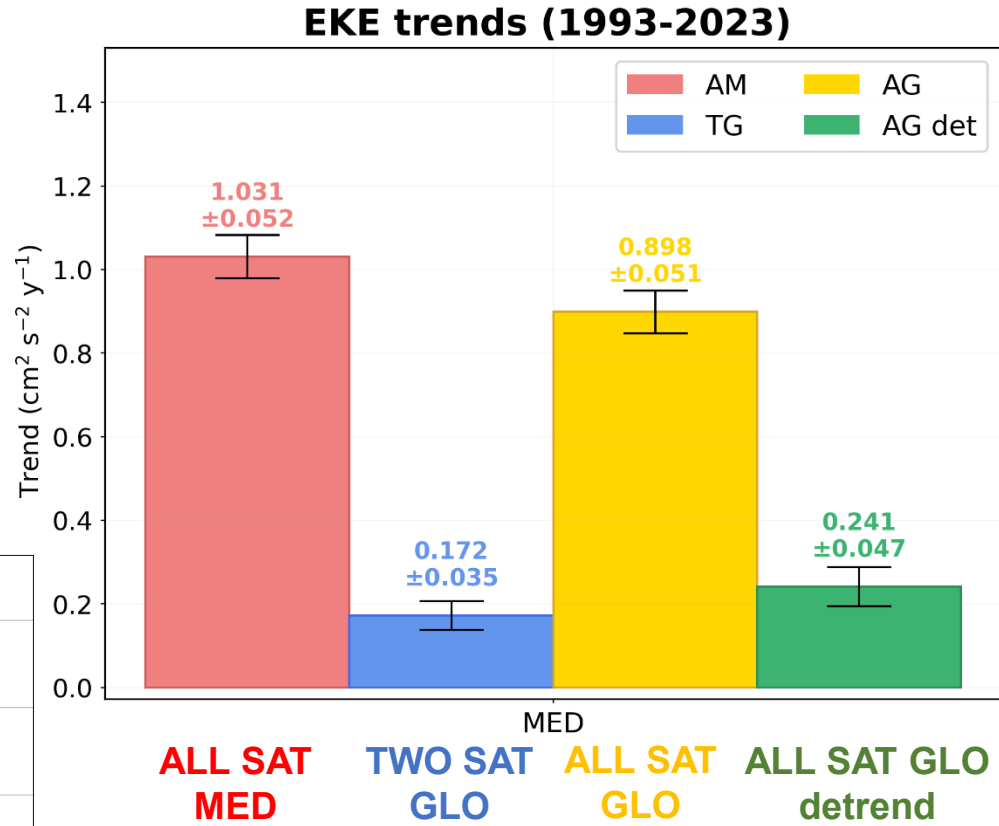
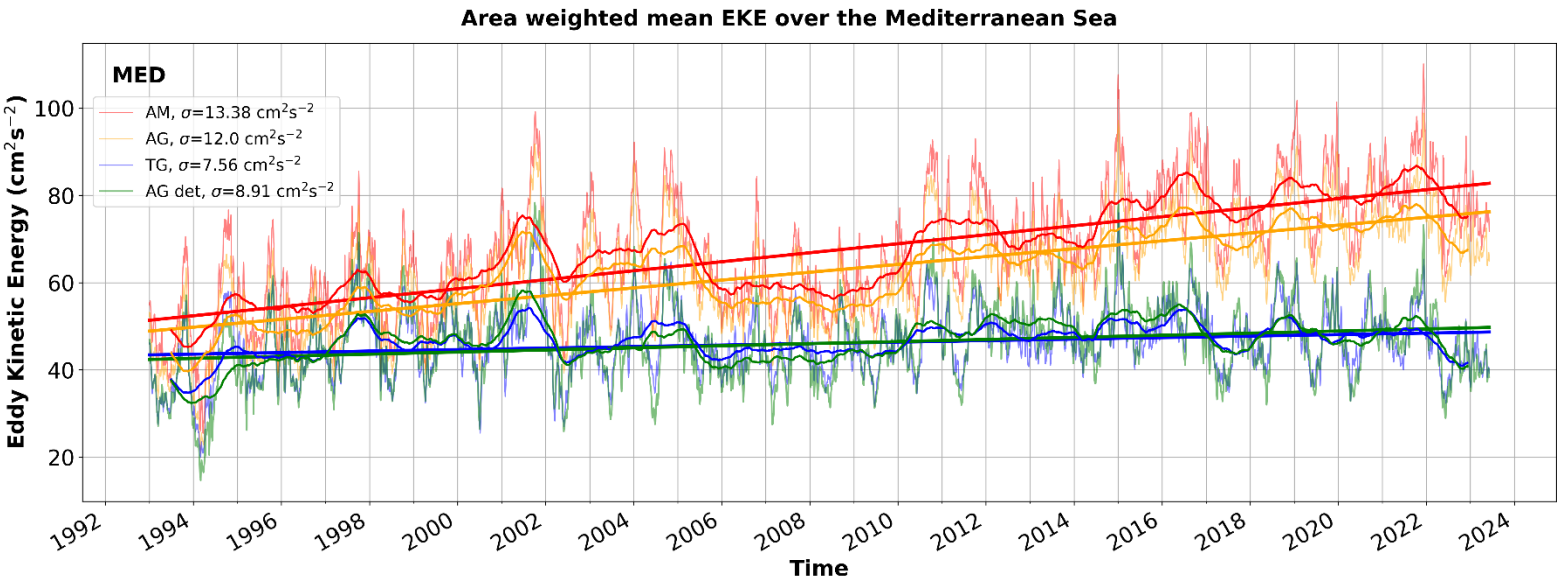
Results - Area weighted mean EKE over the Mediterranean Sea



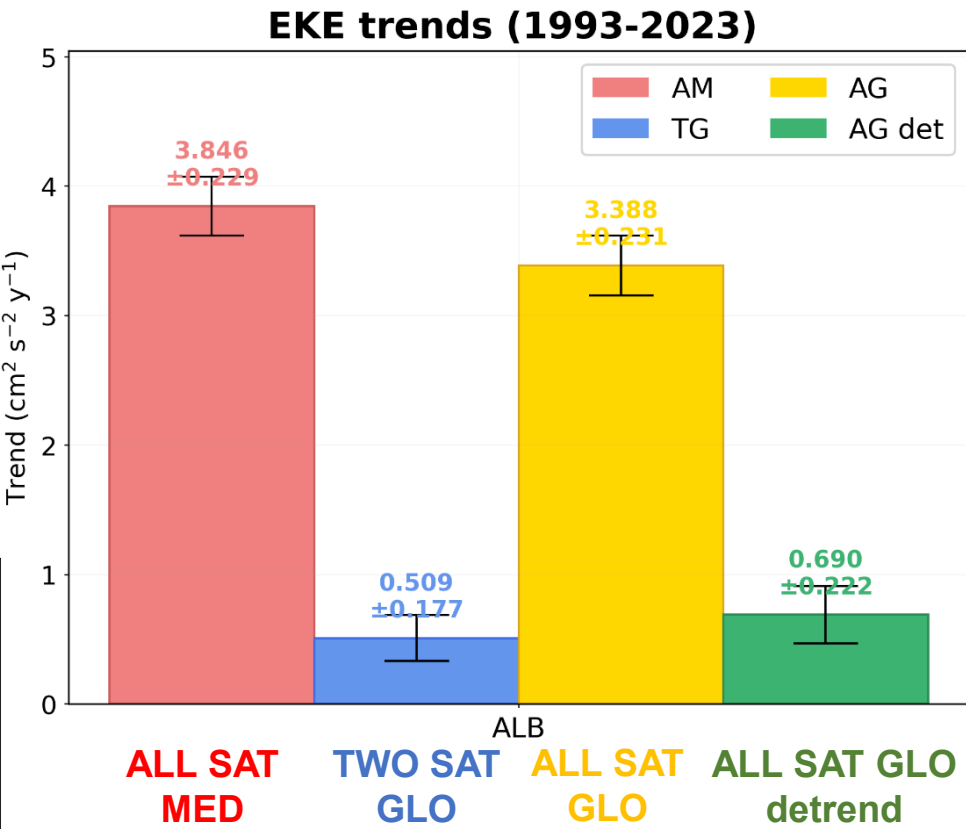
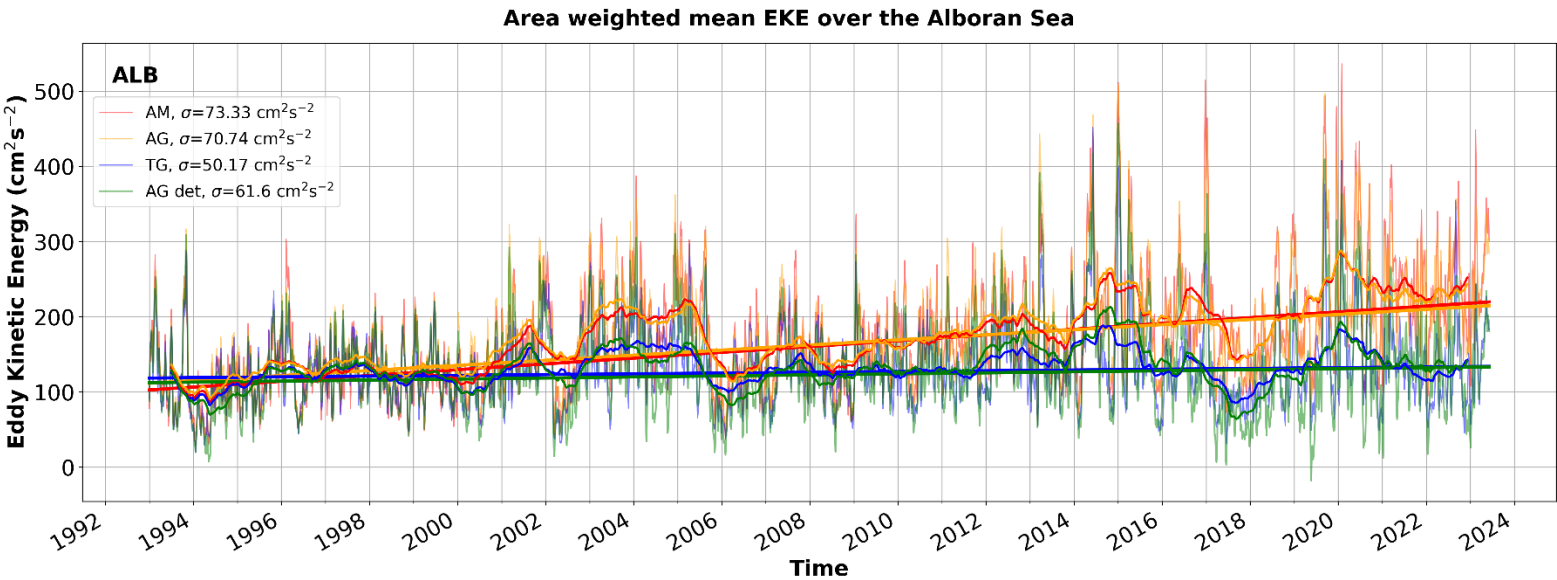
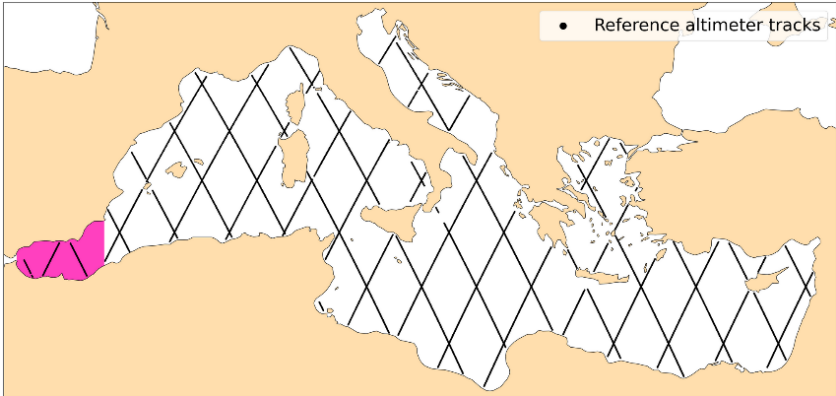
Results - Area weighted mean EKE over the Mediterranean Sea



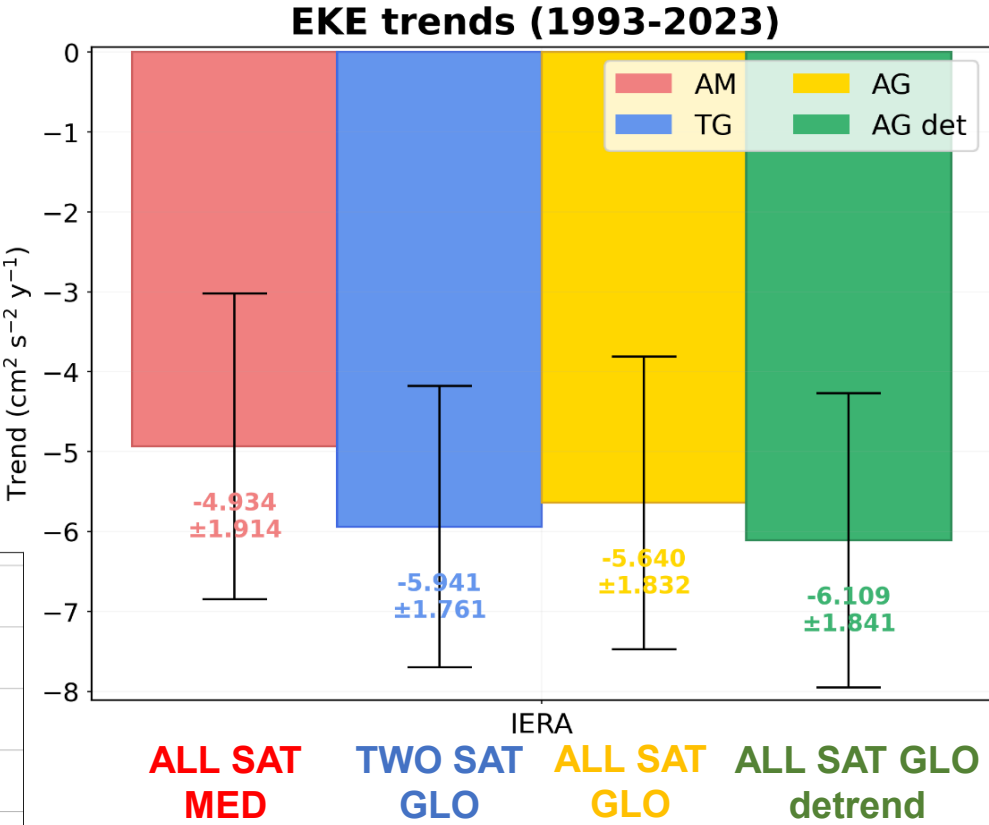
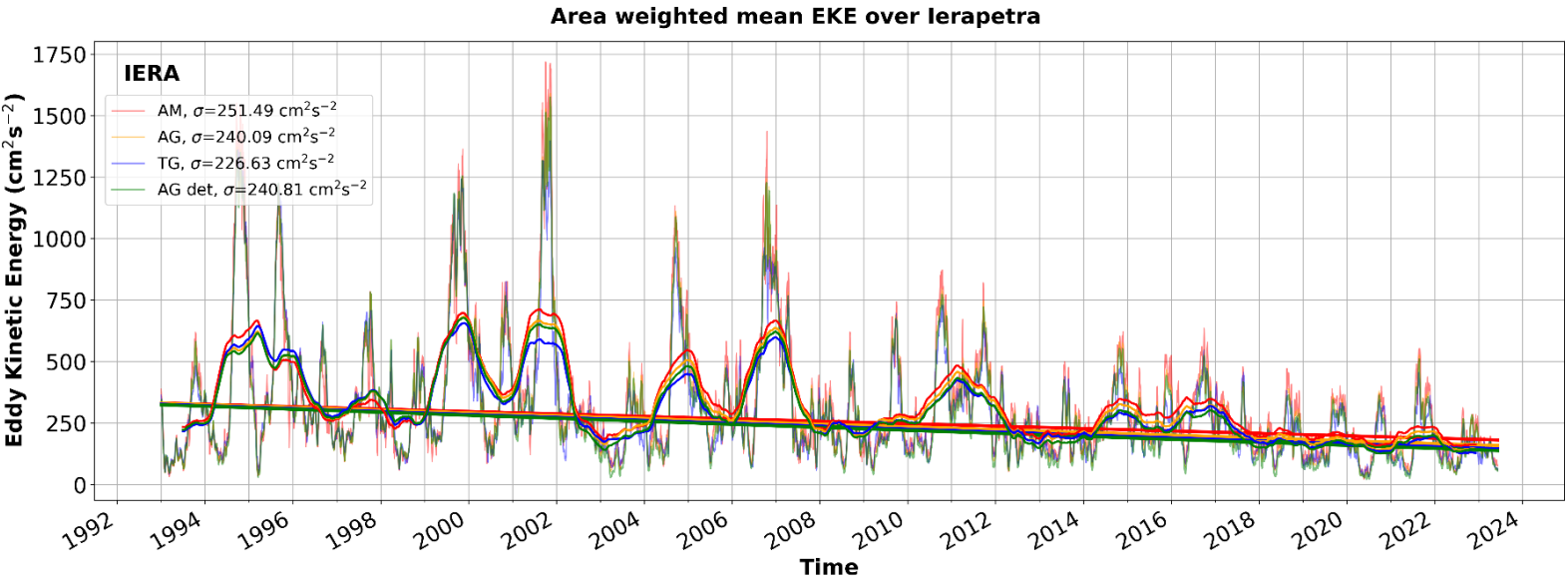
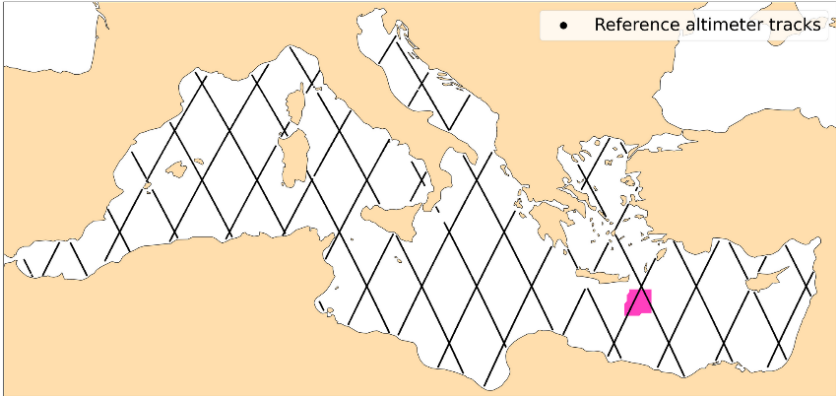
Results - EKE in the Mediterranean Sea



Results - EKE in the Alboran Sea



Results - EKE around Ierapetra



- **ALL SAT** products most likely overestimate EKE trends when computed over the whole Mediterranean, however all products agree on a **positive trend**.
- The number of satellites **does have an influence** when computing EKE and caution should be taken when computing trends and studying climate impacts.
- When studying smaller areas with great variability of EKE, ALL SAT and TWO SAT show **more compliance** when the tracks' configuration is adapted to the structures studied, **importance of maintaining the altimetric record**.
- **THREE SAT product from 2000** to better estimate the trends in larger areas.



**Govern de les
Illes Balears**

Thank you!

Questions?

Comments?

New ideas?

- **Positive trend.**
- **Influence of the dataset when computing EKE.**
- **Importance of maintaining the altimetric record.**
- **THREE SAT product from 2000.**

hargous@imedeauib-csic.es