Mare Pictum

Our Own View of Ocean Colour

Vittorio Barale

Joint Research Centre of the European Commission

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SCRIPPSUS INSTITUTIONIS OCEANOGRAPHIAE LATE MIDDLE AGES

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LATE MIDDLE AGES

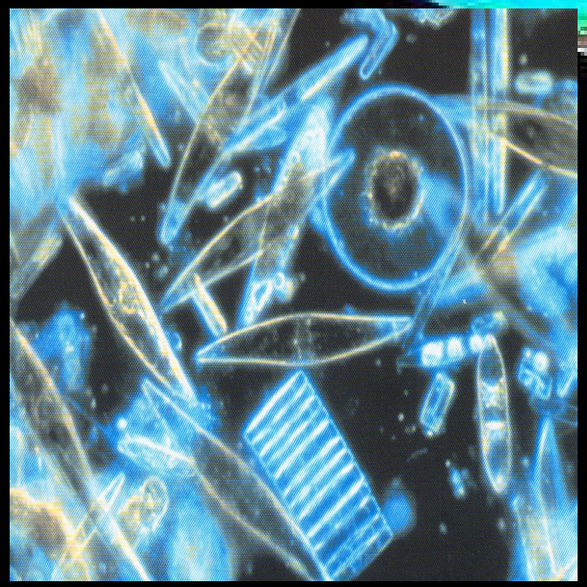
Ocean Color ...

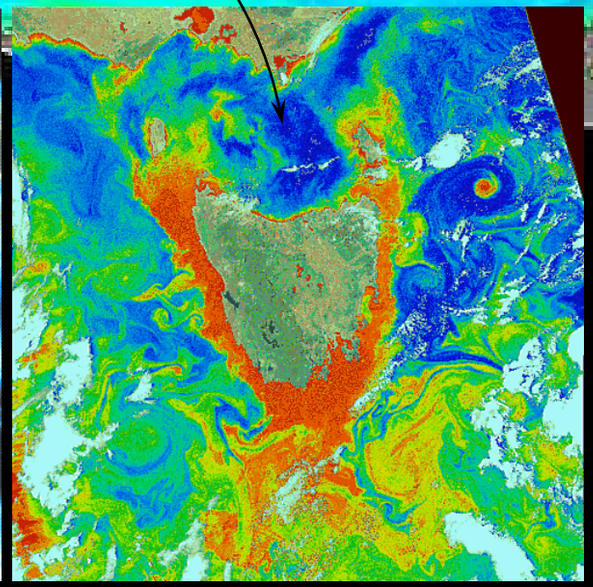
Global Ocean Color

0.01 [mg m^{-3}] 10

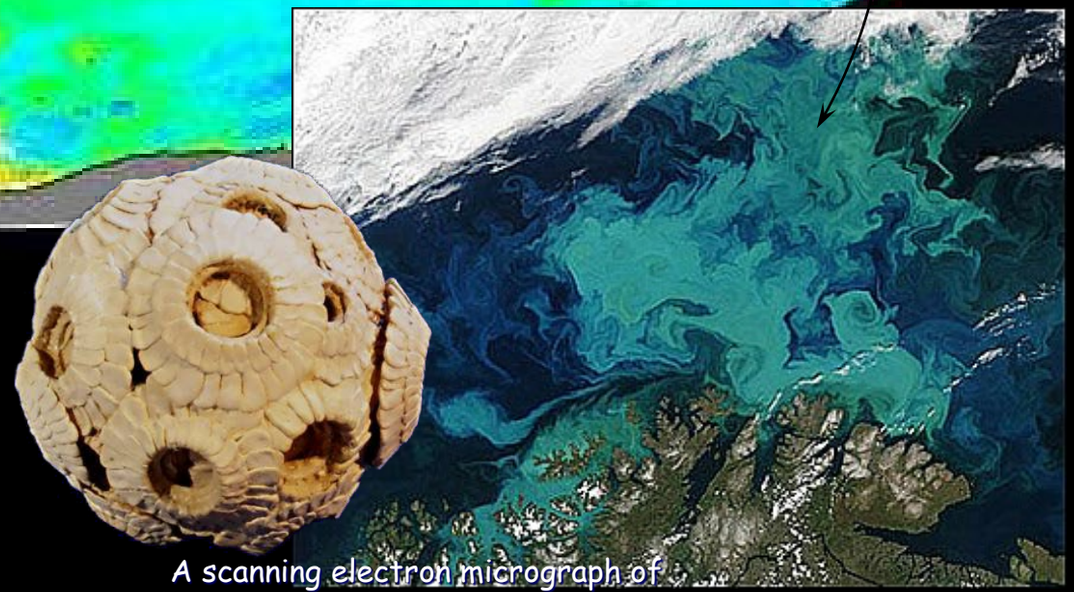
CHL from SeaWiFS data 1997-2003

False-color image by CZCS, 27 November 1981. The color coding indicates the approximate chlorophyll-like pigment concentration (CHL) in the water. Reds and yellows indicate more phytoplankton, greens and blues indicate less. Dark blue and purple indicate very low concentrations in clear oceanic waters.





Simulated true-color image by MODIS, 19 July 2003, showing a large algal bloom off the north coast of Norway due to coccolithophorids, with shells composed of $CaCO_3$ scales.



A scanning electron micrograph of the coccolithophorid *Emiliana huxleyi*, a species which commonly forms phytoplankton blooms.

BARALE, V., AND C.C. TREES (1987)
"SPATIAL VARIABILITY OF THE OCEAN COLOR FIELD IN CZCS IMAGERY"
ADVANCES IN SPACE RESEARCH, VOL. 7, N. 2, P. (2) 95 – (2) 100.

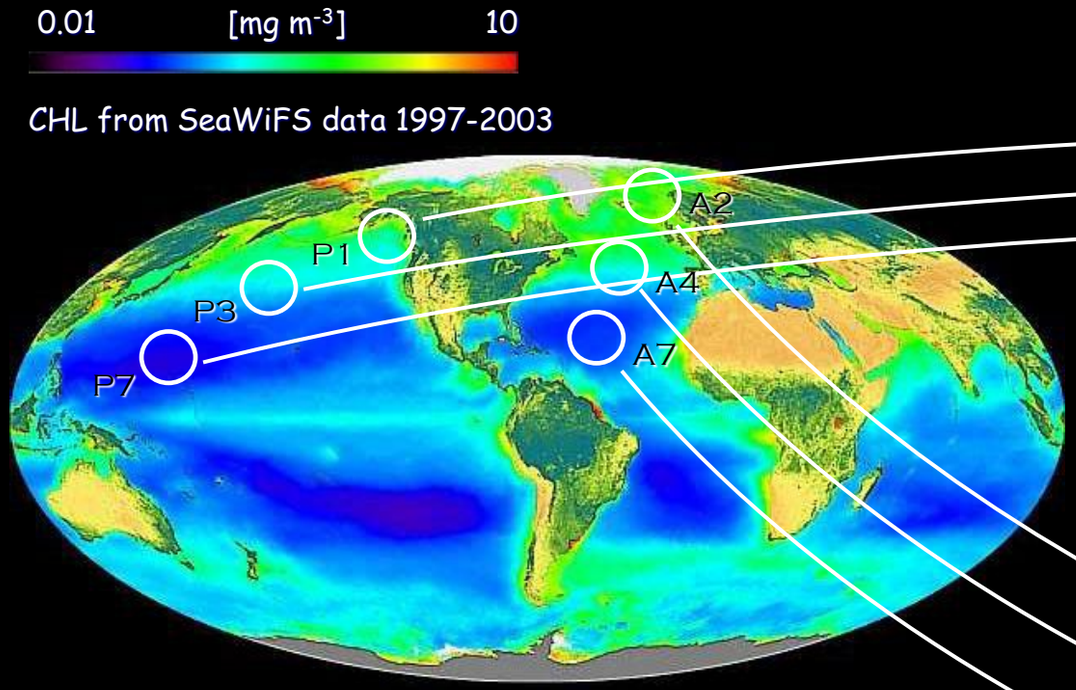
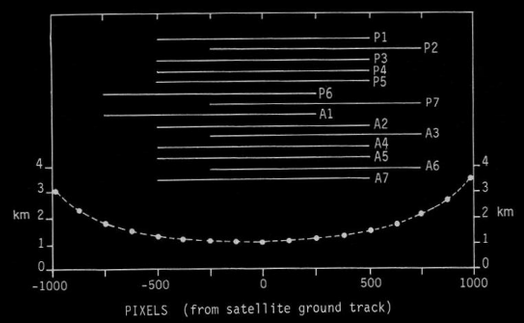


TABLE 1 CZCS Scene Selection and Statistical Summary.

Image Identifier	Orbit	Date	Tilt (°)	K(490) [m^{-1}] Mean	K(490) [m^{-1}] Std. Dev.	Coeff. of Variation	Chl. (mg m^{-3})	Cloud Free (%)
P1	4196	23 Aug 79	+8	0.090	0.039	43.3	0.84	48.9
P2	7776	8 May 80	+8	0.203	0.165	81.3	2.57	63.2
P3	9116	13 Aug 80	+18	0.065	0.061	93.8	0.49	68.0
P4	9503	10 Sep 80	+18	0.044	0.035	81.8	0.23	75.6
P5	6477	4 Feb 80	+16	0.045	0.019	42.2	0.24	90.5
P6	7306	4 Apr 80	+14	0.057	0.035	61.4	0.39	60.5
P7	9684	23 Sep 80	+10	0.039	0.011	28.2	0.17	83.8
A1	2352	12 Apr 79	-6	0.058	0.021	36.2	0.40	34.6
A2	7894	17 May 80	+14	0.107	0.053	49.5	1.08	36.5
A3	2715	8 May 79	+20	0.061	0.041	67.2	0.44	79.5
A4	3226	14 Jun 79	+20	0.073	0.056	76.7	0.60	75.2
A5	4124	18 Aug 79	+10	0.076	0.036	47.3	0.64	74.7
A6	7827	12 May 80	+20	0.033	0.008	24.2	0.10	69.6
A7	7993	24 May 80	+20	0.031	0.006	19.4	0.08	68.3



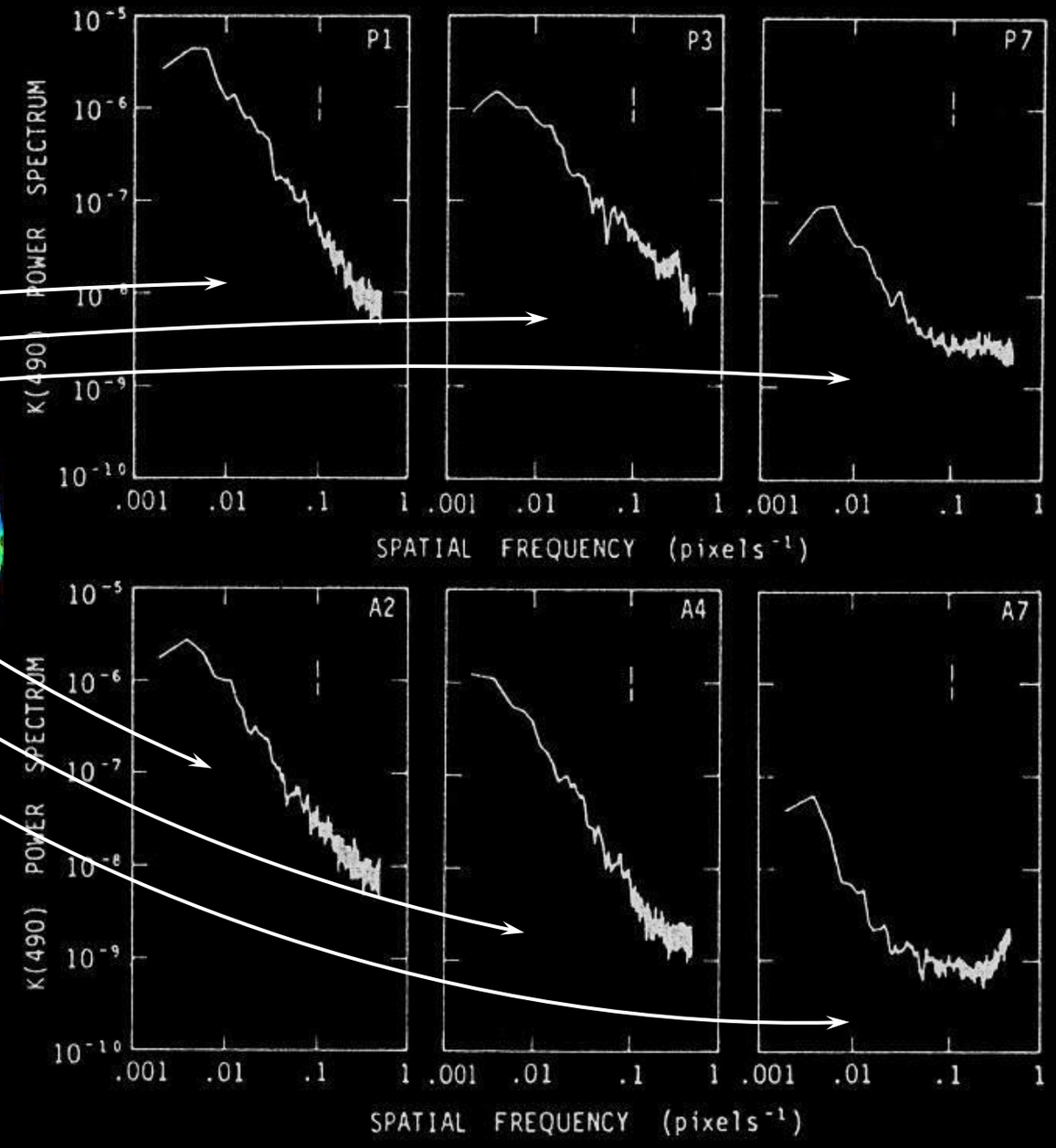
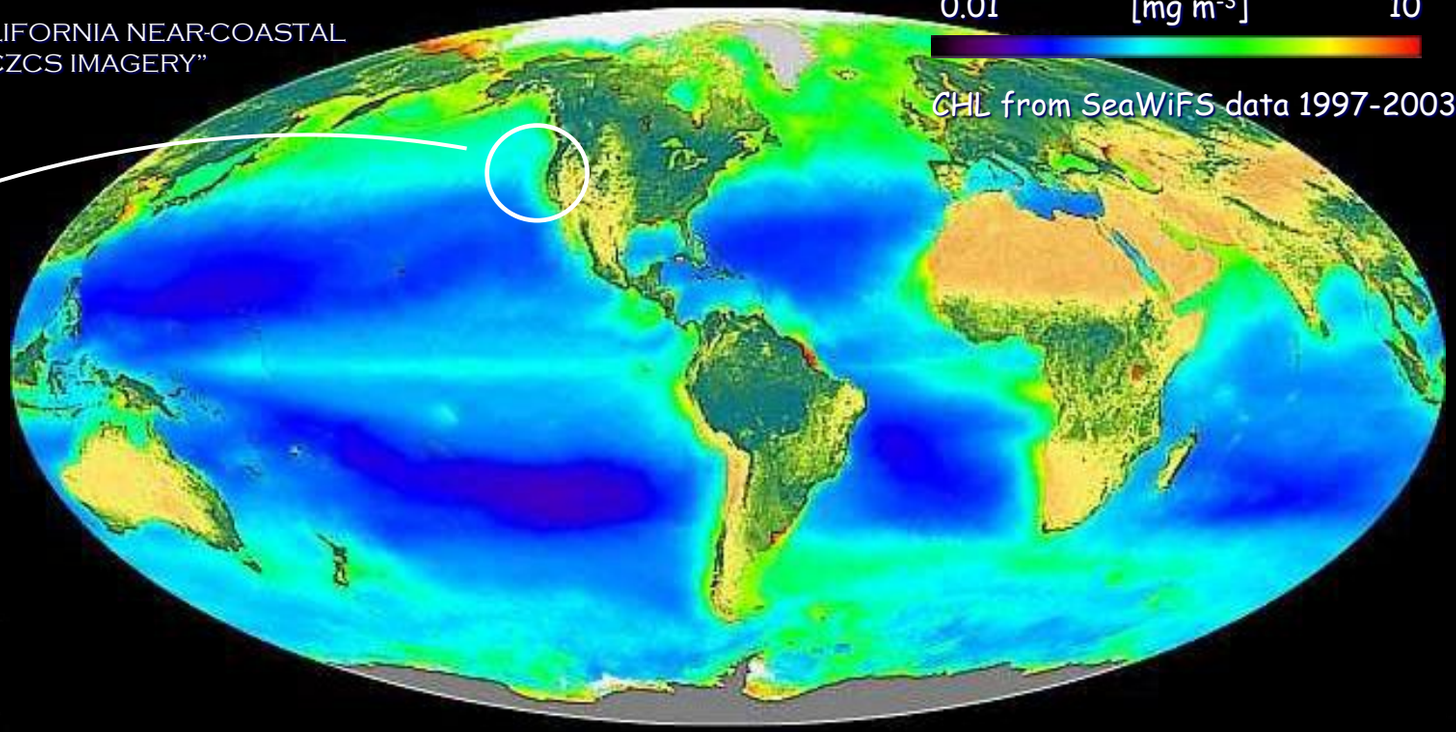


Fig. 3. Selected power spectra of the North Pacific and North Atlantic images. The vertical lines represent 95% confidence intervals. Image identifiers correspond to those in Table 1.

BARALE, V., AND R. WITTENBERG FAY (1986)
"VARIABILITY OF THE OCEAN SURFACE IN CENTRAL CALIFORNIA NEAR-COASTAL WATERS AS OBSERVED IN A SEASONAL ANALYSIS OF CZCS IMAGERY"
JOURNAL OF MARINE RESEARCH, VOL. 44, P. 291– 316.



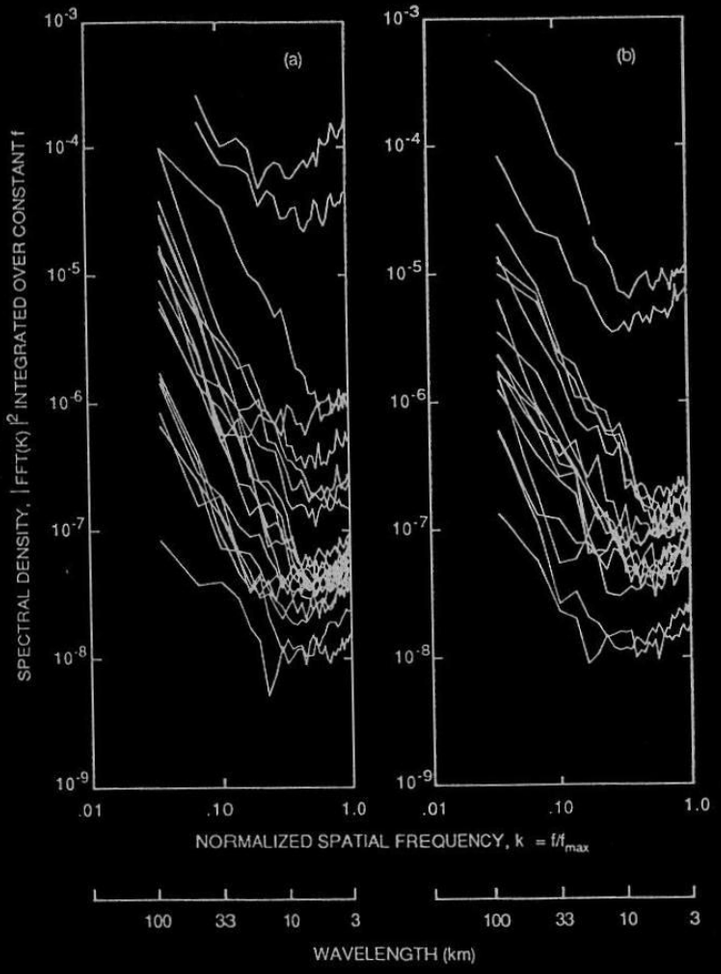


FIGURE 4. Scalar Fourier spectra obtained for the image subsets listed in Tables 1 and 2: (a) southern region; (b) northern region.

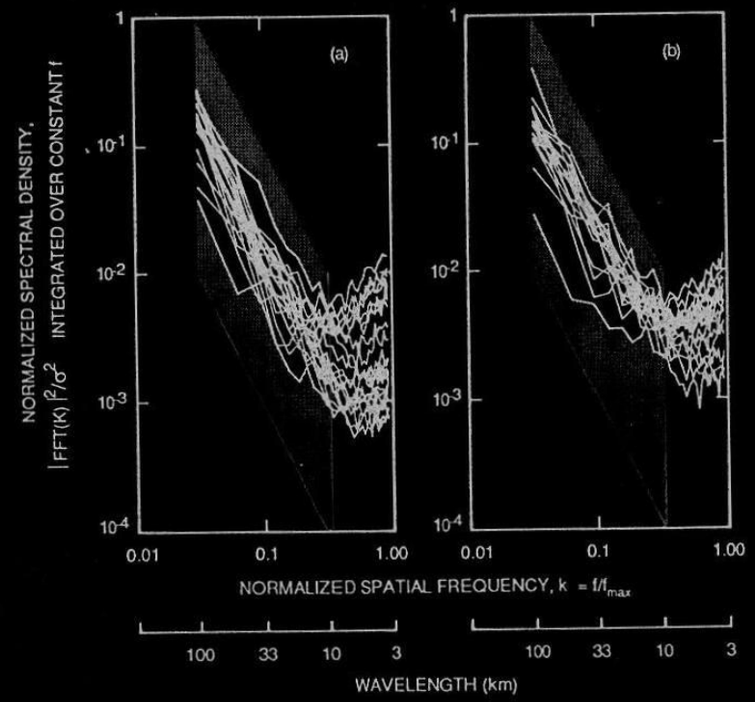


FIGURE 5. Normalized scalar Fourier spectra: (a) southern region, (b) northern region (the dotted fields are delimited by lines decreasing with a -2 slope).

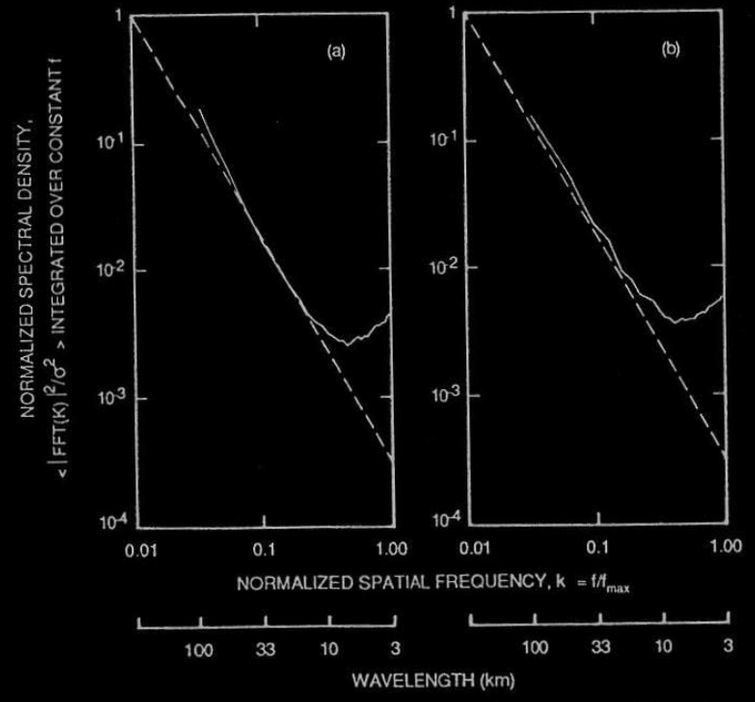
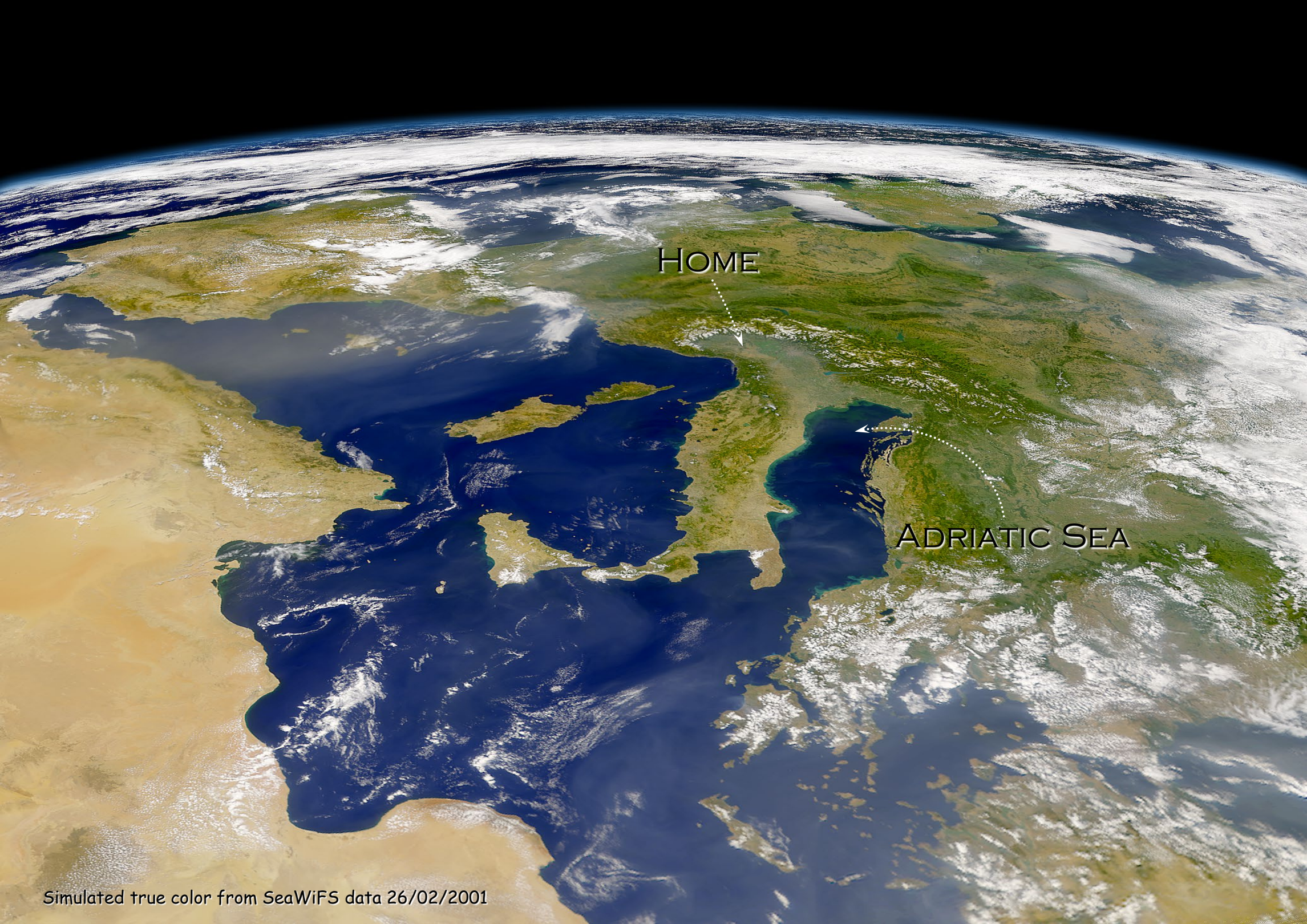


FIGURE 6. Scalar power spectra: (a) southern region, (b) northern region (the dashed lines follow a $k^{-5/3}$ power law).


Home
Adriatic Sea
Simulated true color from SeaWiFS data 26/02/2001

BARALE, V., C.R. MCCLAIN AND P. MALANOTTE RIZZOLI (1986)
"SPACE AND TIME VARIABILITY OF THE SEA SURFACE COLOR FIELD IN THE NORTHERN ADRIATIC SEA"
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 91, N. C11, P. 12957-12974.

Fig. 1. Adriatic Sea: geographical region, bottom topography (depths in meters), and coastal stations. The outlined subset shows the area covered by the CZCS imagery utilized in this work.

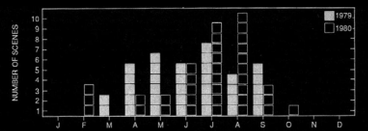


Fig. 2. Temporal distribution of the CZCS data base, for the period 1979–1980 (each square corresponds to one available scene).

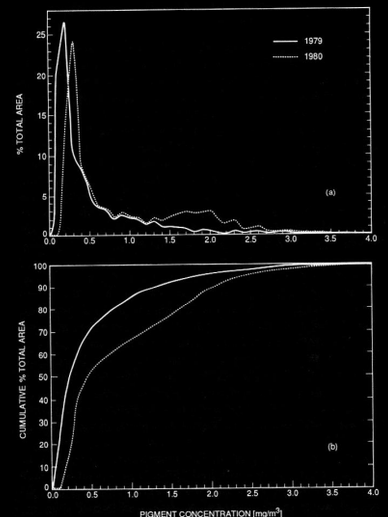


Fig. 4. (*a*) Frequency distribution and (*b*) cumulative frequency distribution of CZCS-derived phytoplankton pigment concentrations [mg/m^3], from the yearly mean images. The total area analyzed included exclusively the sea surface covered by each image.

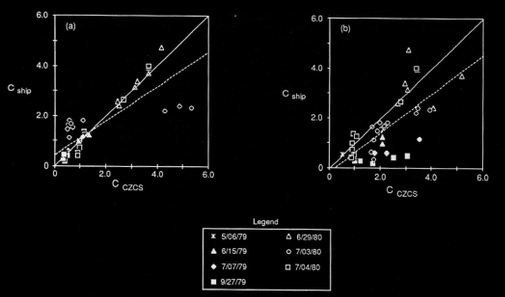
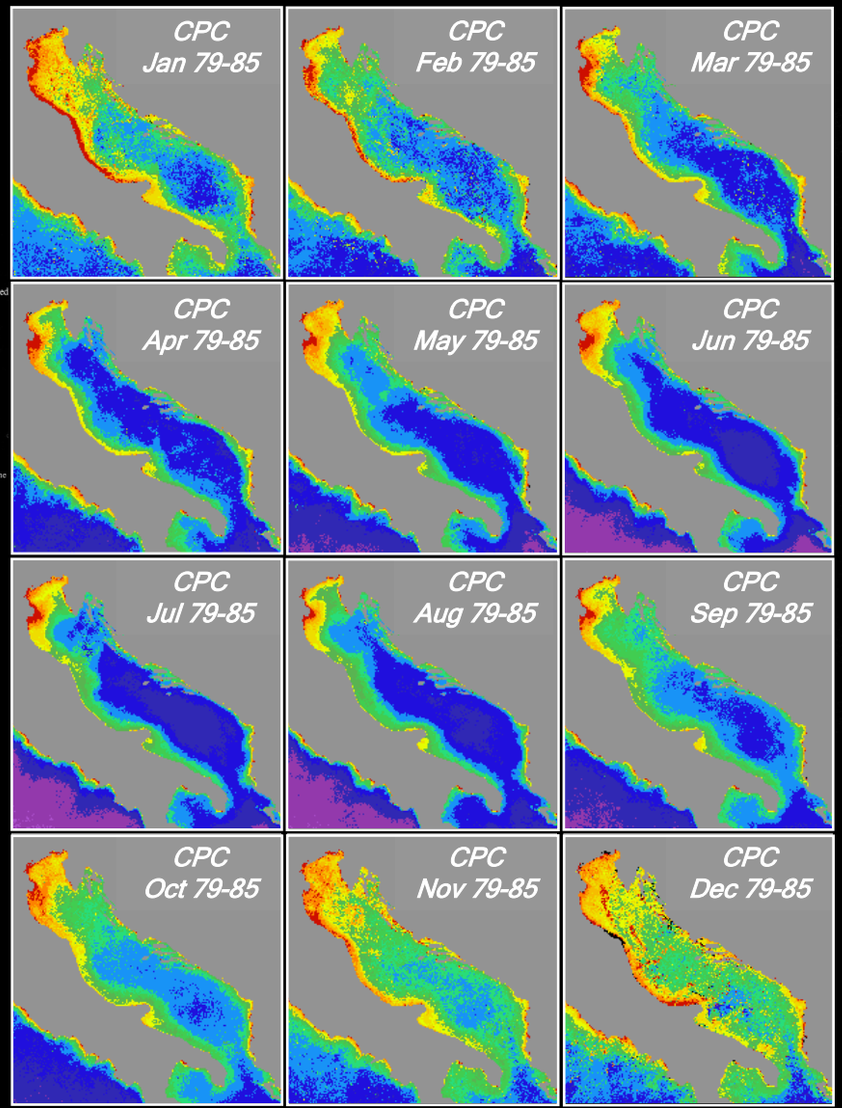


Fig. 3. Intercomparison of ship and satellite derived phytoplankton pigment concentrations [mg/m^3]. (*a*) Satellite estimates from "global" analysis of each scene. (*b*) Satellite estimates from "local" analysis of each scene. The dotted lines represent, in each case, a linear regression of all 40 points.



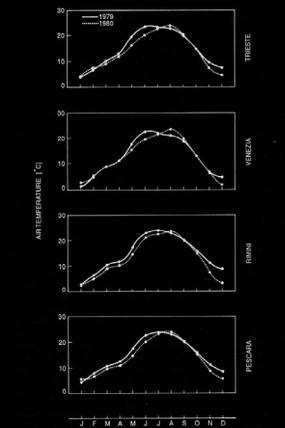


Fig. 6. Air temperature (in degrees Celsius) at selected coastal stations in the Adriatic region. Monthly averages for 1979 and 1980 at Trieste, Venezia, Rimini and Pescara (from A. Tomasin and A. Bergamasco, personal communication, 1985.) Station locations are shown in Figure 1.

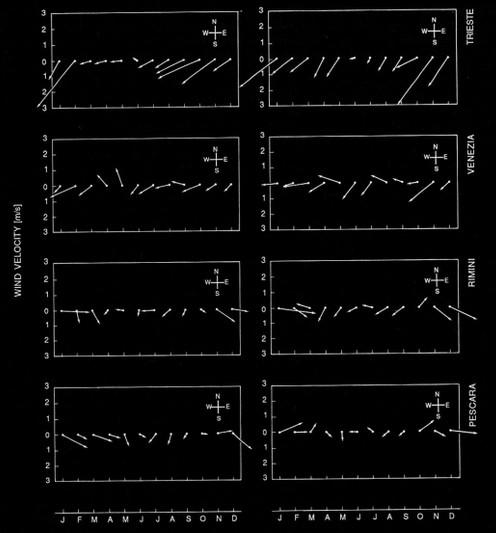


Fig. 7. Wind speed (in meters per second) at selected coastal stations in the Adriatic region. Monthly averages fo 1979 and 1980 at Trieste, Venezia, Rimini and Pescara (from A. Tomasin and A. Bergamasco, personal communicatio 1985). Station locations are shown in Figure 1.

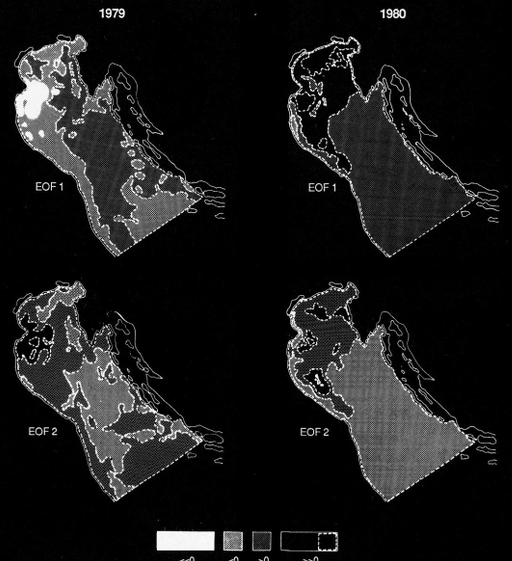


Fig. 8. Empirical orthogonal functions, modes 1 and 2, for the 1979 and 1980 time series. The arbitrary EOF's units have been coded with the gray levels shown, for the categories much less than zero, less than zero, greater than zero, and much greater than zero (this last class also has peaks emphasized by further contouring with a dotted line).

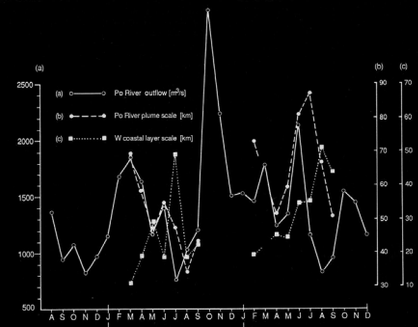


Fig. 11. Comparison of monthly-averaged Po River outflow (in cubic meters per second) with Po River plume and western coastal layer average scales (kilometers) for the period from August 1978 to December 1980 (see also Table 7).

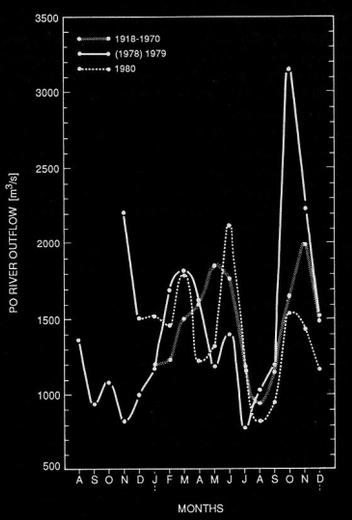


Fig. 5. Po River outflow [m^3/s] monthly averages for 1979, 1980, and long-term, 1918–1970 [from *Marchetti*, 1984].

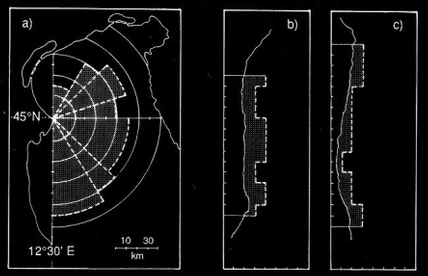
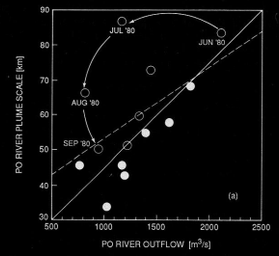


Fig. 10. Geographical grids used for the estimation, in the phytoplankton pigment concentration monthly mean images (*a*) of the spatial characteristics of the Po River plume and (*b*) of the western coastal layer, approximately from Rimini to Ancona and (*c*) from Ancona to Pescara. The estimates shown are relative to the month of March 1979.



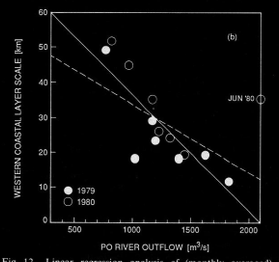
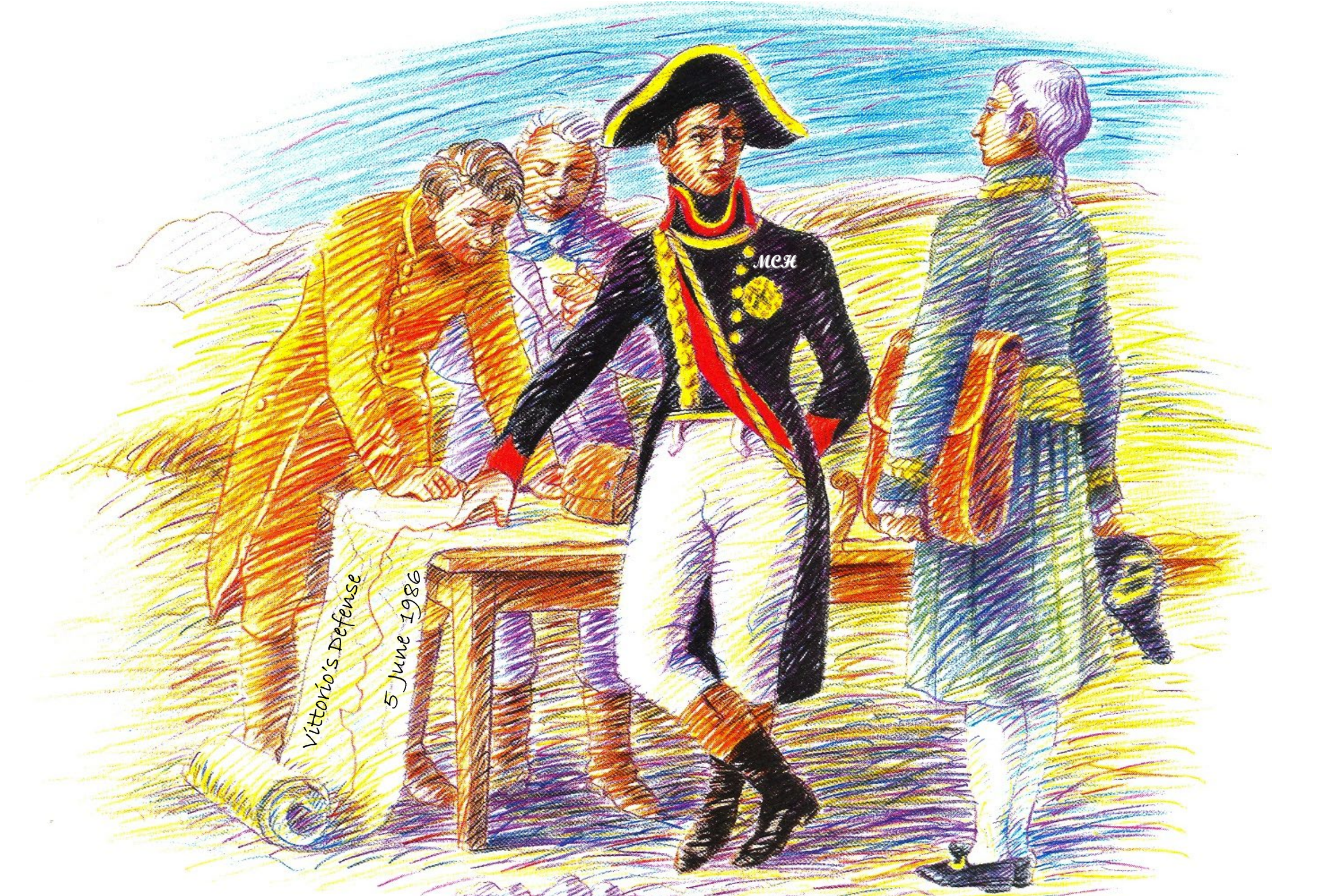


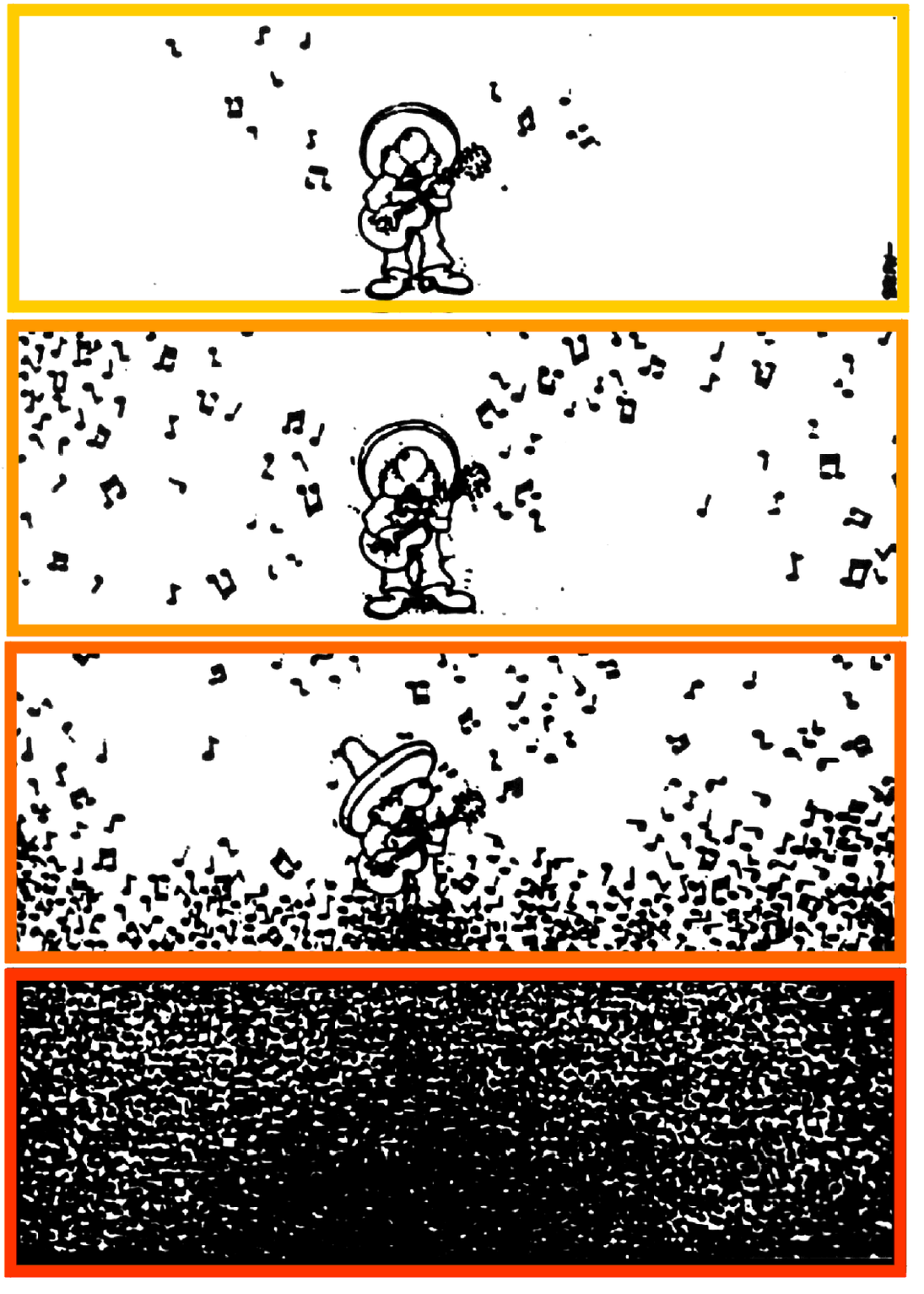
Fig. 12. Linear regression analysis of (monthly averaged) Po River outflow (in cubic meters per second) and surface features scales (in kilometers) (*a*) outflow versus Po River plume average penetration scale and (*b*) outflow versus western coastal layer average width. The dotted lines represent a linear regression of all 14 points, in both cases. When the July 1980 and August 1980 points are excluded from the data set in Figure 12a, and the June 1980 point is excluded from the data set in Figure 12b, the linear regressions are represented by the solid diagonal lines.



The Great Advisor, M.C. Hendershott, and his grad student plan a Thesis Defense (La Jolla, 1986)

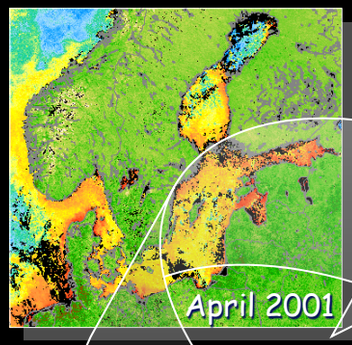
Vittorio
… and then eventually, I DID IT….
HF

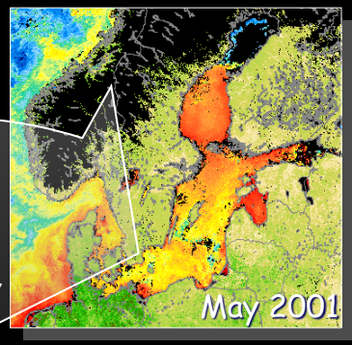
Better Sensors
Larger Satellites
More and More Data …

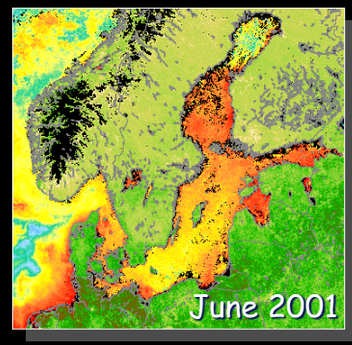


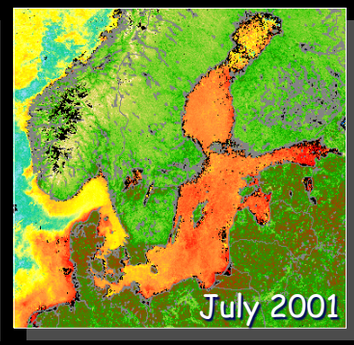
Finally … back in Europe, I started a new career, which made my Advisor proud of me …

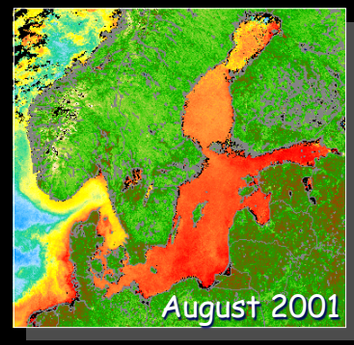
Optical Signatures of the European Seas ...

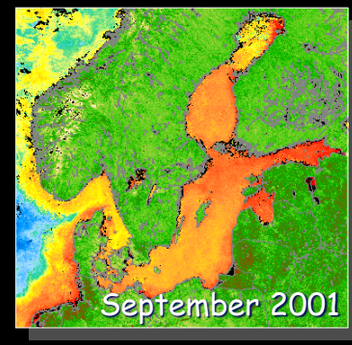






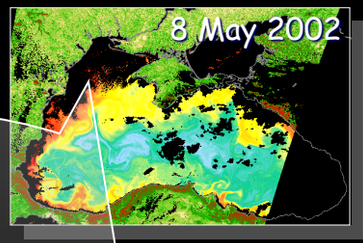


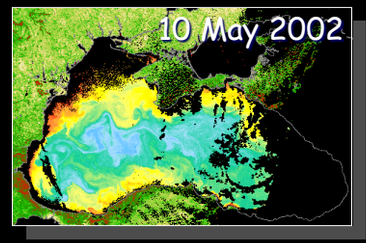


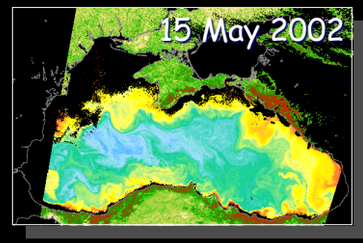


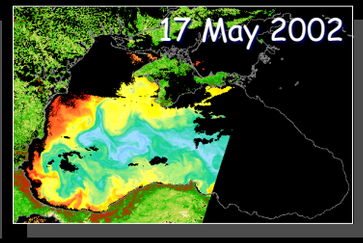
Baltic Sea

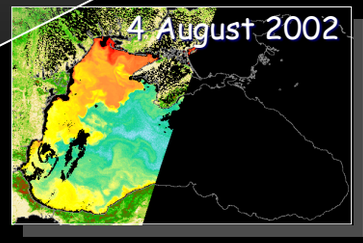
Black Sea

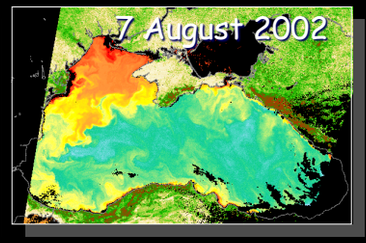


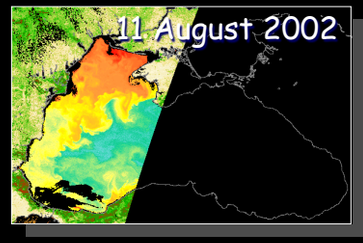


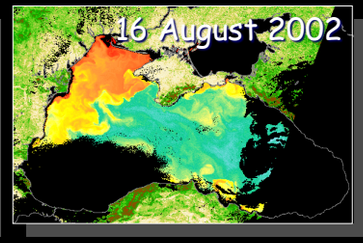


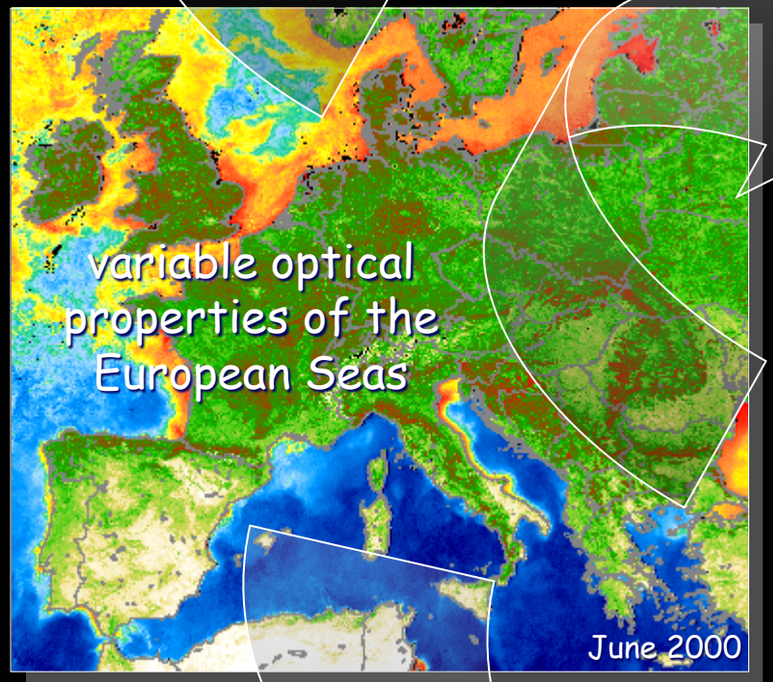


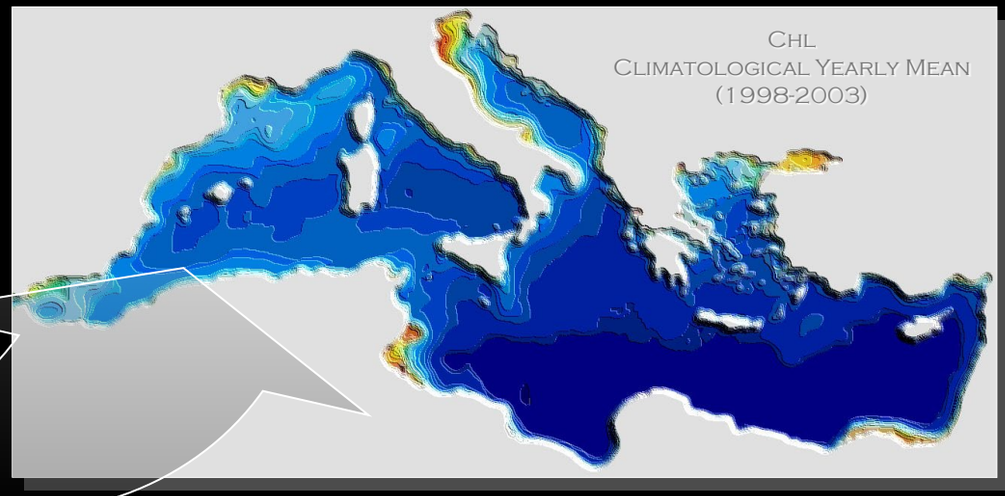


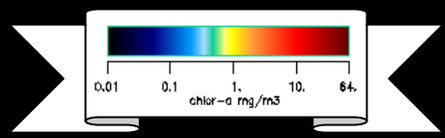


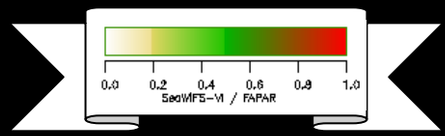








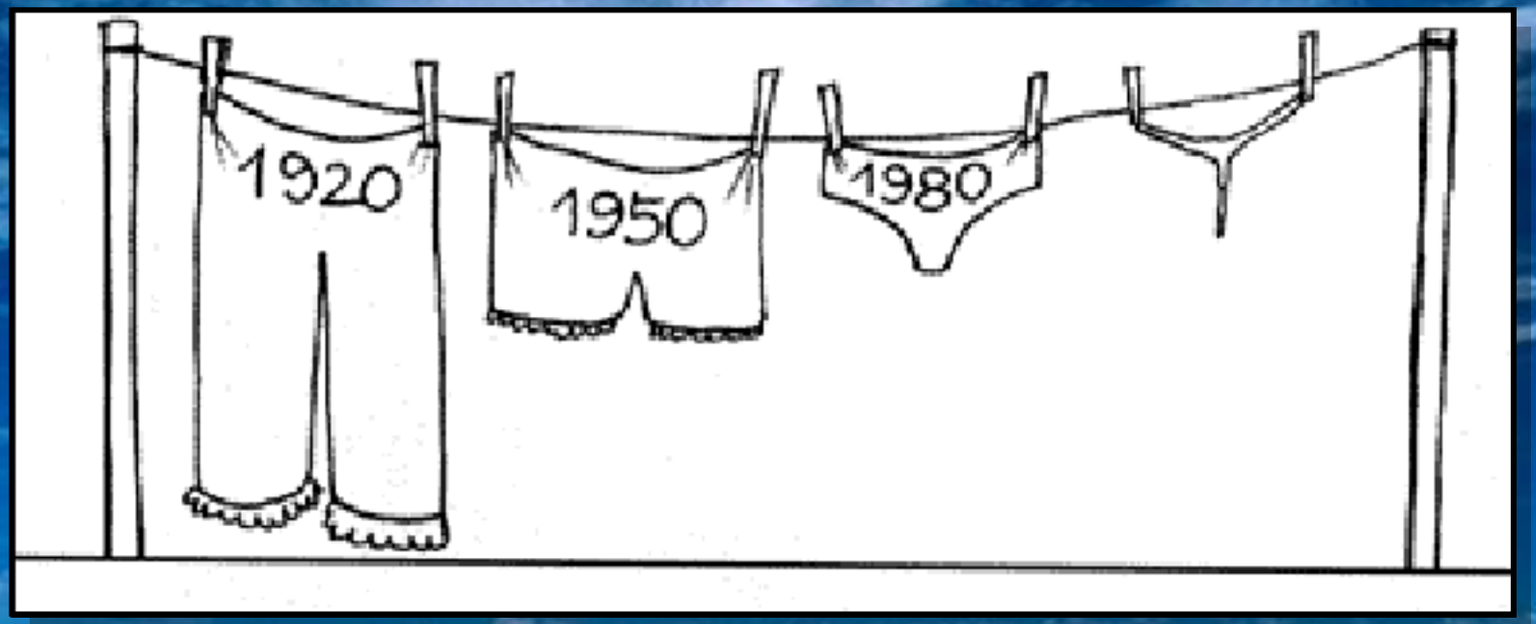


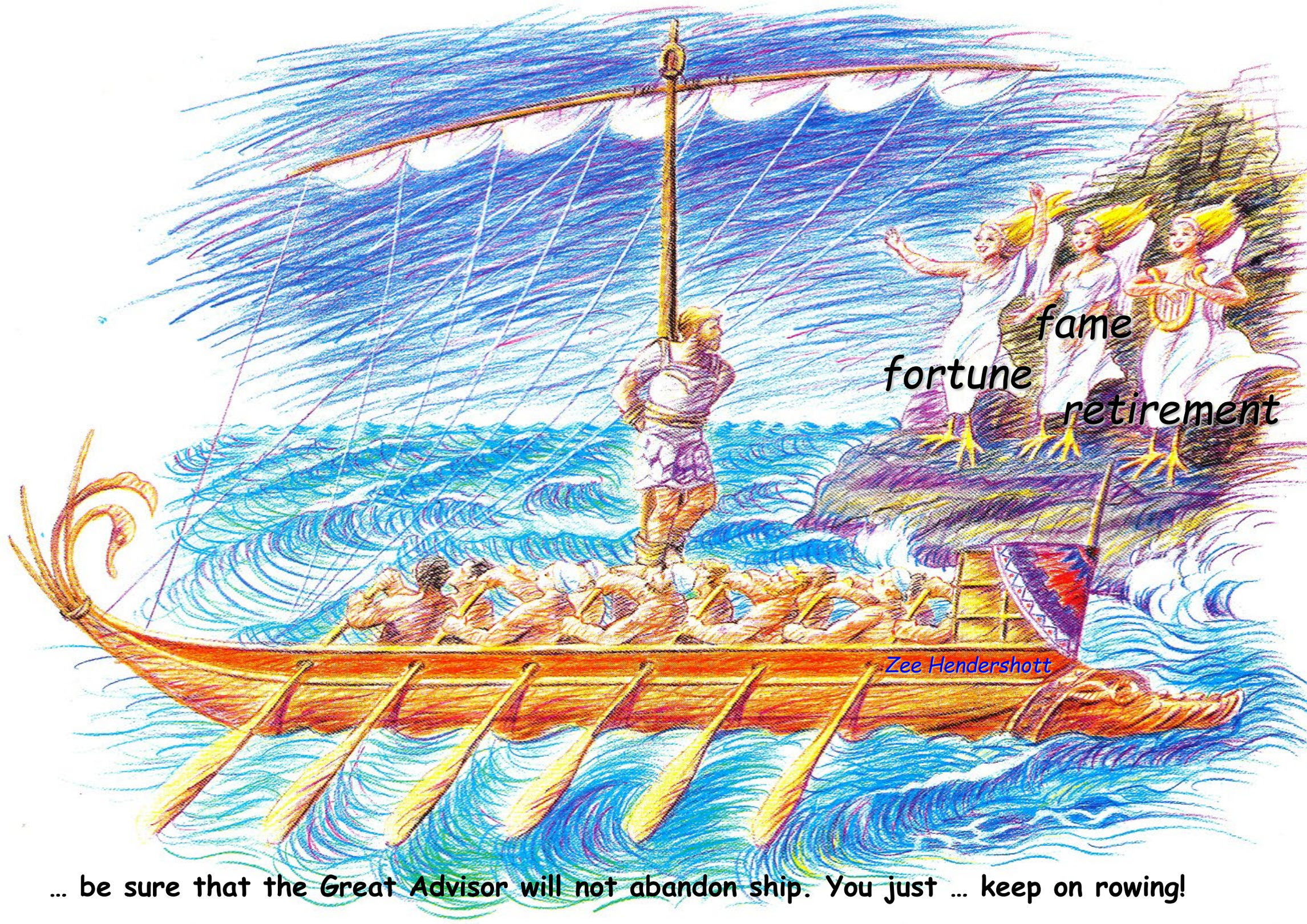


CHL & FAPAR
(SeaWiFS)

Mediterranean Sea

New Environmental Indicators: Climate Change …





… be sure that the Great Advisor will not abandon ship. You just … keep on rowing!

Sunset over Europe...