Variability in Tropical Cyclone induced upper ocean cooling

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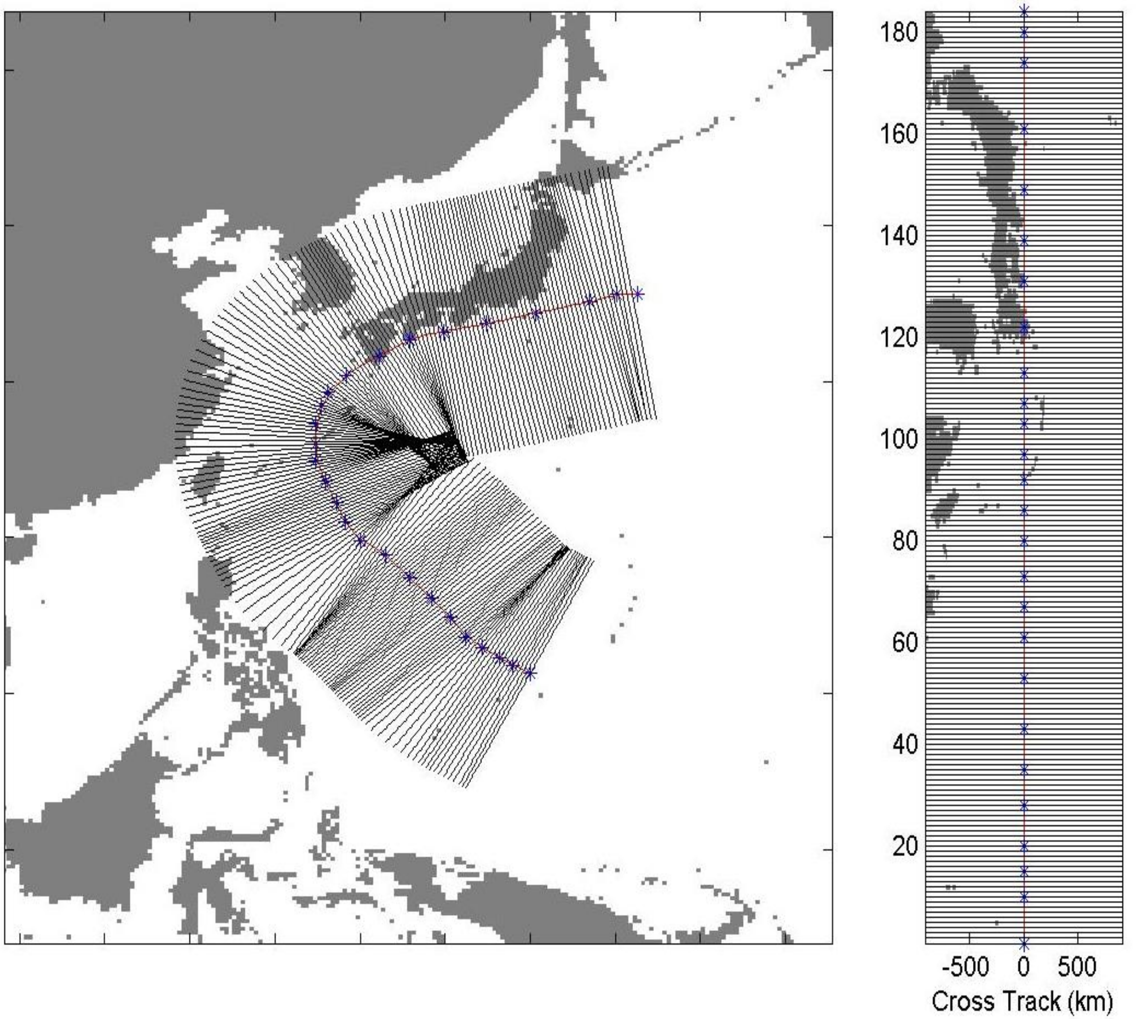
Project objectives

- Develop a storm centric database that includes a broad range of satellite and in situ data
- Distribute database in netcdf (7/2014)
- Use this database to study variability in upper ocean mixing from 1998 – present, using satellite and in situ data

Design

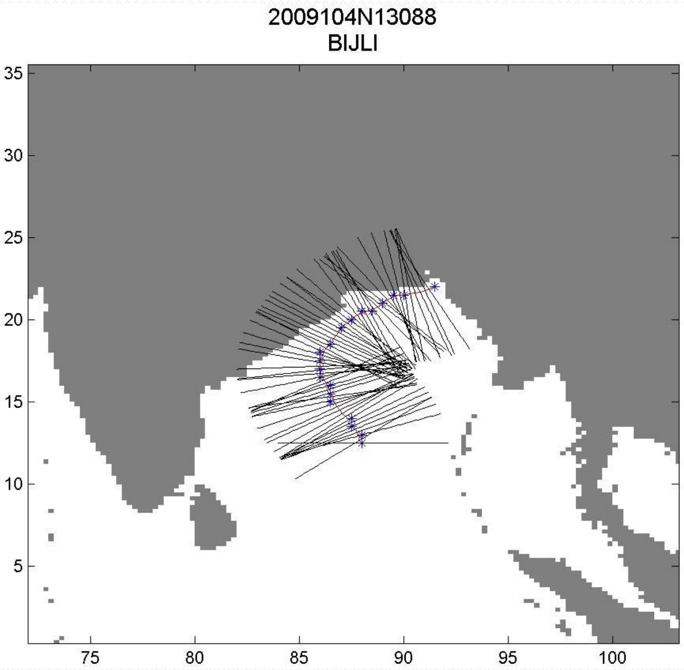


Storm Data

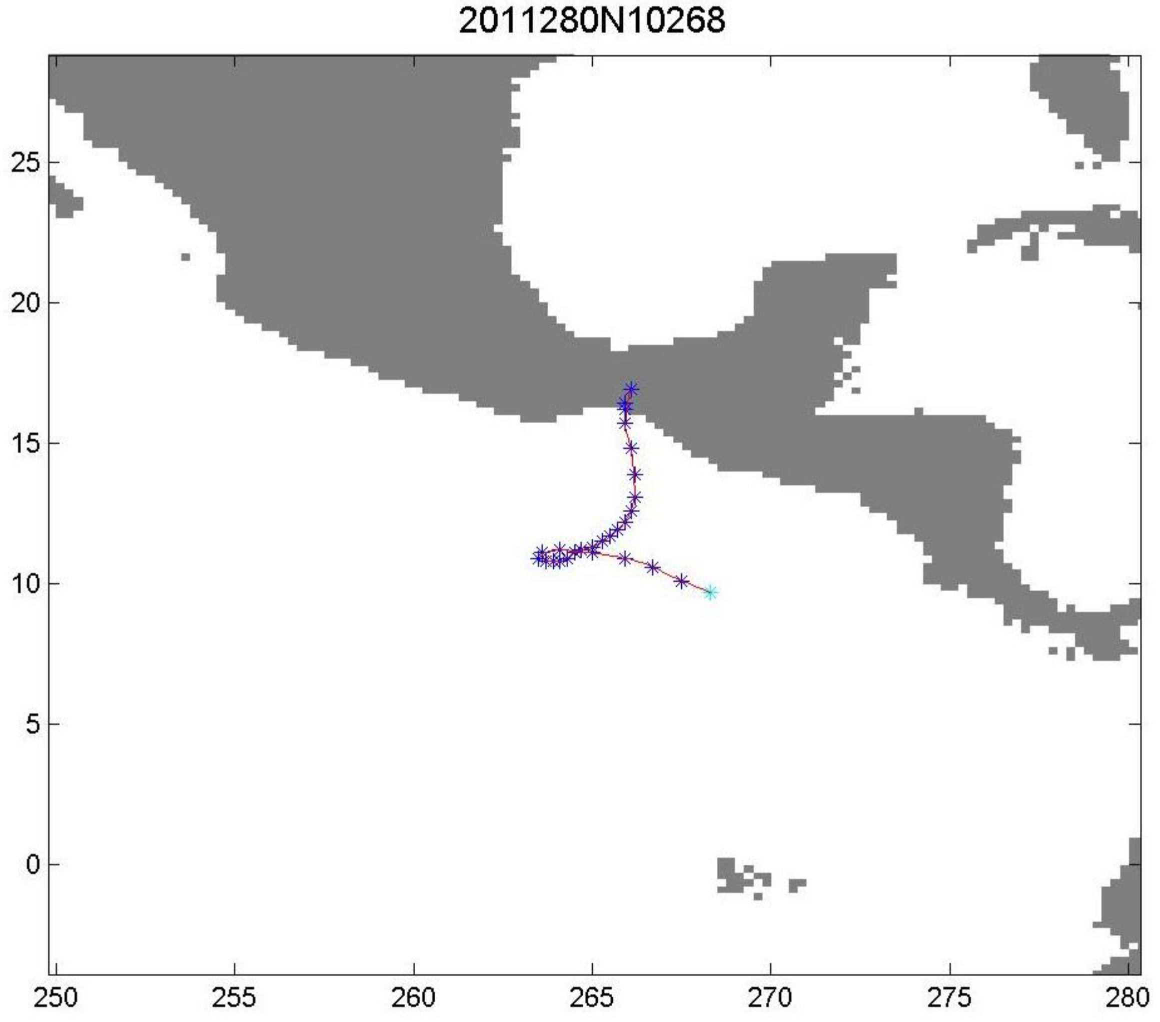
- IBTrACS database (http://www.ncdc.noaa.gov/oa/ibtracs/index.php).
- The IBTrACS database is endorsed by the World Meteorological Organization’s Tropical Cyclone Programme as the official archiving and distribution resource for tropical cyclone best track data.
- IBTrACS includes post-processed and quality-checked best-track storm data from numerous tropical cyclone datasets and monitoring centers in all major ocean basins.

Storm Data

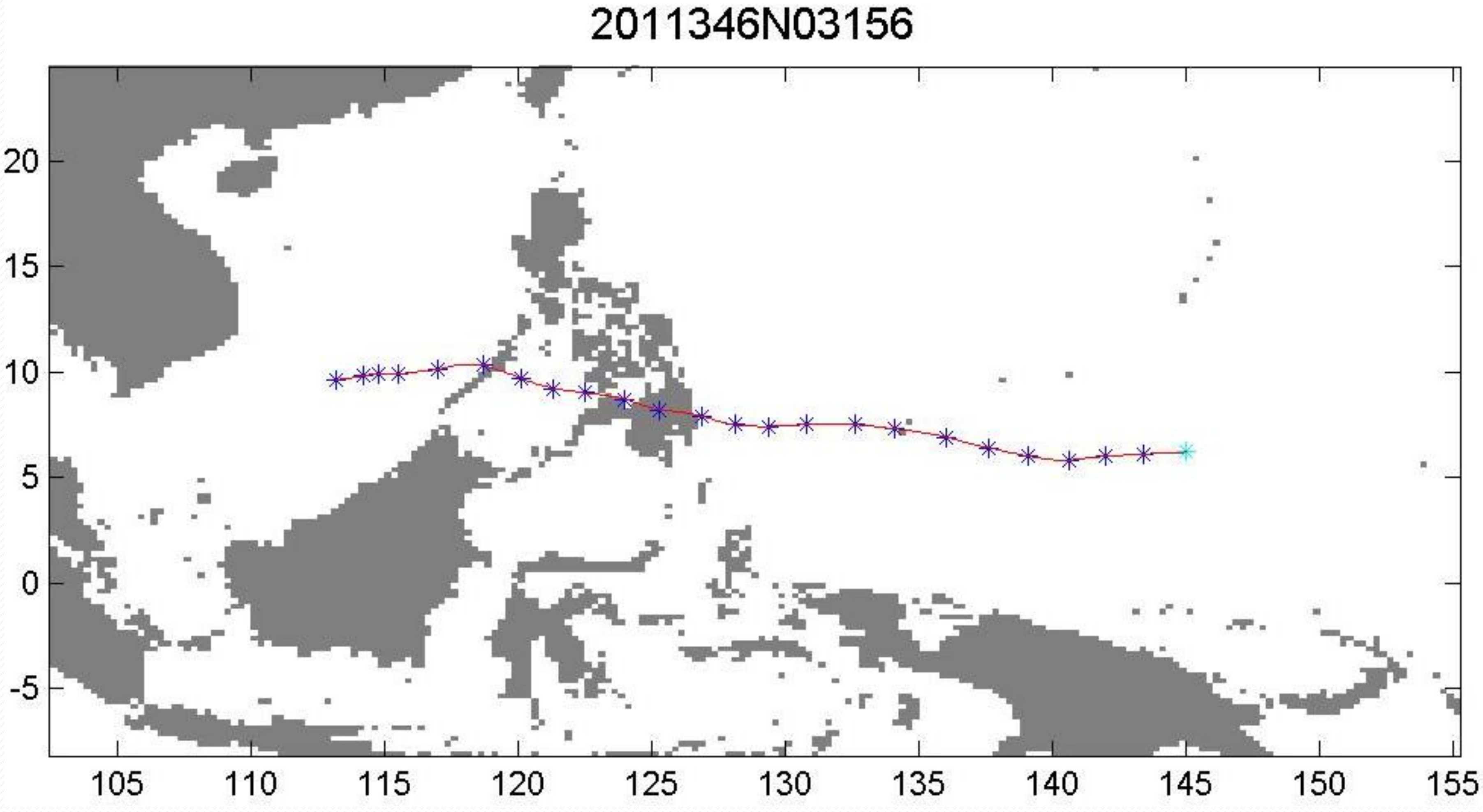
- Indian ocean tracks location (lat/lon) has 0.5 deg precision
- Switched to JTWC which reports in 0.1 deg prec

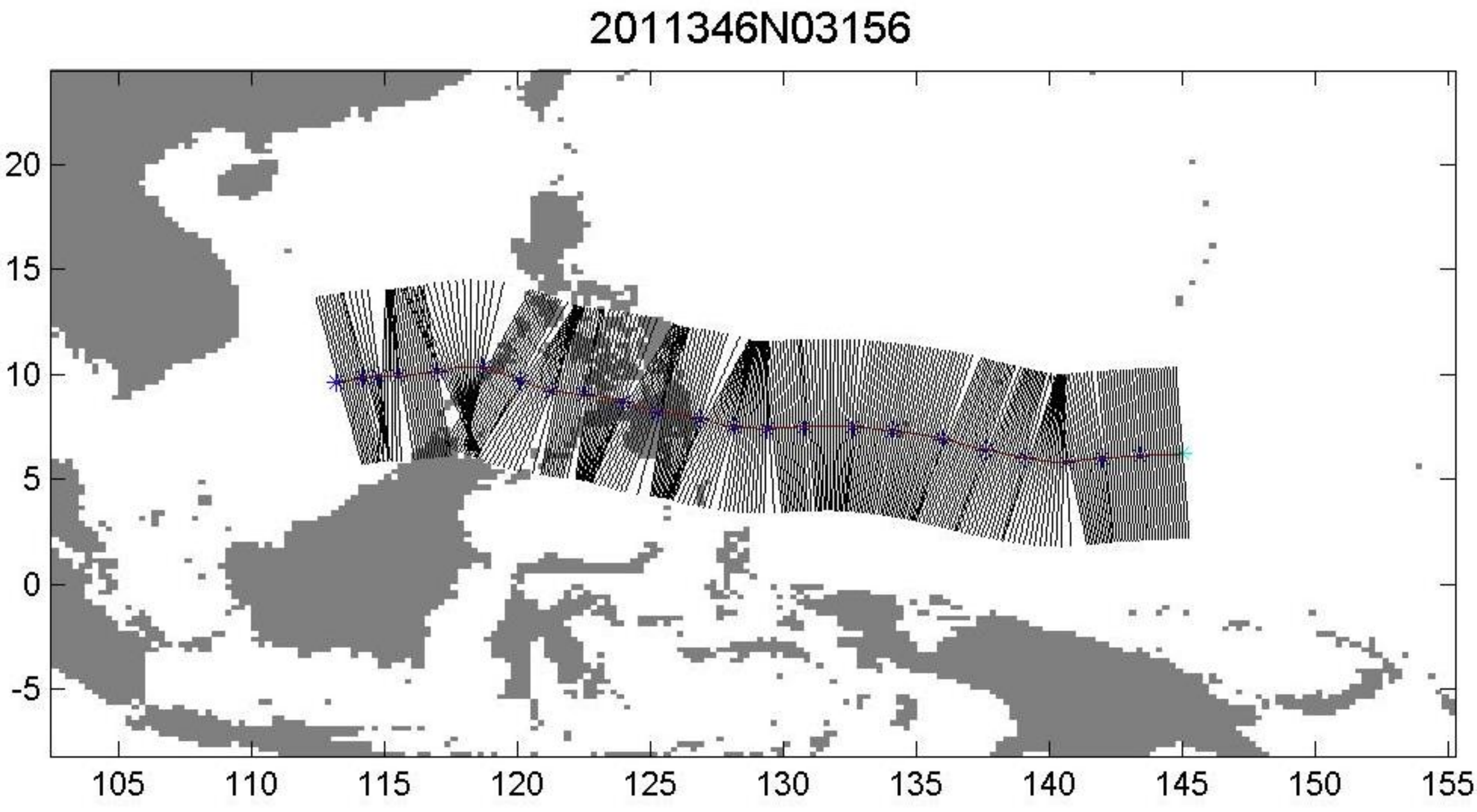


Step 1: Fit curve to storm 6-hr obs

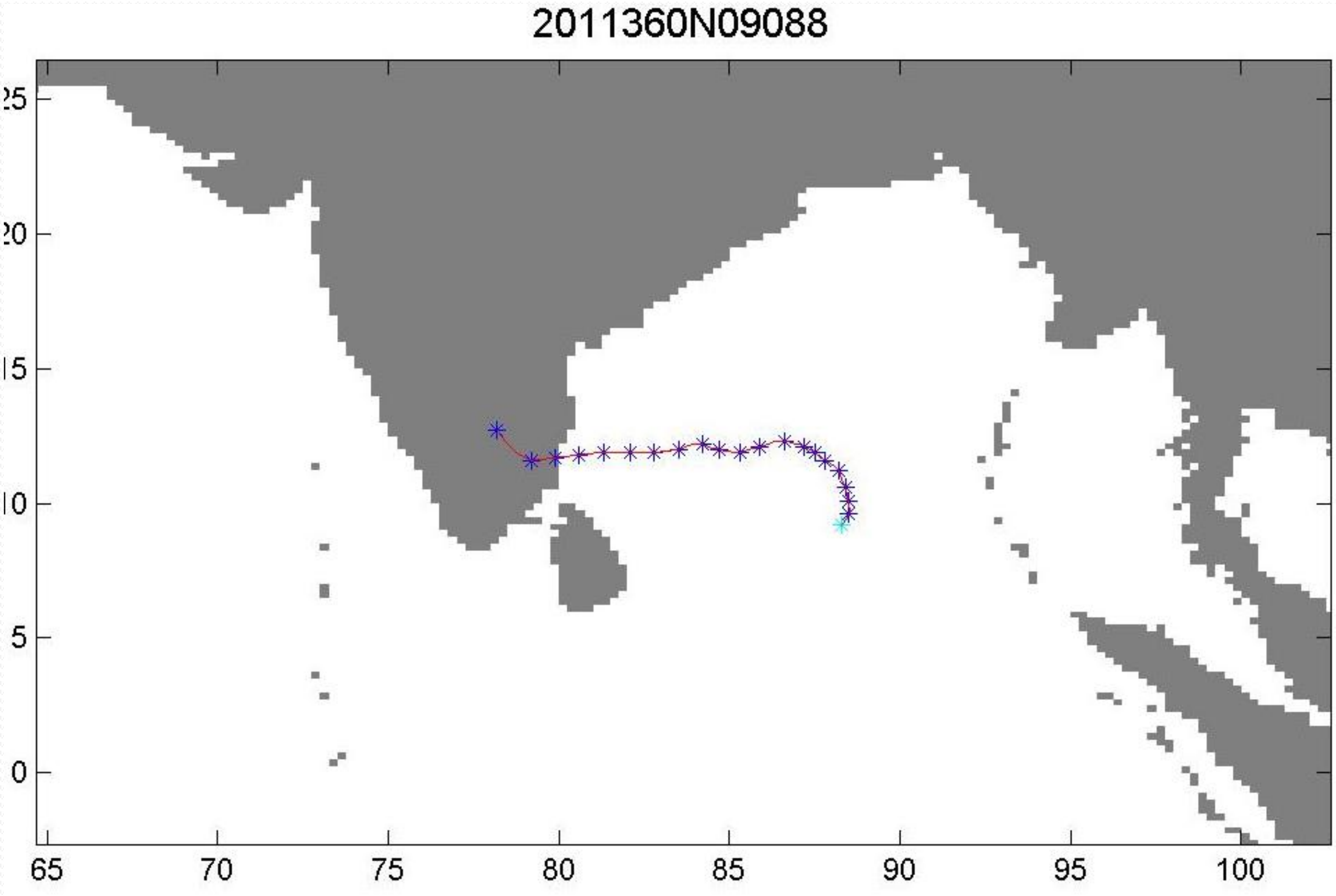


Step 2: track orthogonals

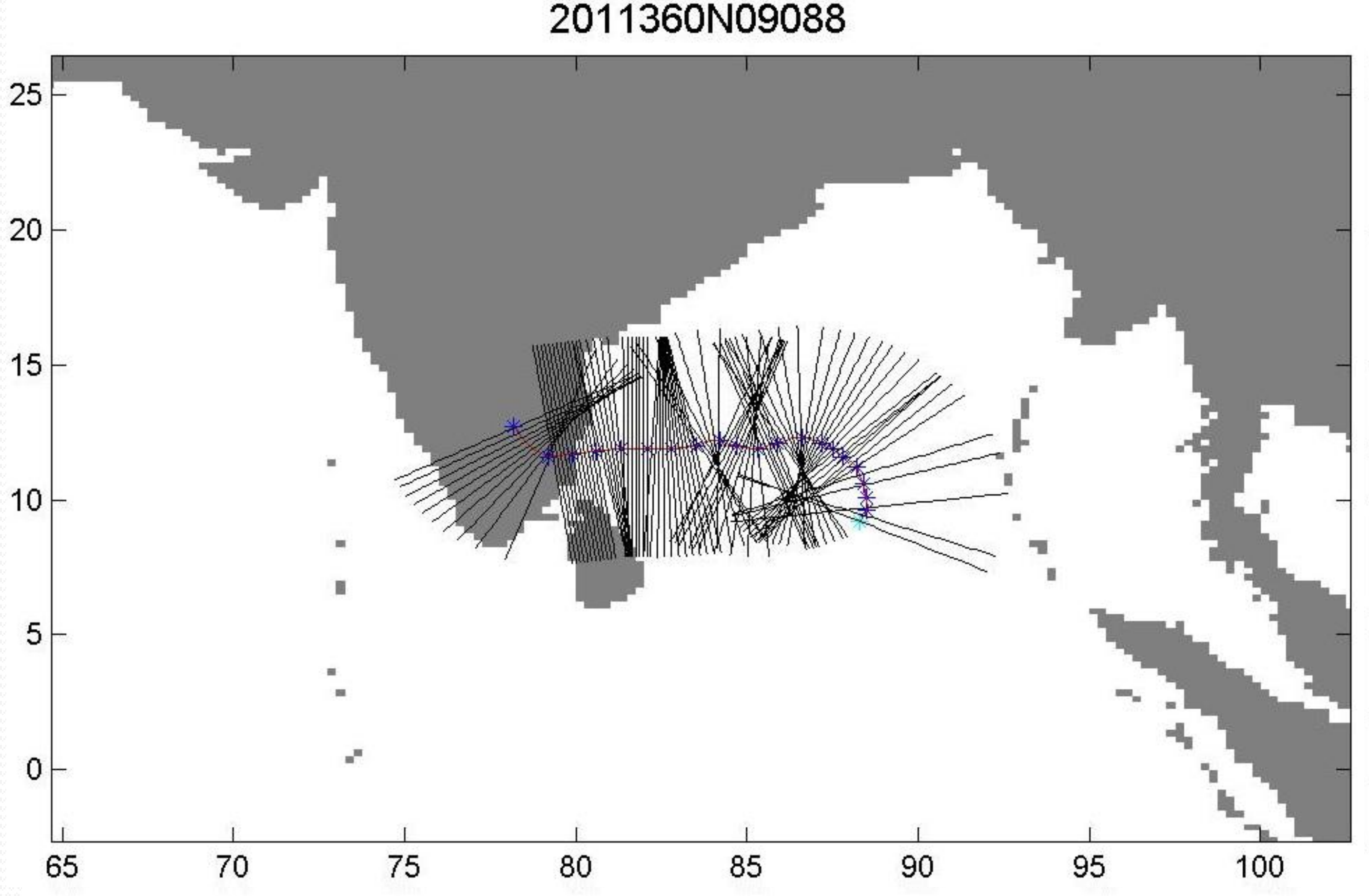



2011346N03156
20
15
10
5
0
-5
105
110
115
120
125
130
135
140
145
150
155

Step 2: track orthogonals



Step 2: track orthogonals



Step 3: lat,lon,time

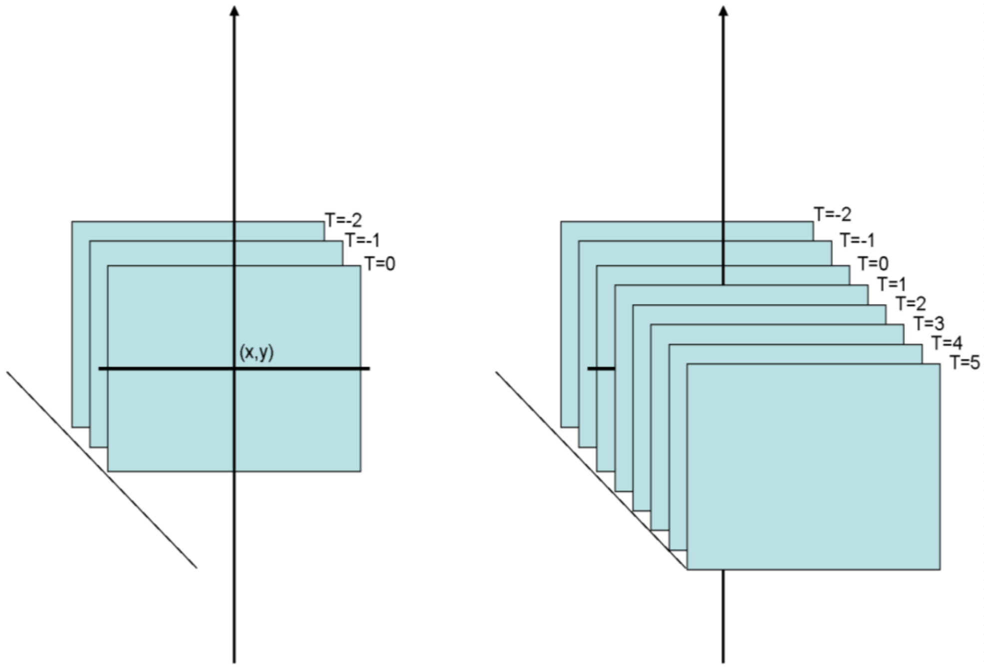


Figure . Illustration of data structure in storm-centered frame of reference. The storm moves up the center vertical line in each panel. The left panel illustrates how the orthogonal is used to center a grid of observations onto the storm spatial frame of reference, with stacks of data in time both before and after (right panel) the storm passage.

- 2 arrays of data are saved (for 2D data)
- 1) lat,lon,time where time is storm-centric time (0=storm passage)
- 2) lat,lon,time where time is julian day

Step 3: profiles

- Instead of 2d array of data, save collocation location and profile information.
- Still organized by either julian day or storm-centric time

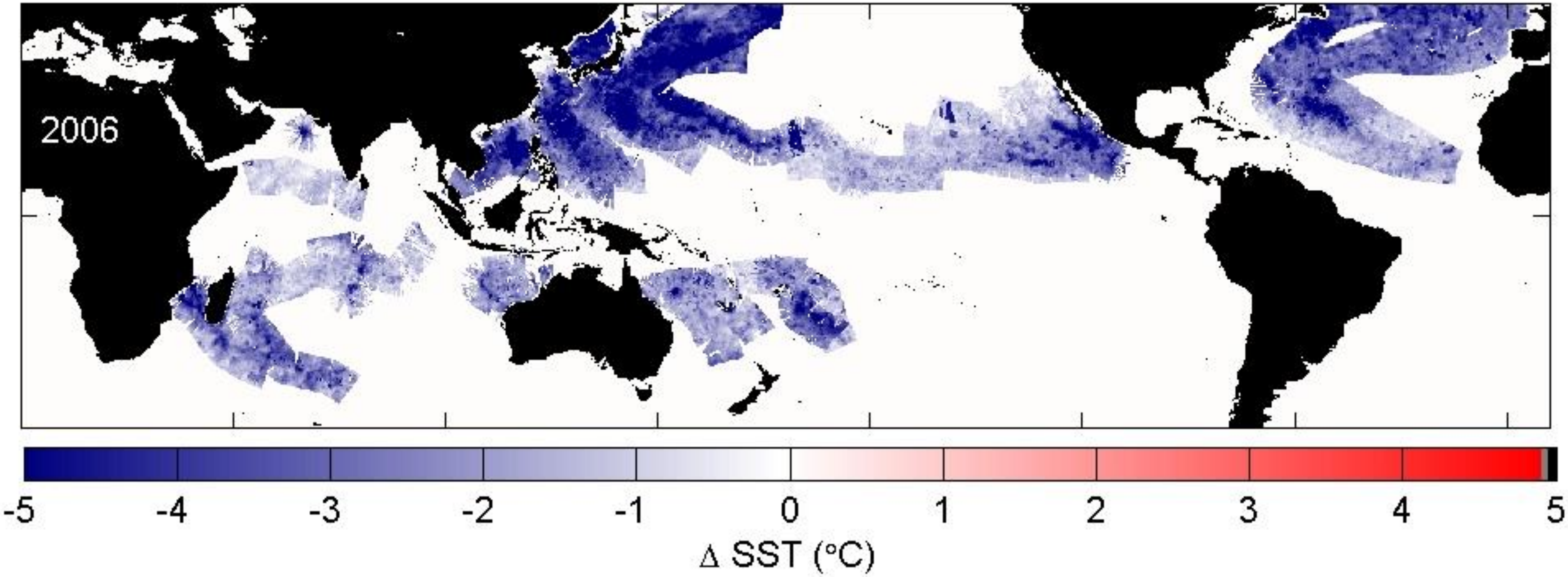
Step 4: collocate data

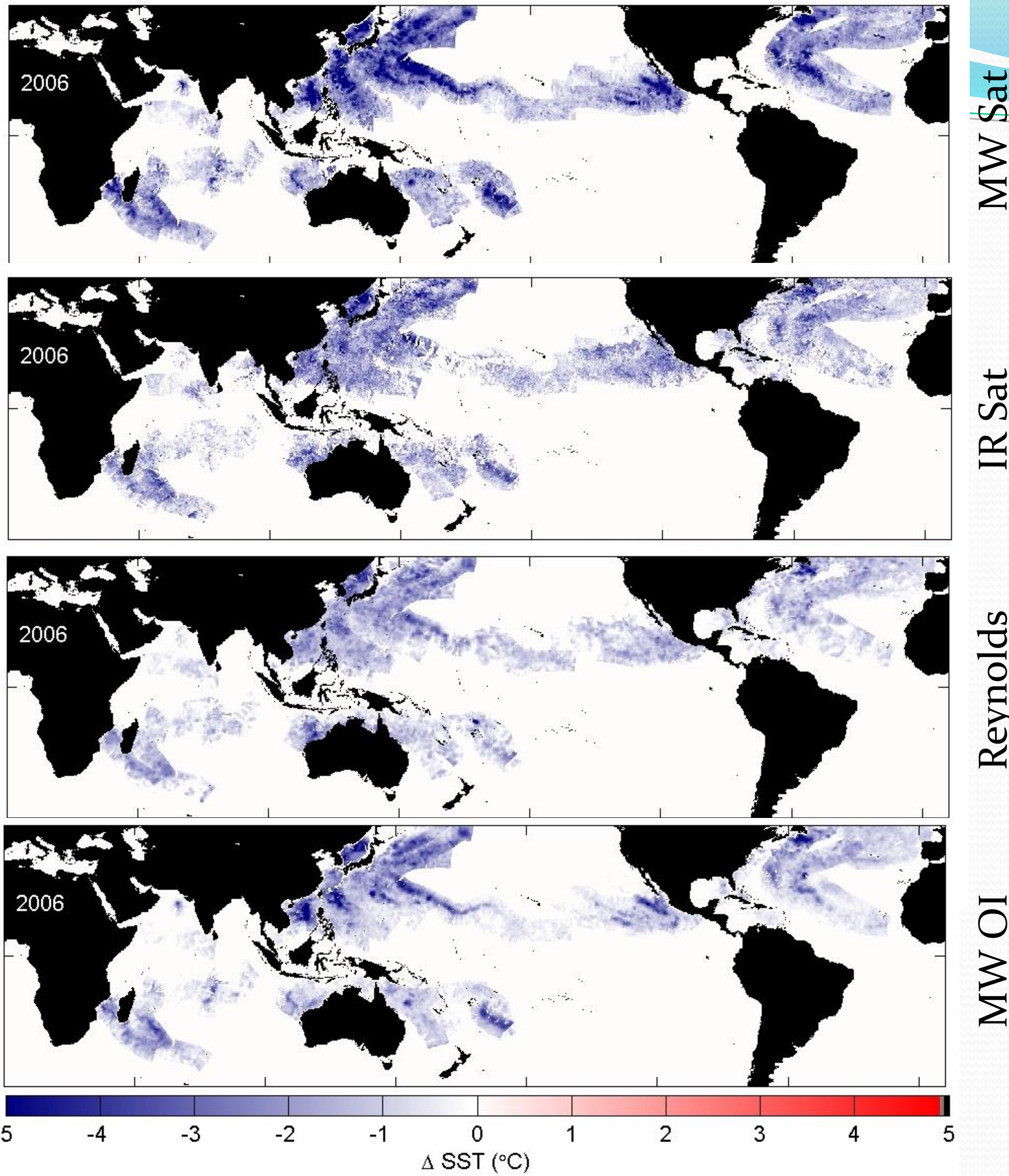
- Data from 1997 – 2012
- All storms globally
- Huge amount of data to collocate

Data

Parameter	Type	Name	Spatial	Temporal	Status
SST	product	NOAA AVHRR OI SST	0.25-deg	daily	completed
|	product	RSS MW OI SST	0.25-deg	daily	completed
|	product	RSS MW+IR OI SST	9 km	daily	completed
|	product	JPL MUR SST	1 km	daily	partially-collocated
|	observation	Terra MODIS	9 km		completed
|	observation	Aqua MODIS	9 km		completed
|	observation	TRMM TMI	0.25-deg		completed
|	observation	Aqua AMSR-E	0.25-deg		completed
|	observation	WindSAT	0.25-deg		completed
|	observation	SEVIRI	4 km	30 min	completed
|	observation	GOES	4 km	60 min	completed
|	observation	moored buoys	point		ready for collocation
|	observation	drifting buoys	point		ready for collocation
|	observation	ship data	point		ready for collocation
|	observation	ARGO profiling drifters	point		completed
Chlorophyll-a	product	merged	9 km		completed
wind speed & direction	observation	All PMW/Scat	0.25-deg	daily	completed
|	product	H*wind	25 km	daily	ready for collocation
Atmospheric water vapor	observation	All PMW	0.25-deg		completed
Cloud	observation	All PMW	0.25-deg		completed
Rain Rate	observation	All PMW	0.25-deg		completed
Net Primary Production	product	OSU Ocean Productivity		monthly	ready for collocation
Mixed layer depth climatology	product	NRL	111 km	monthly	need data
Mixed layer depth	product	OSU Ocean Productivity	19 km	monthly	data quality issues
sea level anomaly	product	AVISO	25 km	weekly	ready for collocation
geostrophic velocity anomaly	product	AVISO	37 km	weekly	ready for collocation
Significant Wave Height	product	AVISO	111 km	daily	ready for collocation
SSS	product	HYCOM			ready for collocation
|	observation	Aquarius			ready for collocation
|	product	SMOS			ready for collocation
currents	product	oscar	33 km	weekly	ready for collocation

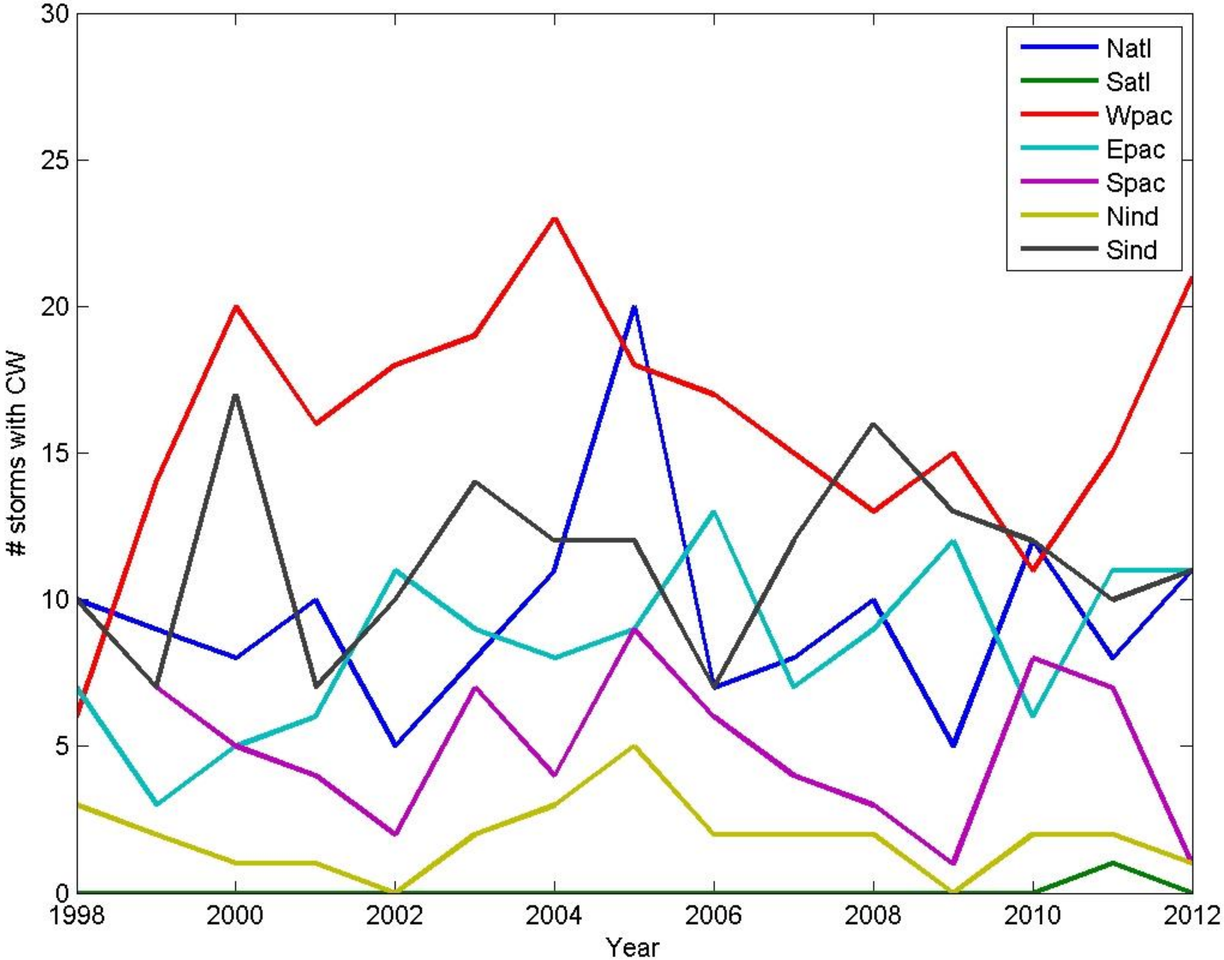
AMSRE,WindSAT, & TMI



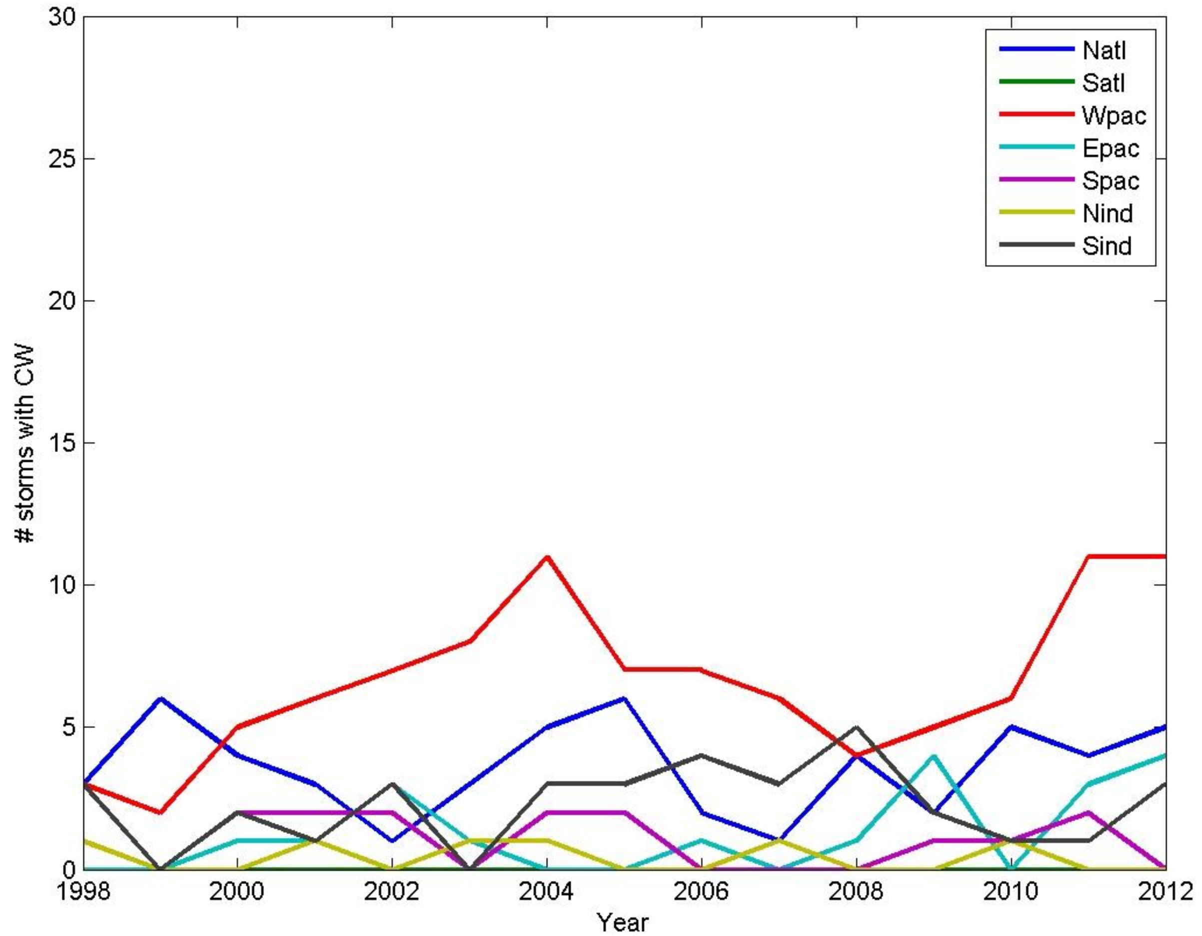


- Which SST is the best to use to examine cold wakes?
- MW sat & MW OI are only +-40 lat from 1998 – June 2002

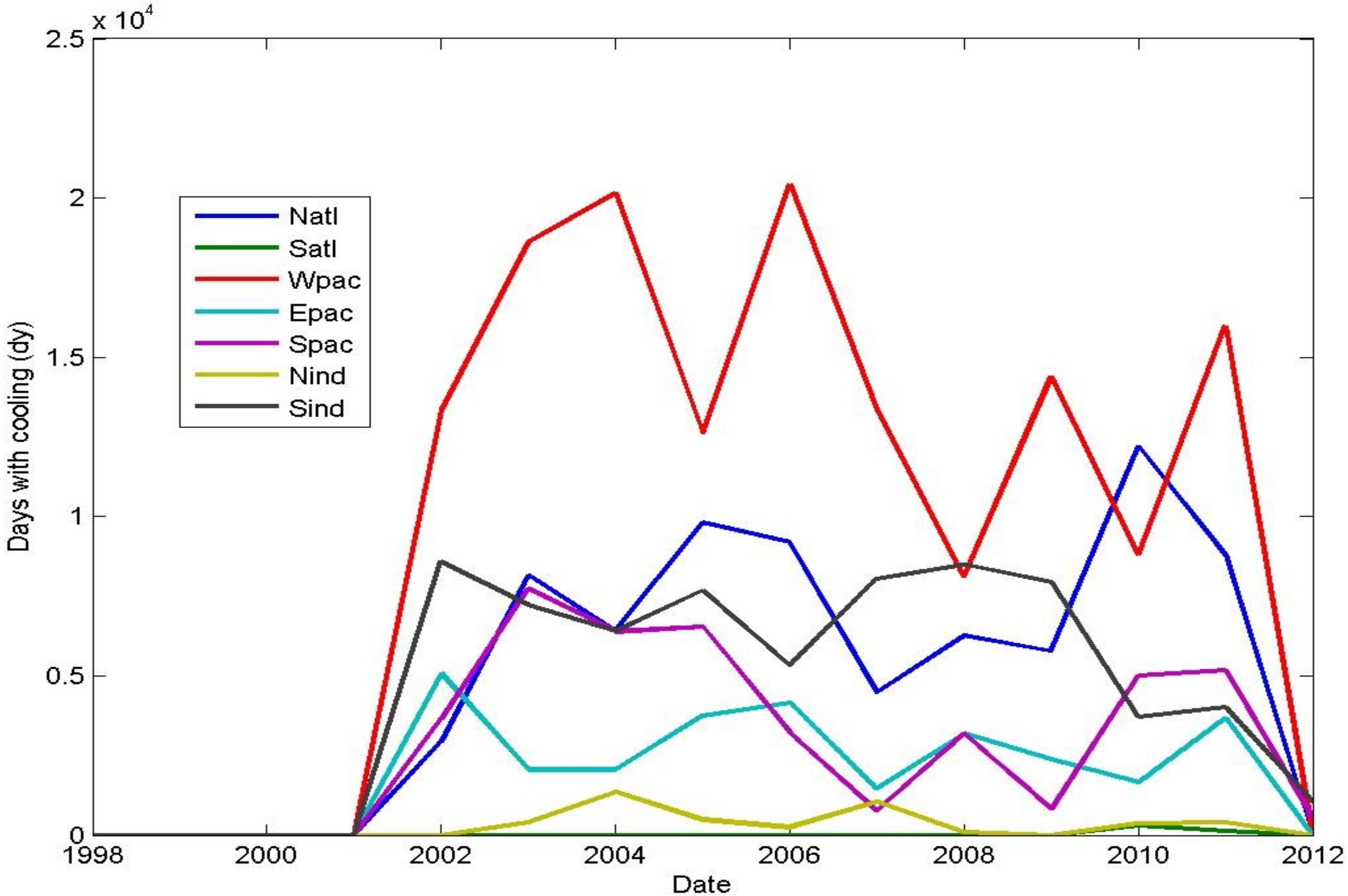
Number of storms



Storms with cold wakes

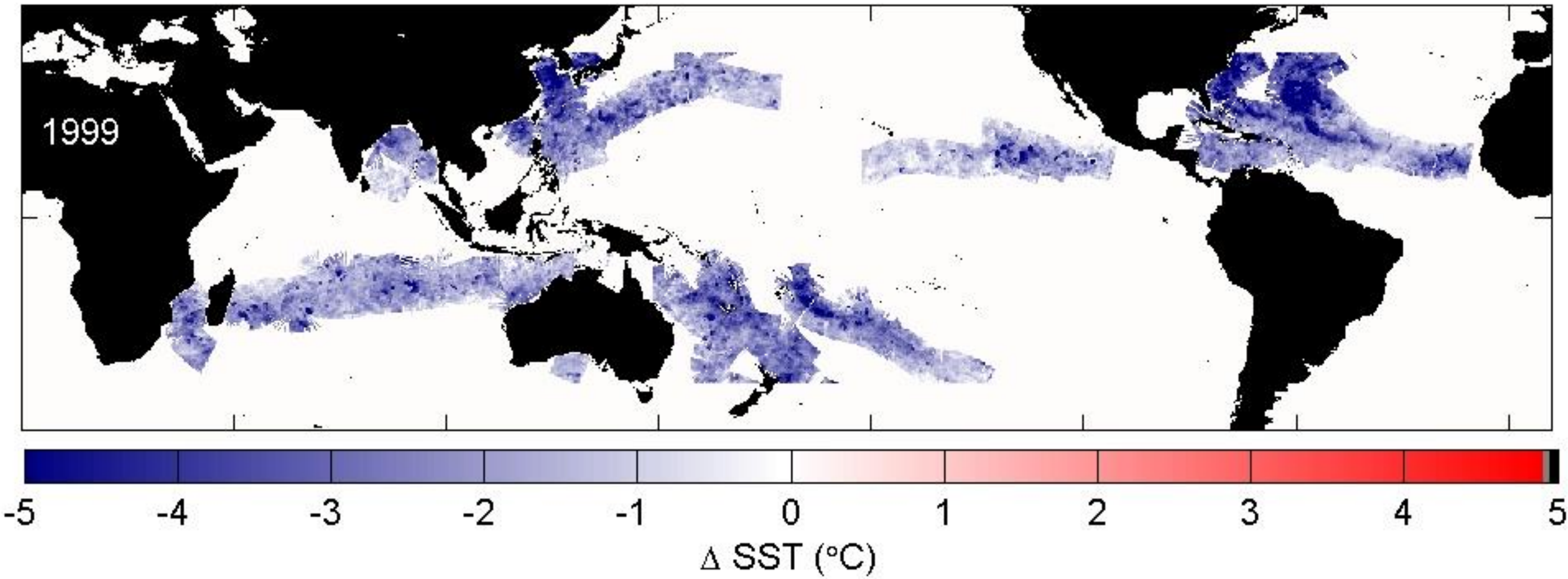


Number of points and days/yr with cooling

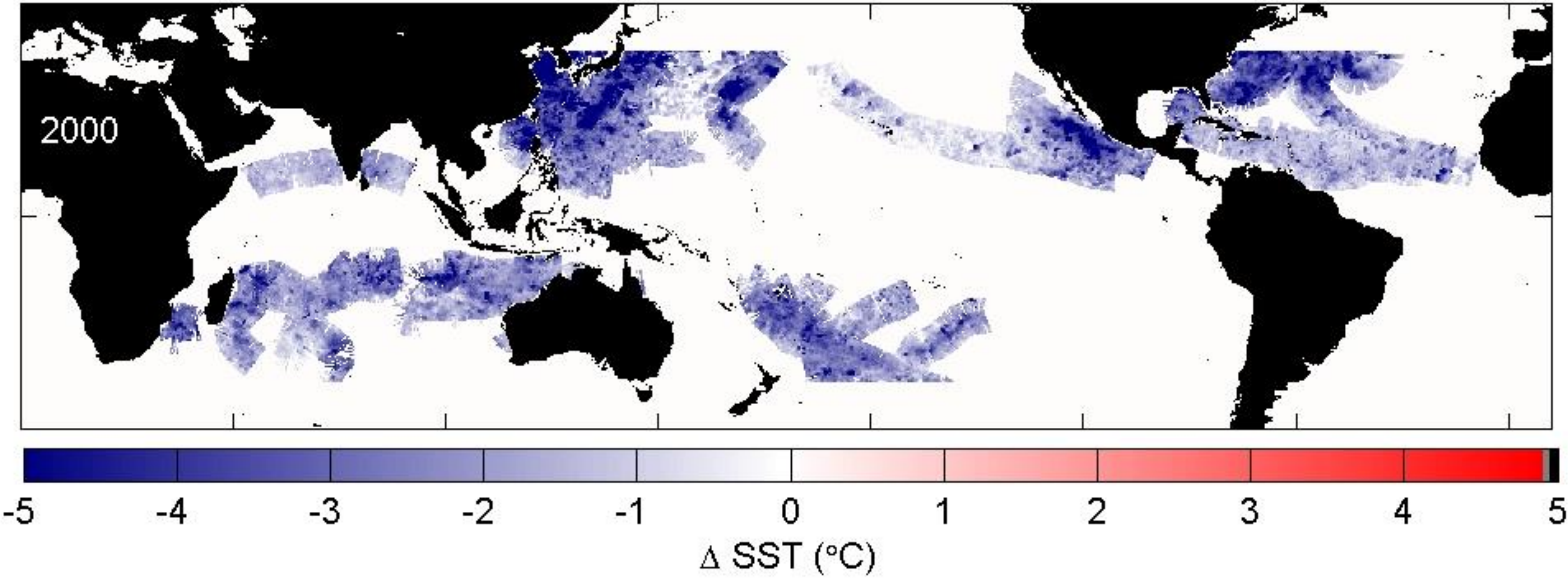


	Natl	Satl	Wpac	Epac	Spac	Nind	Sind	all
1998	3	0	3	0	1	1	3	11
1999	6	0	2	0	0	0	0	8
2000	4	0	5	1	2	0	2	14
2001	3	0	6	1	2	1	1	14
2002	1	0	7	3	2	0	3	16
2003	3	0	8	1	0	1	0	13
2004	5	0	11	0	2	1	3	22
2005	6	0	7	0	2	0	3	18
2006	2	0	7	1	0	0	4	14
2007	1	0	6	0	0	1	3	11
2008	4	0	4	1	0	0	5	14
2009	2	0	5	4	1	0	2	14
2010	5	0	6	0	1	1	1	14
2011	4	0	11	3	2	0	1	21
2012	5	0	11	4	0	0	3	23
all	54	0	99	19	15	6	34	227

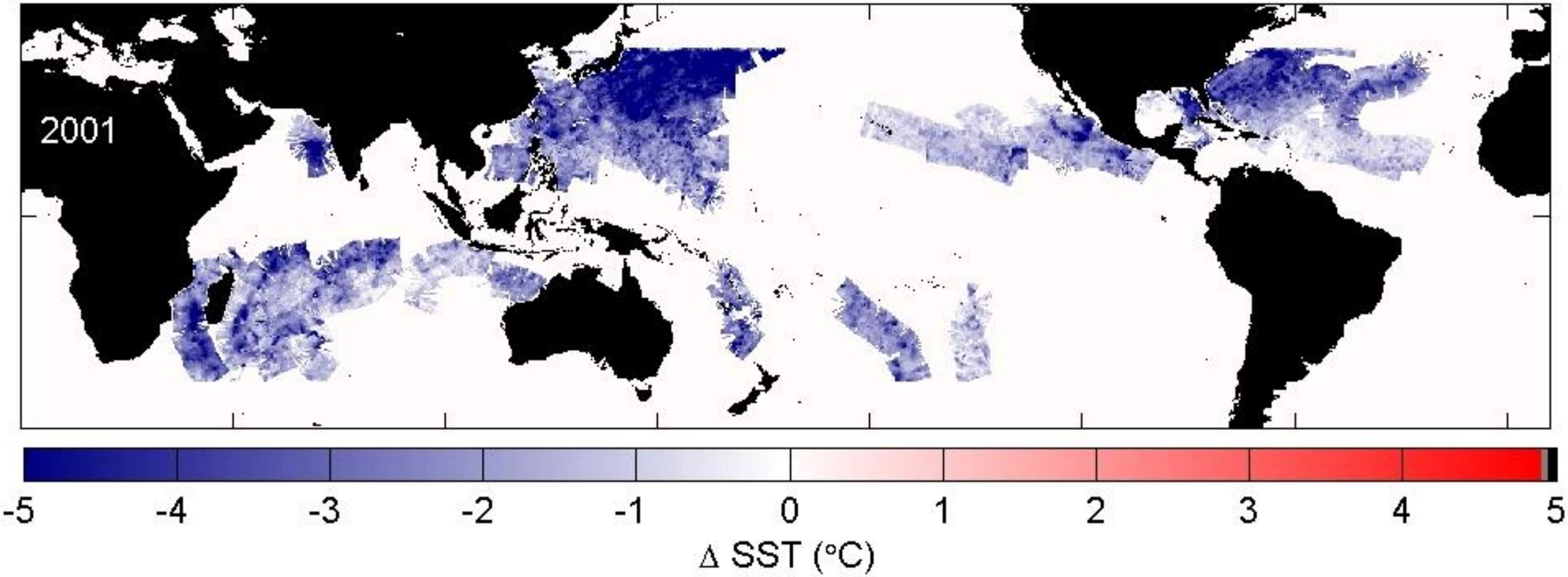
1999



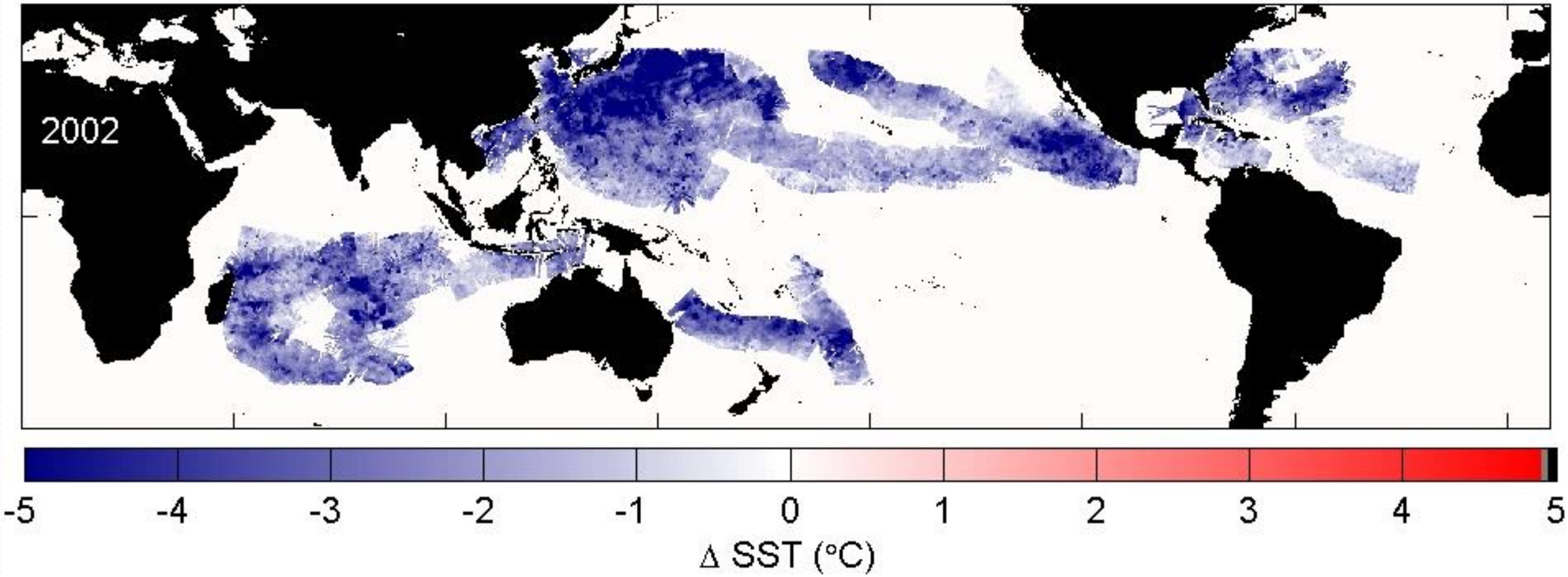
2000



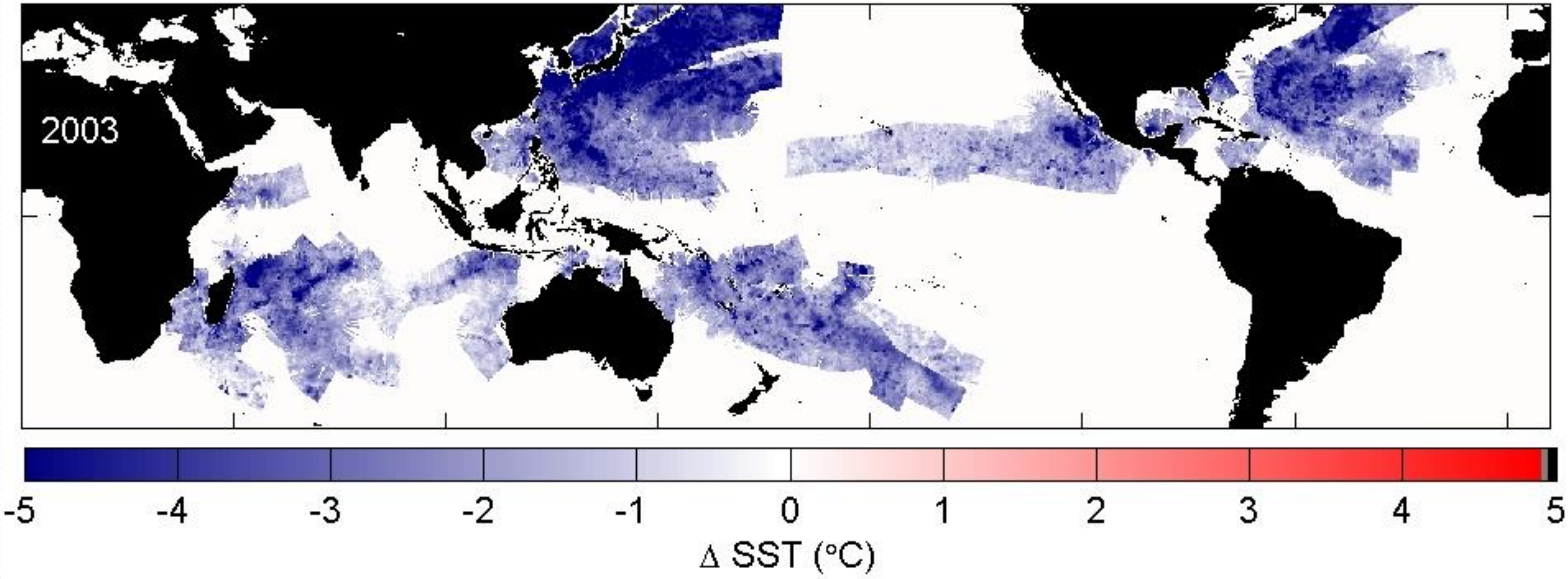
2001



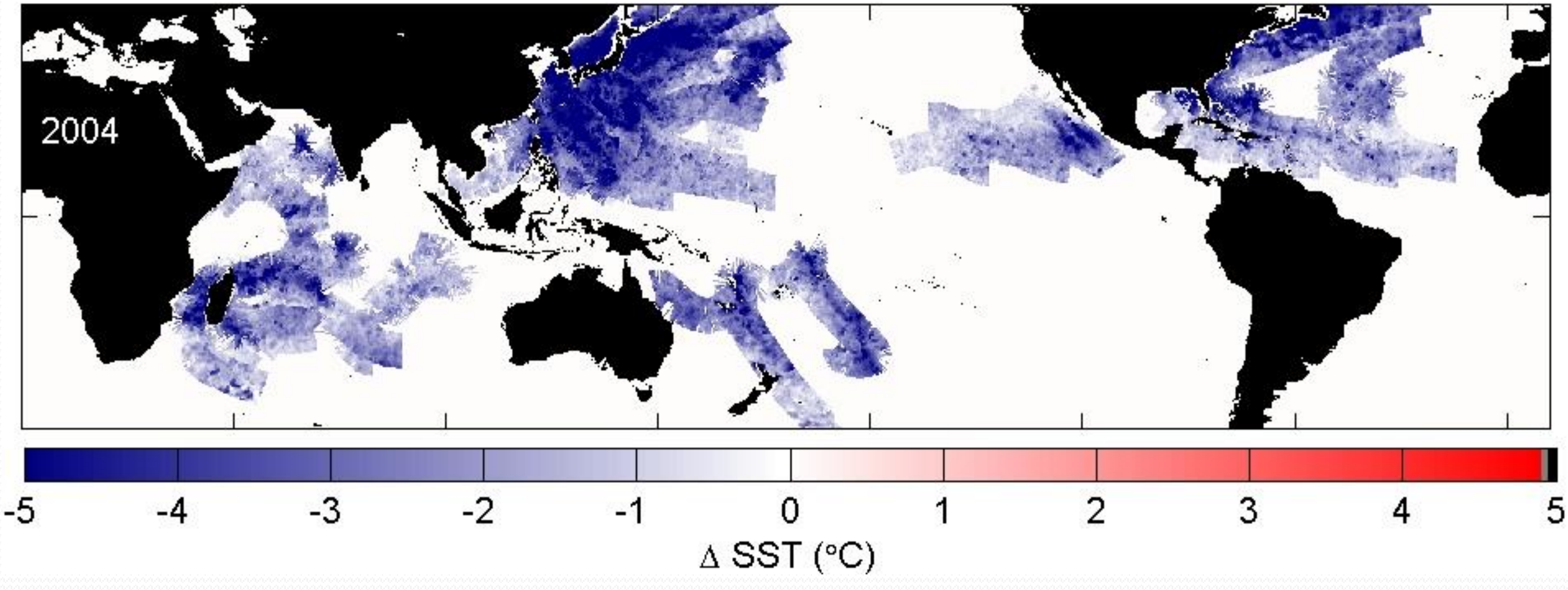
2002



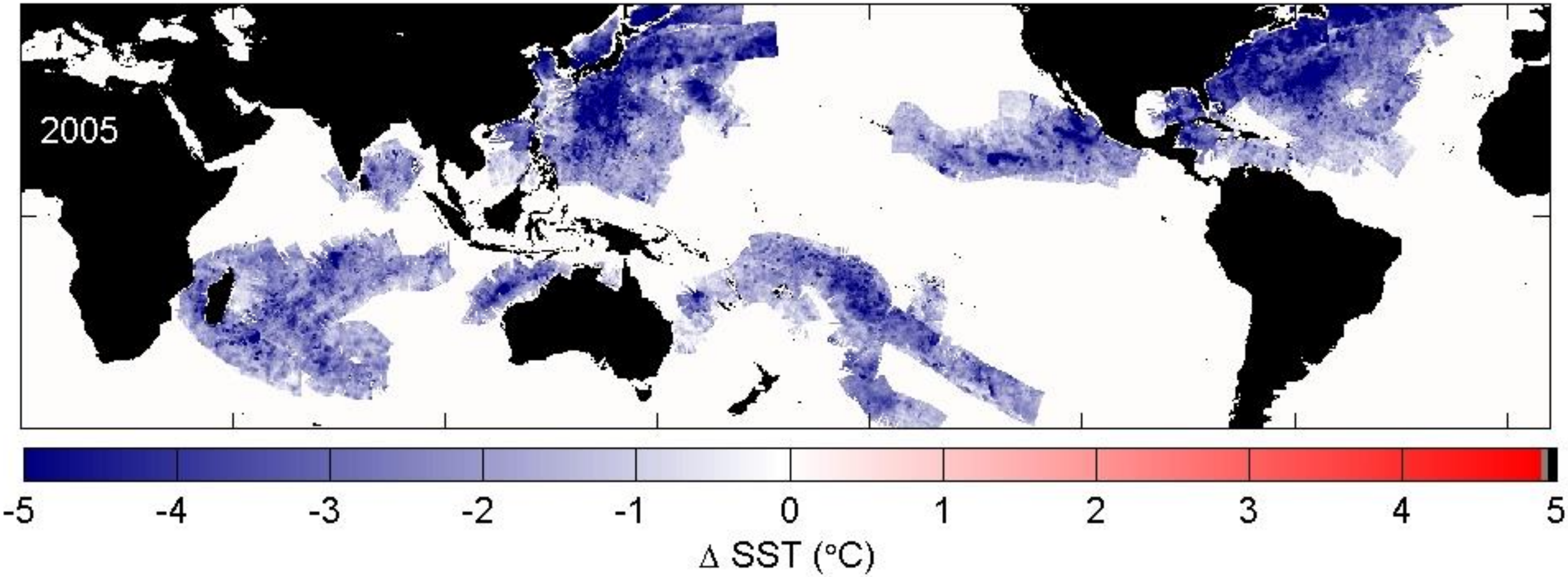
2003



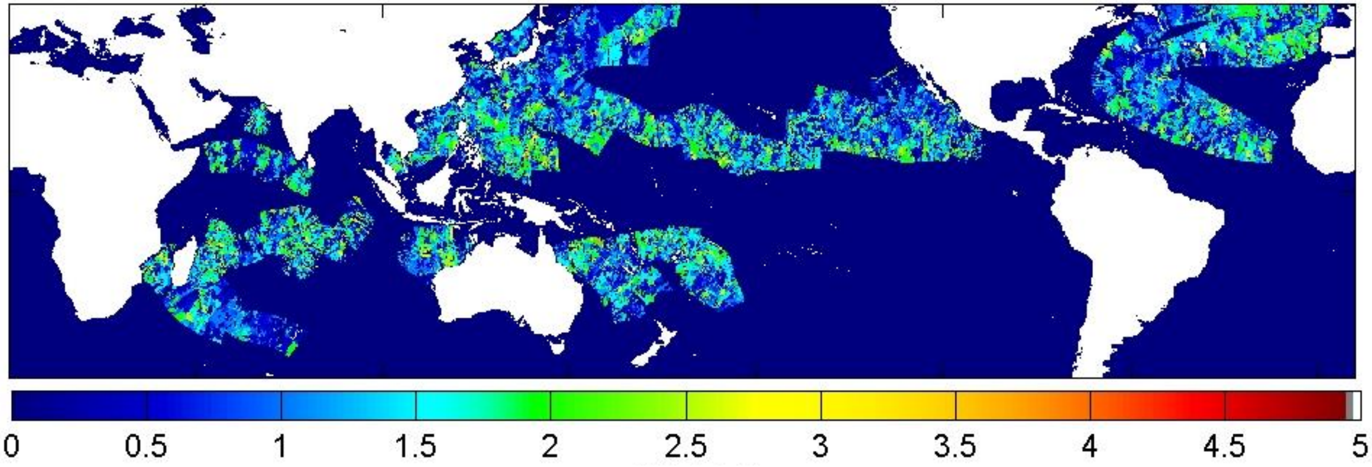
2004



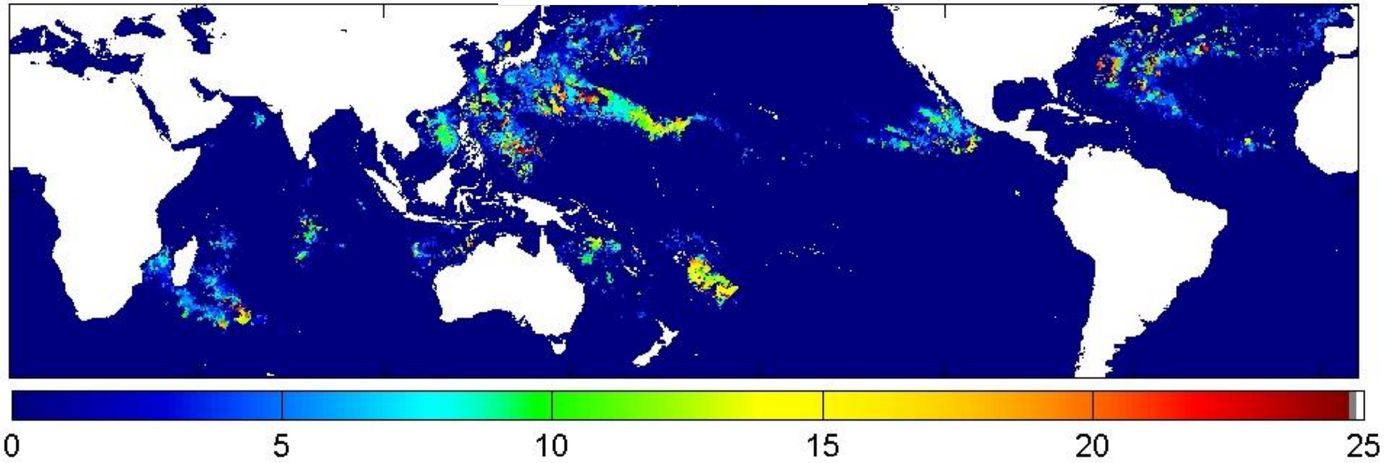
2005



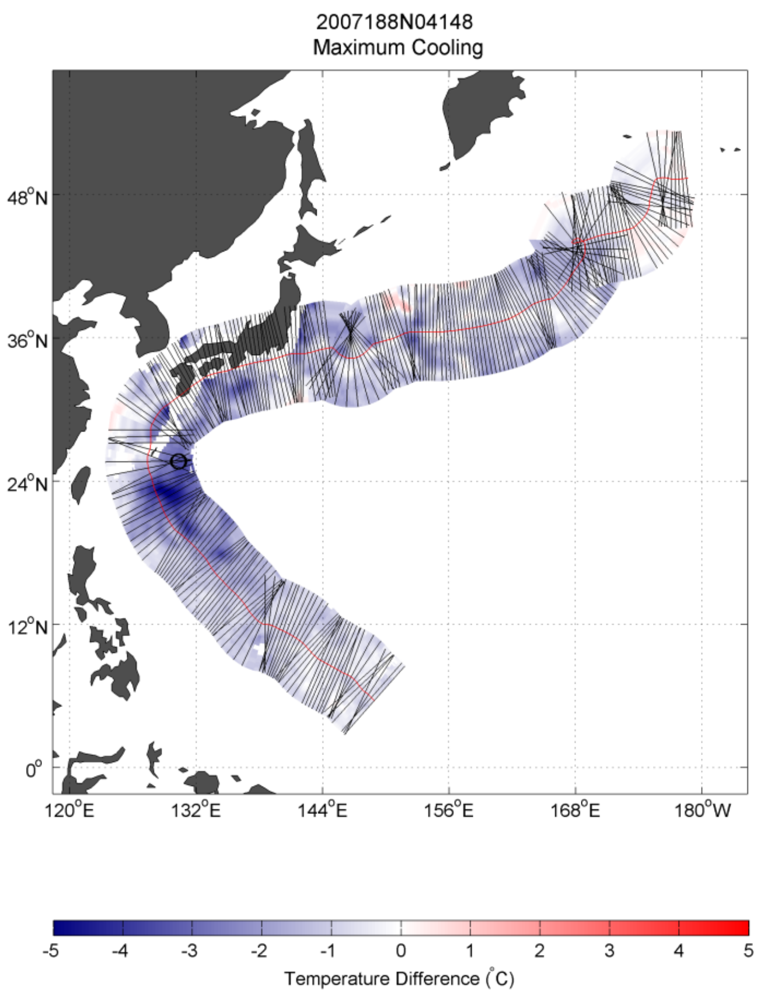
Minimum day and duration



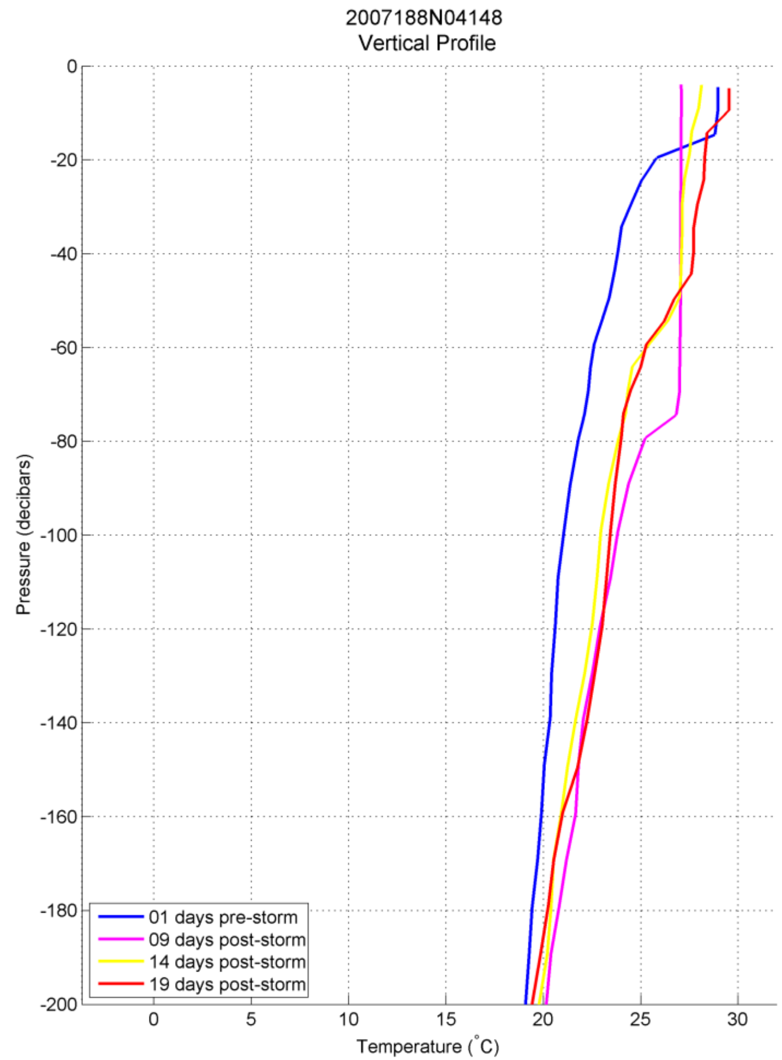
Day min cooling



duration cooling (dy)

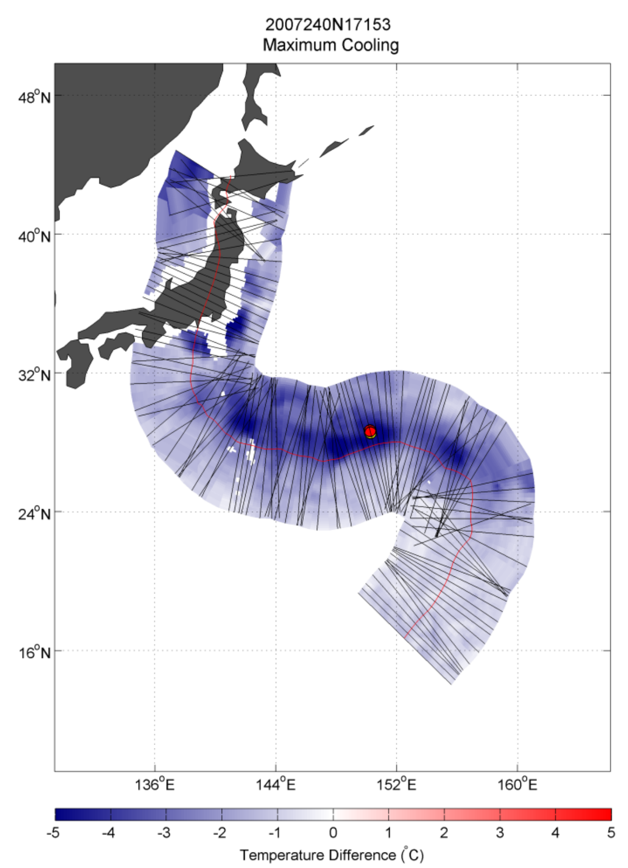


2007188N04148
Maximum Cooling
48°N
36°N
24°N
12°N
0°
120°E
132°E
144°E
156°E
168°E
180°W
-5
-4
-3
-2
-1
0
1
2
3
4
5
Temperature Difference (°C)

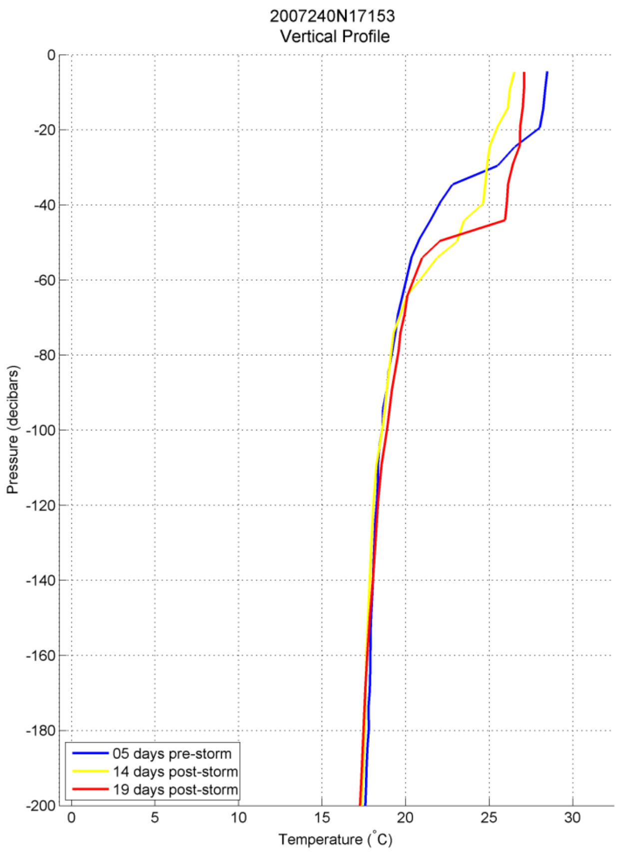


2007188N04148
Vertical Profile
Pressure (decibars)
Temperature (°C)
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
0
5
10
15
20
25
30
01 days pre-storm
09 days post-storm
14 days post-storm
19 days post-storm

Example



2007240N17153
Maximum Cooling
48°N
40°N
32°N
24°N
16°N
136°E
144°E
152°E
160°E
-5
-4
-3
-2
-1
0
1
2
3
4
5
Temperature Difference (°C)



2007240N17153
Vertical Profile
Pressure (decibars)
Temperature (°C)
05 days pre-storm
14 days post-storm
19 days post-storm
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
0
5
10
15
20
25
30

ARGO Profiling Float Collocations

Number of Storm-grid Collocated ARGO Profiles																
Basin	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**
North Atlantic	32	0	85	183	251	1062	1404	2509	2322	1074	1647	1440	2974	2449	3451	**20883**
South Atlantic	0	0	0	0	0	0	0	0	0	0	0	0	0	114	0	**114**
West Pacific	53	39	334	1111	2501	2549	5578	5485	6788	6667	6045	8530	4227	9907	12600	**72414**
East Pacific	0	5	11	27	120	283	380	503	1598	936	1908	2280	561	1360	1686	**11658**
South Pacific	0	0	4	32	11	100	55	1002	888	533	382	18	1257	1719	301	**6302**
North Indian	0	0	3	3	0	99	479	377	284	343	325	0	446	218	211	**2788**
South Indian	0	30	117	91	104	603	617	1067	771	2533	1454	1794	896	958	1488	**12523**
Total	**85**	**74**	**554**	**1447**	**2987**	**4696**	**8513**	**10943**	**12651**	**12086**	**11761**	**14062**	**10361**	**16725**	**19737**	**126682**

Number of Storm-grid Collocated ARGO Profiles With Before-After Collocated Pairs																
Basin	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**
North Atlantic	1	0	4	3	5	32	33	50	78	23	64	55	165	65	75	**653**
South Atlantic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
West Pacific	2	0	3	64	112	148	372	276	680	590	608	786	370	817	1262	**6090**
East Pacific	0	0	0	0	19	13	23	22	92	48	137	110	43	60	125	**692**
South Pacific	0	0	0	1	0	6	4	51	29	48	17	1	59	69	7	**292**
North Indian	0	0	0	0	0	5	45	16	32	30	27	0	11	34	10	**210**
South Indian	0	0	16	0	1	28	10	38	19	133	53	58	29	39	23	**447**
Total	**3**	**0**	**23**	**68**	**137**	**232**	**487**	**453**	**930**	**872**	**906**	**1010**	**677**	**1084**	**1502**	**8384**

Conclusions

- Database to be publically distributed 7/2014
- Satellite and in situ data collocated in a storm-centric framework
- Cold wake variability large from year to year
- MW SSTs key to study (new AMSR2)