



**SOFIA UNIVERSITY**  
**“ST. KLIMENT OHRIDSKI”**

# **Mesoscale variability of the Black Sea circulation seen from SSALTO/DUAC altimeter data**

**Elisaveta Peneva, Emil Stanev, Milena Milanova**

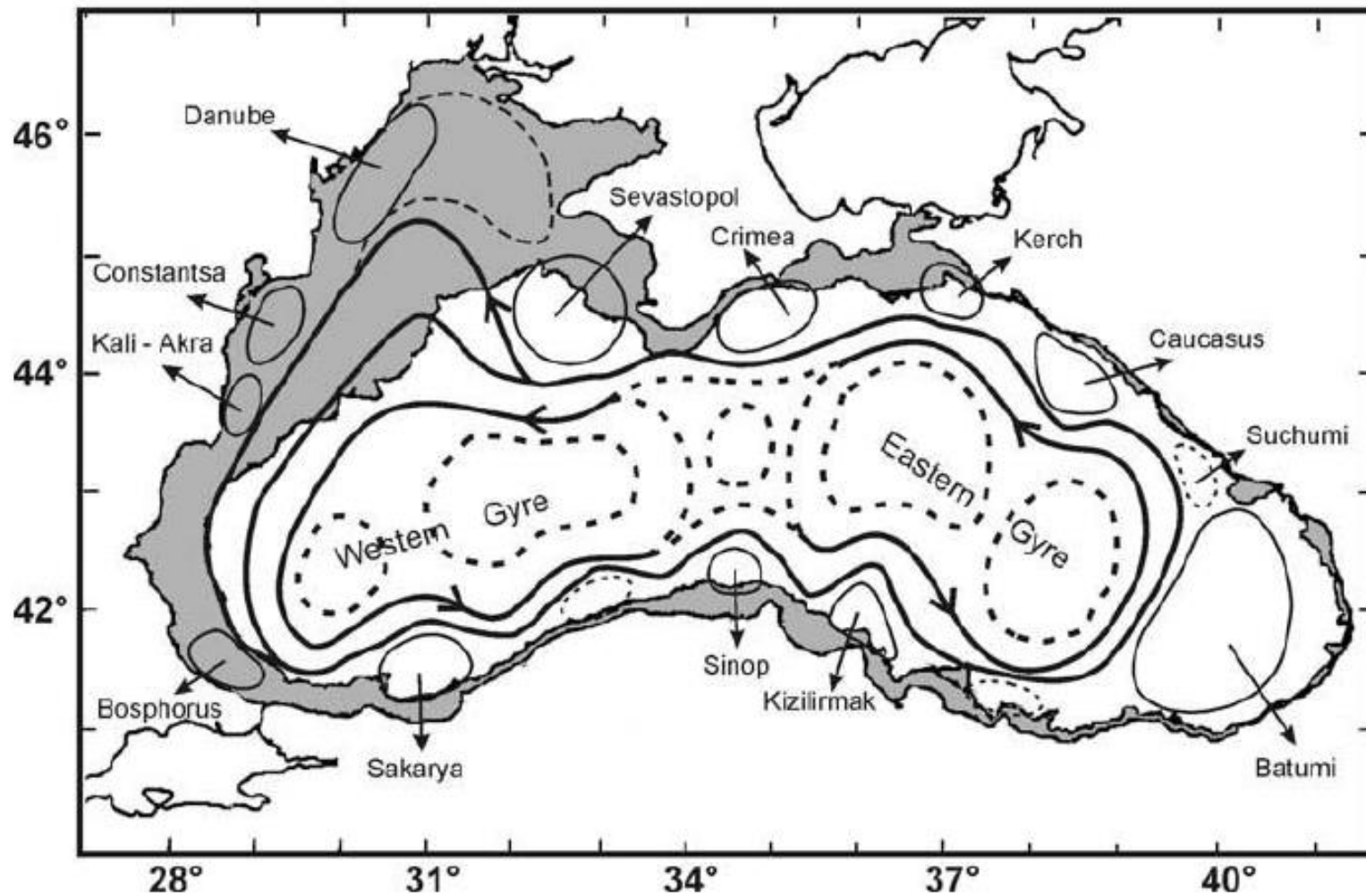
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# Classical view for the Black Sea circulation -

Rim current, quasi-stationary eddies, coastal eddies

**Motivation:** Do we see this picture in the altimeter data?





## Data used in the study:

**AVISO regional product for Black Sea SSALTO/DUAC: compilation of several altimeter missions (Topex/Poseidon, ERS 1 and 2, Jason-1 and 2, Envisat, Cryosat-2) ([www.aviso.oceanobs.com](http://www.aviso.oceanobs.com))**

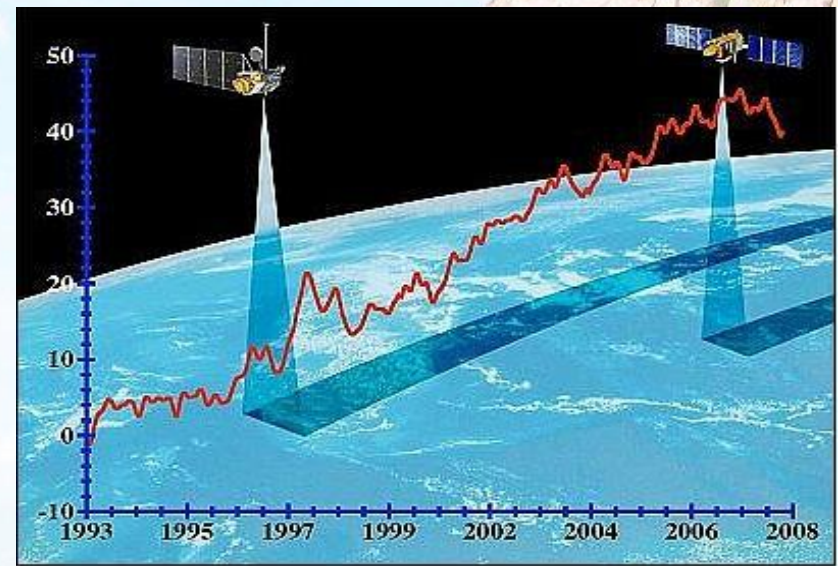


**Sea level anomalies and calculated geostrophic currents anomalies, optimally interpolated on a regular grid with spatial resolution of  $1/8^\circ \times 1/8^\circ$  degrees (approximately ~10 km) and temporal resolution of 1 week.**

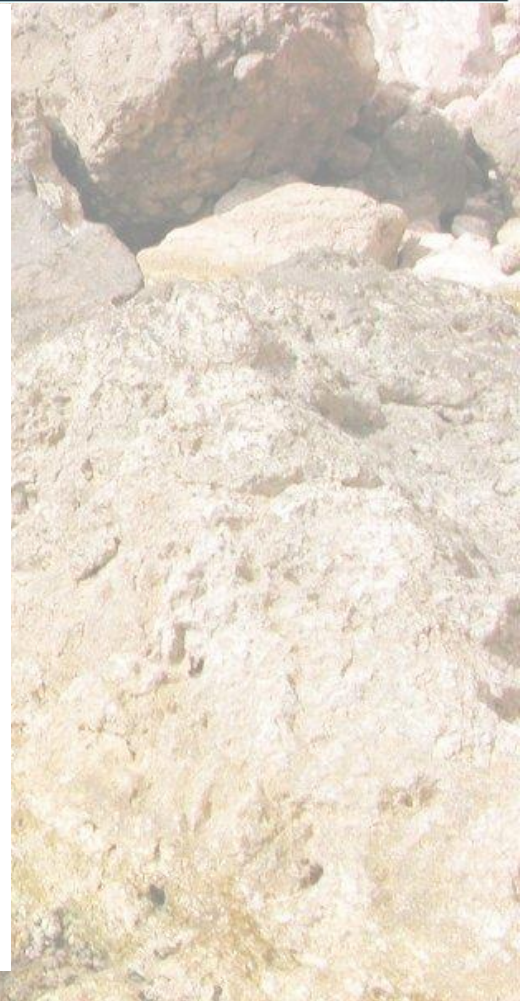
**The data cover the 20 year period 1993 to 2012.**



# Temporal Coverage

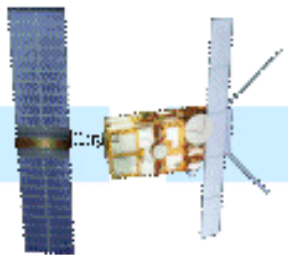
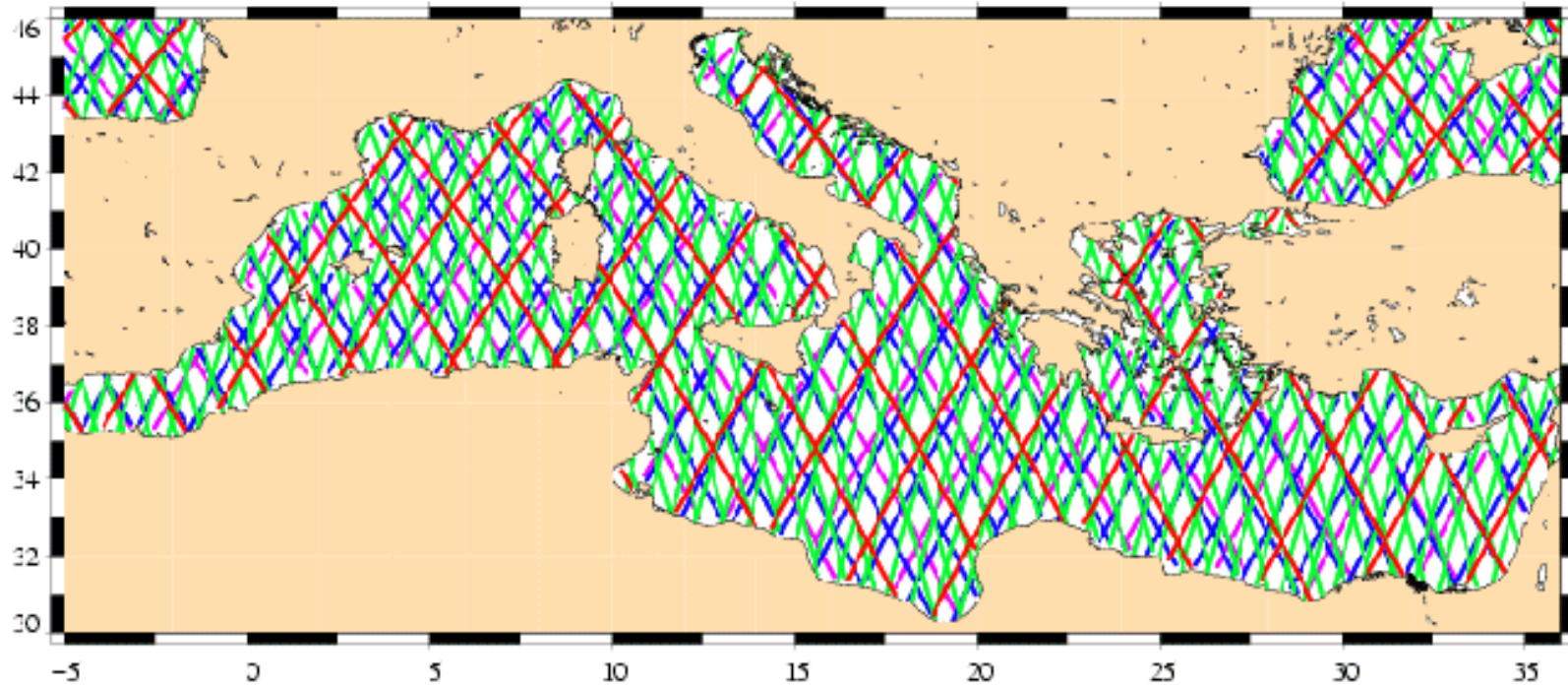


<u>Cryosat-2</u>	along-track	Apr. 2012 - ongoing
Jason-2	along-track	Oct.2008 - ongoing
Jason-1	along-track	August 2002 - ongoing
<u>Envisat</u>	along-track	June 2003 - ongoing
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Merged	gridded	October 1992 - ongoing

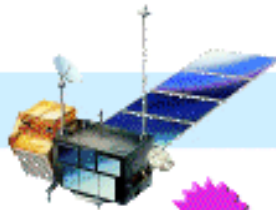




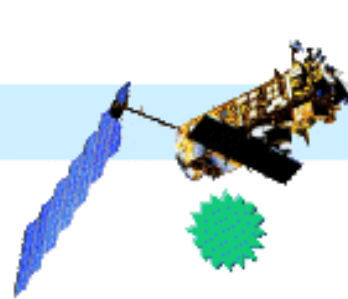
# Spatial Coverage



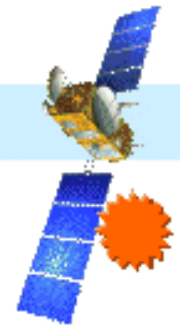
GFO



TP



ENVISAT



JASON



# EOF Analysis performed

**EOF0 => 78%**

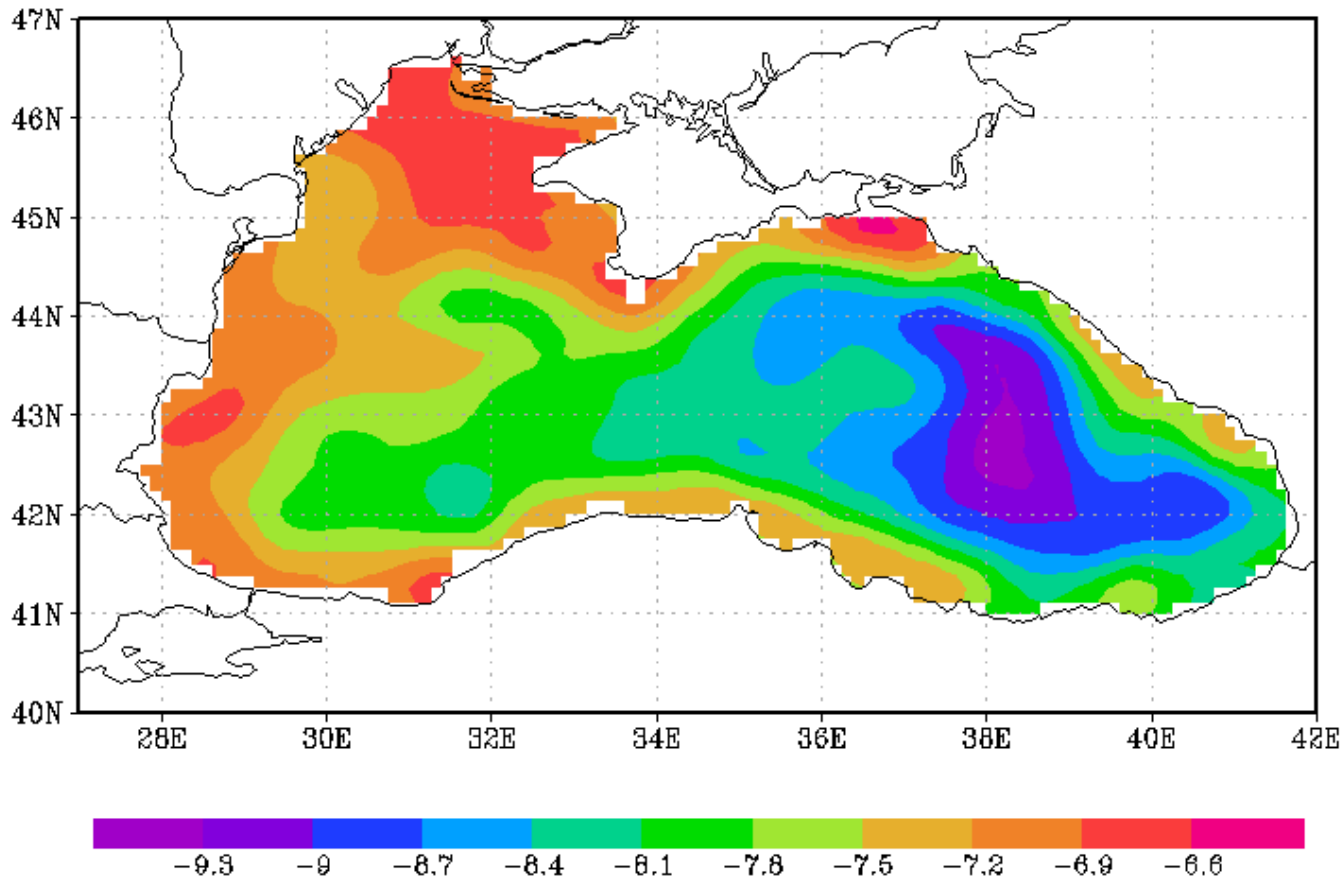
**EOF1 => 26%**

**EOF2 => 8%**

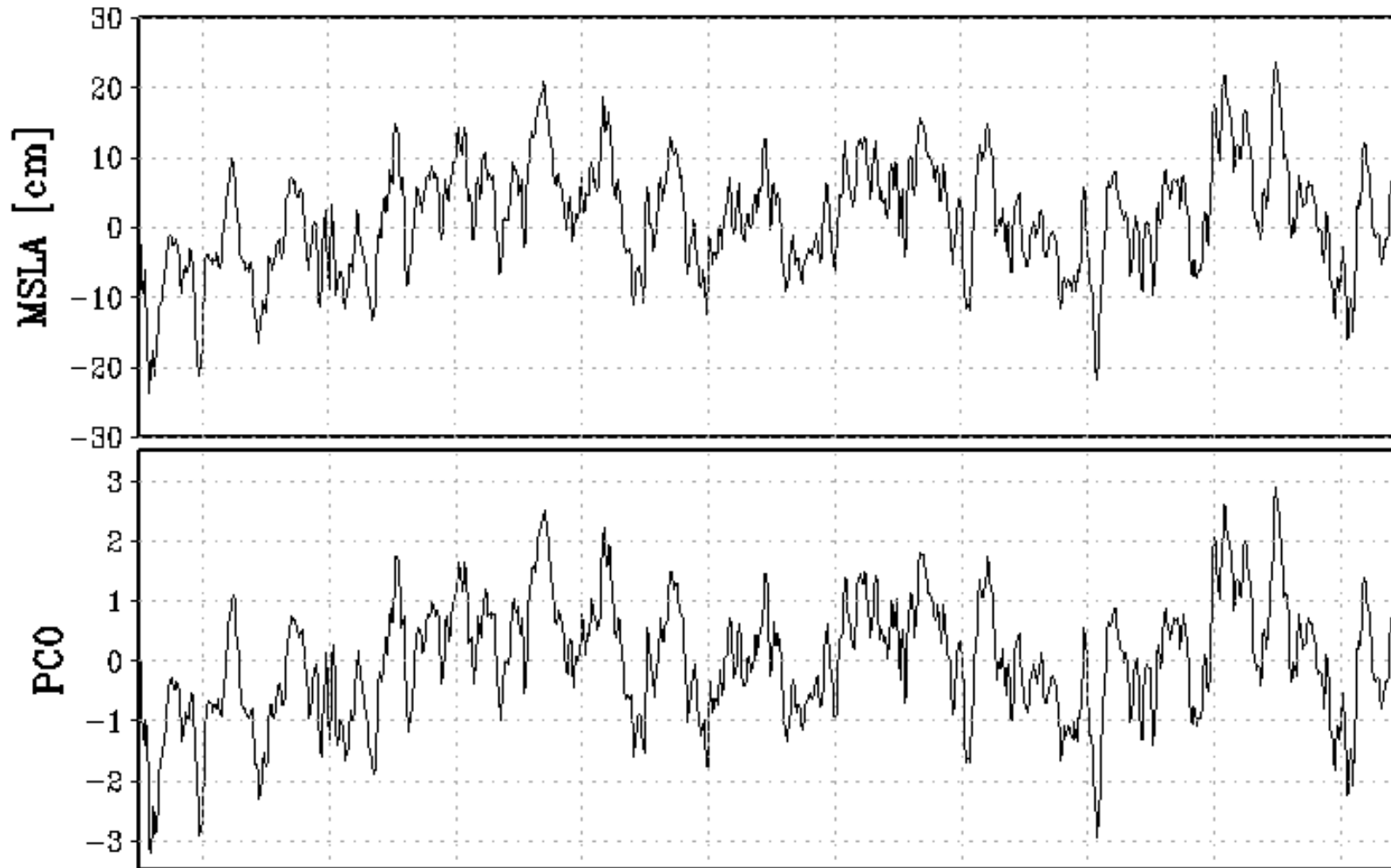
**EOF3 => 6%**

**EOF4 => 5%**

MSLA EOF0 VAL=78%

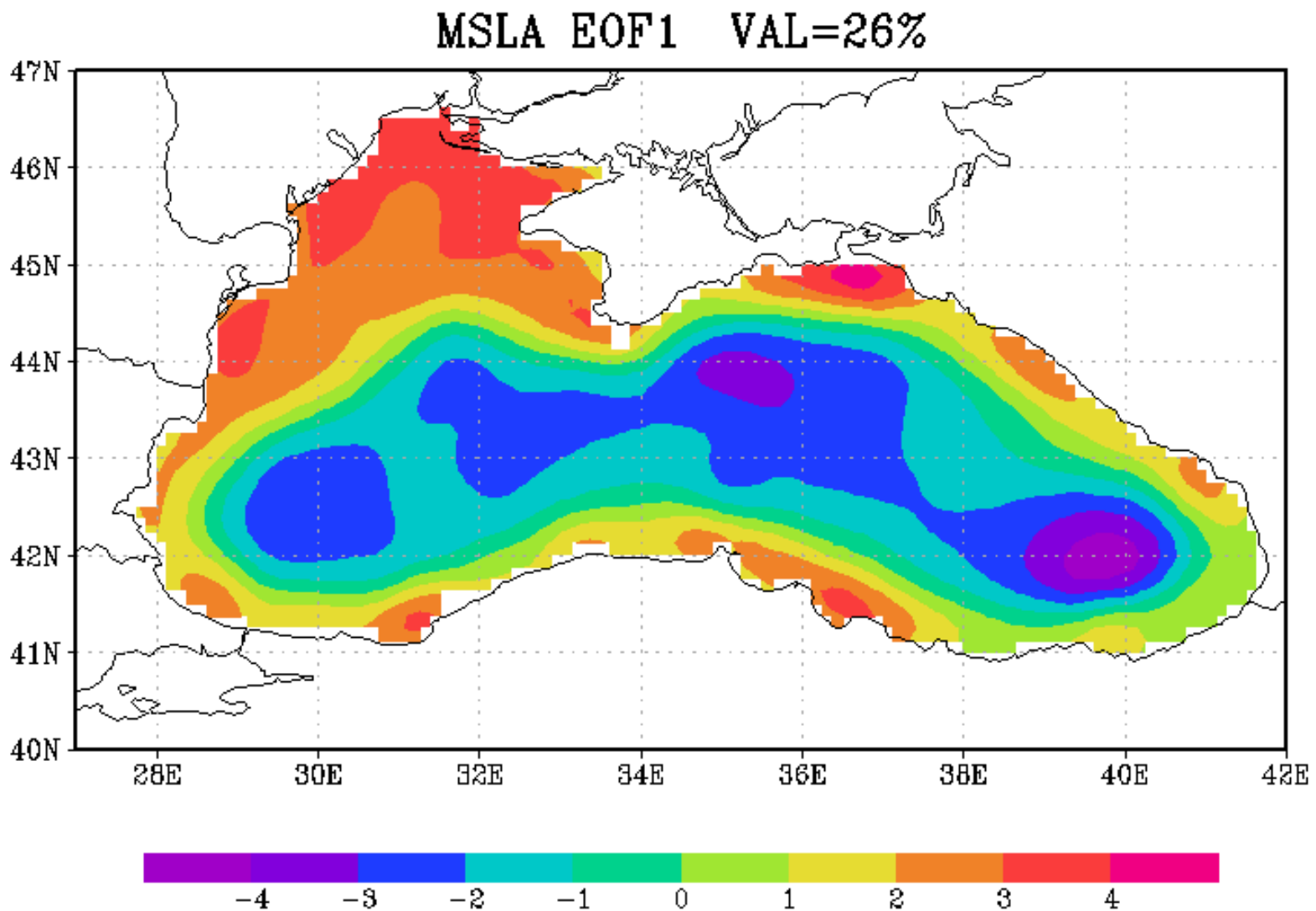


# Comparison EOF0 projection in time and mean sea level anomaly => EOF0 is related to the mean sea level



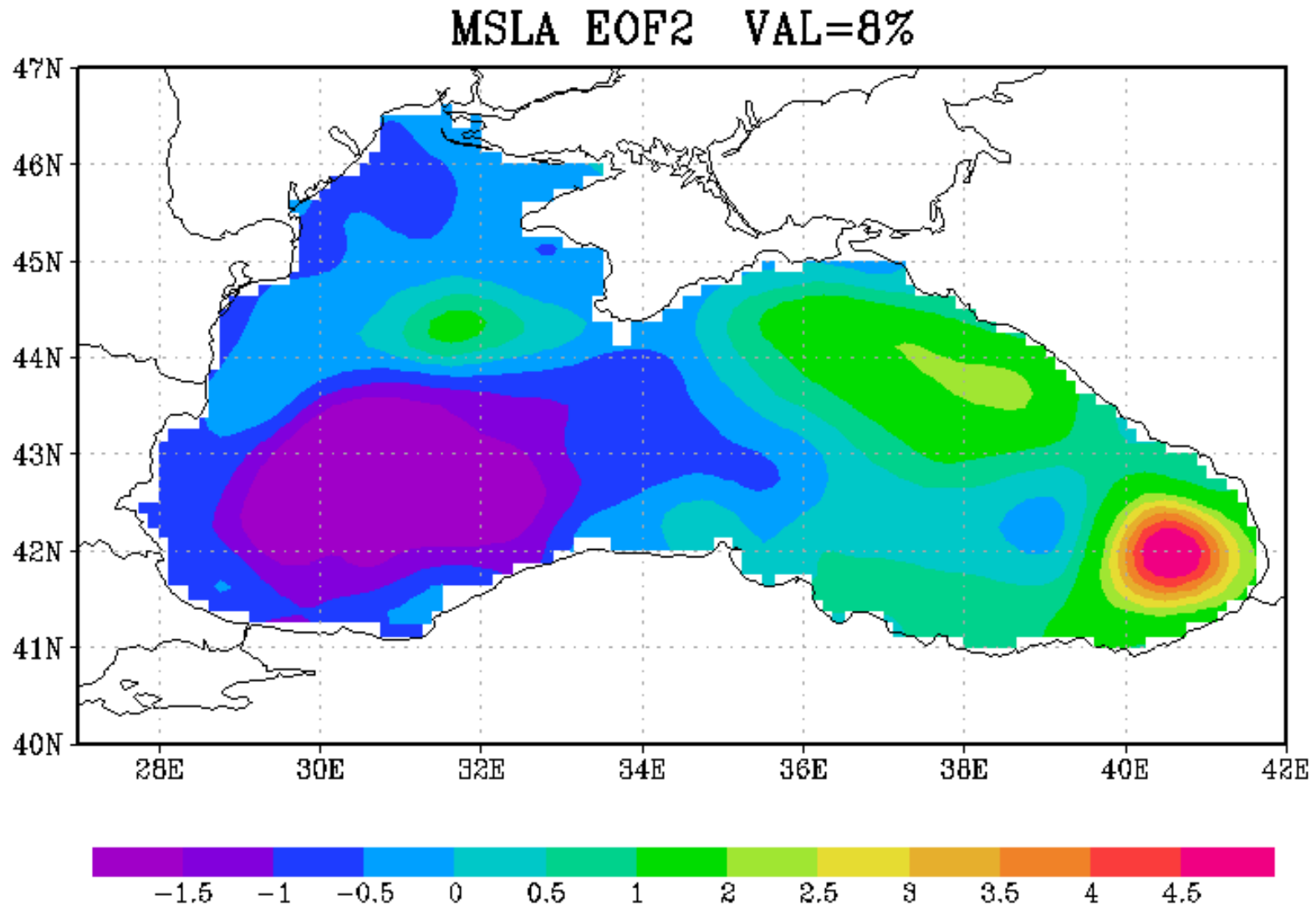


# EOF1 is related to seasonal intensification of the Rim current



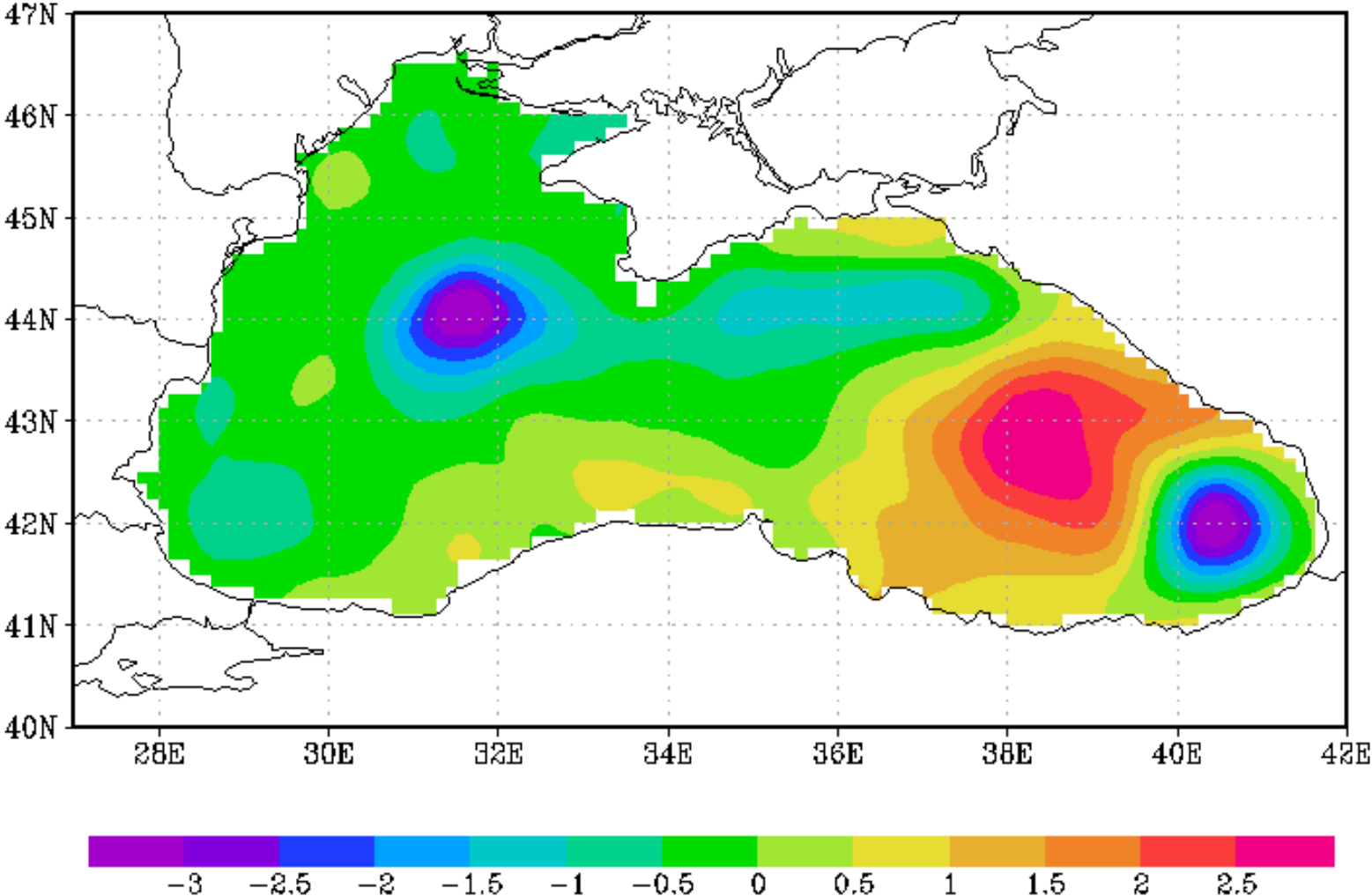


# EOF2 is related to quasi-stationary anticyclonic eddies



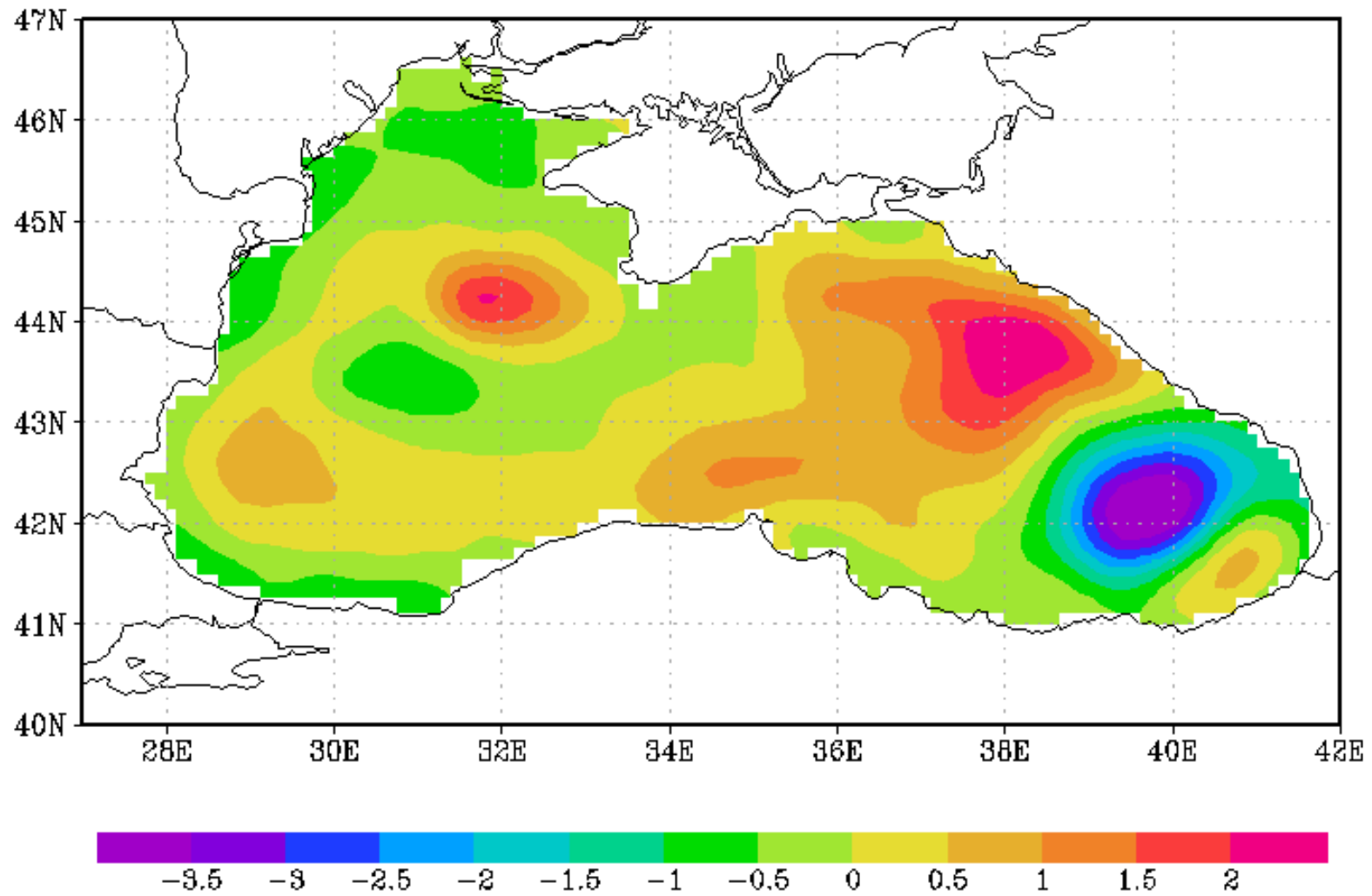


# MSLA EOF3 VAL=6%

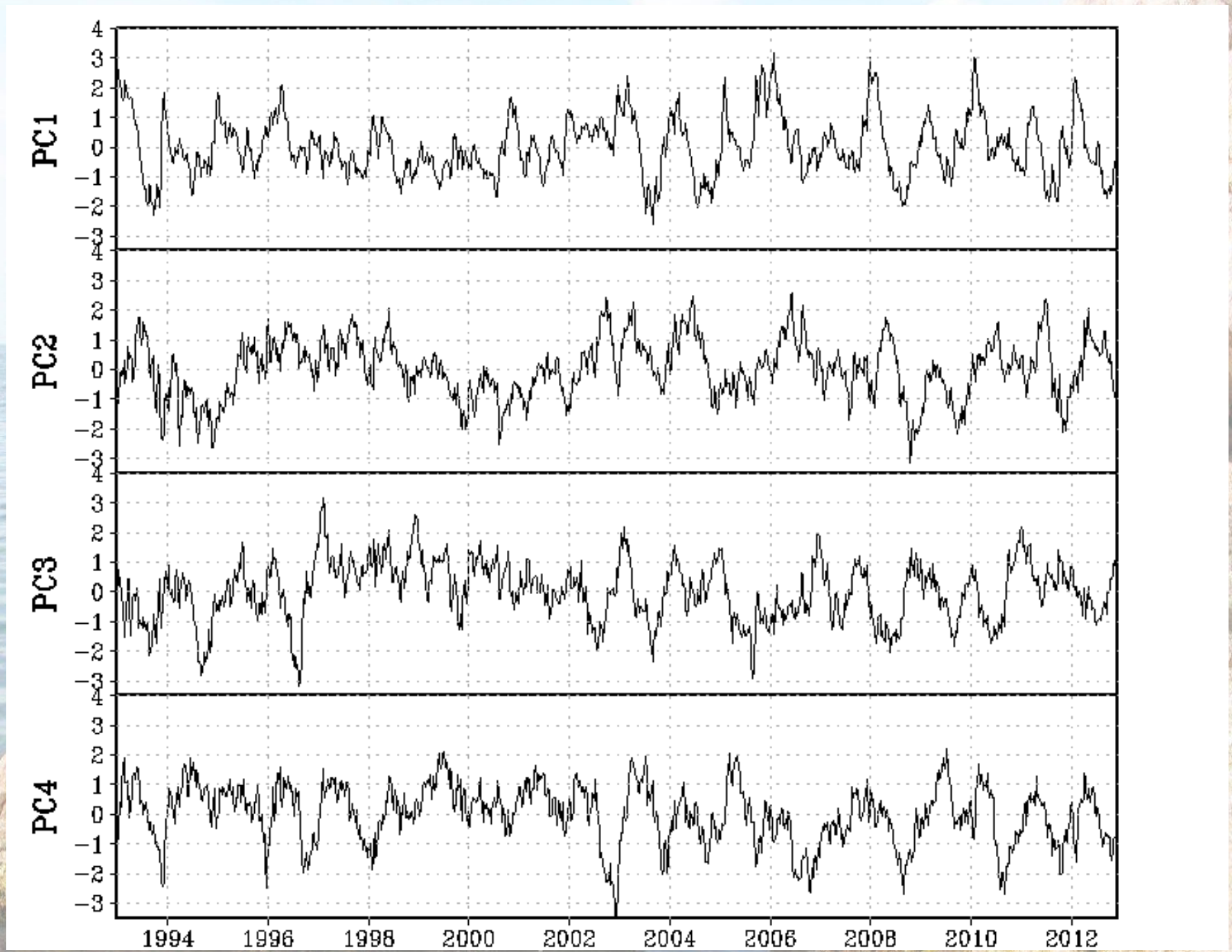




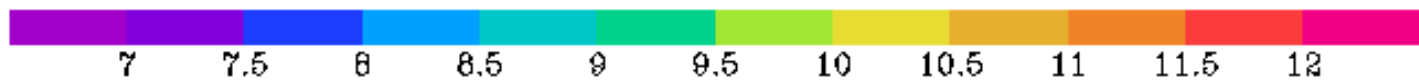
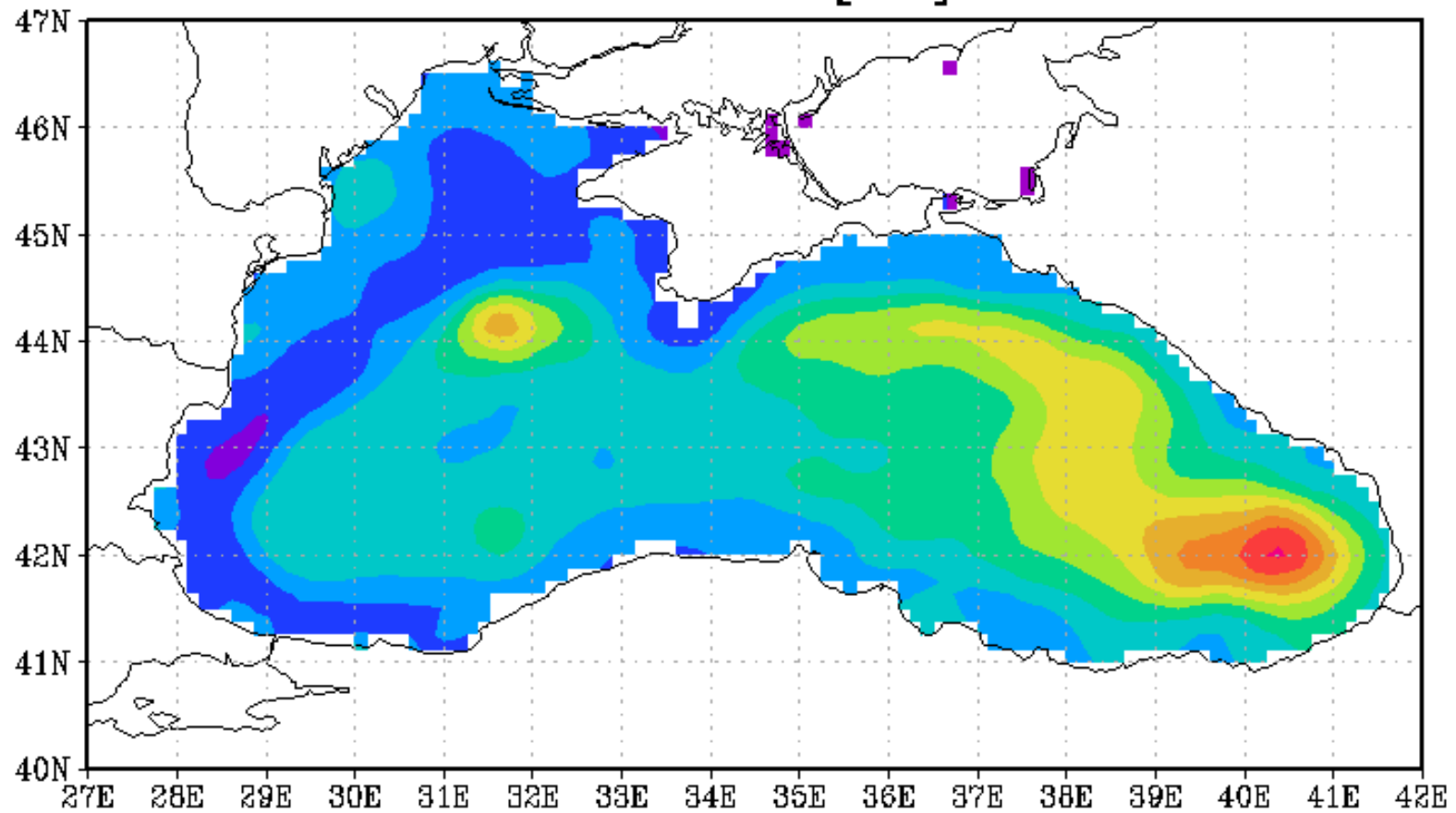
# MSLA EOF4 VAL=5%





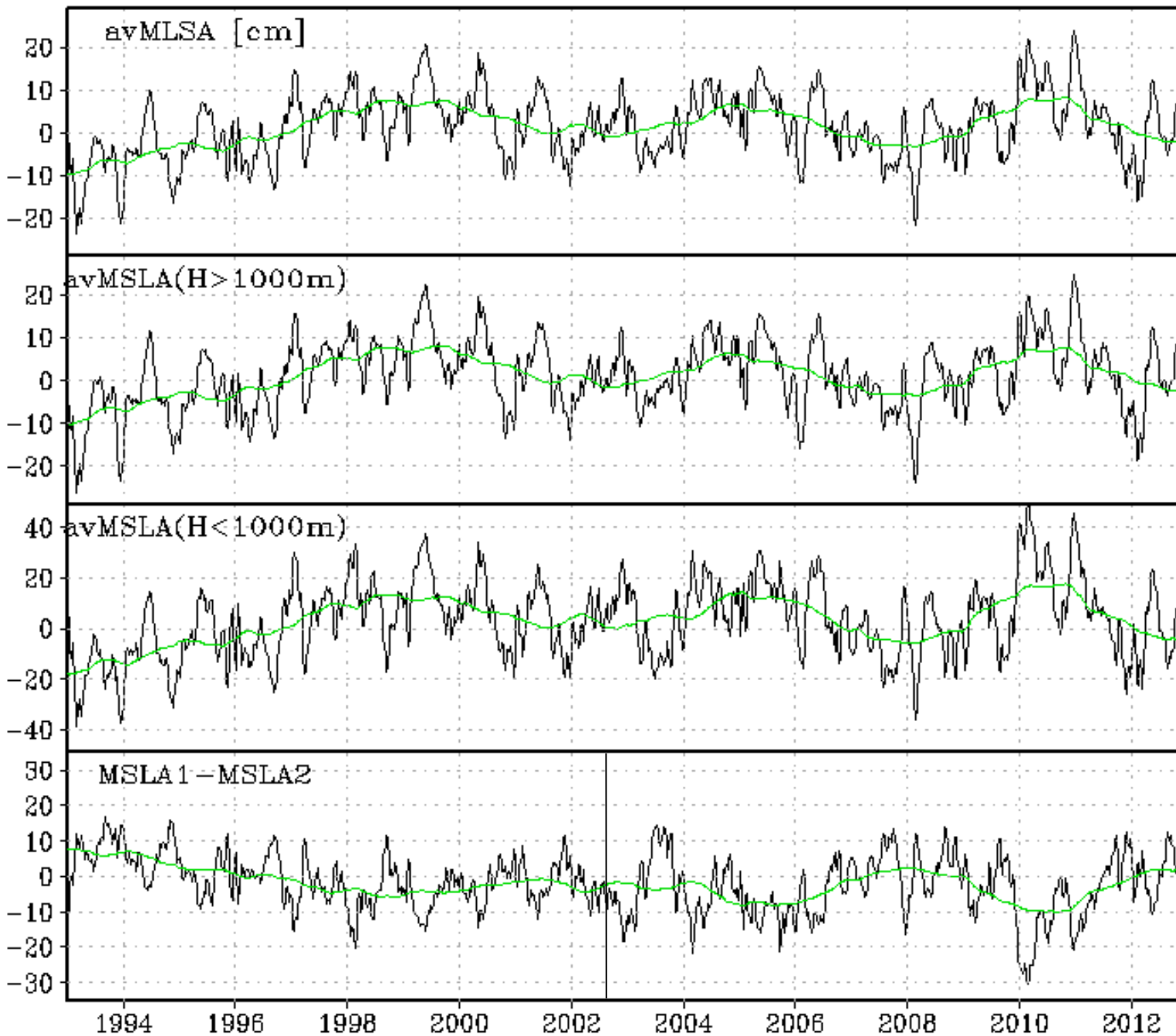
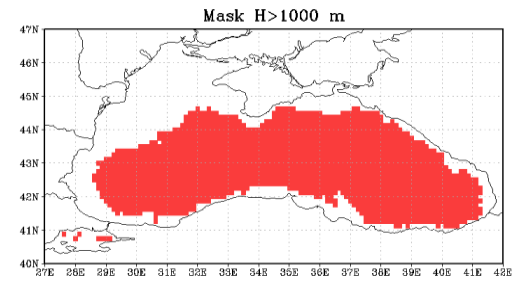


# RMS MLSA [cm]

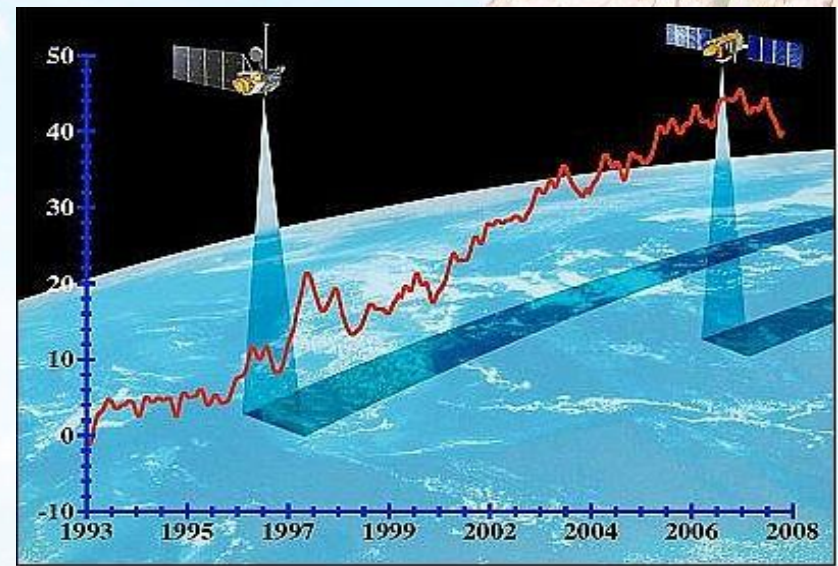




# Interannual variability of the Rim current?



# Temporal Coverage

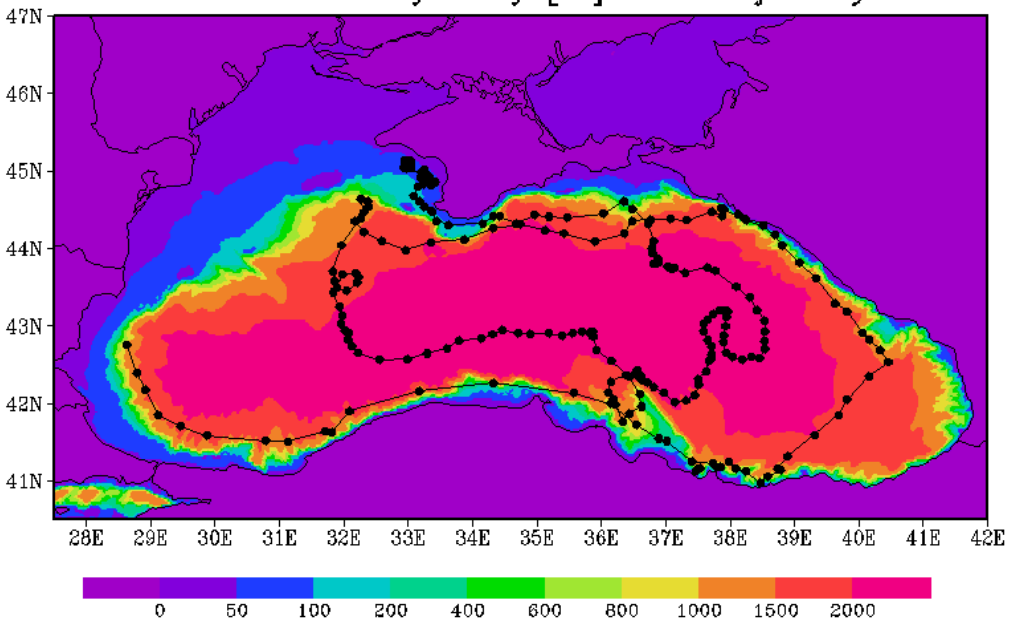


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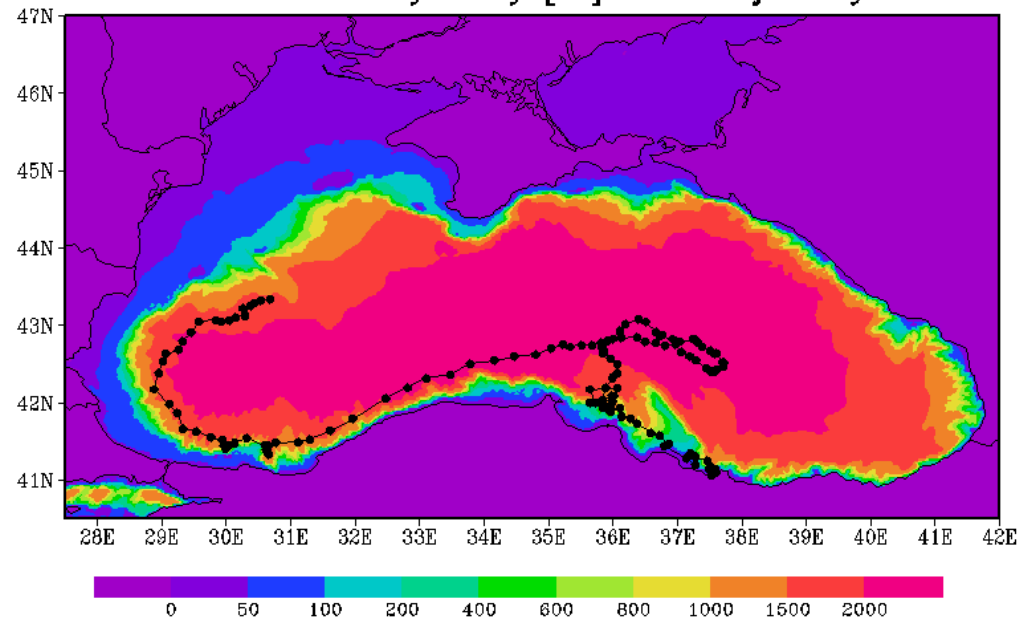




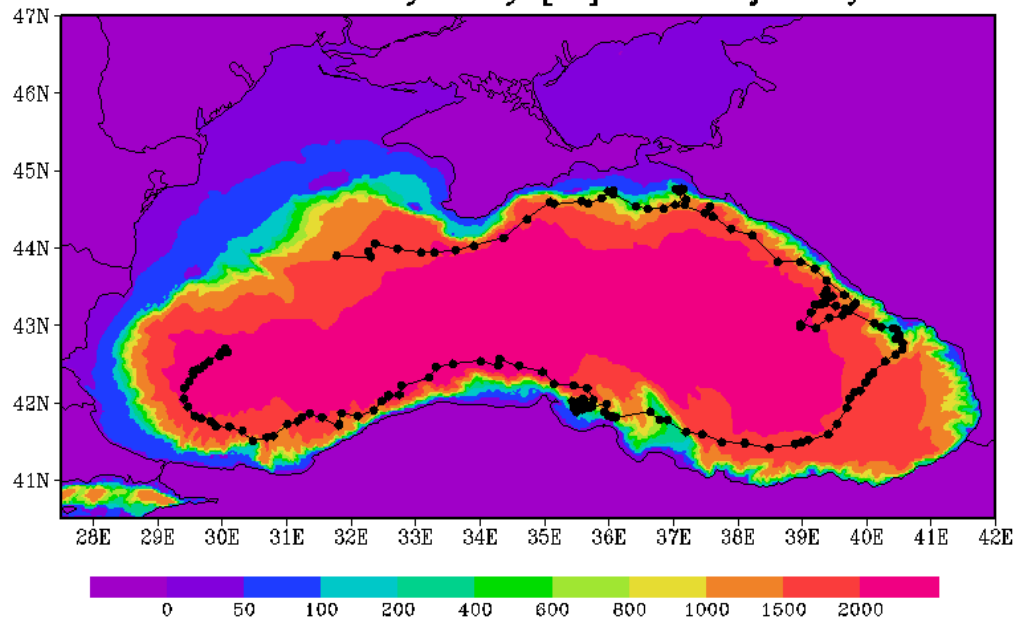
Kaliakra: Bathymetry [m] and Trajectory



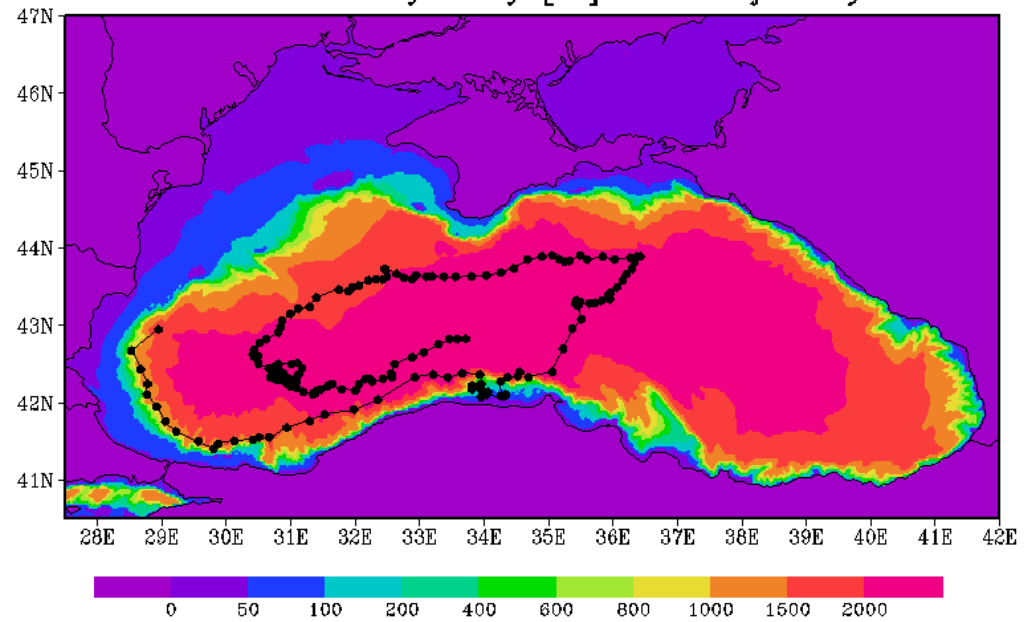
Shabla: Bathymetry [m] and Trajectory



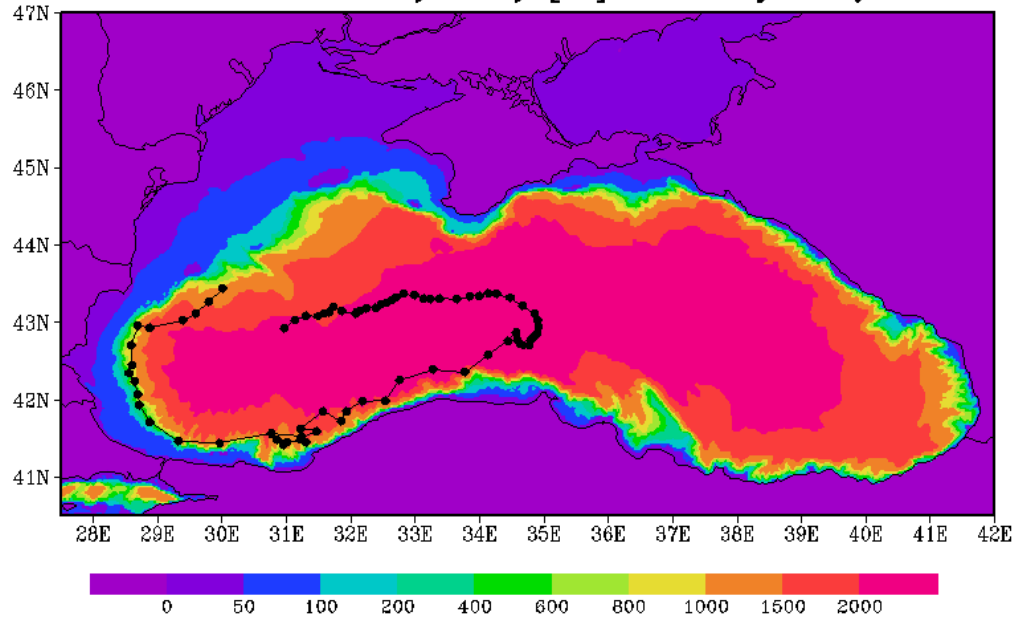
Emona: Bathymetry [m] and Trajectory



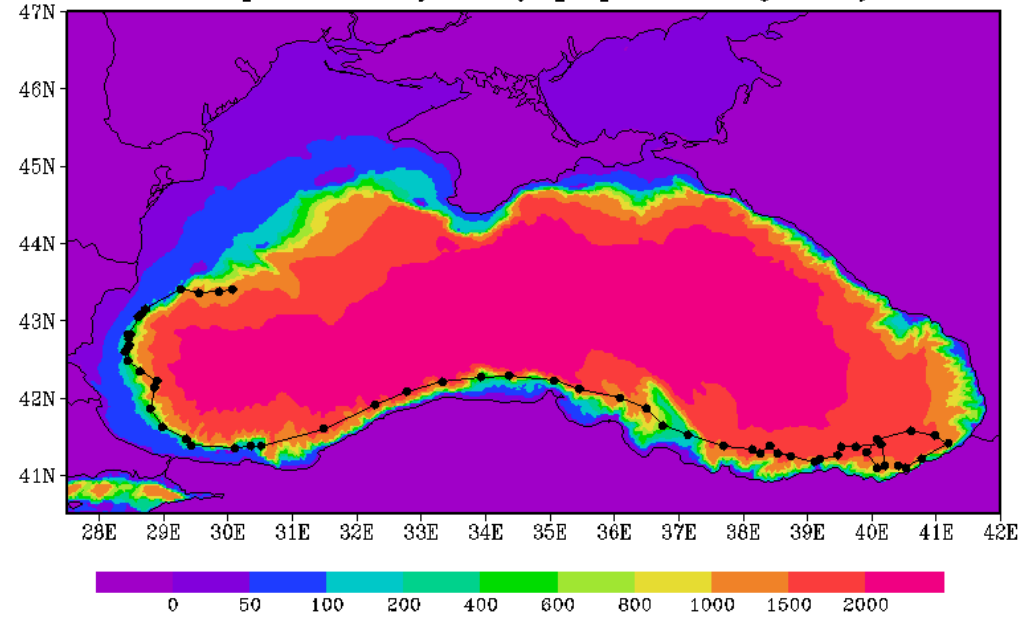
Galata: Bathymetry [m] and Trajectory



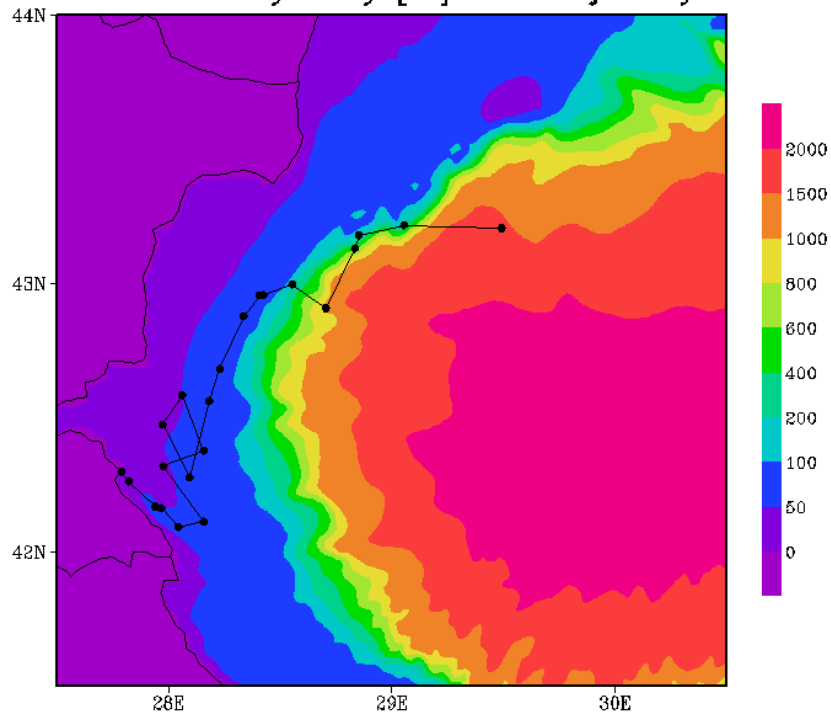
Rusalka: Bathymetry [m] and Trajectory



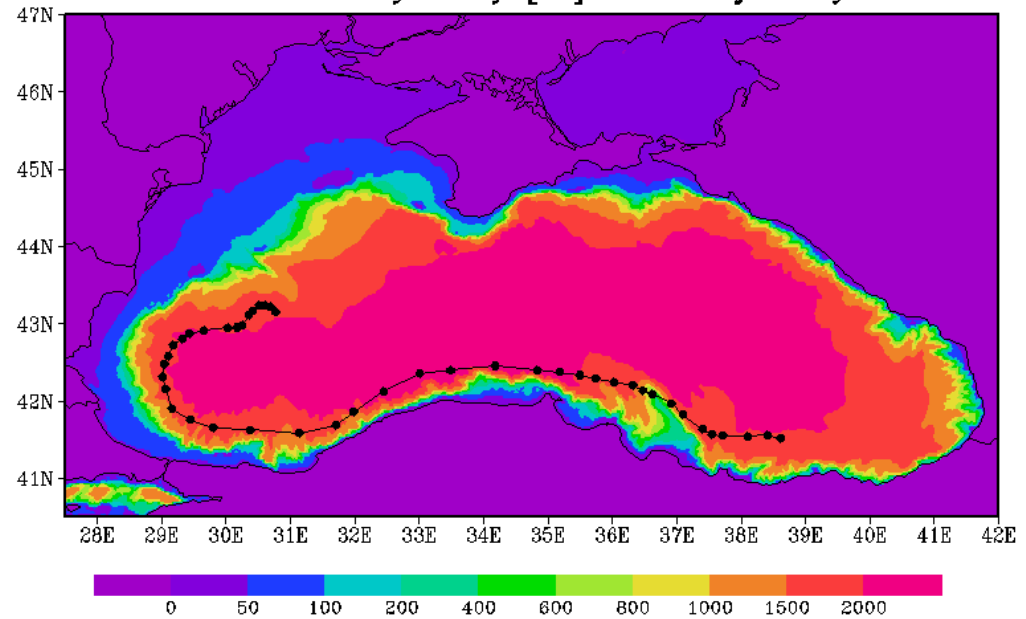
Dolphin: Bathymetry [m] and Trajectory



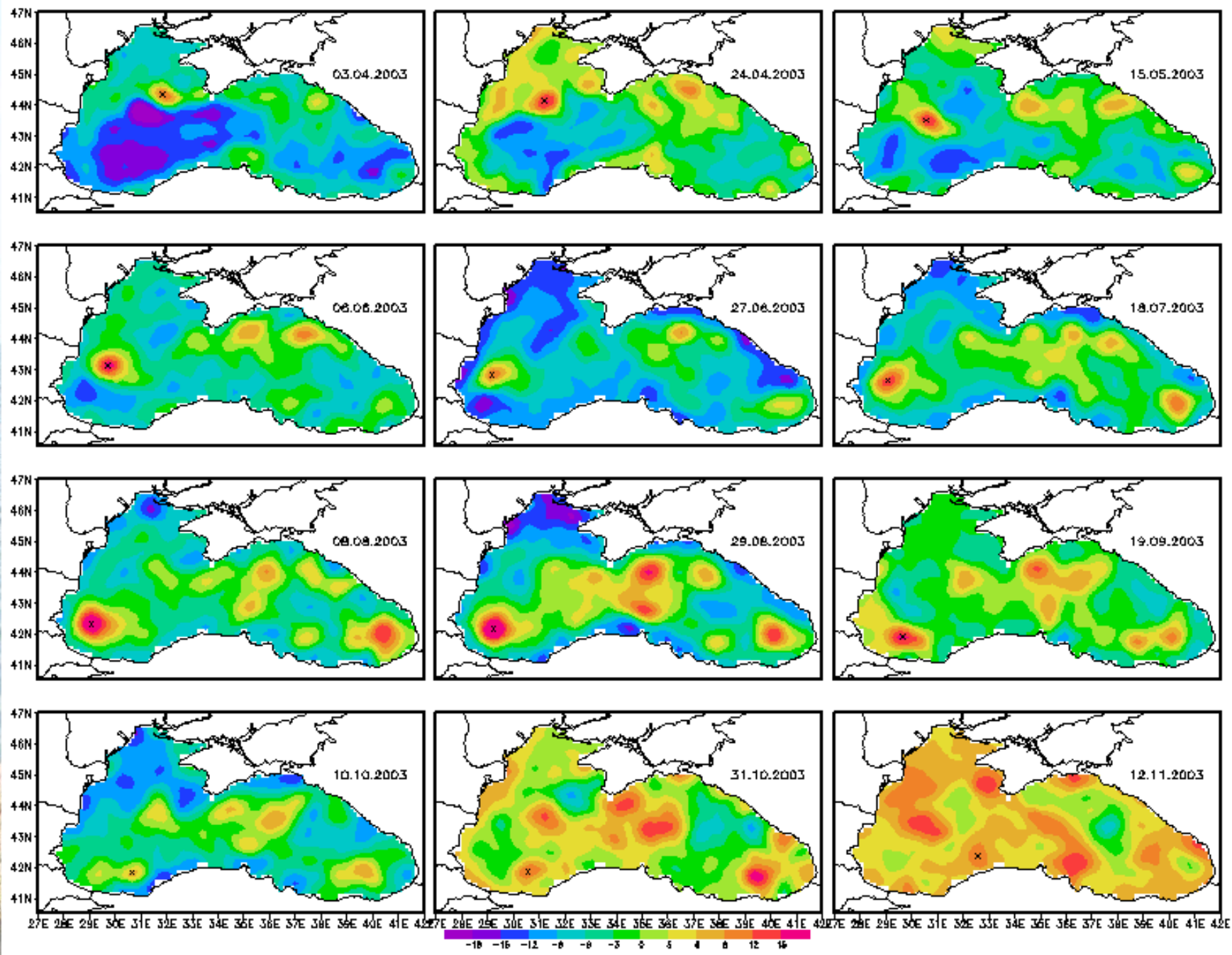
Varna: Bathymetry [m] and Trajectory



Elito: Bathymetry [m] and Trajectory





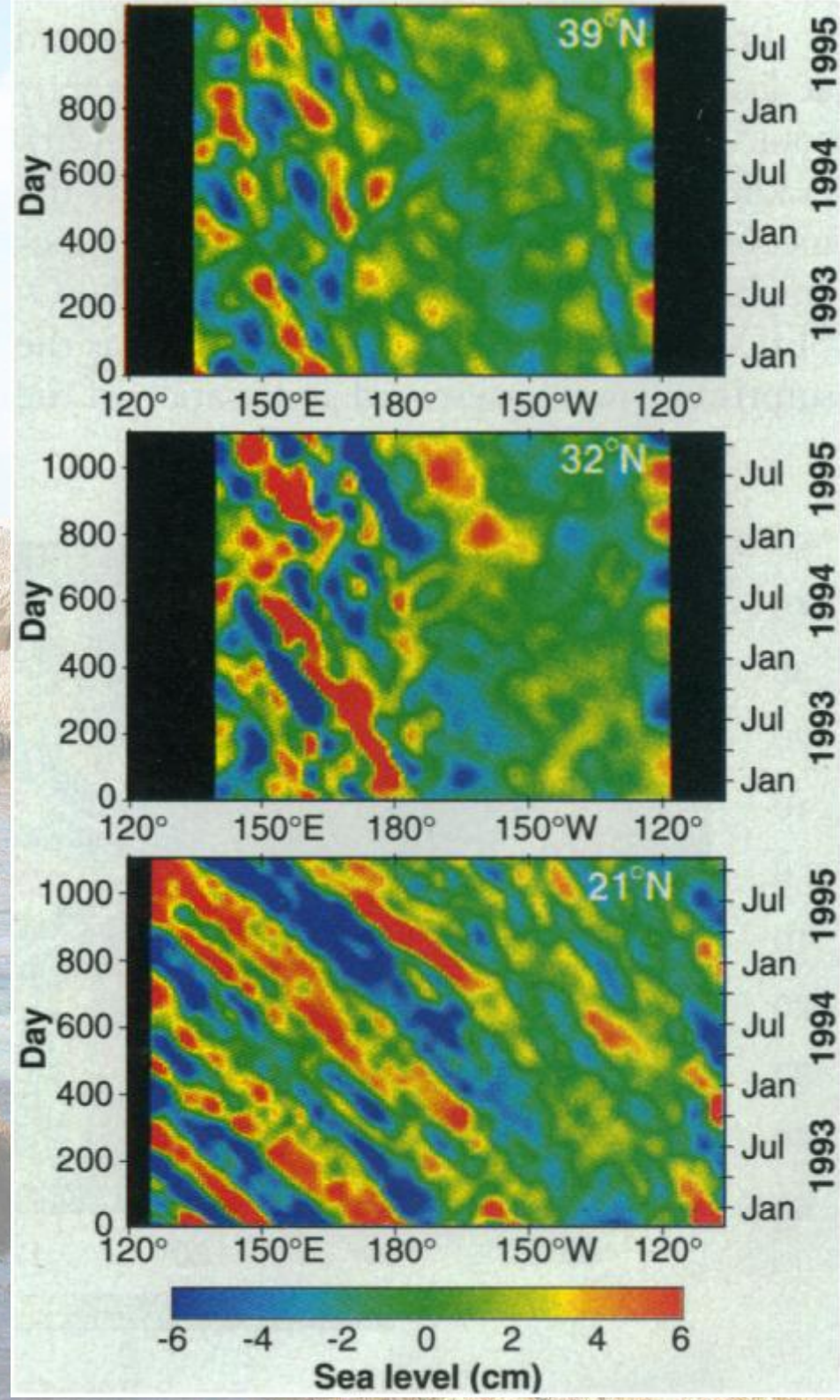




Such mesoscale eddies were discovered in the ocean and they propagated westward with a speed of order of 10 cm/s, so they were believed to be linear Rossby waves. (Chelton and Schlax, 1996)

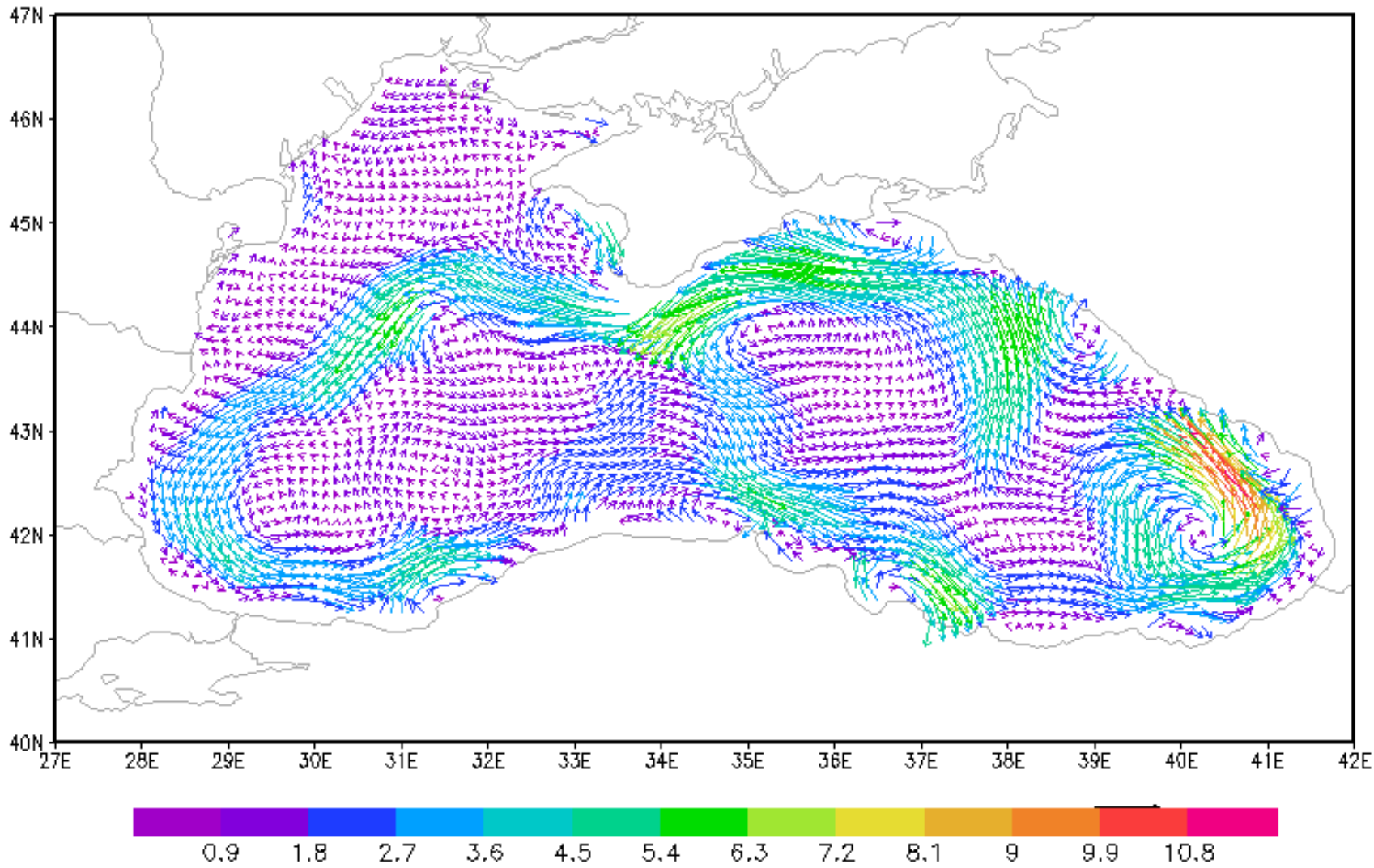
Actually after they were defined as mesoscale nonlinear coherent structures (eddies) in the main flow (Chelton et al, 2011)

Do we find propagation paths of such structures in the Black Sea?

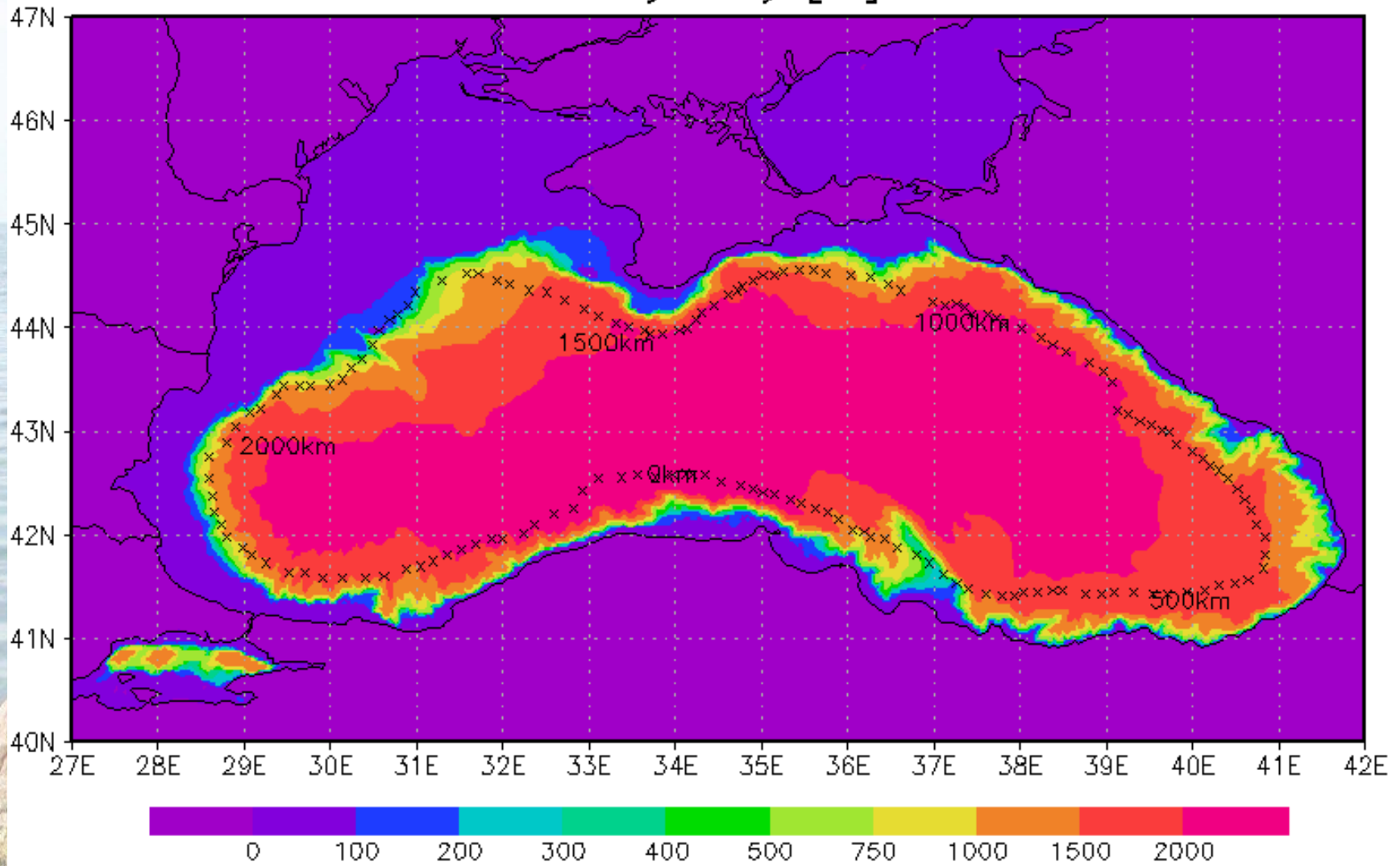




# The annual geostrophic velocities

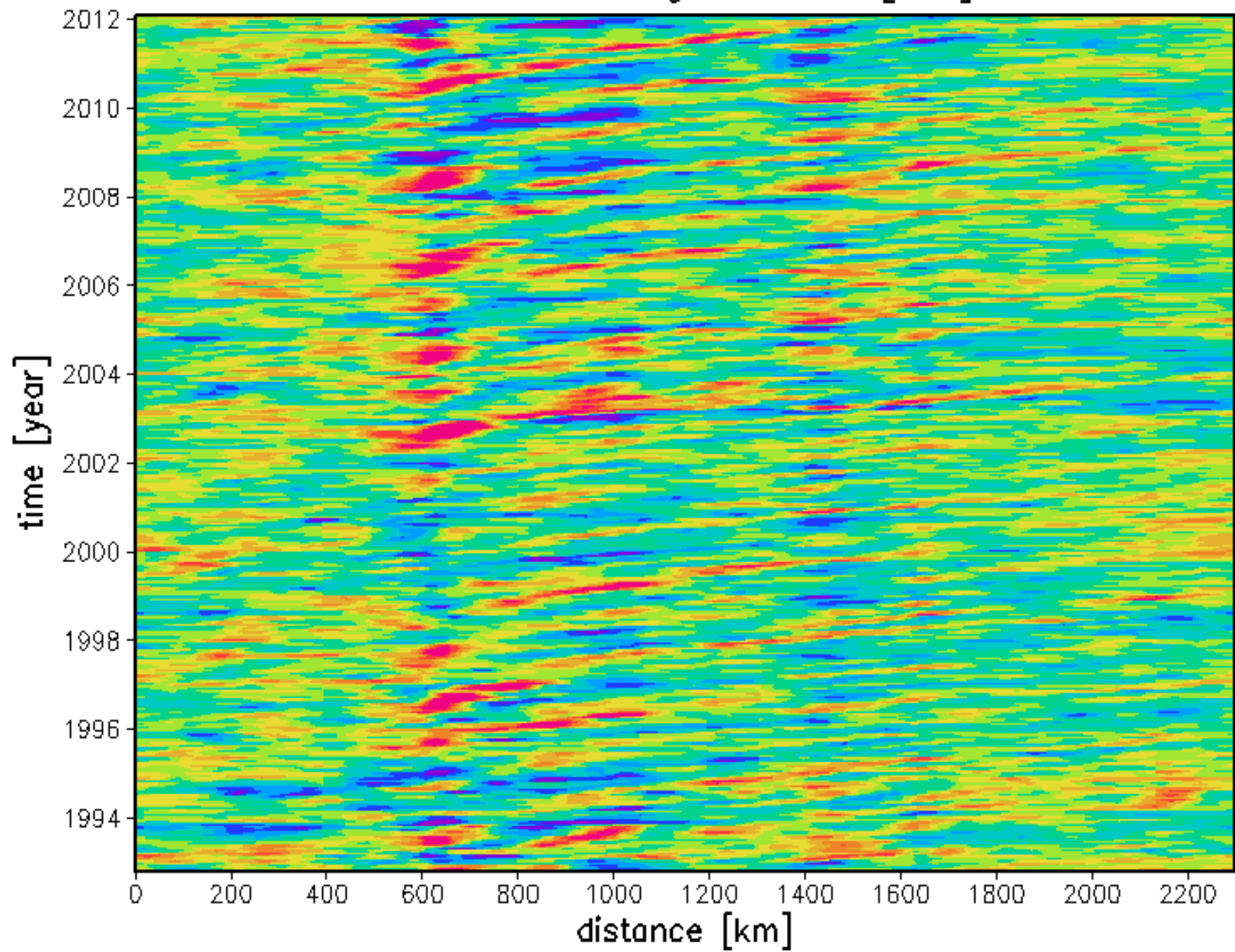


# Bathymetry [m]

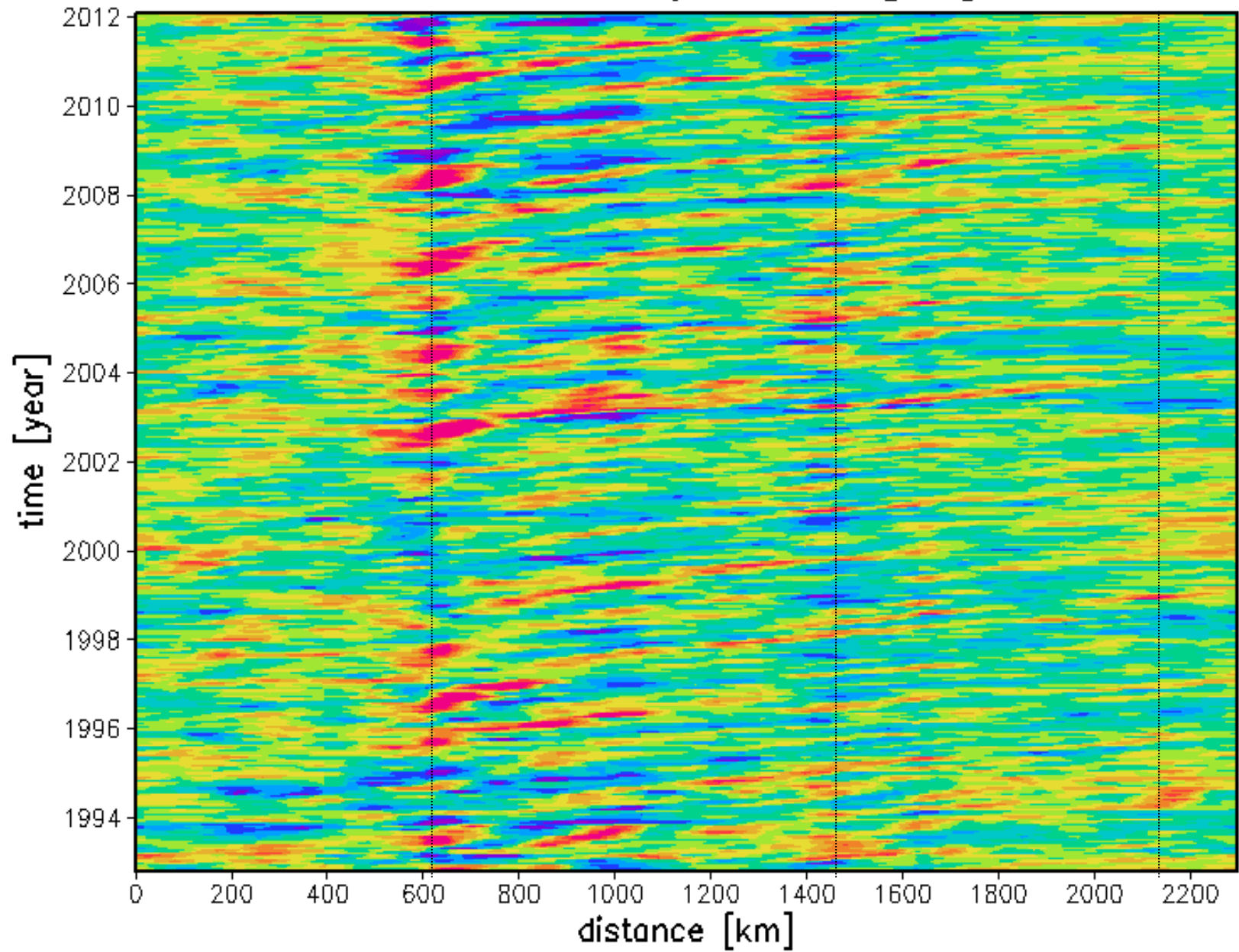




Hovmoller diagram SSH [cm]



# Hovmoller diagram SSH [cm]



800 km per 1.5 yr = 2 cm/s



# CONCLUSIONS

**20 years of weekly altimeter data were analysed in order to investigate the variability of the Black Sea surface**

**EOF analysis shows largest contributions of the mean sea level variations, followed by the seasonal intensification of Rim current and then mesoscale processes (78%, 5%, 2%)**

**Highest value of the variations amplitude is calculated in the regions of quasi-stationary eddies.**

**Propagating mesoscale structures were discovered following the east, north and north-west coast with an approximate speed of 2 cm/s**