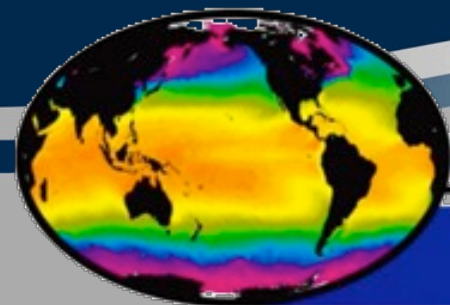


Characterization of Agulhas Bank Upwelling from Multiscale Ultrahigh Resolution blended sea surface temperature and 1km MODIS data

GHR SST XV

Christo Whittle

4 June 2014



GHR SST

*Group for High Resolution
Sea Surface Temperature*

CSIR

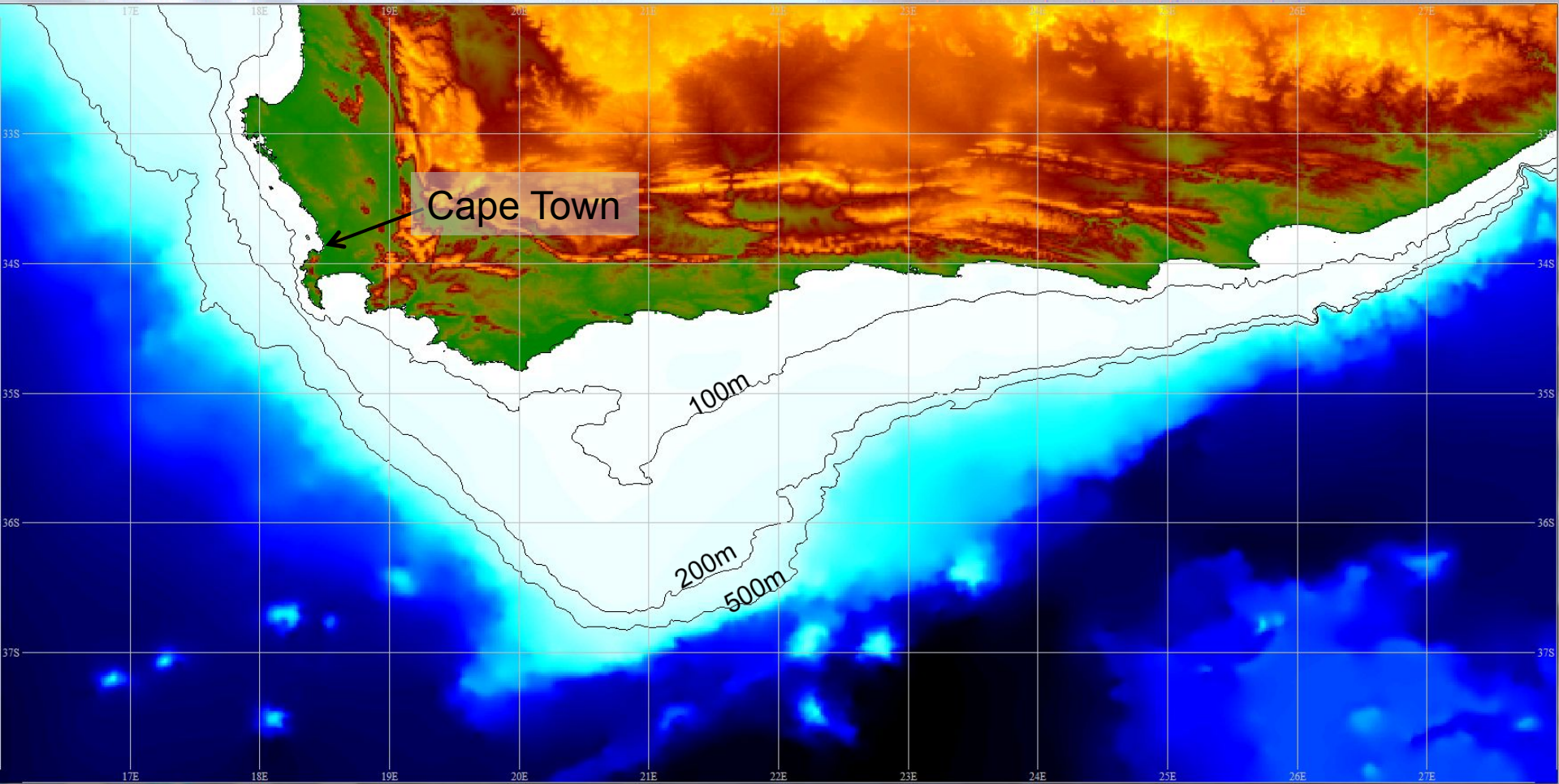
our future through science

Overview

- Motivation
- Mesoscale features and variability
- Analysis of SST and Chl data
- Summary



Location of the Agulhas Bank...

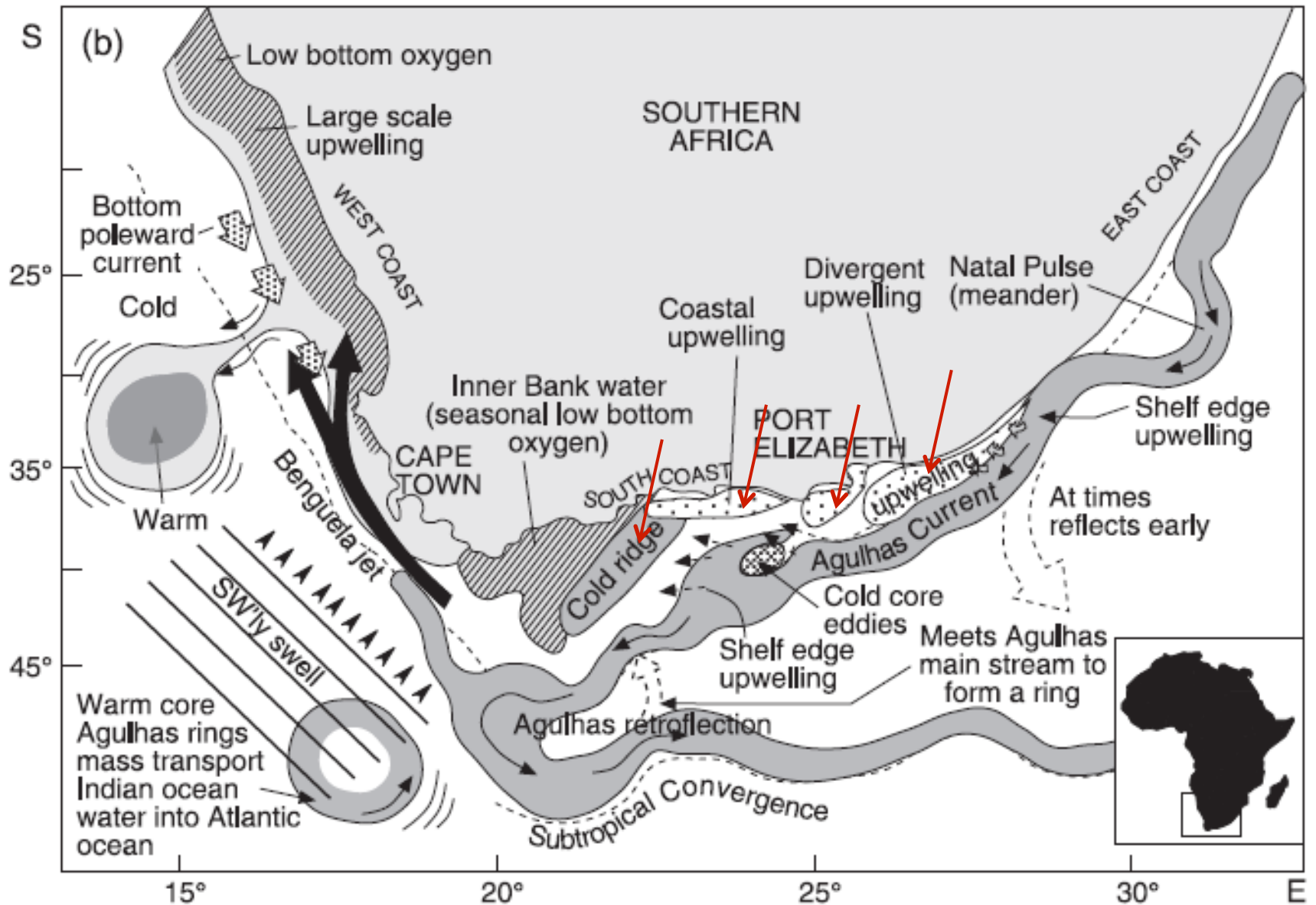


Bathymetry of the shelf region off southern Africa, showing the 100m, 200m and 500m contours

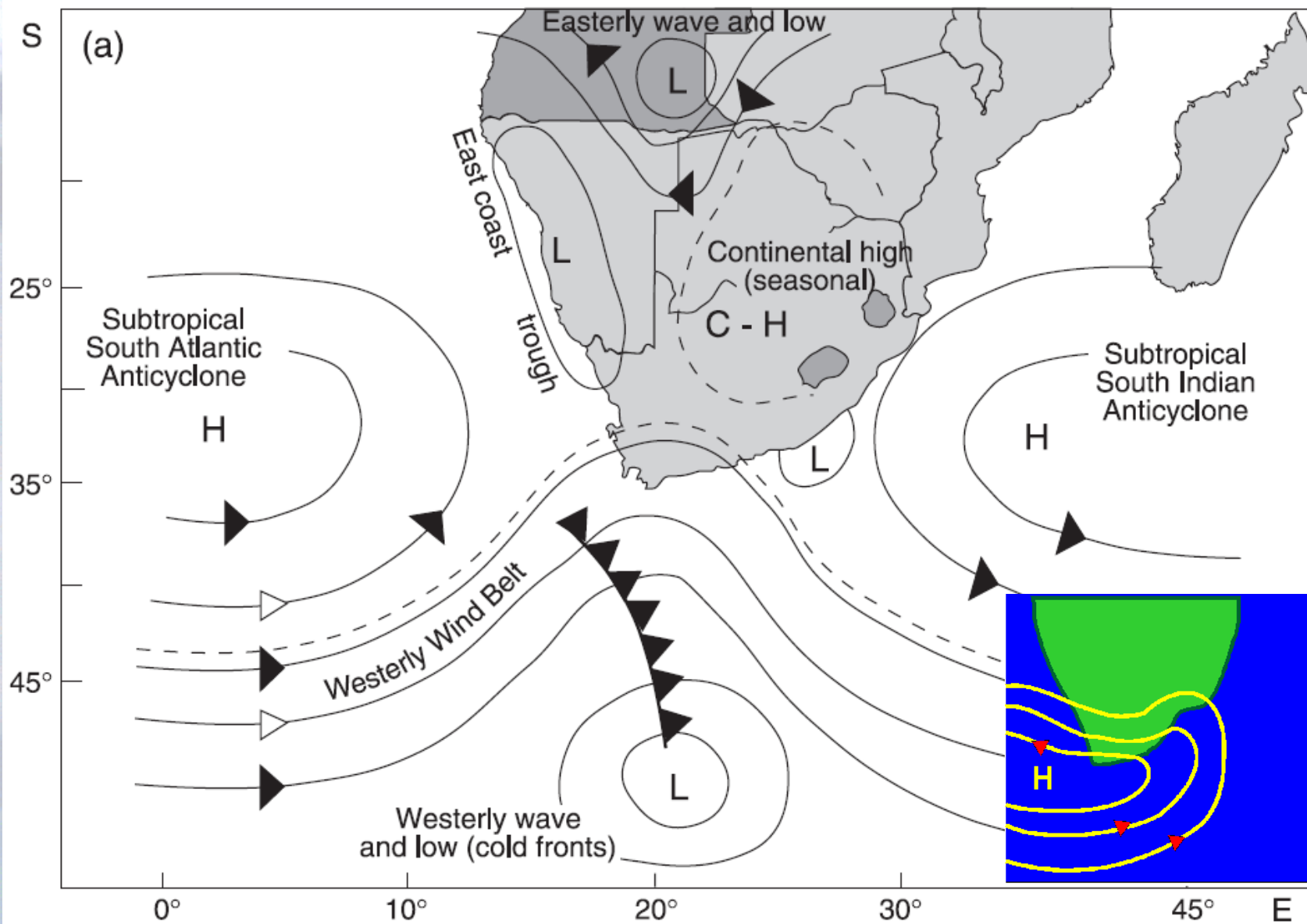
Motivation

To date, event scale forcing driving the physical variability of the cool ridge formation on the eastern Agulhas Bank have been inadequately described and it is my intention to achieve the necessary results from the analysis of high temporal and spatial resolution satellite data, complimented by hydrographic survey data, that will contribute to answering oceanographic research questions pertinent to this oceanic region. These results should contribute significantly to the understanding of physical processes driving the variability of primary production that possibly play a role in the changes observed in the spawning habits of economically important fish species (generating revenue of ~ \$50 million per annum to the South African economy).

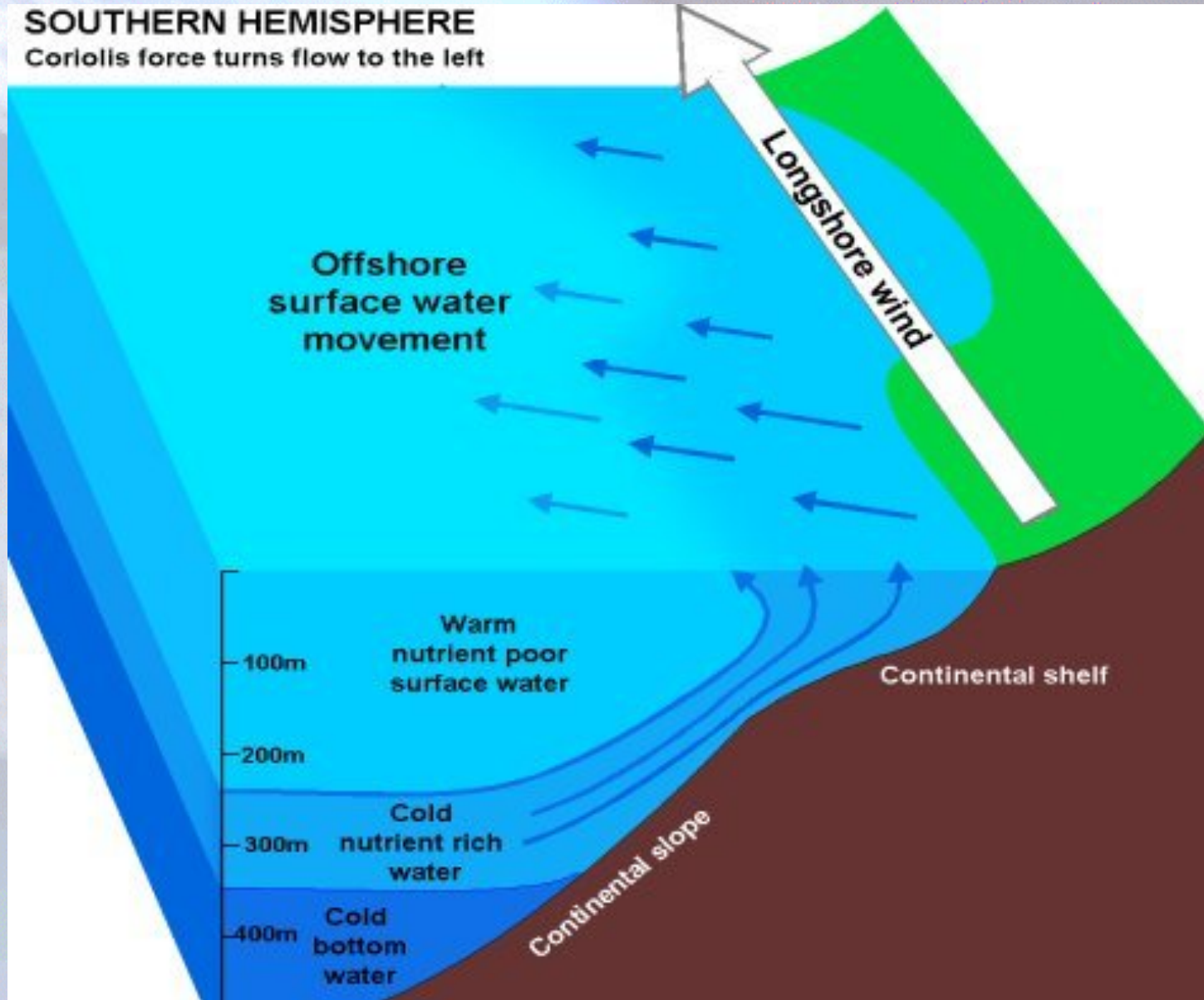
Complex physical dynamics



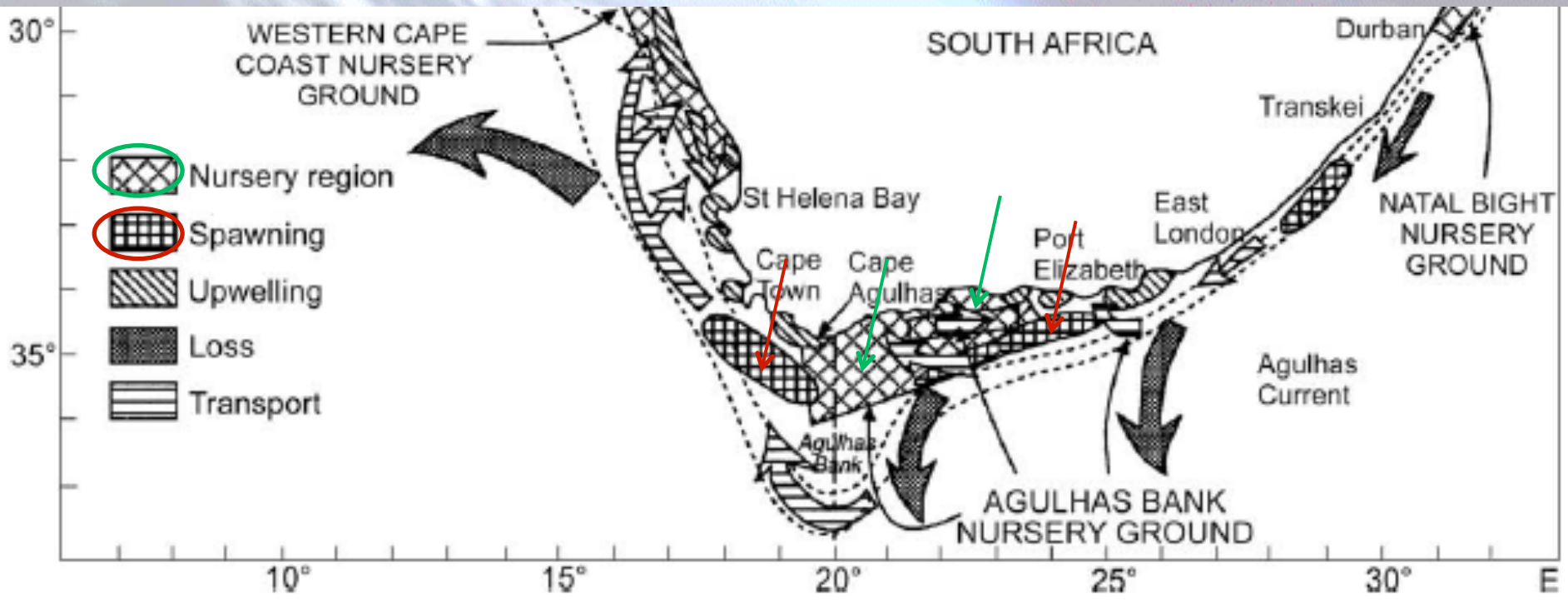
Atmospheric drivers...



Wind driven coastal upwelling



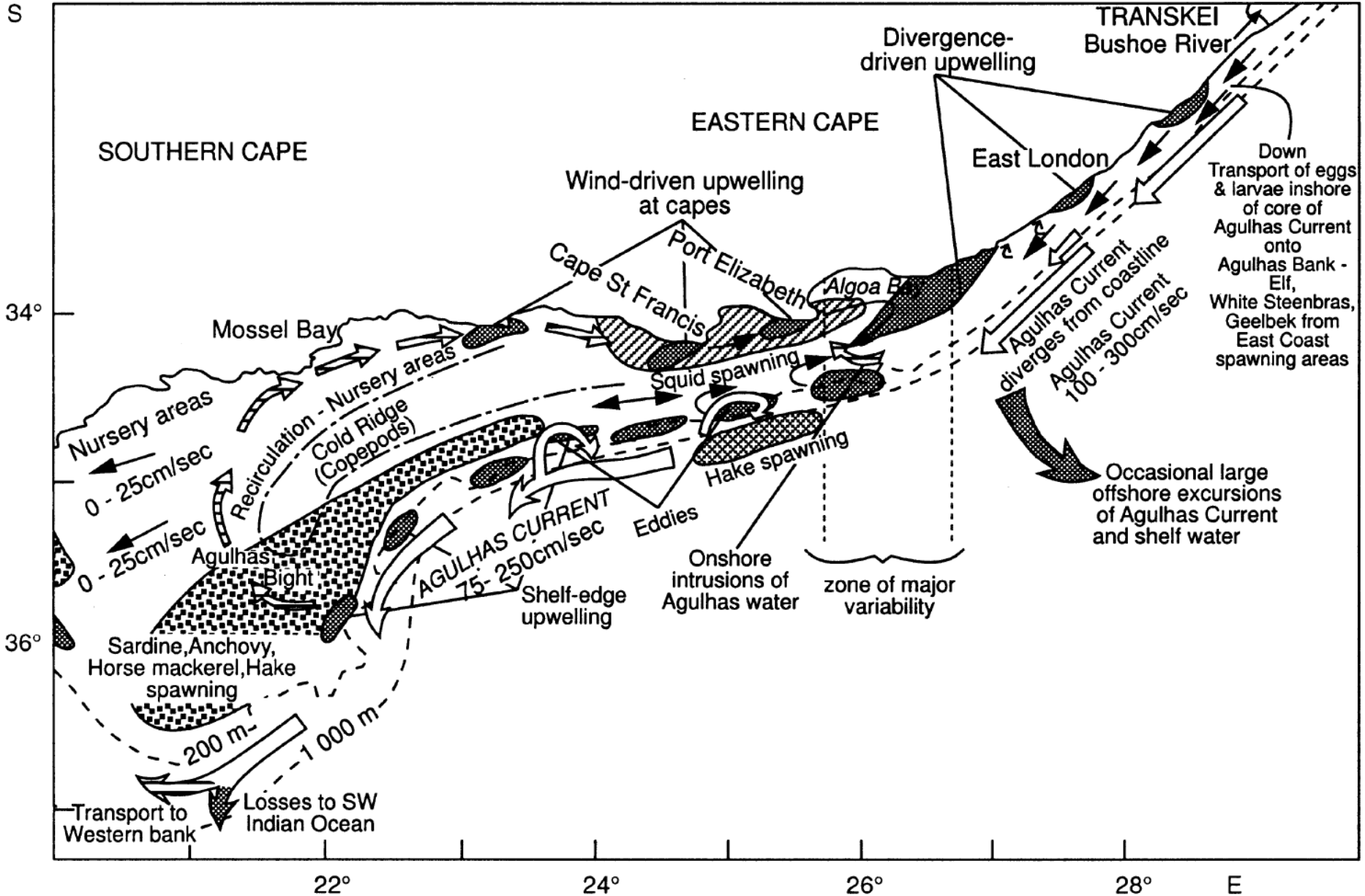
Important Spawning and Nursery Grounds

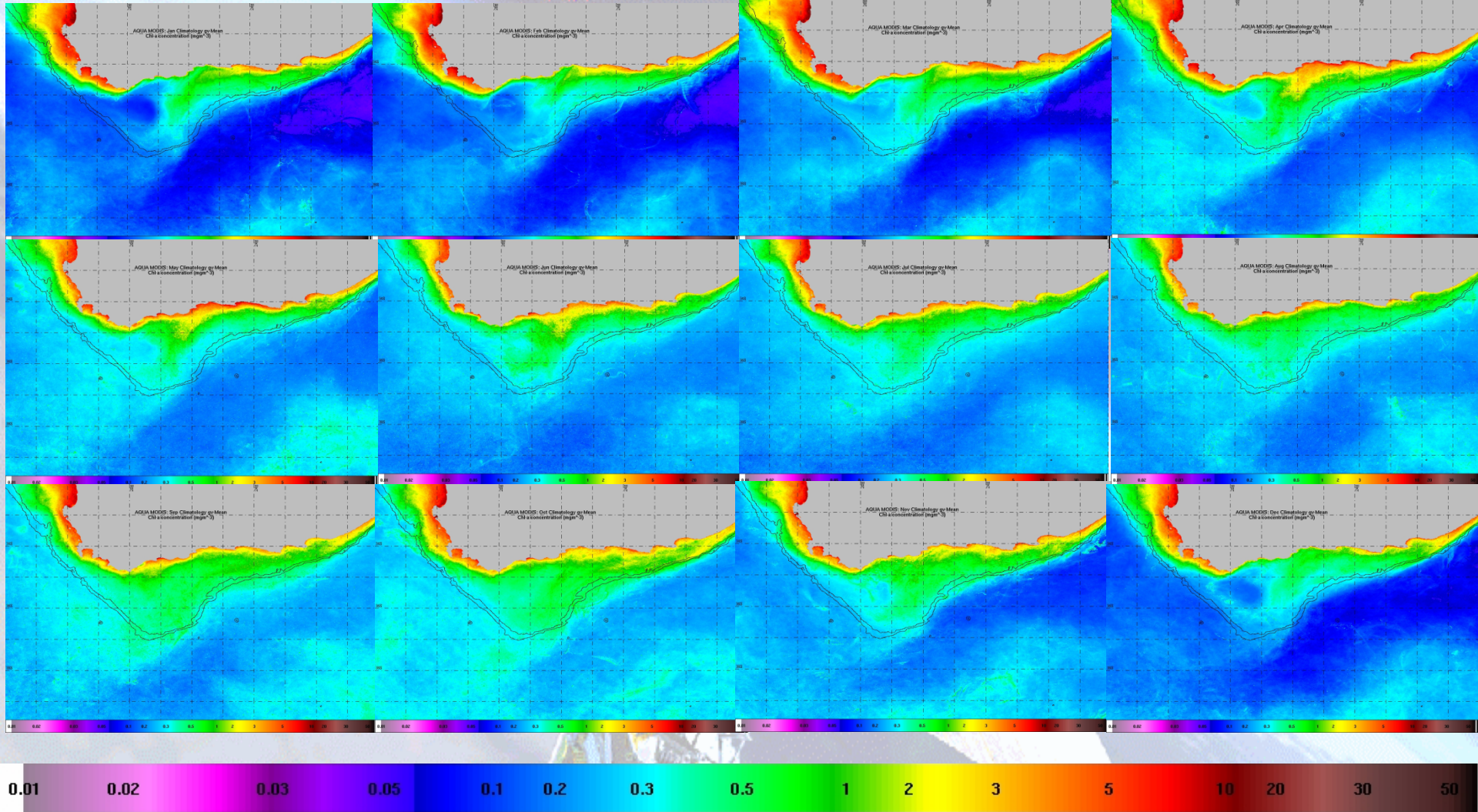


From Hutchings et al. 2002

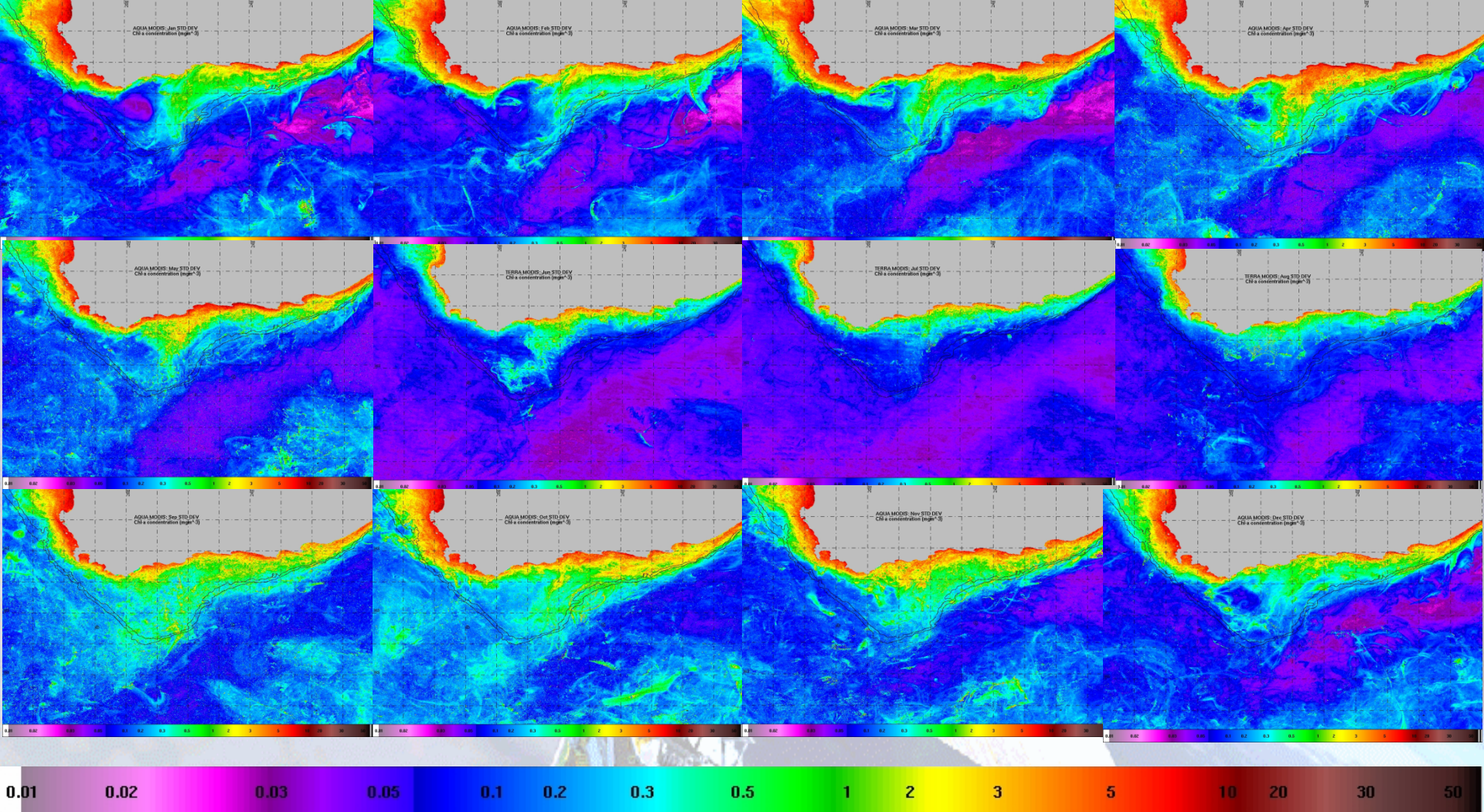
Enrichment, Retention and Concentration (Bakun 1996)

S

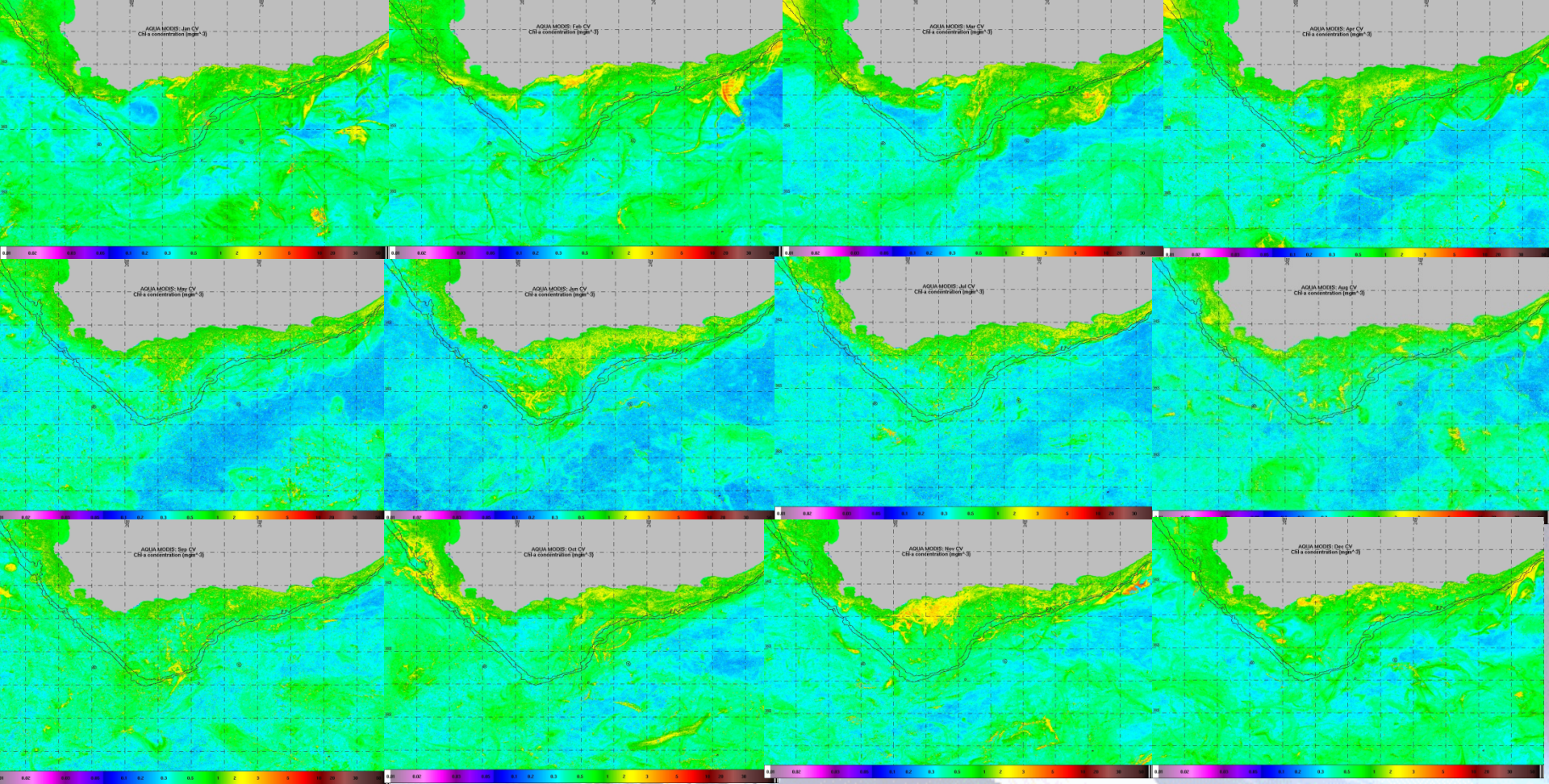




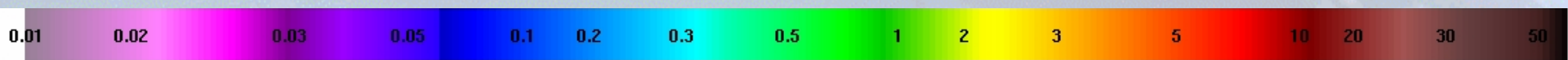
MODIS AQUA Chl-a Monthly Mean Climatologies 2003 - 2013

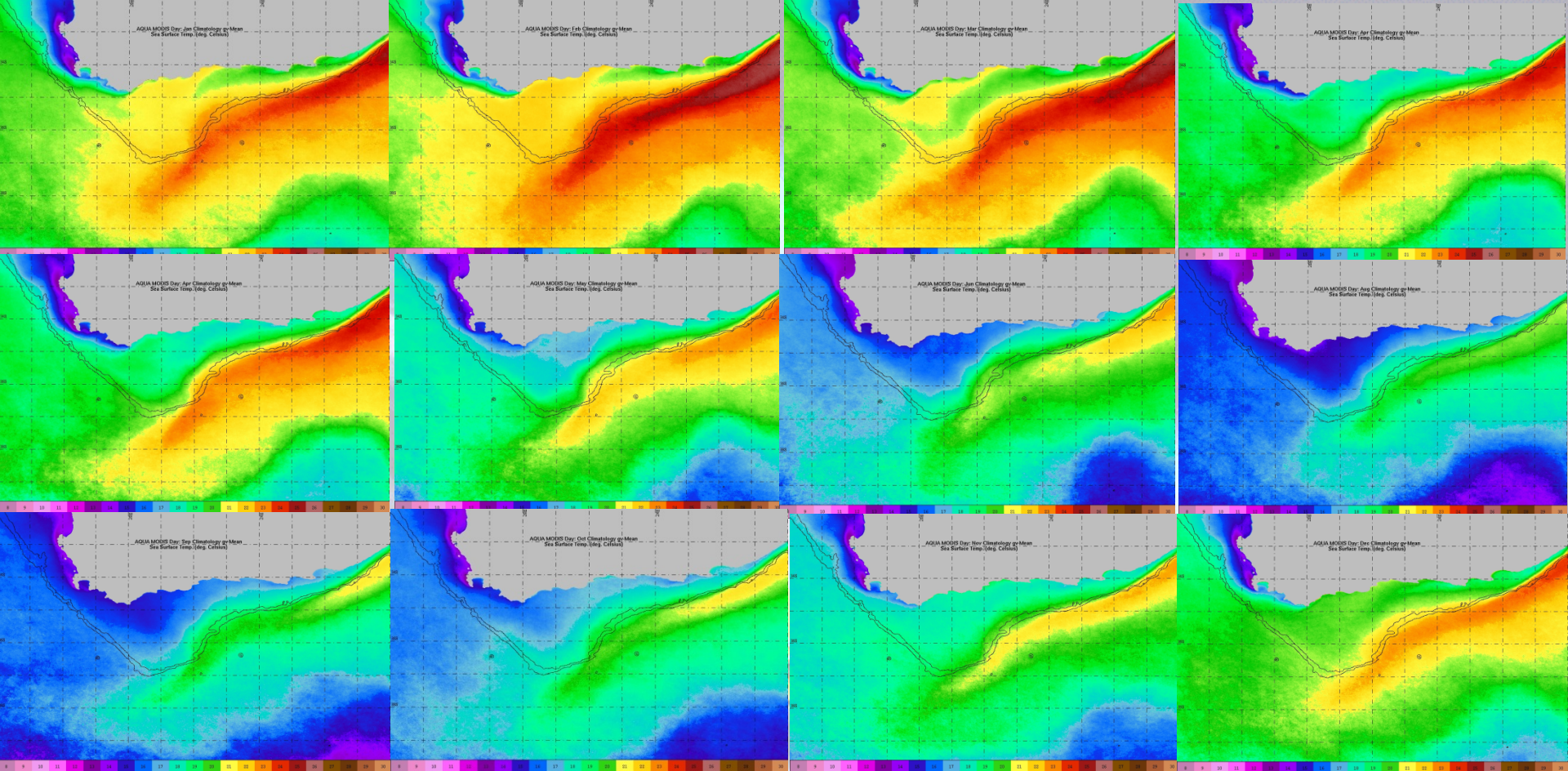


MODIS AQUA Chl-a Monthly Mean Std Dev 2003 - 2013

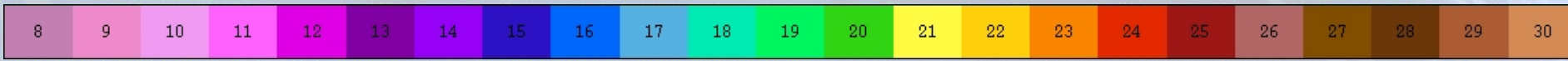


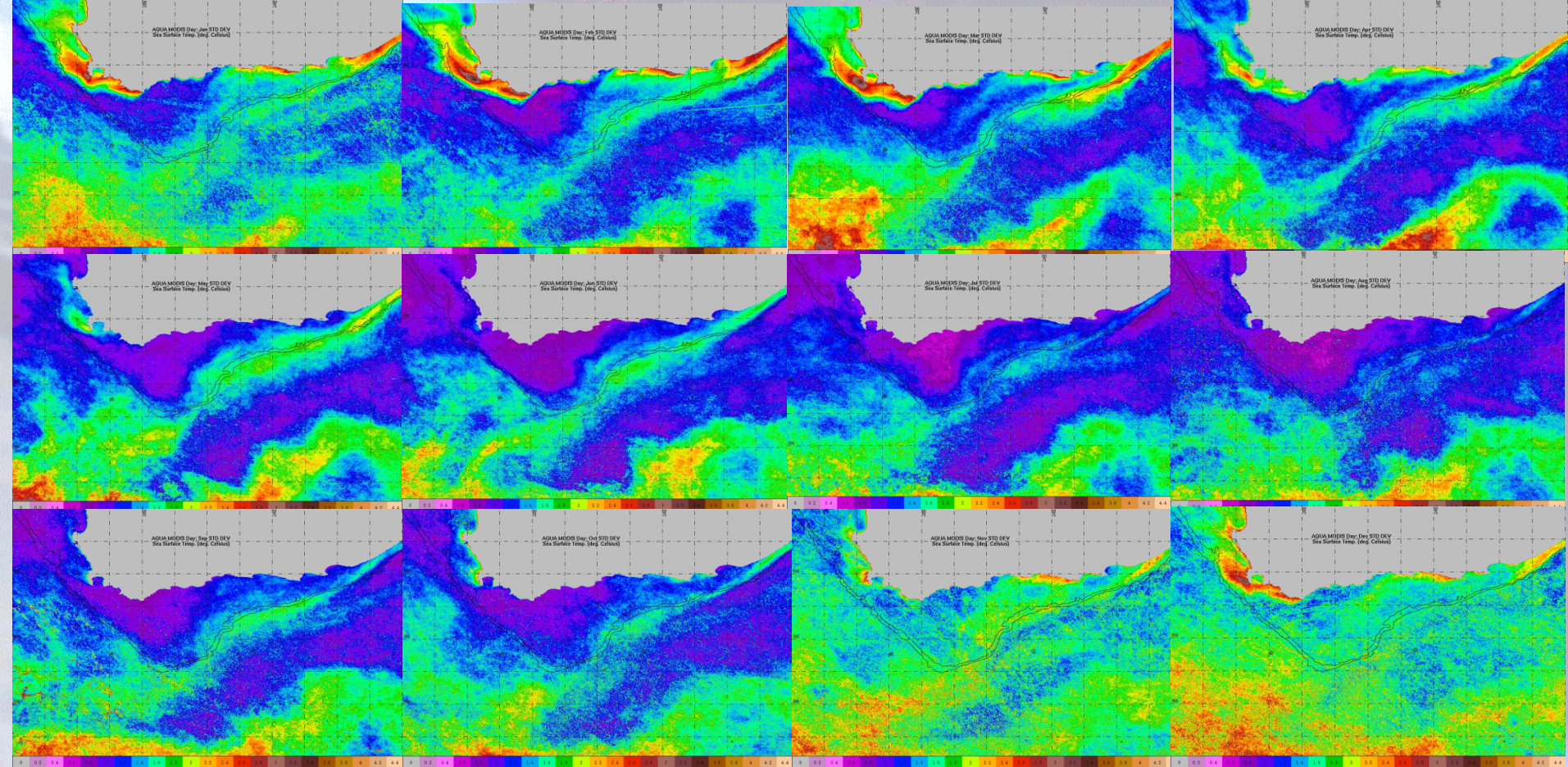
MODIS AQUA Chl-a Monthly Coefficient of variation 2003 - 2013



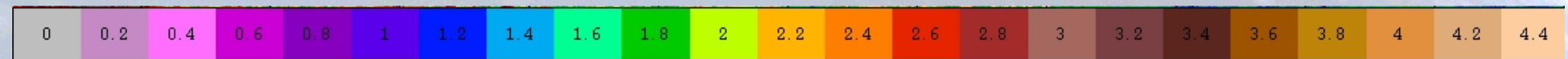


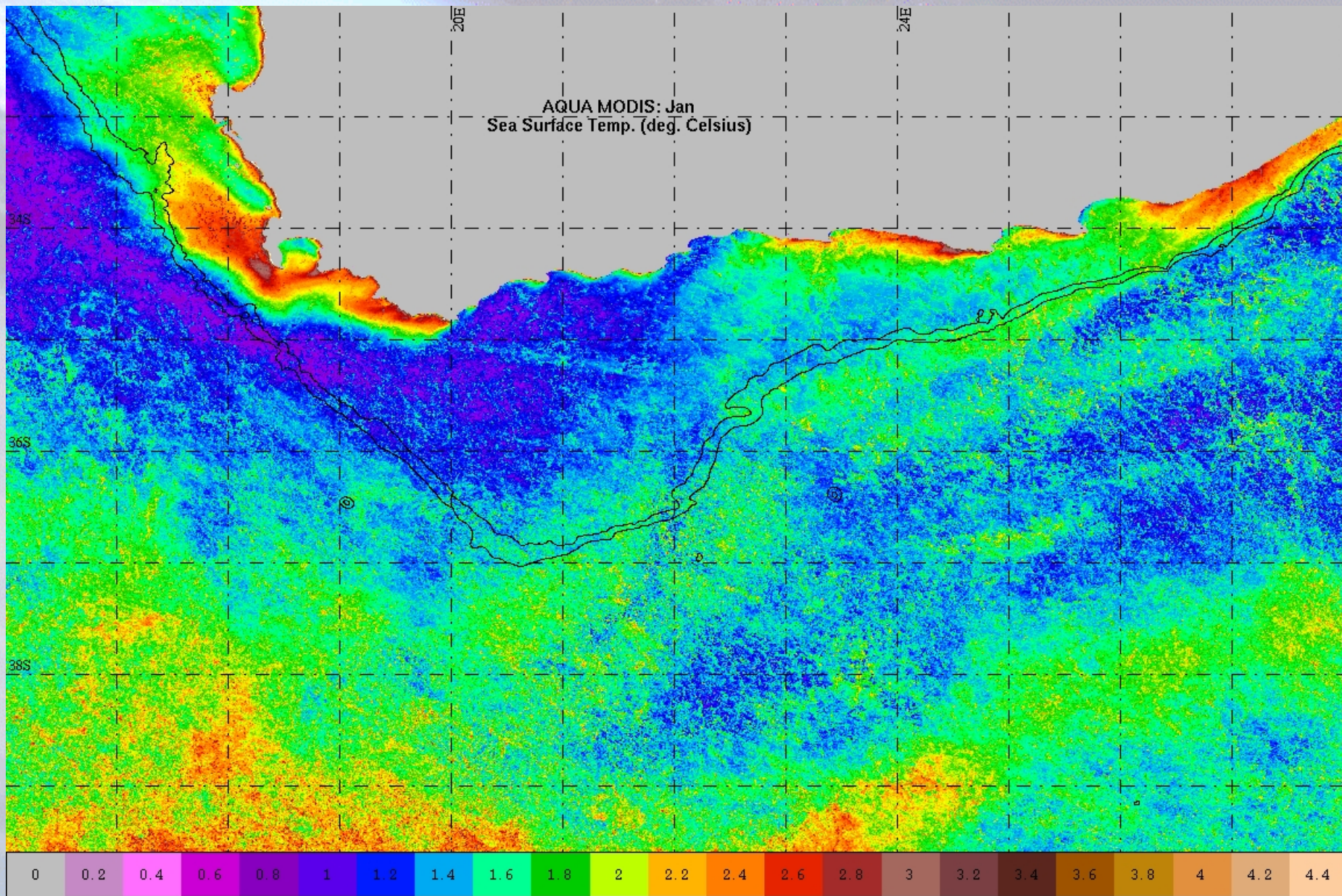
MODIS AQUA SST Monthly Mean Climatology 2003 - 2013





MODIS AQUA SST Monthly Std Dev 2003 - 2013





Aqua MODIS STD DEV for January Climatology 2003-2012

MODIS Aqua SST product: Quality Flags

Bit	Name	Description
00	ISMASKED	Pixel was already masked
01	BTBAD	Brightness temperatures are bad
02	BTRANGE	Brightness temperatures are out-of-range
03	BTDIFF	Brightness temperatures are too different
04	SSTRANGE	SST outside valid range
05	SSTREFDIFF	SST is too different from reference
06	SST4DIFF	Longwave SST is different from shortwave SST
07	SST4VDIFF	Longwave SST is very different from shortwave SST
08	BTNONUNIF	Brightness temperatures are spatially non-uniform
09	BTVNONUNIF	Brightness temperatures are very spatially non-uniform
10	BT4REFDIFF	Brightness temperatures differ from reference
11	REDNONUNIF	Red-band spatial non-uniformity or saturation
12	HISENZ	Sensor zenith angle high
13	VHISENZ	Sensor zenith angle very high
14	SSTREFVDIFF	SST is too different from reference
15	Spare	Spare

MODIS Aqua SST product: Quality Flags

Daytime Long-Wave SST

Quality Bit	Minimum Quality Level
ISMASKED	4
BTBAD	4
VHISENZ	3
BTRANGE	3
SSTRANGE	3
BTVNONUNIF	3
SSTREFVDIFF	3
BTNONUNIF	2
REDNONUNIF	2
SSTREFDIFF	1
HISENZ	1
	0

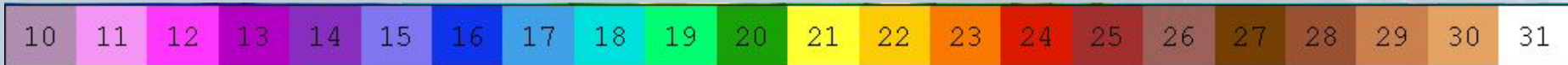
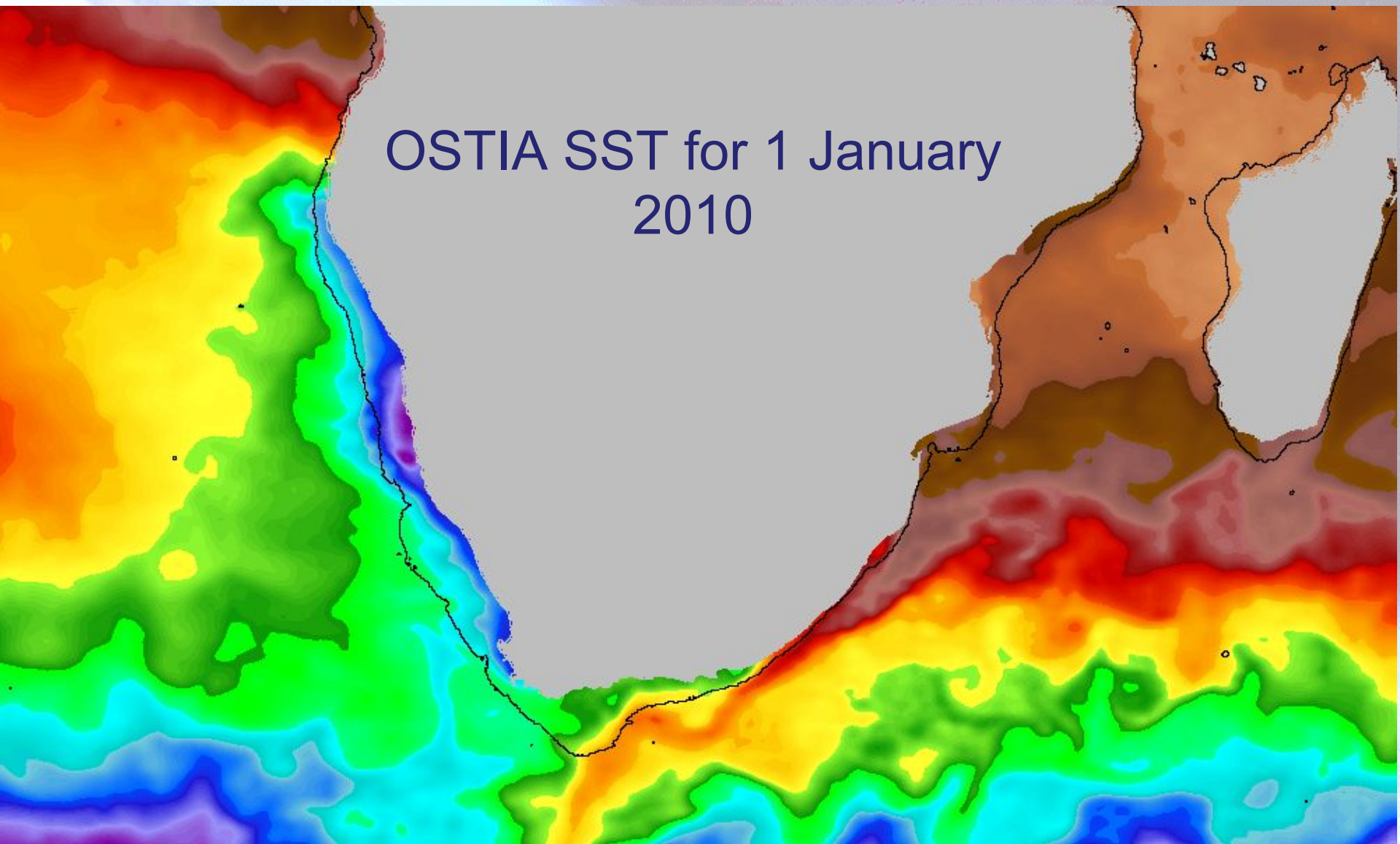
Nighttime Short-Wave SST

Quality Bit	Minimum Quality Level
ISMASKED	4
BTBAD	4
BTRANGE	3
SSTRANGE	3
BT4REFDIFF	3
SSTREFVDIFF	3
BTVNONUNIF	2
SST4VDIFF	2
VHISENZ	2
SSTREFDIFF	1
BTNONUNIF	1
SST4DIFF	1
HISENZ	1
	0

- Sst_qual_ix is a 5 element integer array whose indices specify which SST quality levels to load from a MODIS level 2 SST product. All the specified quality levels are combined into 1 loaded band. For example, SST_qual_ix = [1,1,0,0,0] would display all the pixels of quality level 0 and 1.

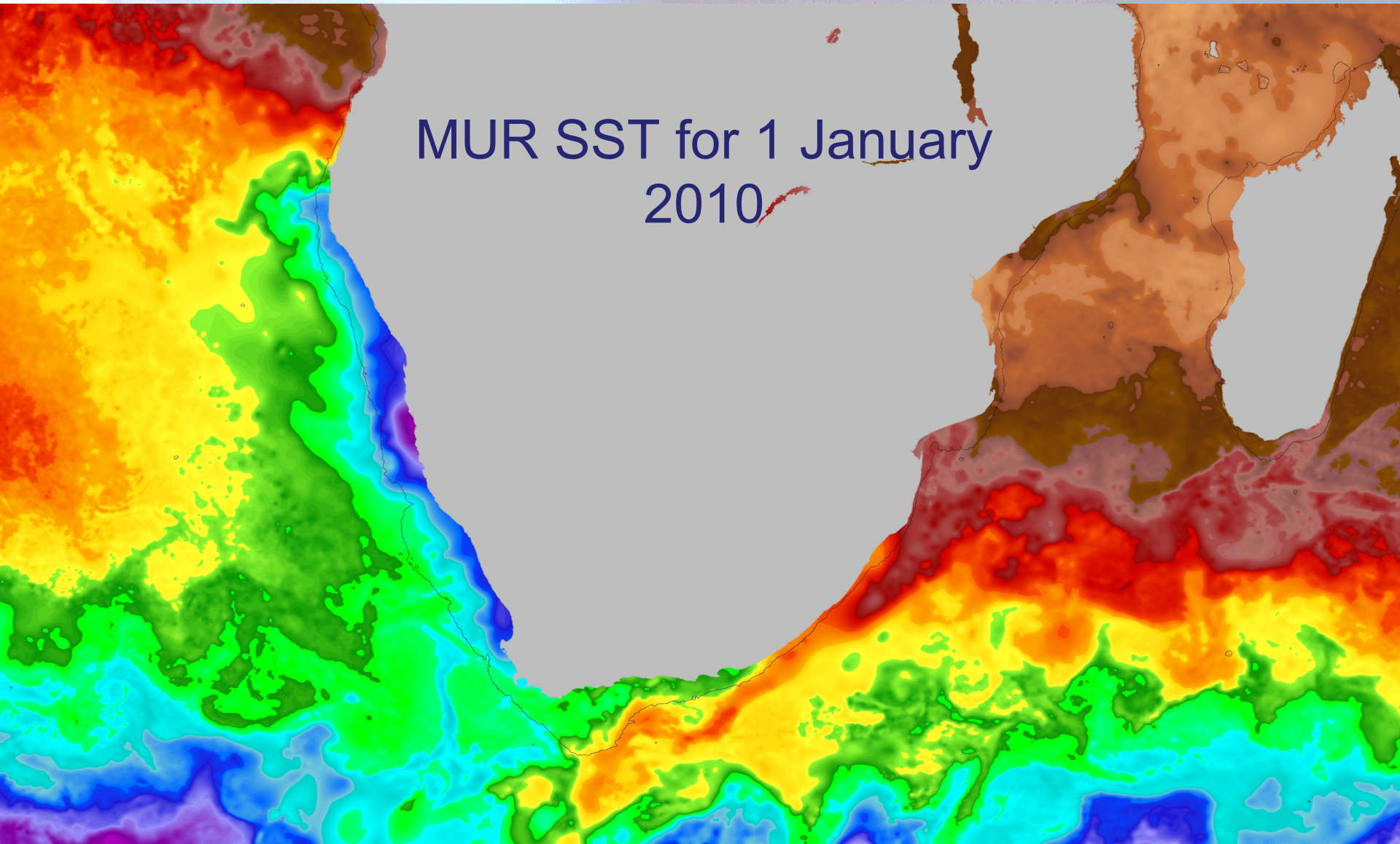
OSTIA vs MURSST

OSTIA SST for 1 January
2010

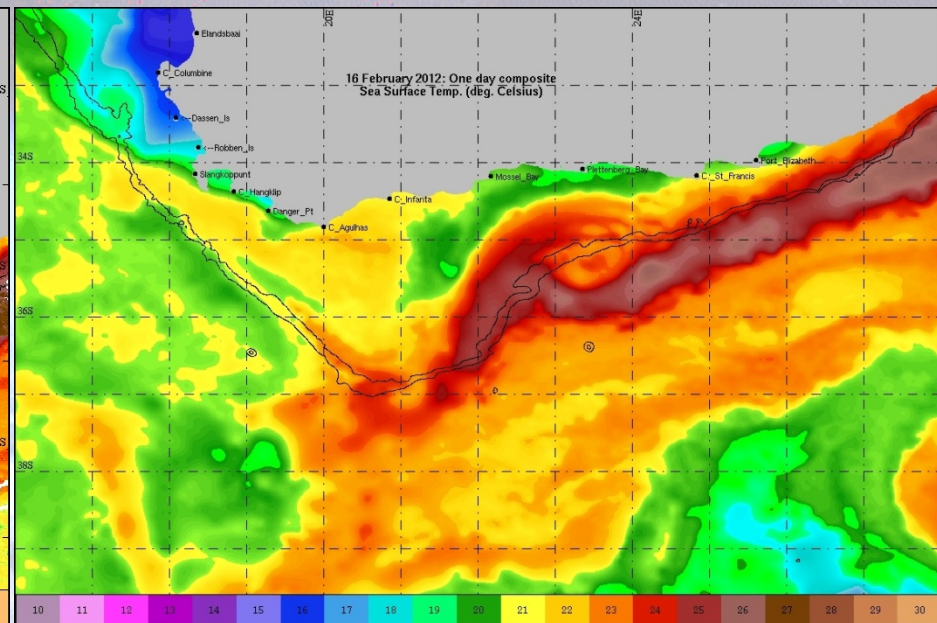
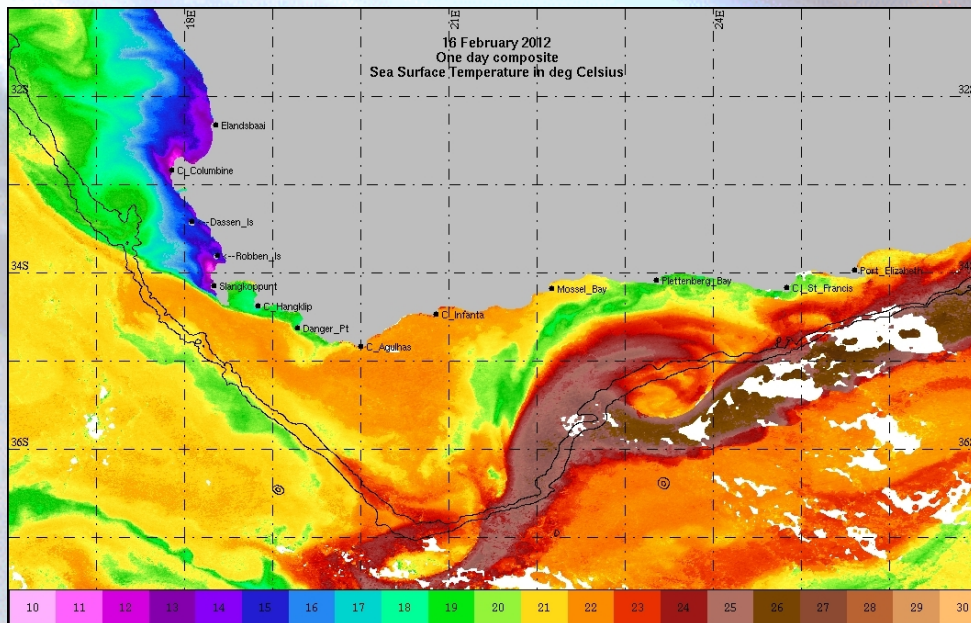


OSTIA vs MUR SST

MUR SST for 1 January
2010



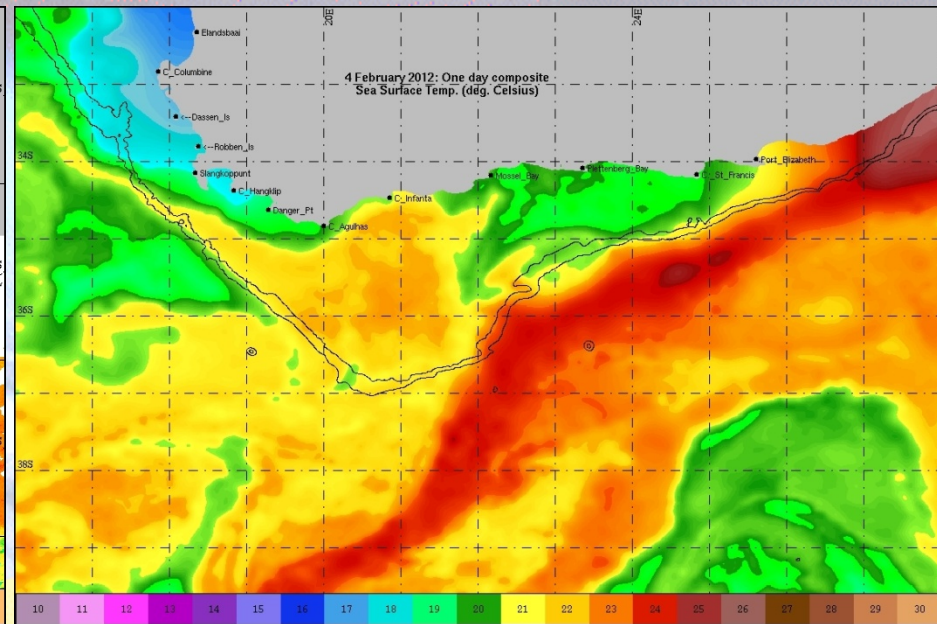
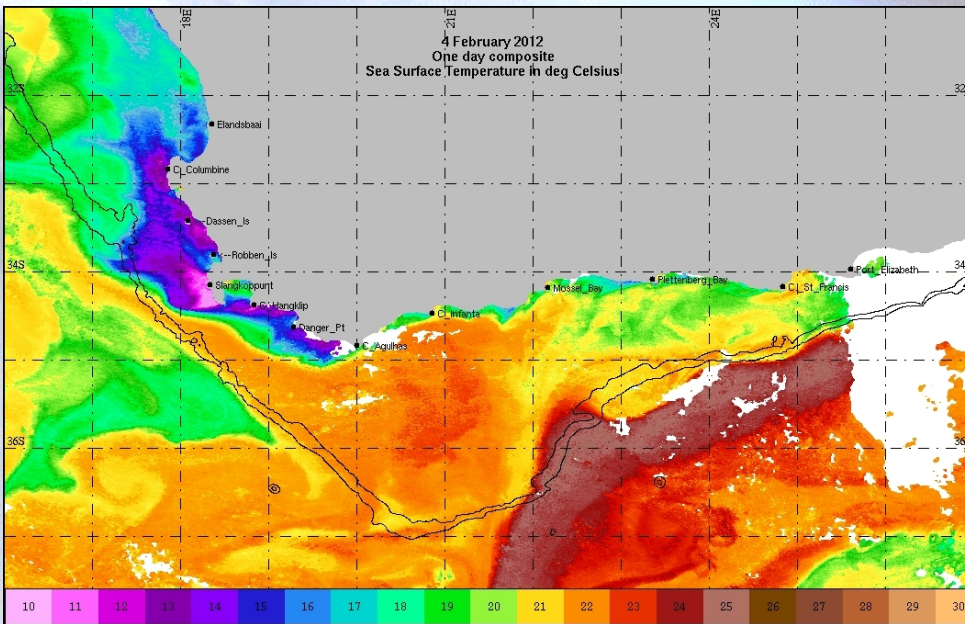
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----



MODIS AQUA/TERRA
SST for 16 February 2012

MUR SST for 16 February
2012

Comparing MODIS daily composites to MUR
GHRSSST

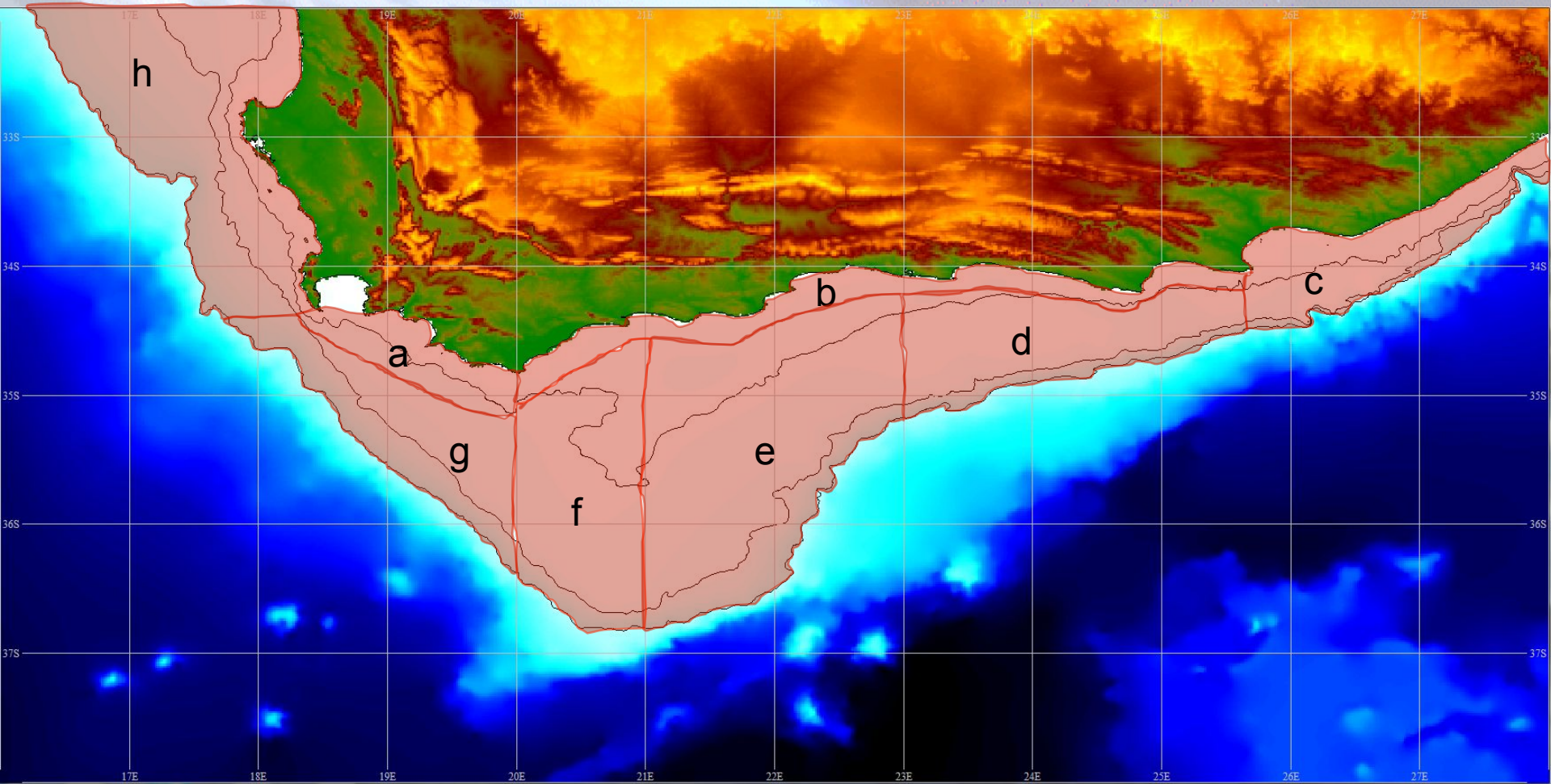


MODIS AQUA/TERRA
SST for 4 February 2012

MUR SST for 4 February
2012

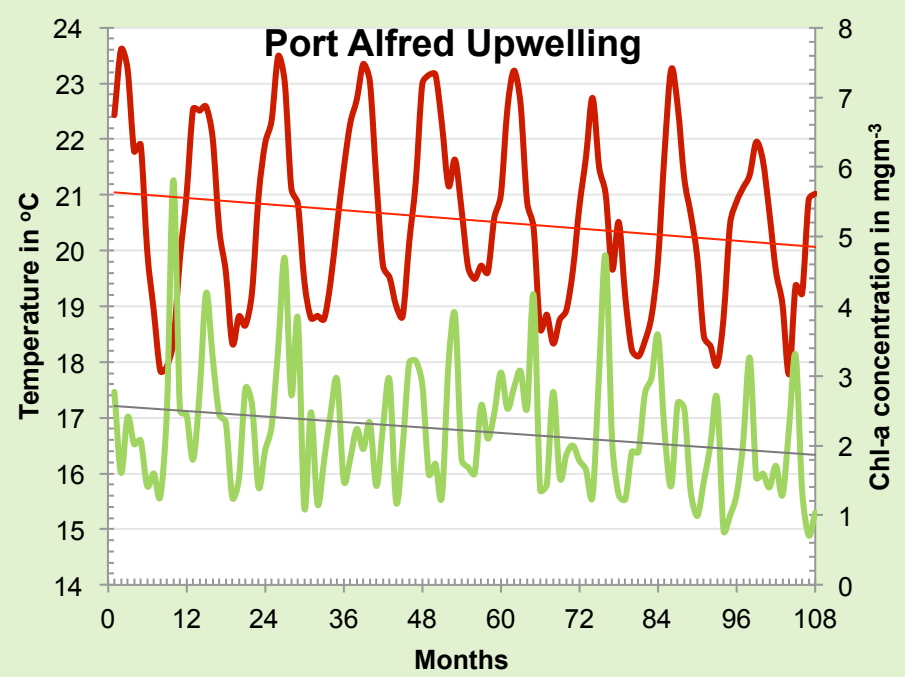
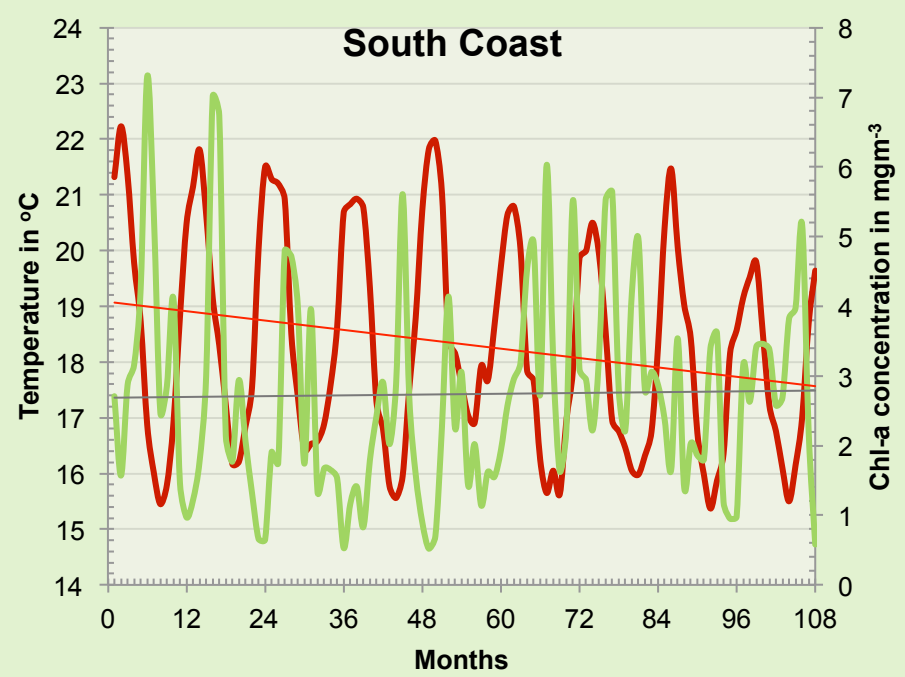
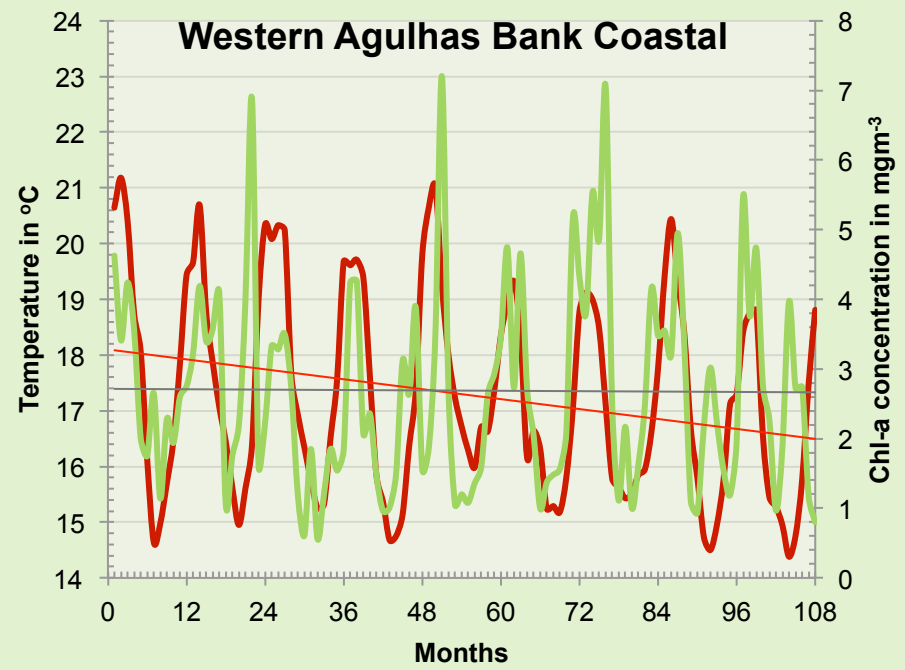
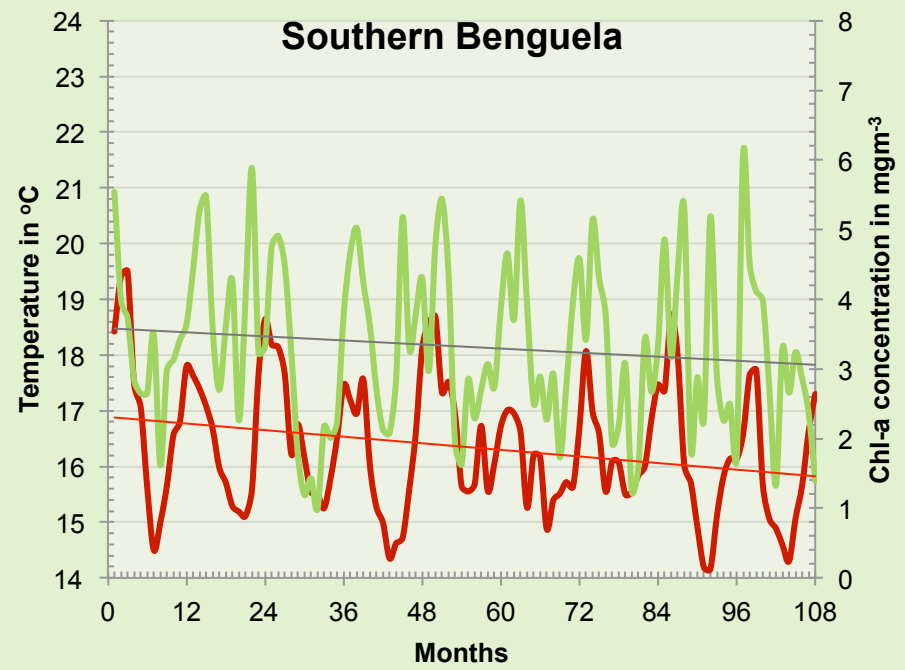
Comparing MODIS daily composites to MUR
GHRSSST

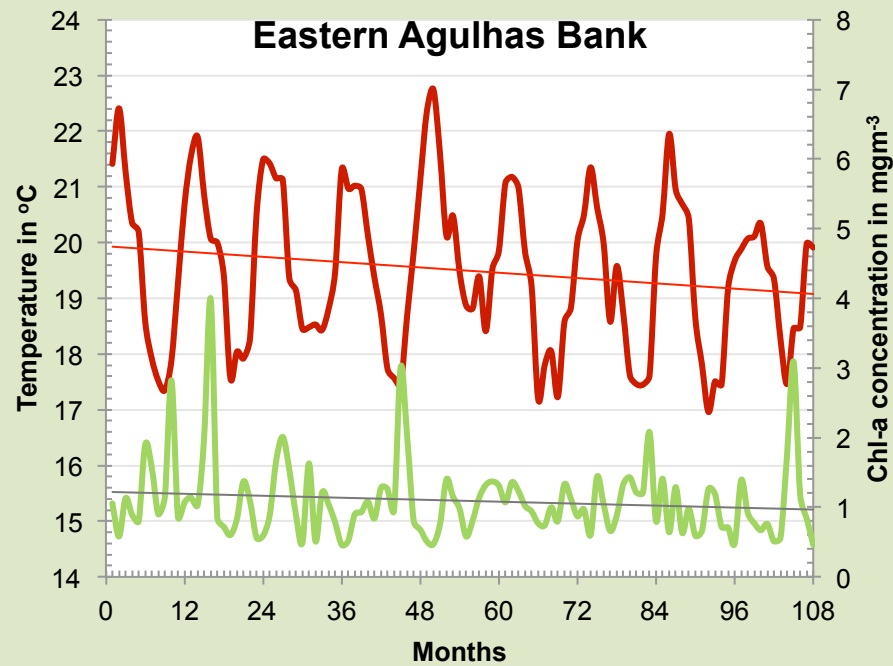
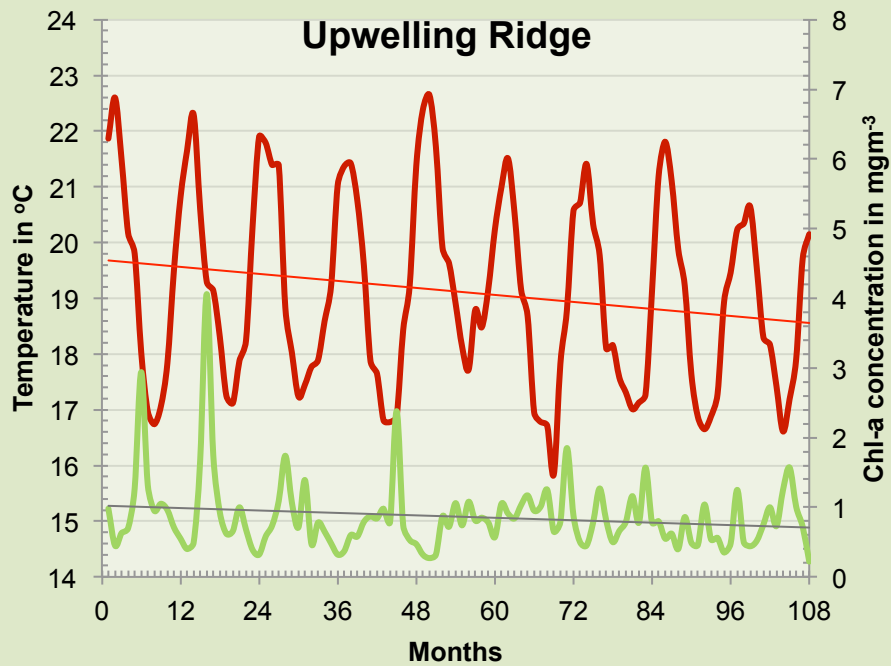
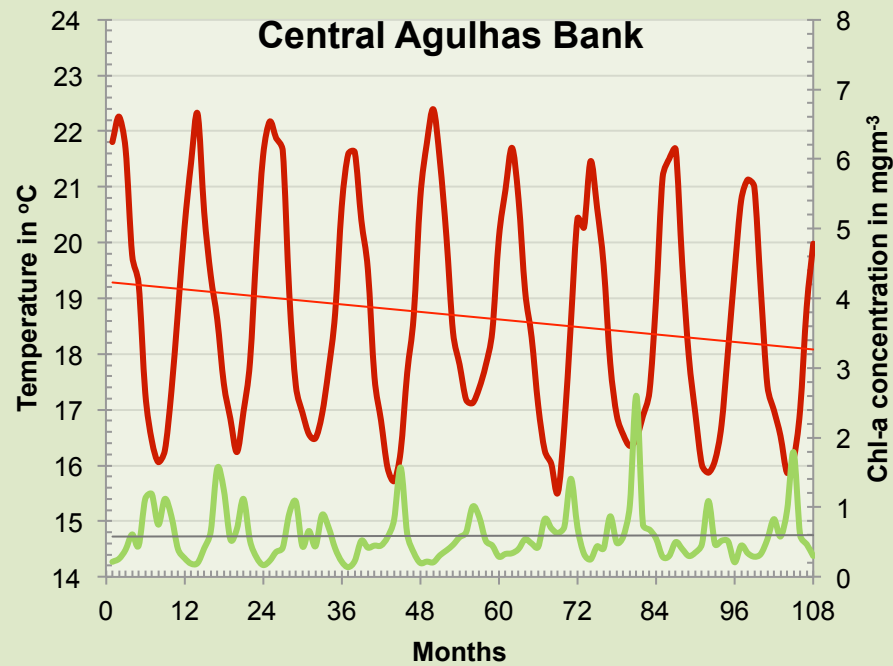
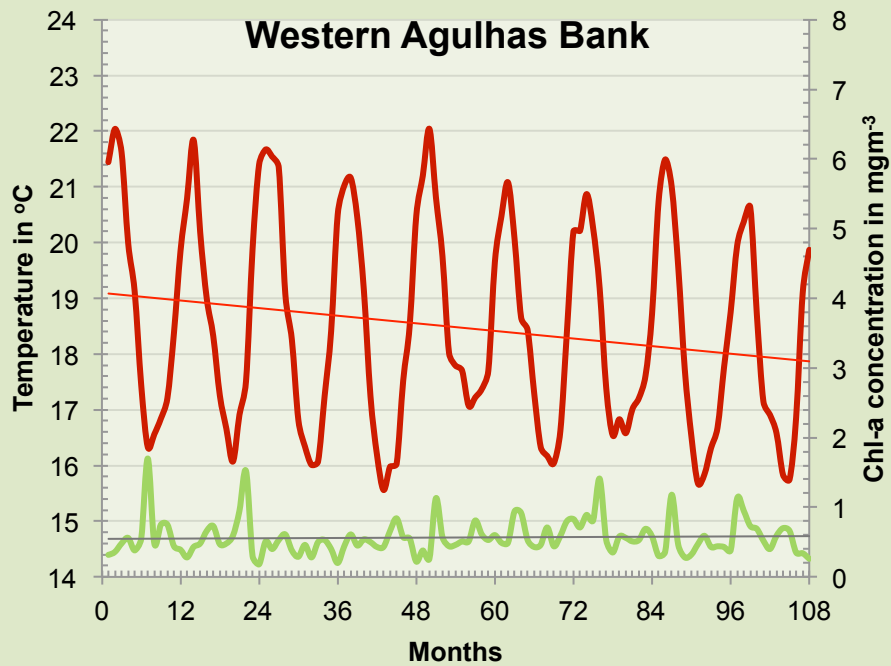
Marine provinces derived from Chl-a climatology

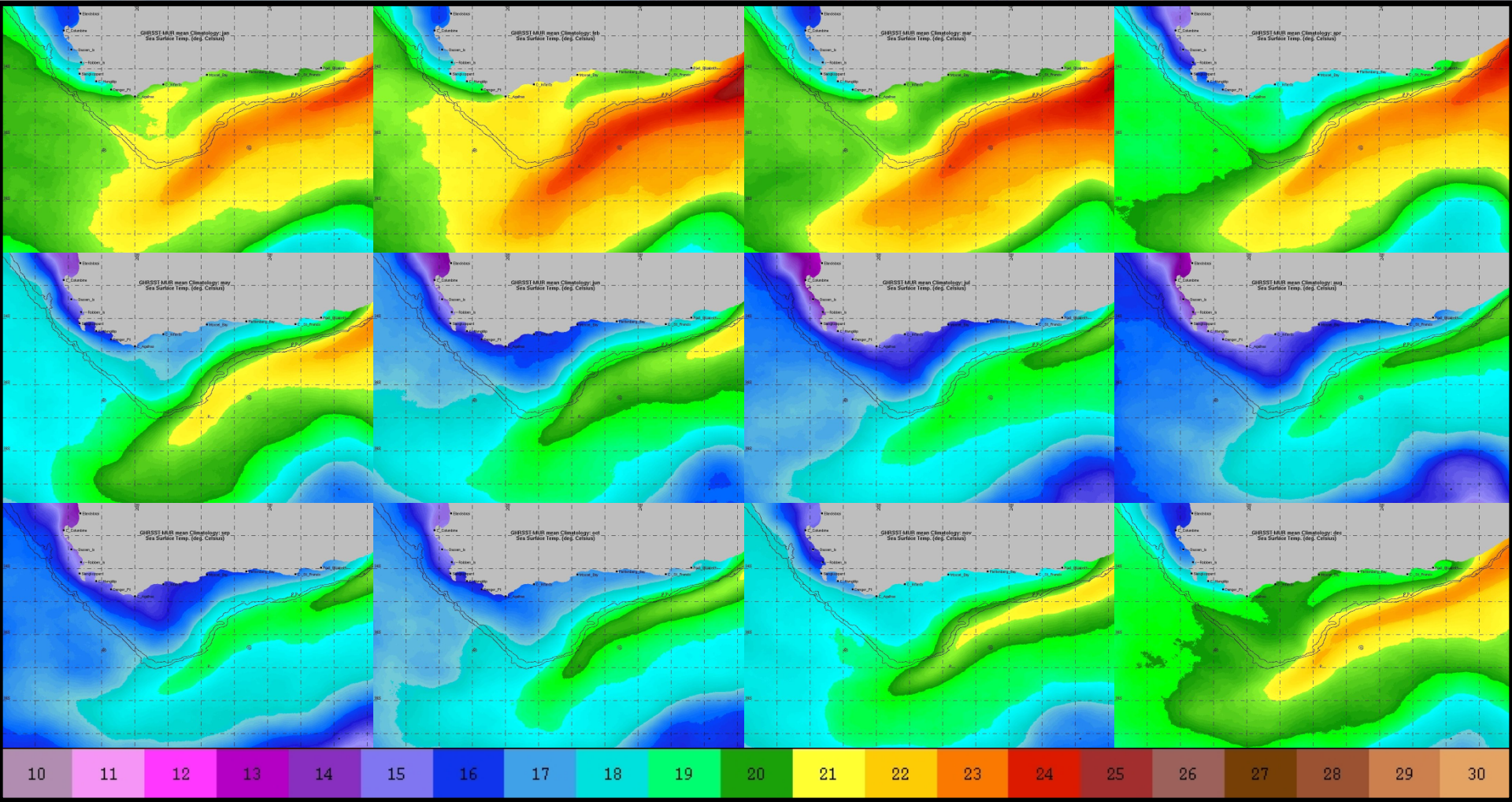


Marine provinces derived from Chl-a climatology

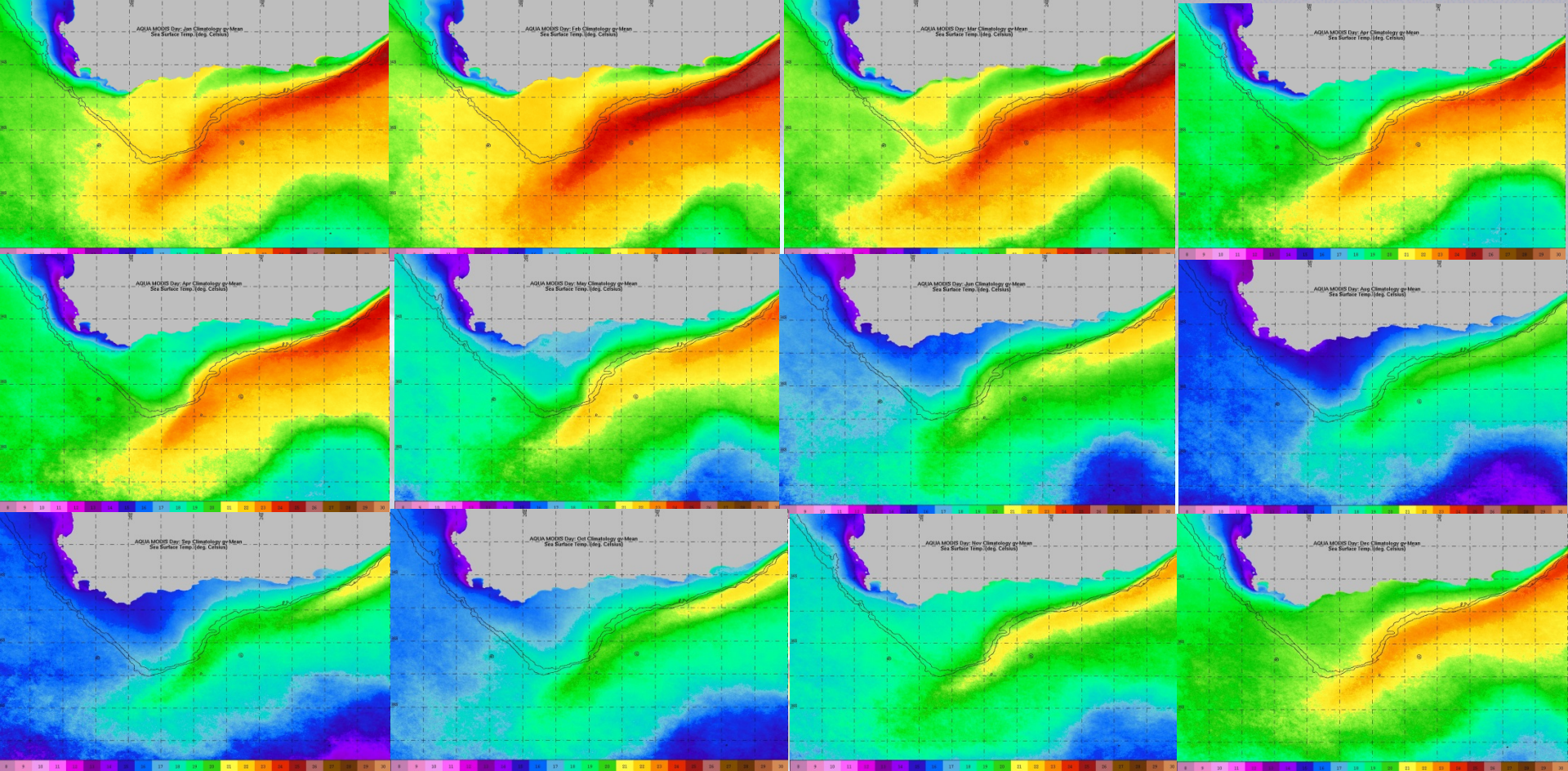
- A – Western Agulhas Bank Coast
- B – South Coast
- C – Port Alfred
- D – Eastern Agulhas Bank
- E – Central Ridge
- F – Central Agulhas Bank
- G – Western Agulhas Bank
- H – Southern Benguela



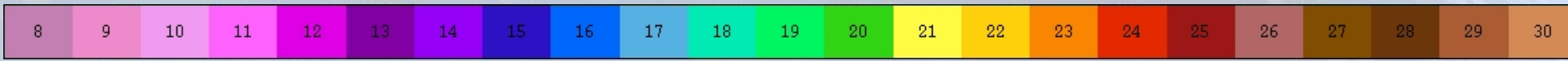


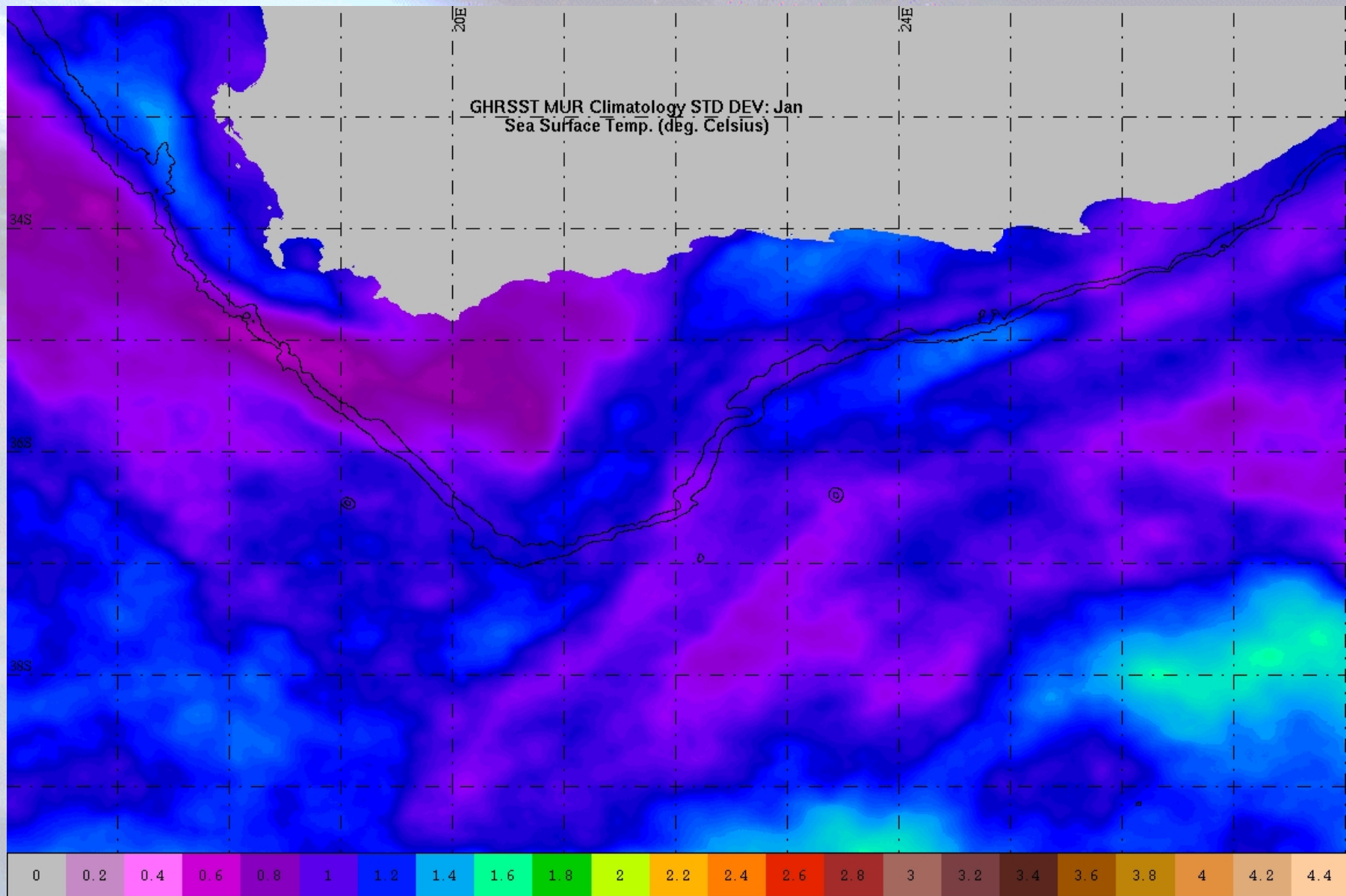


MUR SST Monthly Mean Climatologies 2003 - 2011

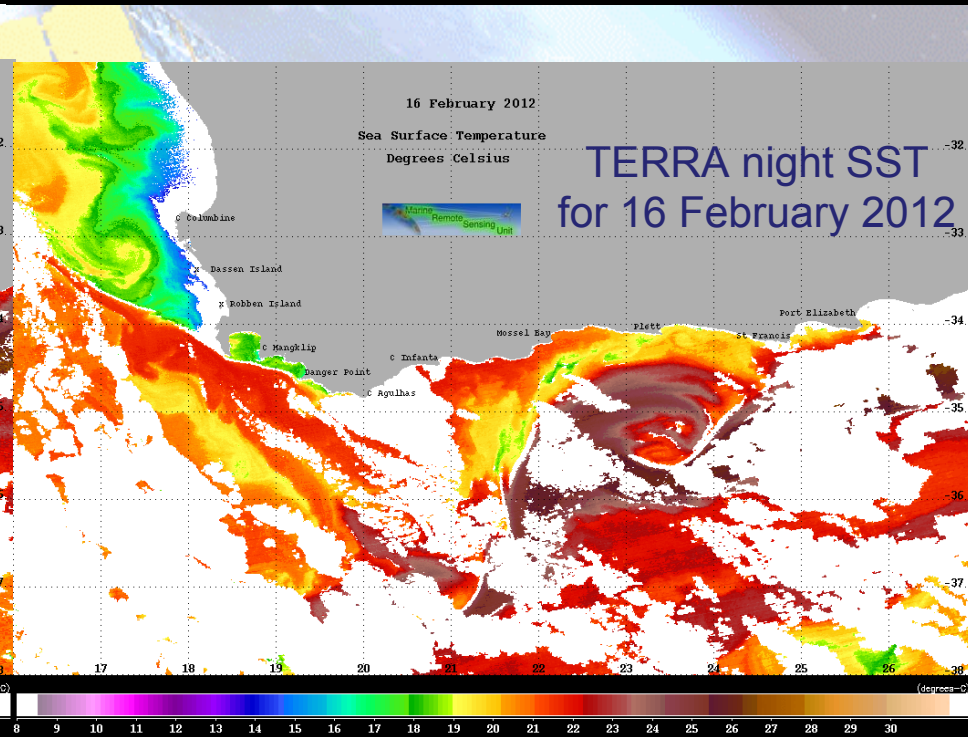
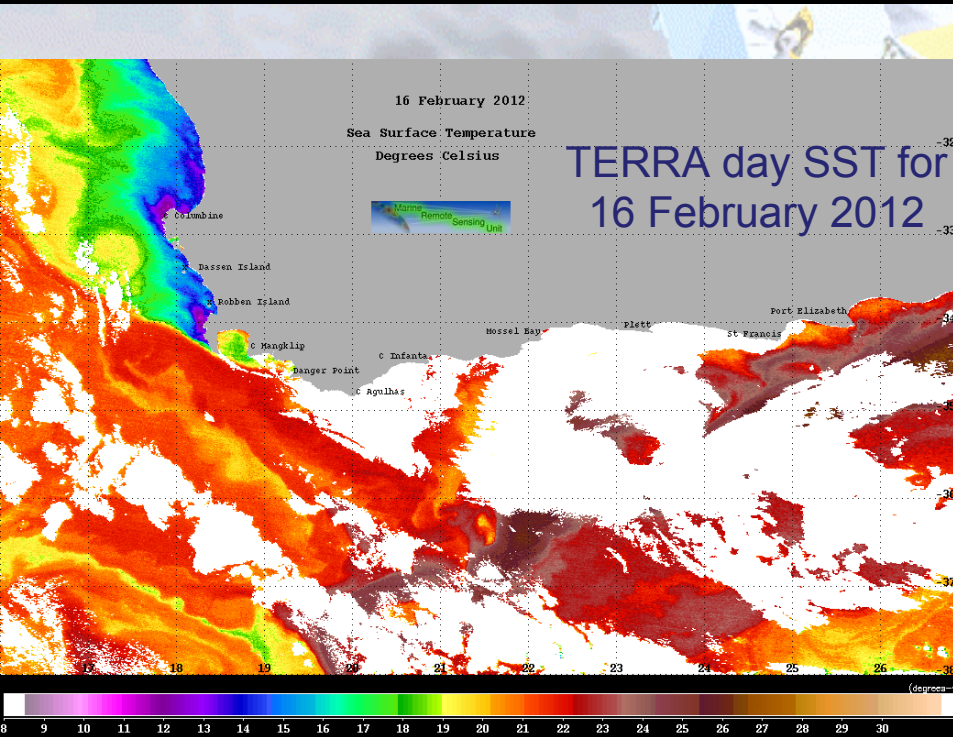
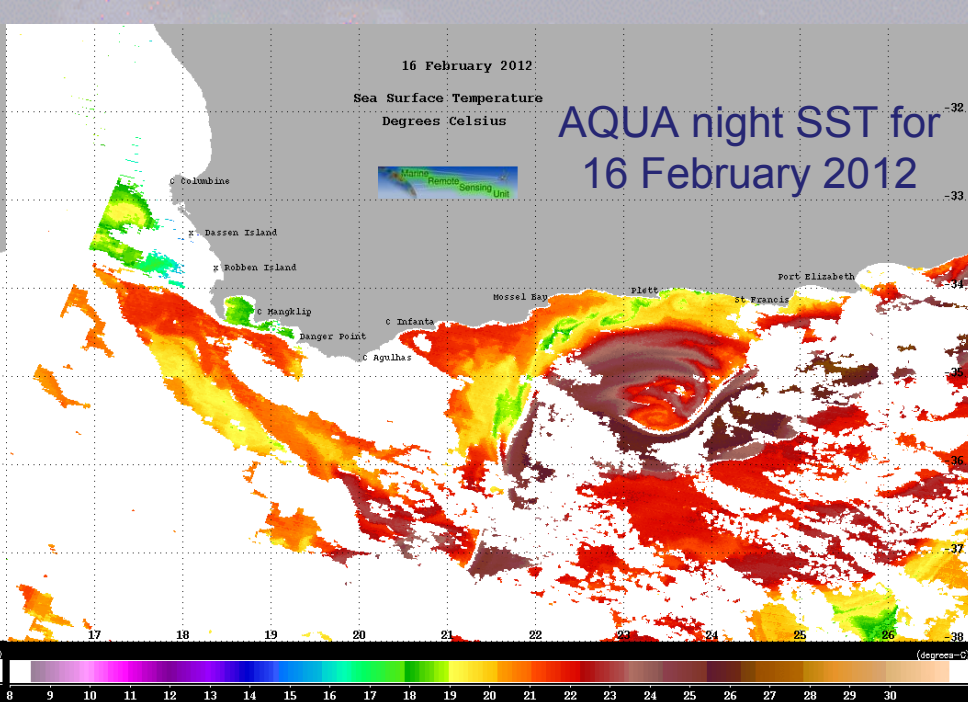
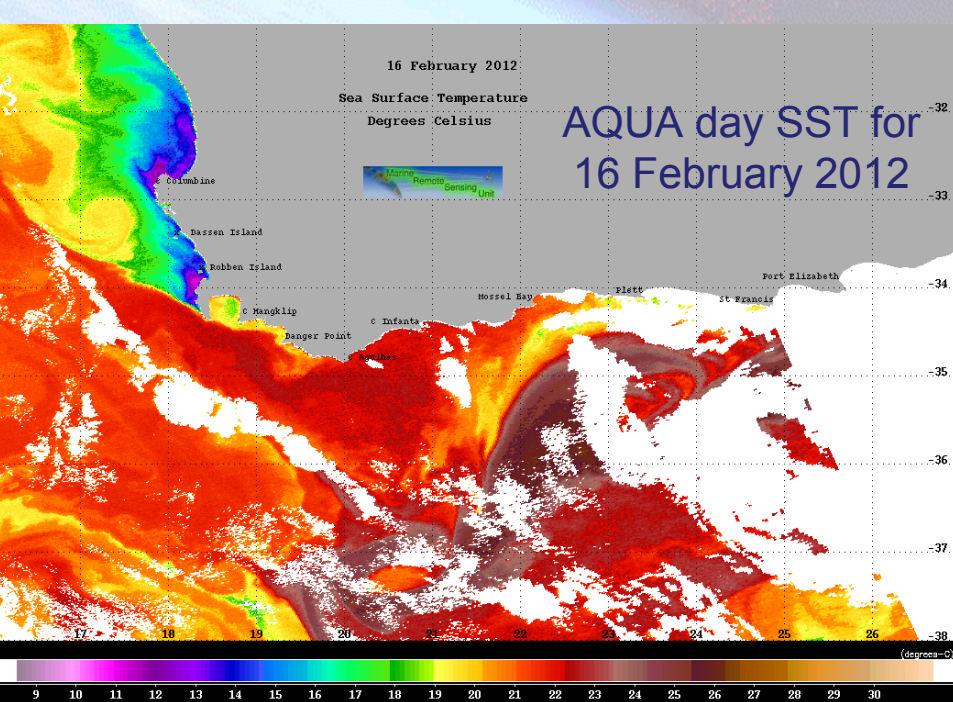


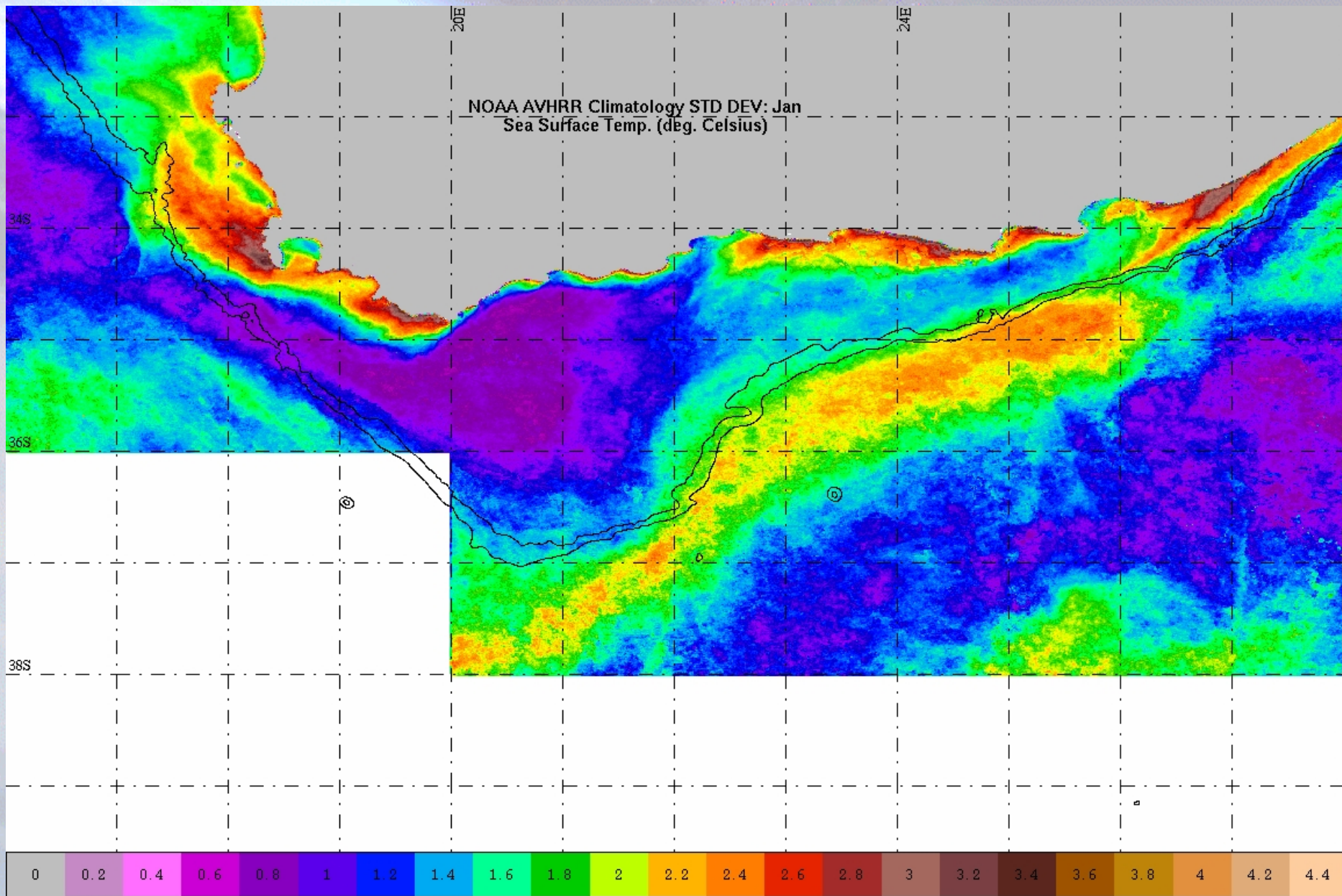
MODIS AQUA SST Monthly Mean Climatology 2003 - 2013



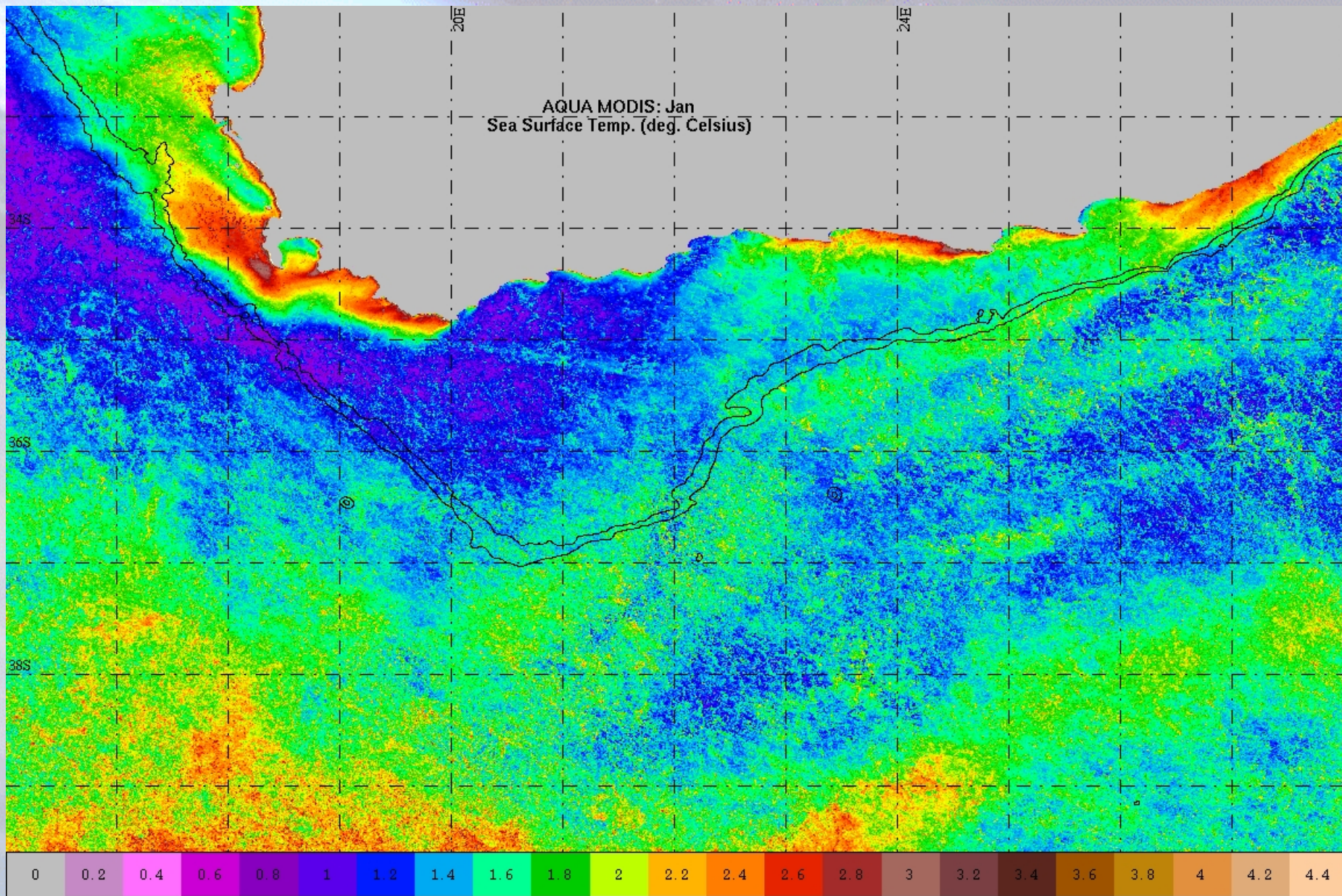


MUR GHRSSST STD DEV for January Climatology
2003-2012

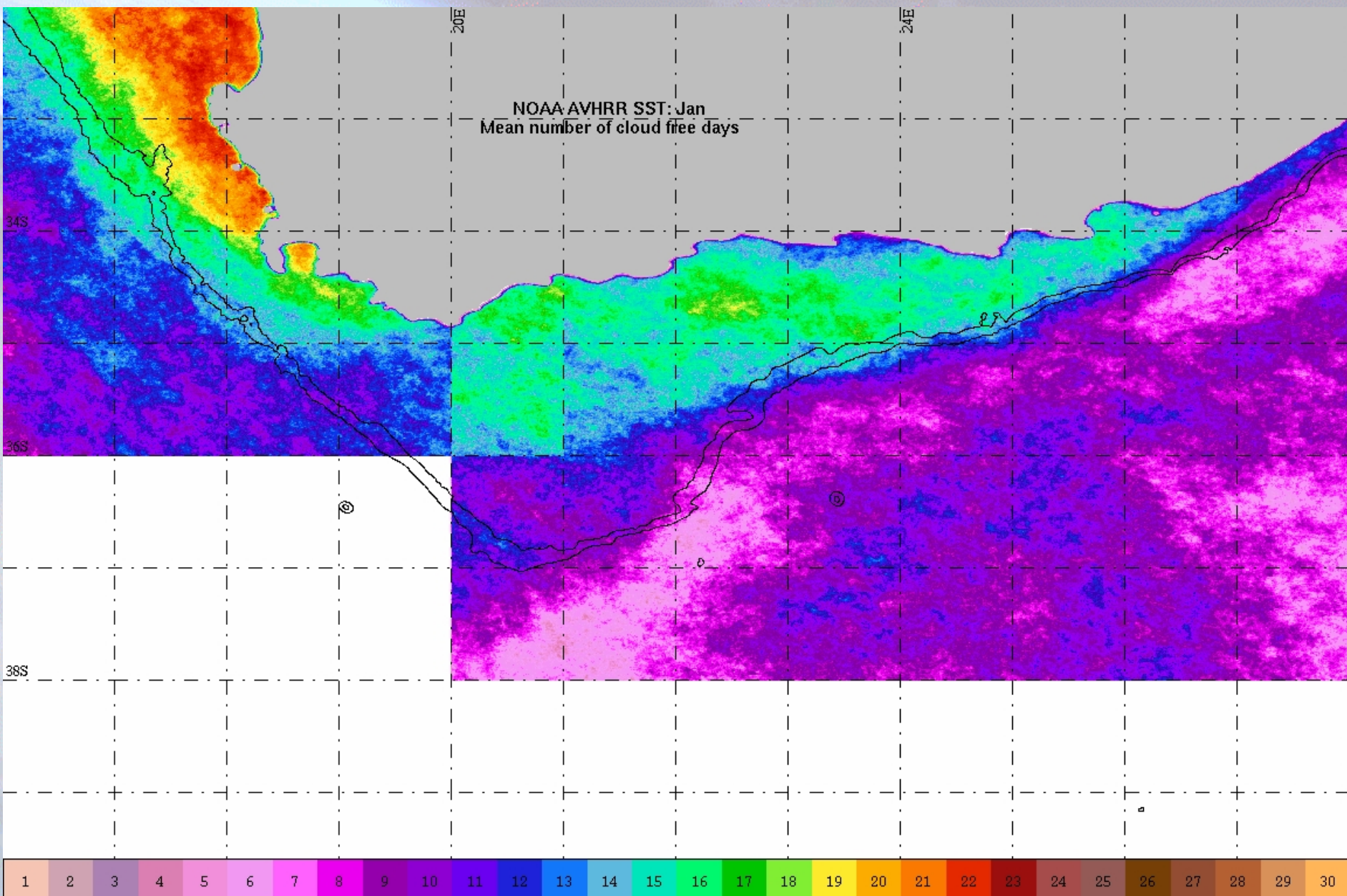




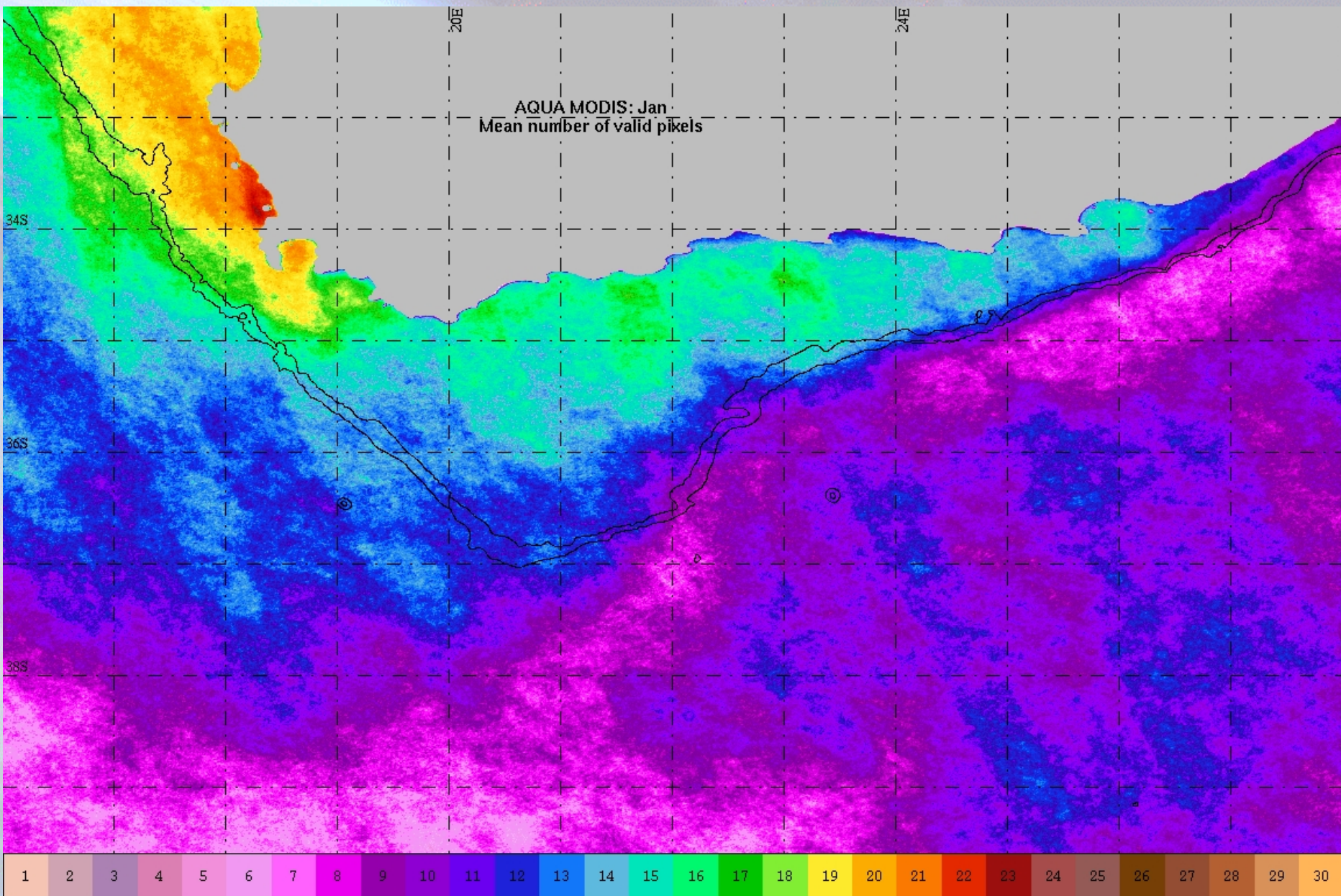
NOAA AVHRR STD DEV for January Climatology
1999-2003



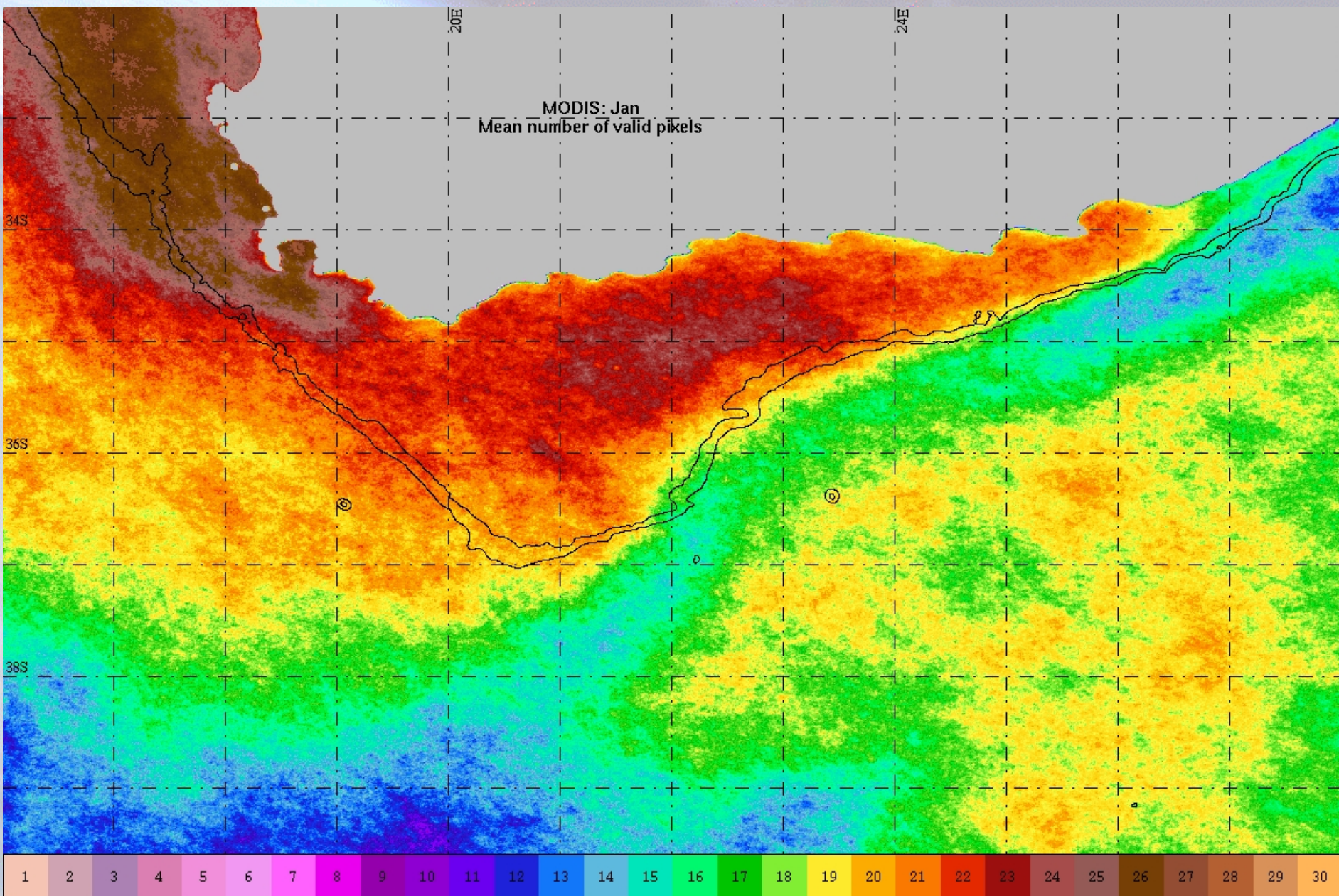
Aqua MODIS STD DEV for January Climatology 2003-2012



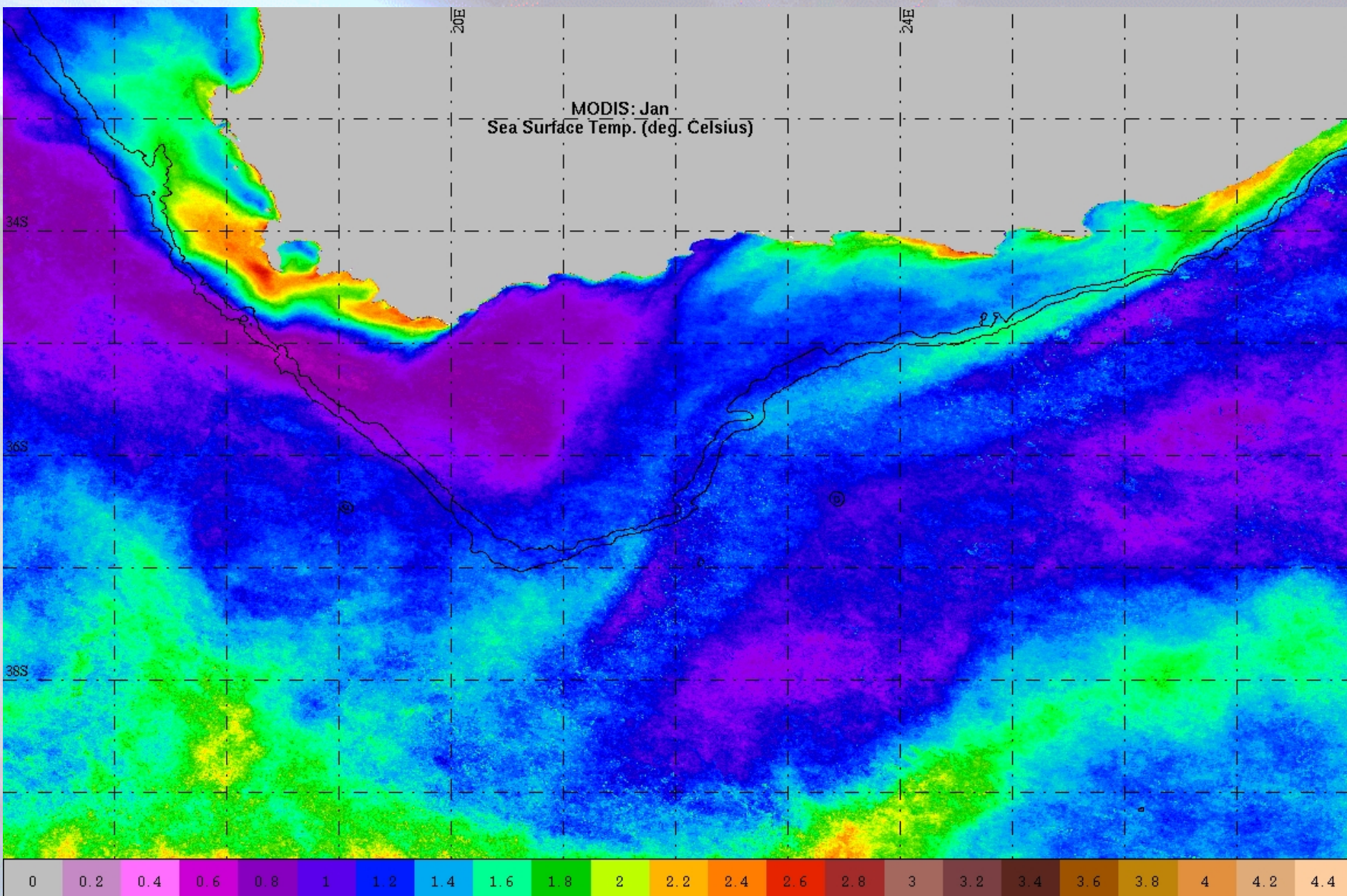
NOAA AVHRR mean cloud free days for January
Climatology 1999-2003



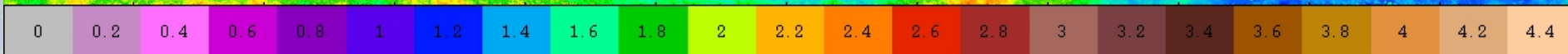
Aqua MODIS mean cloud free days for January Climatology
2003-2013 (Flag 0 & 1)



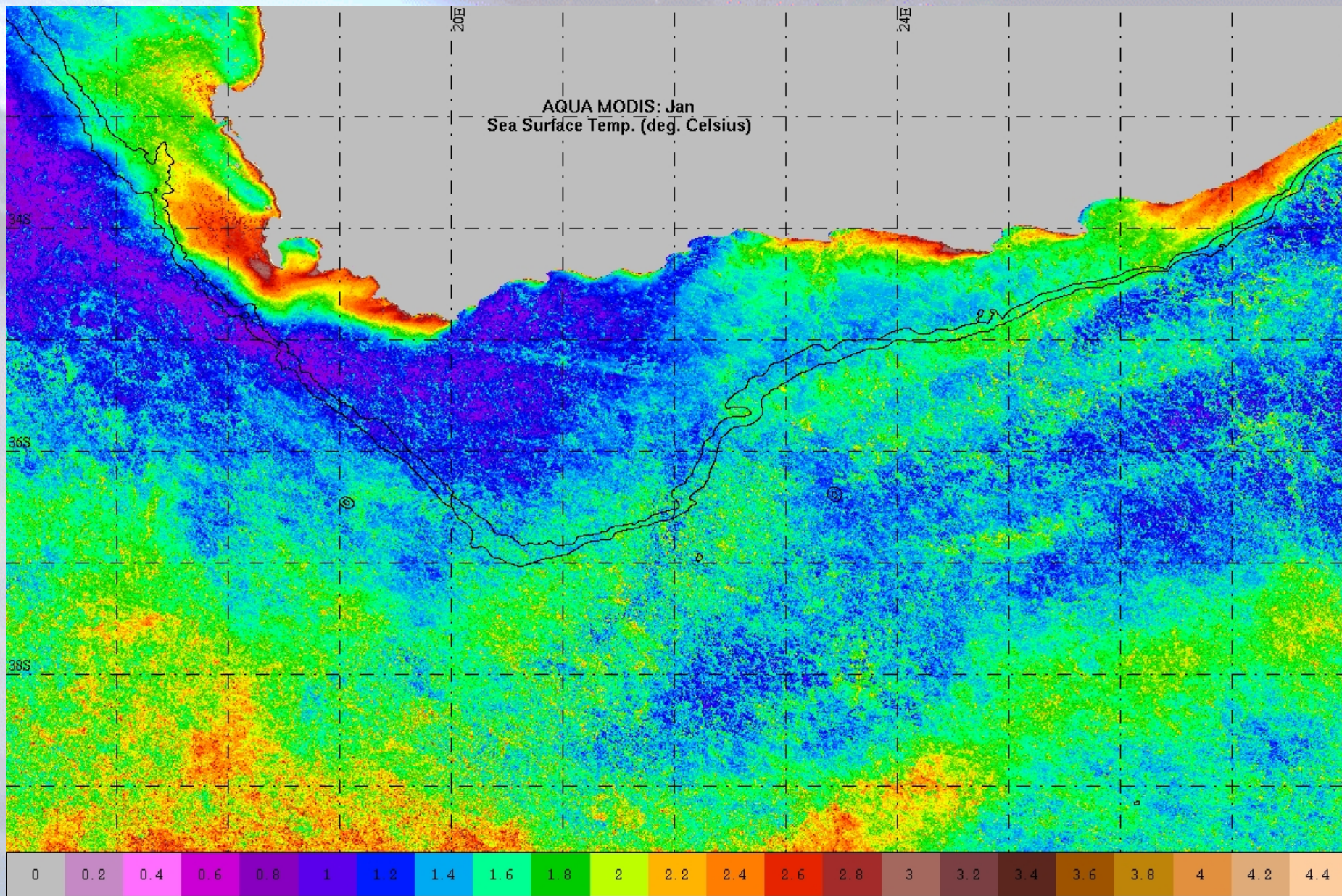
Blended MODIS mean cloud free days for January
Climatology 2003-2013: In house declouding algorithm
($[x-5d] > 1.5 * Stddev$)



MODIS: Jan
Sea Surface Temp. (deg. Celsius)

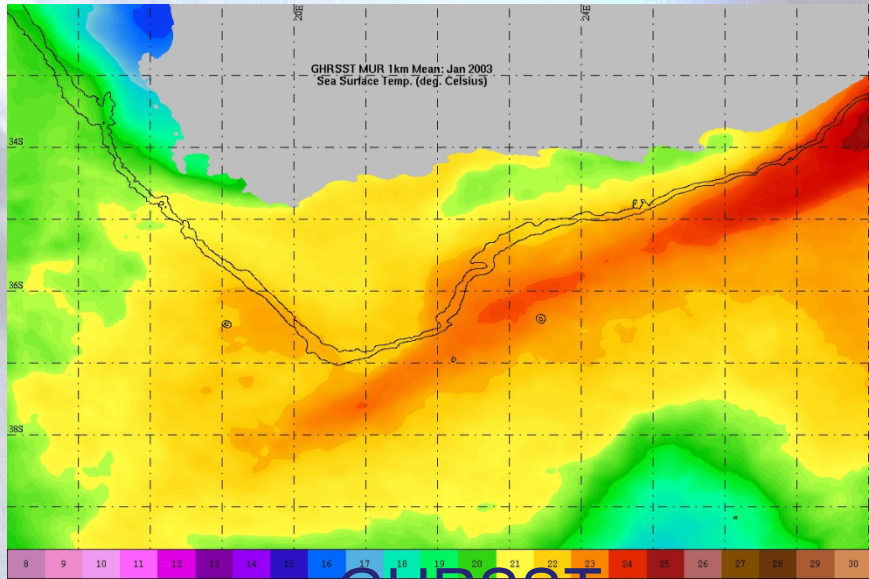


Blended MODIS STD DEV for January Climatology
2003-2013 (New declouding algorithm)

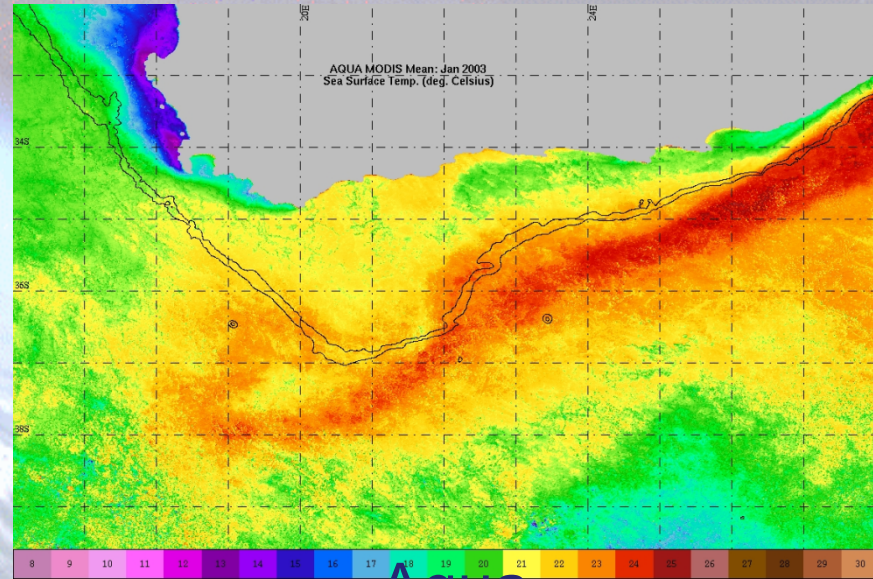


Aqua MODIS STD DEV for January Climatology 2003-2012

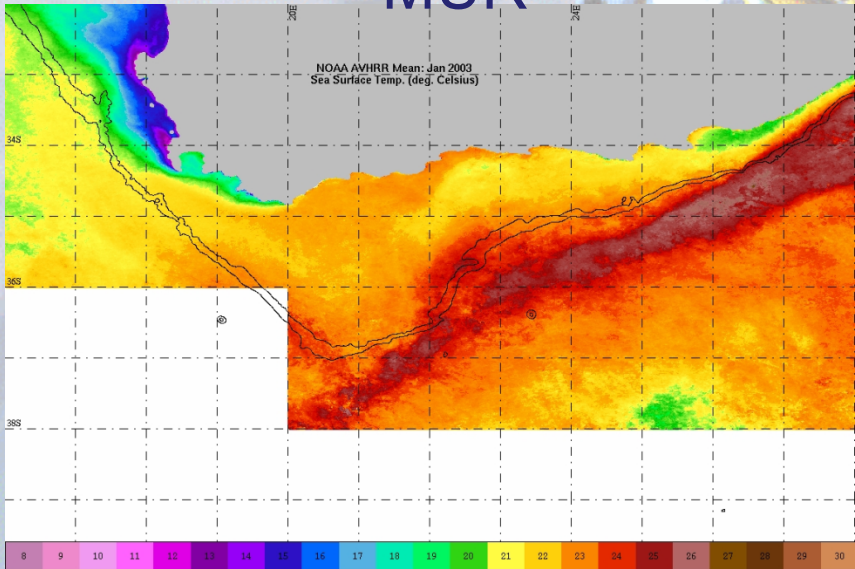
January 2003 Mean SST



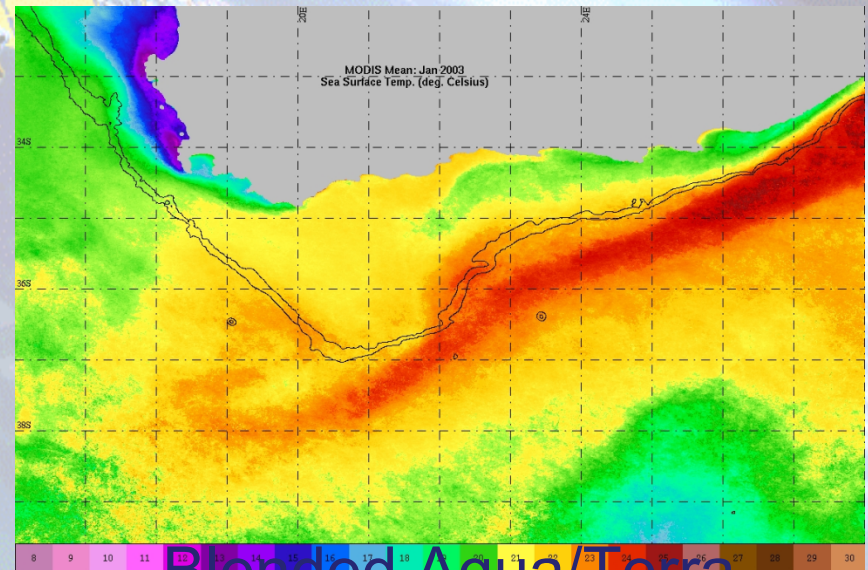
GHRSSST
MUR



Aqua
MODIS

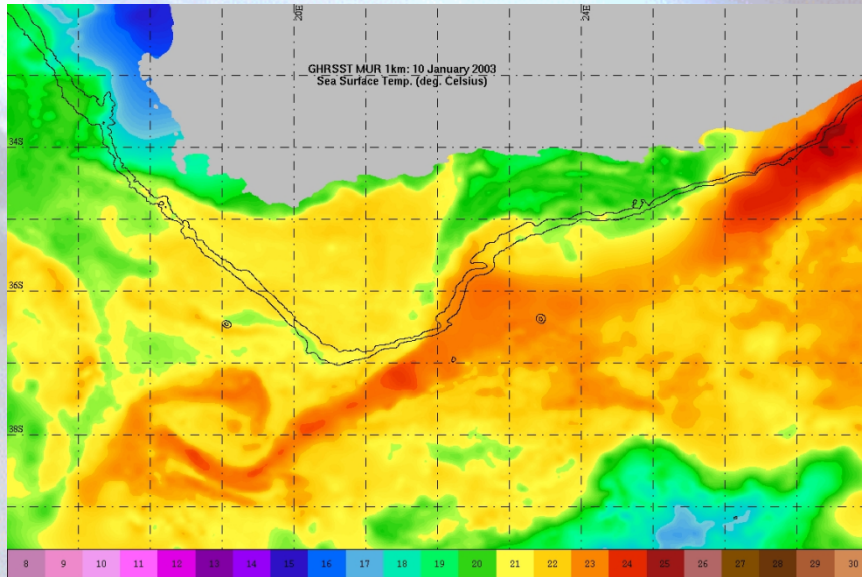


NOAA AVHRR

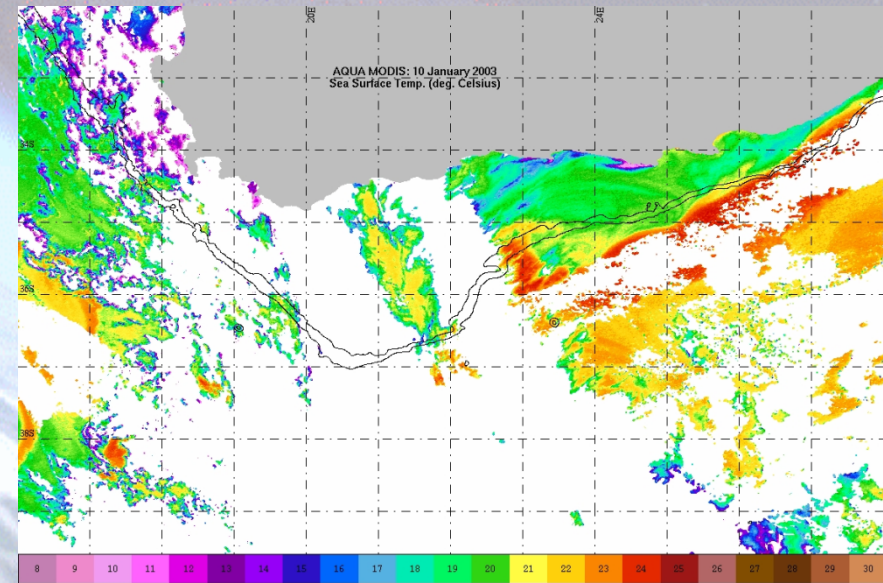


Blended Aqua/Terra
MODIS

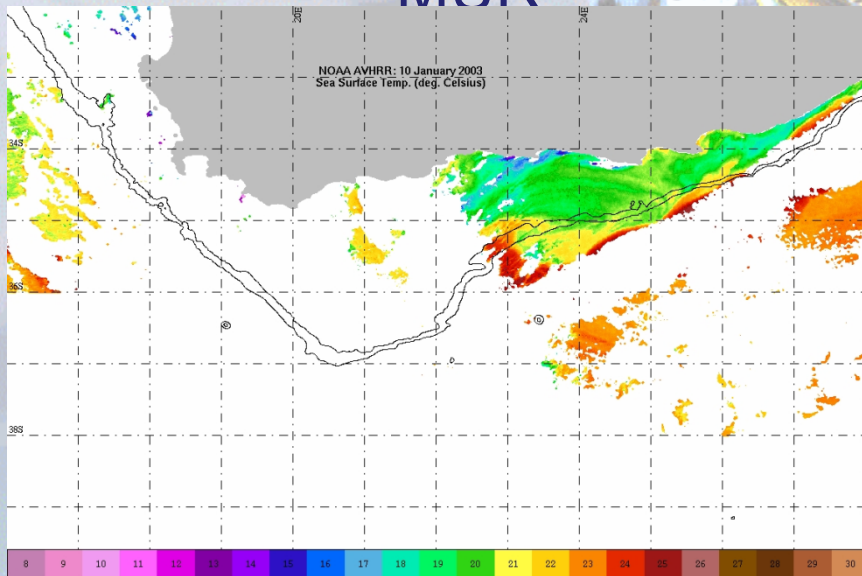
10 January 2003



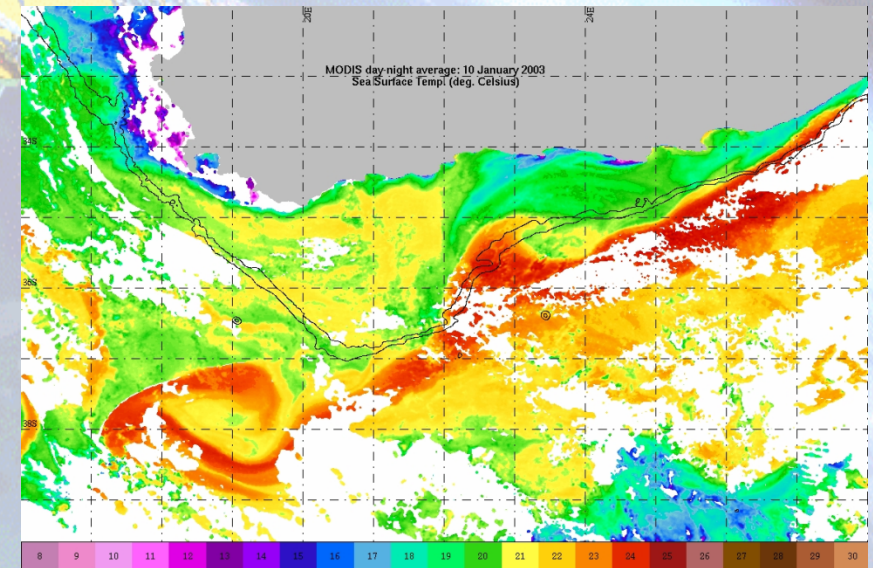
**GHRSSST
MUR**



**Aqua
MODIS**

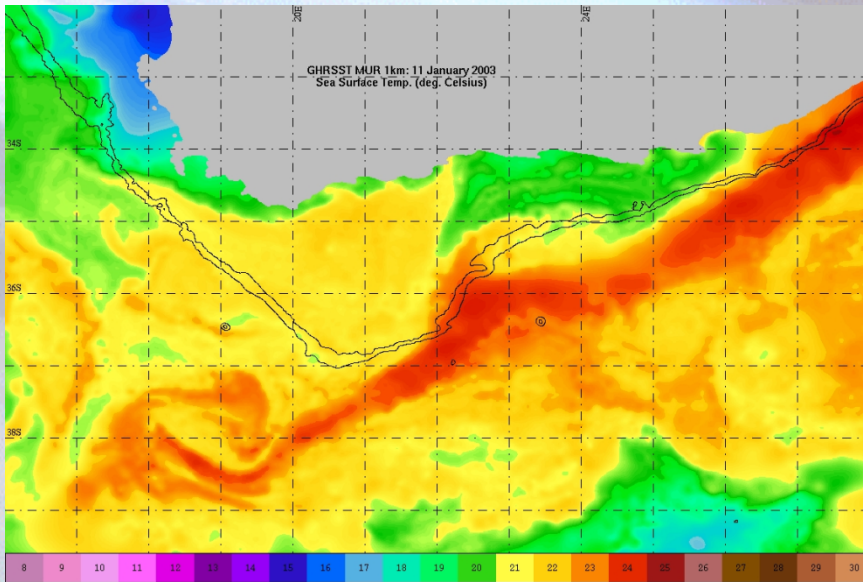


NOAA AVHRR

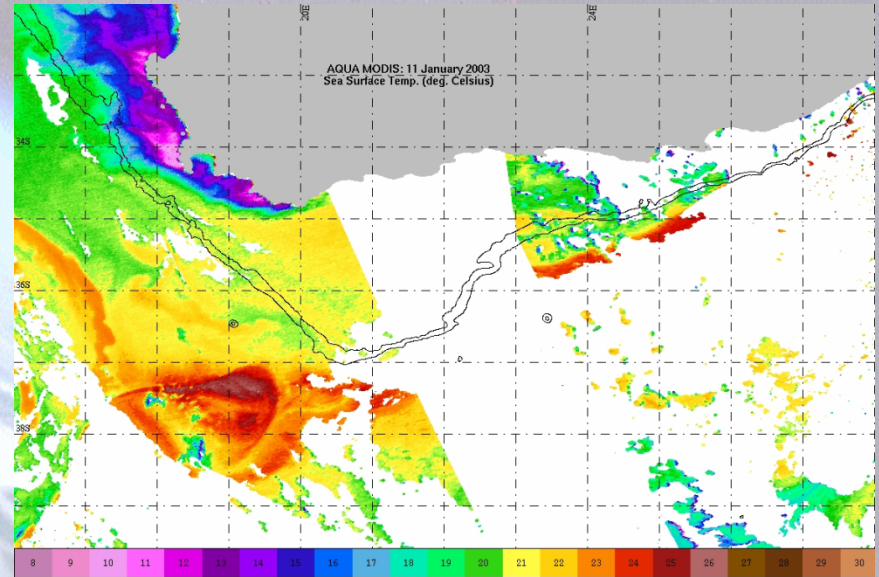


**Blended Aqua/Terra
MODIS**

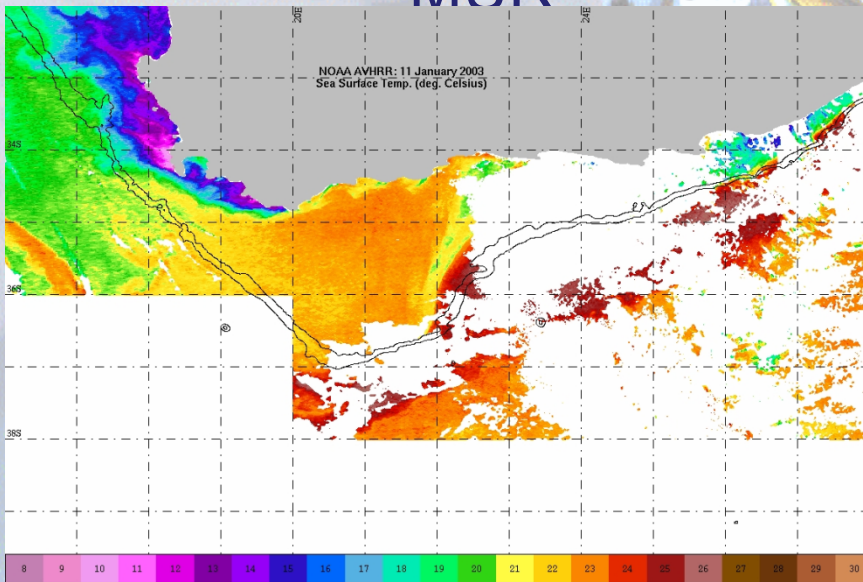
11 January 2003



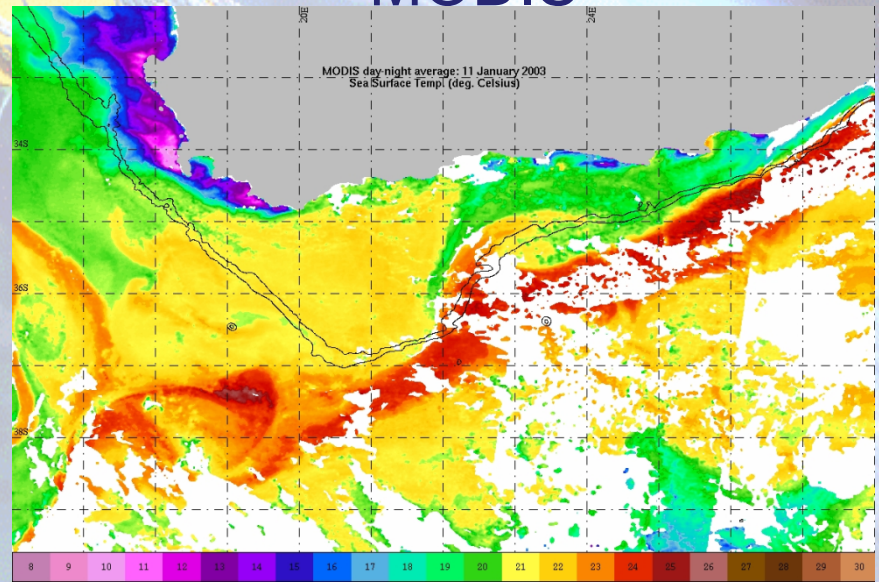
**GHRSSST
MUR**



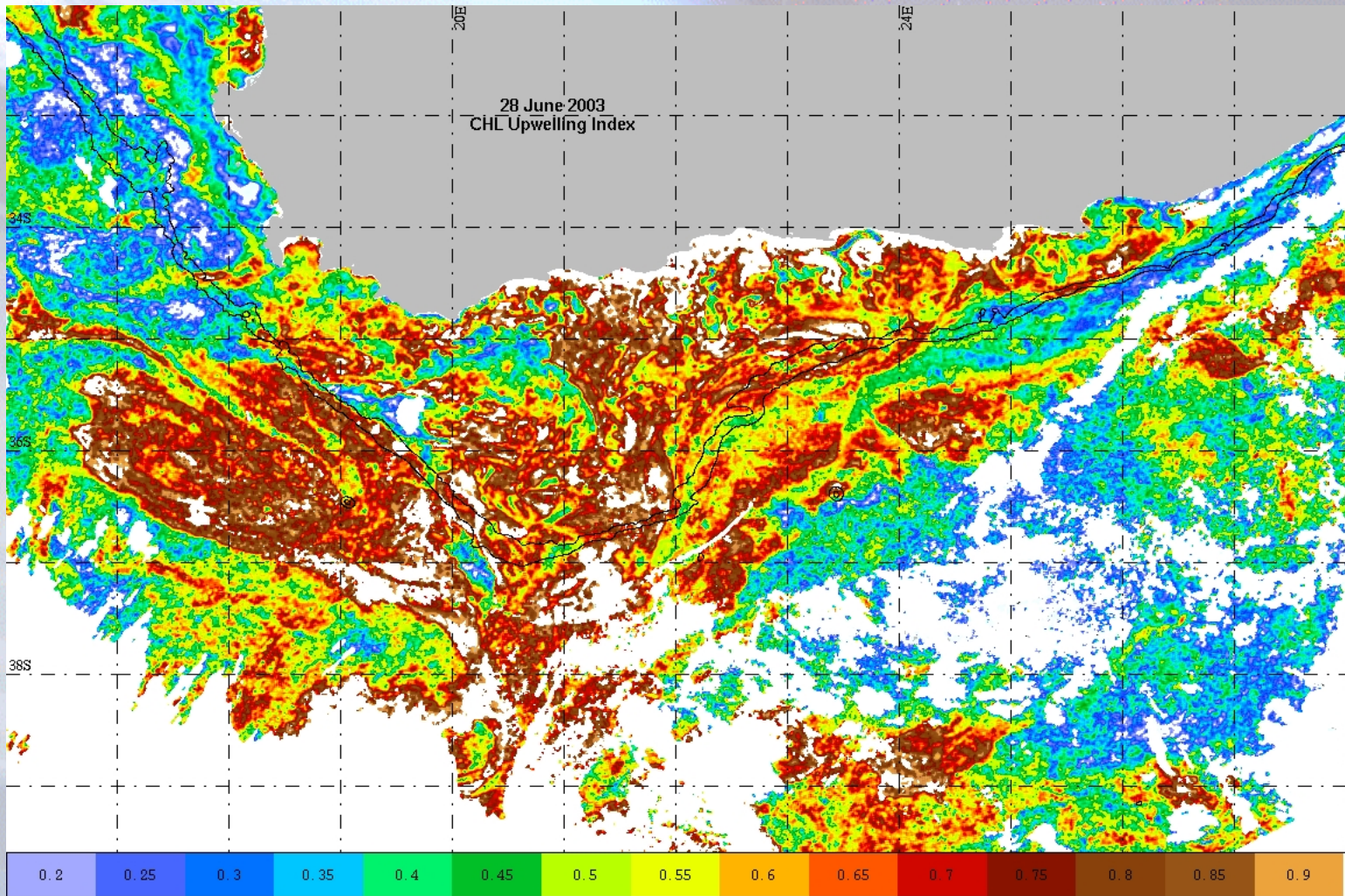
**Aqua
MODIS**



NOAA AVHRR



**Blended Aqua/Terra
MODIS**



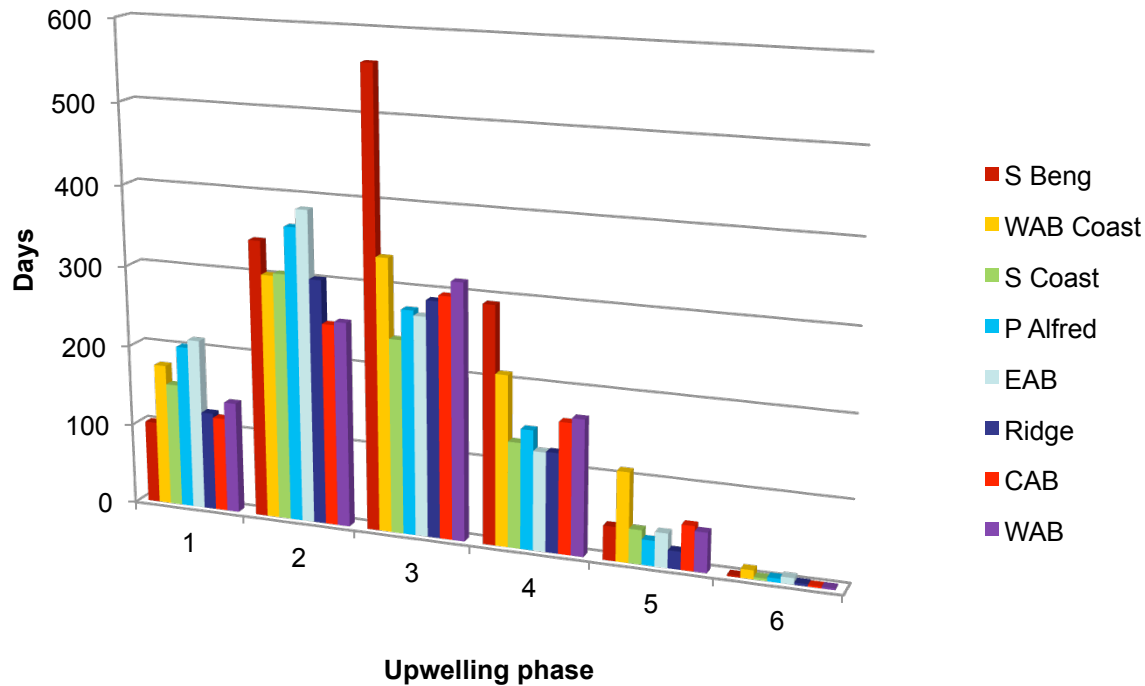
Production Index: $\text{Chl}(\text{day}) - \text{Chl}(\text{month_min}) / \text{Chl}(\text{month_range})$

Phase	1	2	3	4	5	6
Southern Benguela	102	343	562	292	42	2
Western Agulhas Bank Coast	176	302	336	210	110	11
South Coast	153	305	239	130	42	3
Port Alfred	202	363	276	147	31	5
Eastern Agulhas Bank	212	385	270	122	42	8
Ridge	122	302	290	123	22	3
Central Agulhas Bank	117	249	297	161	55	2
Western Agulhas Bank	138	253	315	167	49	2

1 : index < 0.3
 2 : index < 0.4
 3 : index < 0.5
 4 : index < 0.6
 5 : index < 0.7
 6 : index > 0.7

Upwelling days within different categories of production for each province over 2003-2011

Regional diversity of upwelling phase index



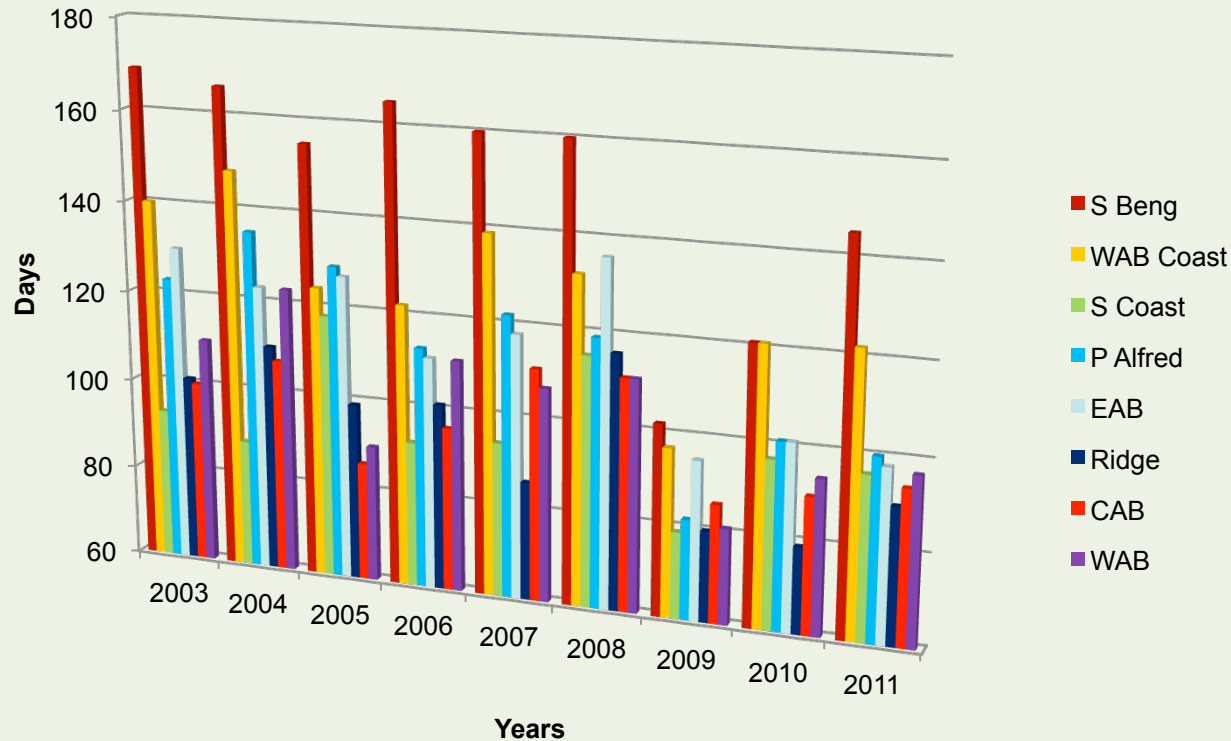
- 1 : index < 0.3
- 2 : index < 0.4
- 3 : index < 0.5
- 4 : index < 0.6
- 5 : index < 0.7
- 6 : index > 0.7

Upwelling days within different categories of production for each province over 2003-2011

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Southern Benguela	169	166	155	165	160	160	102	121	145
Western Agulhas Bank Coast	140	148	124	122	139	132	97	121	122
South Coast	93	88	118	92	94	115	79	97	96
Port Alfred	123	135	129	113	122	119	82	101	100
Eastern Agulhas Bank	130	123	127	111	118	136	95	101	98
Ridge	101	110	99	101	86	116	80	79	90
Central Agulhas Bank	100	107	86	96	111	111	86	90	94
Western Agulhas Bank	110	123	90	111	107	111	81	94	97

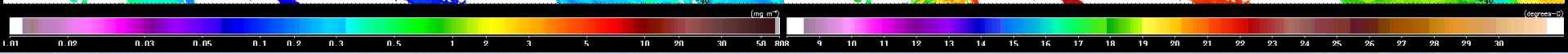
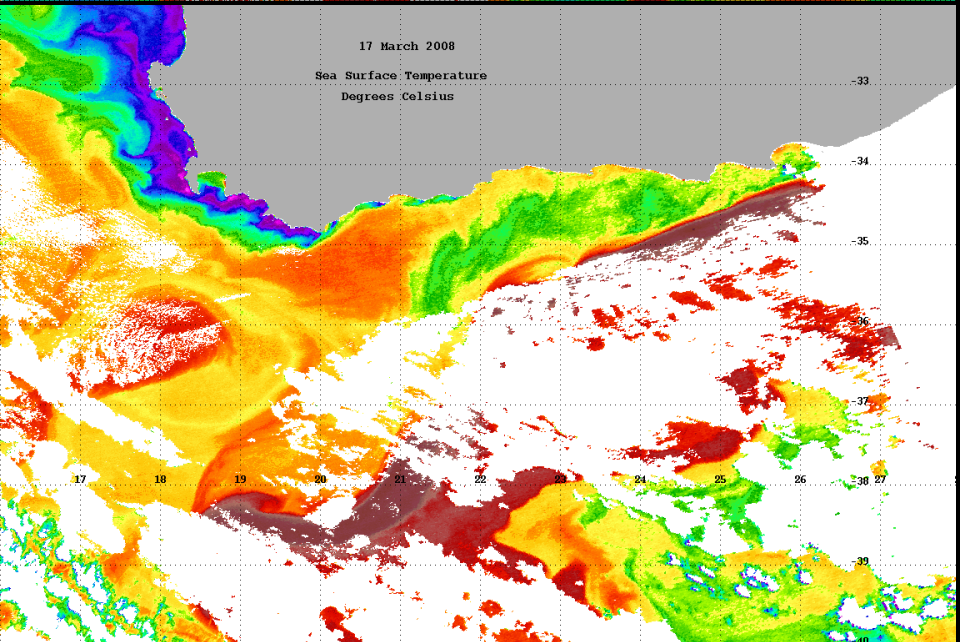
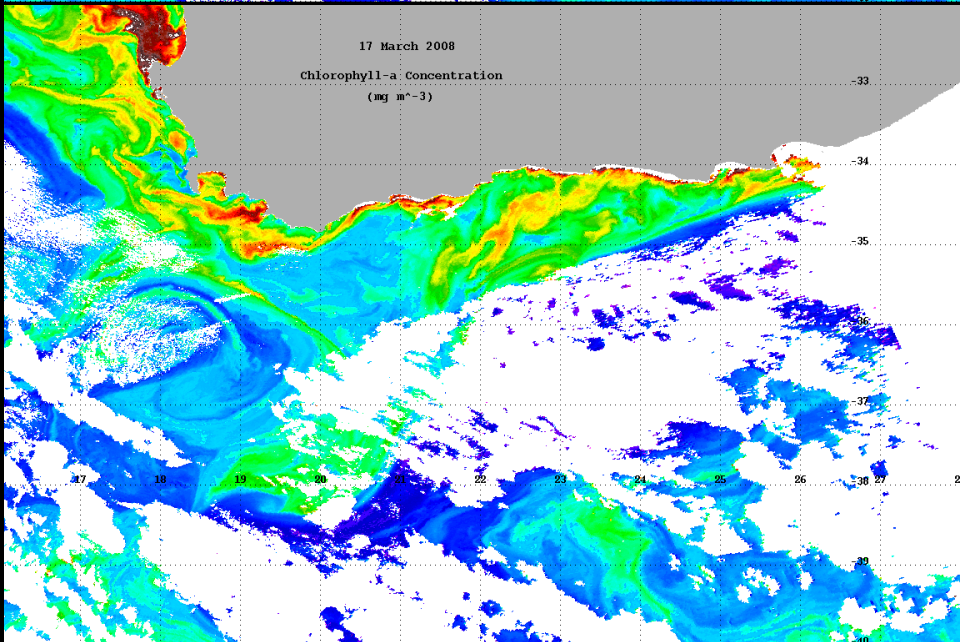
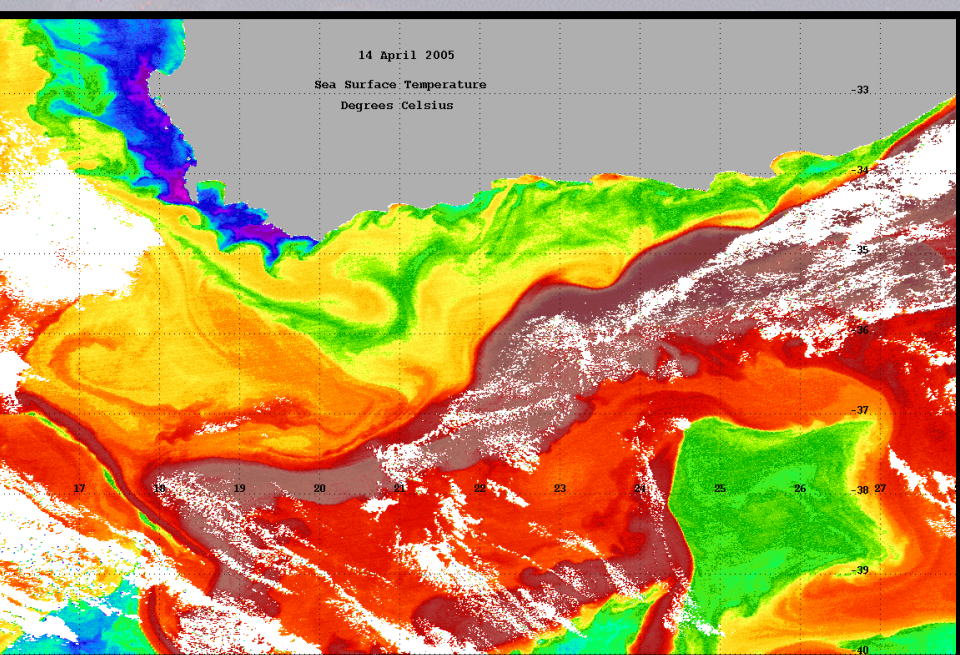
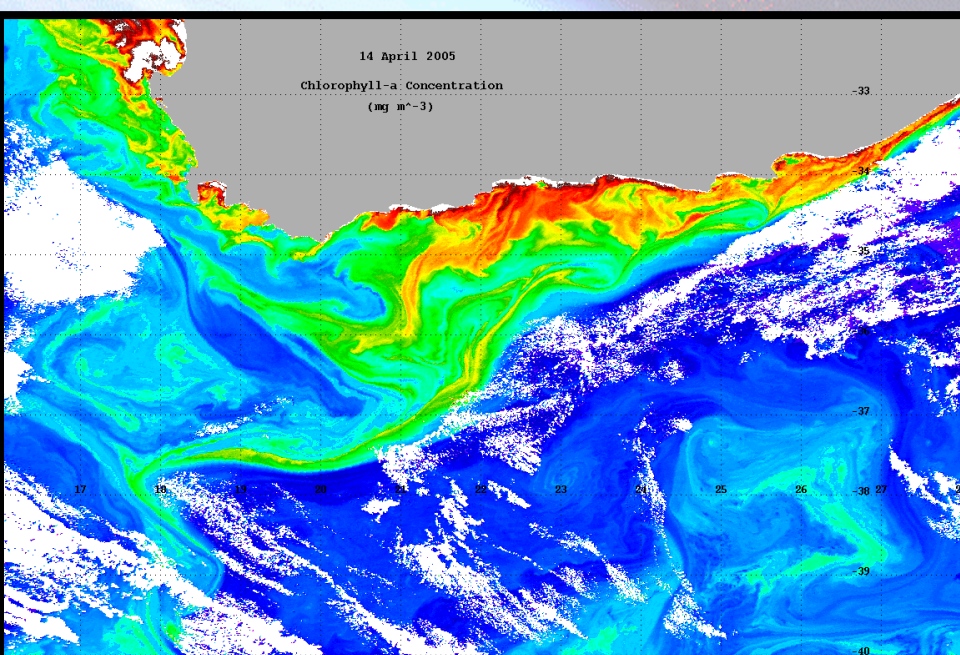
Total upwelling days per year for each province

Upwelling days per year

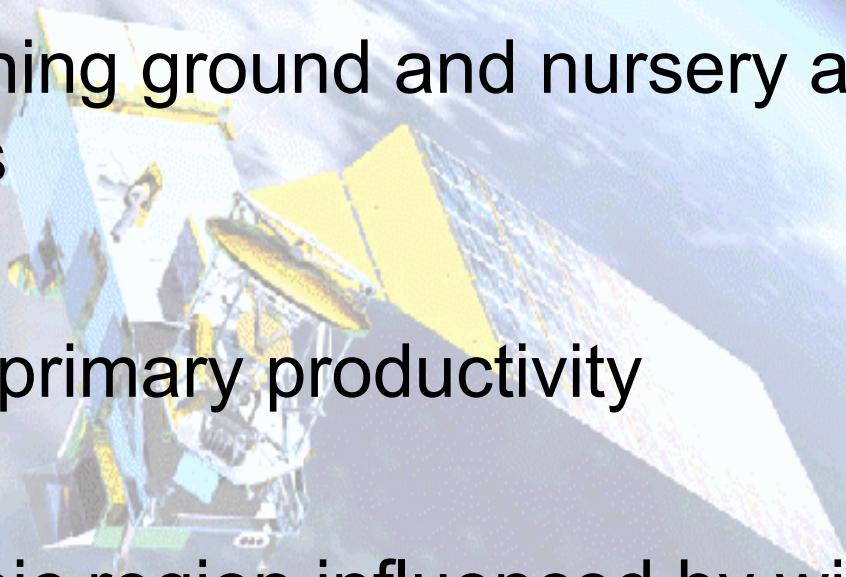


- 1 : index < 0.3
- 2 : index < 0.4
- 3 : index < 0.5
- 4 : index < 0.6
- 5 : index < 0.7
- 6 : index > 0.7

Total upwelling days per year for each province



Summary

- Centre of abundance for numerous commercially exploitable fish species
 - Provides spawning ground and nursery area for several species
 - Region of high primary productivity
 - Complex oceanic region influenced by wind-driven coastal upwelling, as well as dynamic current driven upwelling
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Summary

- 2 Wind driven coastal upwelling zones; WAB coast extension of Benguela upwelling system with peak Chl-a in summer; SC driven by different wind regime with peak Chl-a in autumn
- PA cell exhibit high variability and not dominated by seasonal cycle
- Chl-a peak in winter for WAB and CAB
- Ridge and EAB higher productivity than other offshore regions, high variability
- SST dominated by seasonal cycle, with cooling trend