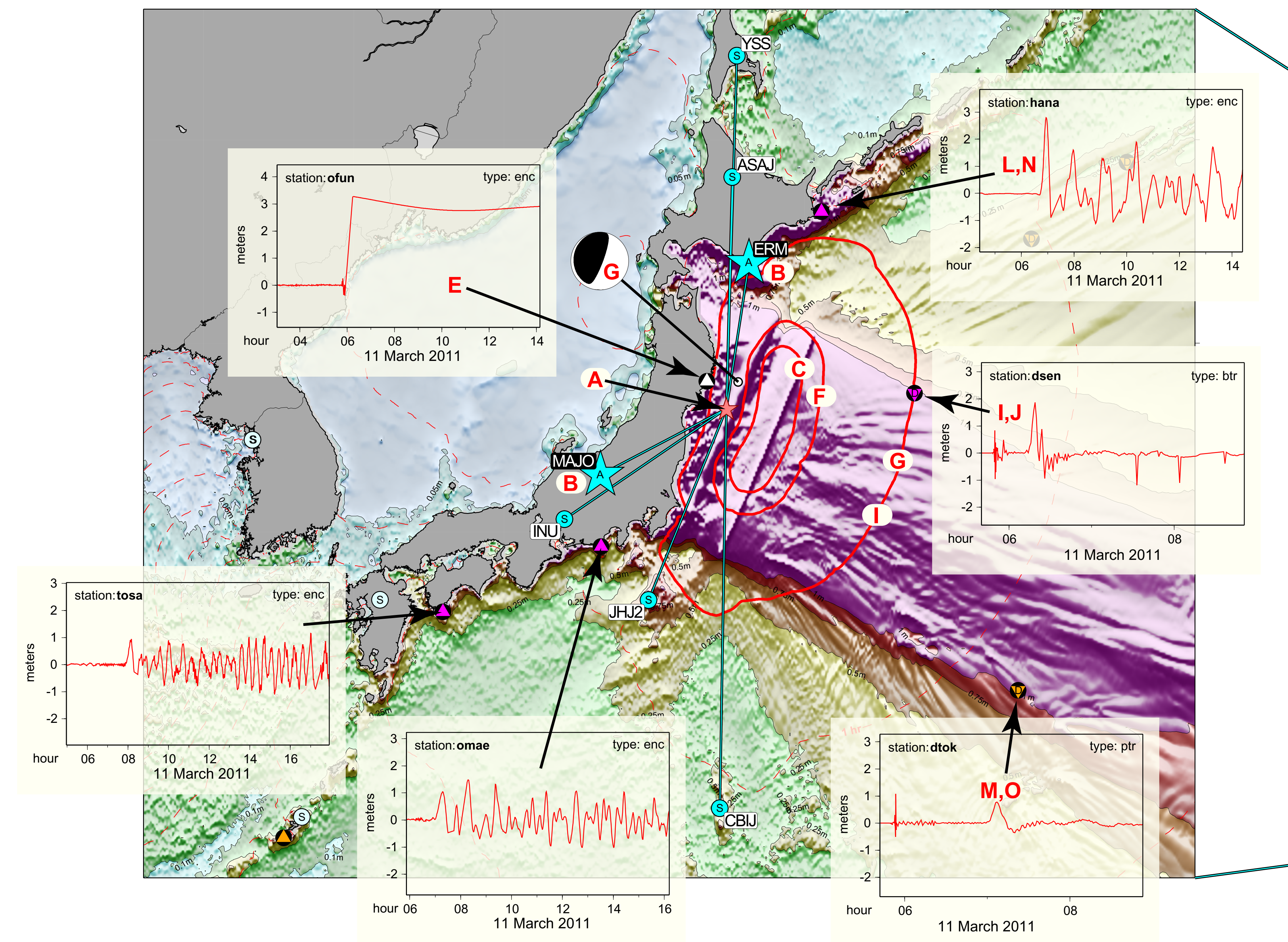
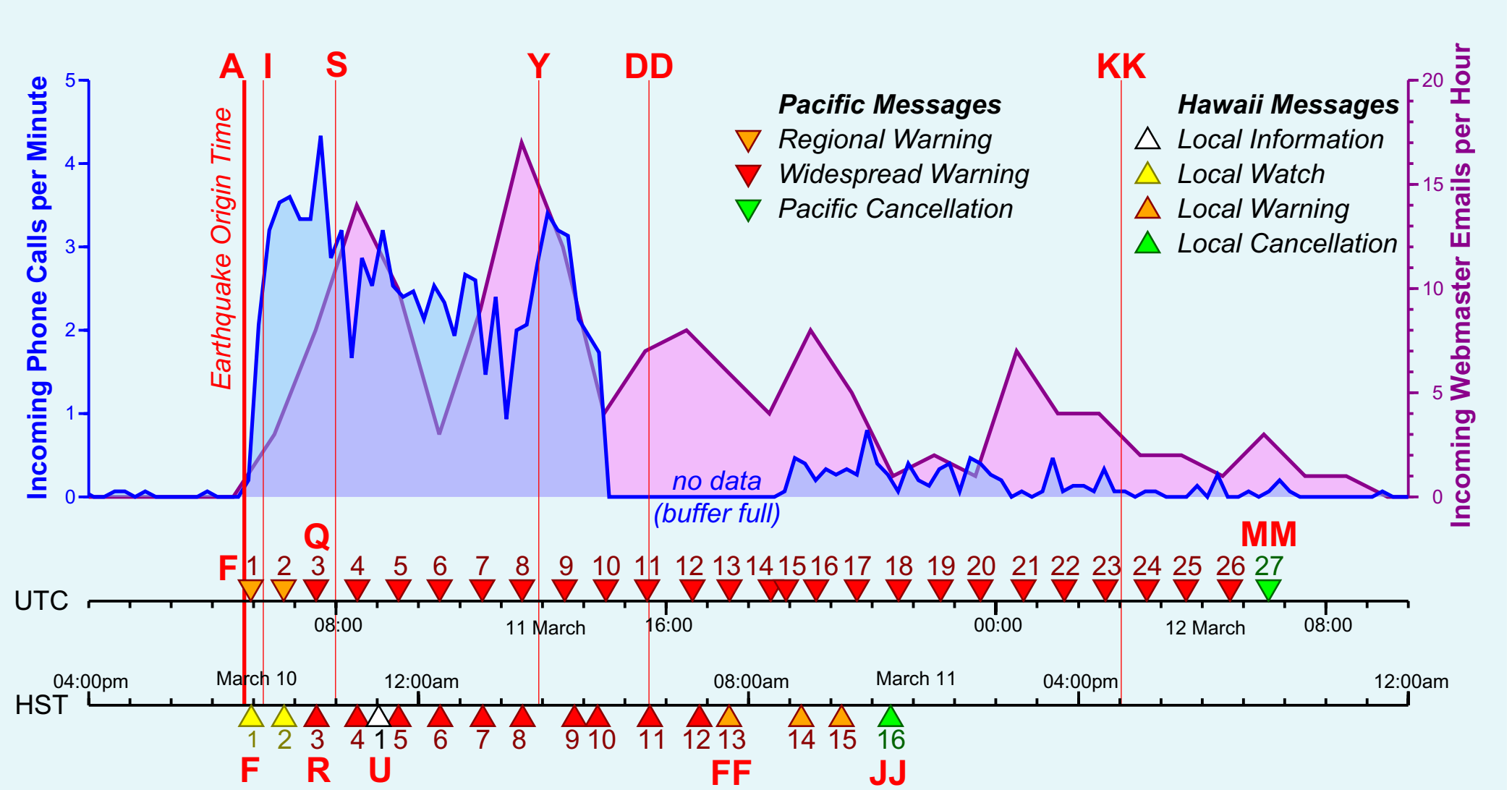


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## Timeline of Key Events

Time (UTC)	Elapsed Time Since Origin (HH:MM:SS)	Event	Map Code
March 11, 2011 05:46:28	00:00:00	Tohoku earthquake begins	A
March 11, 2011 05:48:02	00:01:34	Digital alarm triggered by ERM, MAJO stations	B
March 11, 2011 05:50:36	00:04:08	PTWC issues earthquake message (M = 7.5)	C
March 11, 2011 05:51:10	00:04:42	PTWC scientists realize M=8.0	D
March 11, 2011 05:53:00	00:06:32	First RIFT tsunami wave-height forecast calculated	E
March 11, 2011 05:55:02	00:08:34	PTWC issues International Bulletin #1: Regional Tsunami Watch/Warning (M = 7.8, JMA)	F
March 11, 2011 06:13:10	00:26:42	First W-phase CMT obtained with (M = 8.8) Final W-phase CMT had M=9.0	G
March 11, 2011 06:13:20	00:26:52	SIFT model and SIMs launched	H
March 11, 2011 06:14:00	00:27:32	Tsunami arrives at Sendai DART, dsen	I
March 11, 2011 06:20:00	00:33:32	PTWC aware of tsunami recorded at DART dsen	J
March 11, 2011 06:41:22	00:54:54	PTWC issues International Bulletin #2: Regional Tsunami Watch/Warning Supplement (M = 8.8, 2.15 Amplitude at Sendai DART)	K
March 11, 2011 06:42:00	00:55:32	Tsunami arrives at Hanasaki, Japan	L
March 11, 2011 07:01:00	01:14:32	Tsunami arrives at DART station dtok	M
March 11, 2011 07:05:00	01:18:32	PTWC aware of tsunami recorded at Hanasaki	N
March 11, 2011 07:18:00	01:31:32	PTWC aware of tsunami recorded at DART dtok	O
March 11, 2011 07:25:00	01:38:32	PTWC performs SIFT DART inversion	P
March 11, 2011 07:28:38	01:42:10	PTWC issues Bulletin #3: Pacific-Wide Tsunami Warning	Q
March 11, 2011 07:31:00	01:44:32	PTWC issues Hawaii Bulletin #3: Tsunami Warning for State of Hawaii	R
March 11, 2011 07:59:00	02:12:32	Siens sound in Hawaii and evacuation of Hawaii's coastline commences	S
March 11, 2011 08:58:26	03:11:58	Earthquake occurs on Kilauea Flank, Hawaii Island (M = 4.6)	T
March 11, 2011 09:01:16	03:14:48	PTWC issues Tsunami Information Statement for Kilauea Earthquake	U
March 11, 2011 09:14:00	03:27:32	Tsunami arrives at Wake Island	V
March 11, 2011 10:27:00	04:40:32	Tsunami arrives at Midway Island	W
March 11, 2011 12:20:00	06:33:32	Tsunami arrives at King Cove, Alaska	X
March 11, 2011 12:55:00	07:08:32	Tsunami arrives at Hanalei, Hawaii (Kauai Island)	Y
March 11, 2011 13:27:00	07:31:32	Tsunami arrives at Kahului, Hawaii (Maui Island)	Z
March 11, 2011 13:43:00	07:48:32	Tsunami arrives at Hilo, Hawaii (Hawaii Island)	AA
March 11, 2011 15:02:00	09:15:32	Tsunami arrives at Pago Pago, American Samoa	BB
March 11, 2011 15:19:19	09:32:51	Runup detector (100m inland) tripped at Napoopoo, Hawaii Island (Kona Coast)	CC
March 11, 2011 15:35:00	09:48:32	Tsunami arrives at Crescent City, California	DD
March 11, 2011 17:16:00	11:29:32	Tsunami arrives at Papeete, Tahiti	EE
March 11, 2011 17:31:00	11:44:32	PTWC issues Hawaii Bulletin #13: Tsunami Advisory for State of Hawaii (downgrade of Warning)	FF
March 11, 2011 17:52:00	12:05:32	Tsunami arrives at North Cape, New Zealand	GG
March 11, 2011 19:17:00	13:30:32	Tsunami arrives at Rosslyn Bay, Australia	HH
March 11, 2011 19:38:00	13:51:32	Tsunami arrives at Manzanillo, Mexico	II
March 11, 2011 21:26:00	15:39:32	PTWC issues Hawaii Bulletin #16: Final Tsunami Advisory for State of Hawaii	JJ
March 12, 2011 03:02:00	21:15:32	Tsunami arrives at Iquique, Chile	KK
March 12, 2011 04:35:00	22:48:32	Tsunami arrives at Talcahuano, Chile	LL
March 12, 2011 06:36:00	24:39:32	PTWC issues International Bulletin #27: Widespread Warning Cancellation	MM



The Tohoku Japan earthquake of March 11, 2011 was the largest earthquake to strike in the Pacific Basin since the Prince William Sound earthquake of 1964. The Tohoku earthquake had a rupture length of ~400km, a source duration of ~150s and a seismic moment of  $5.3 \times 10^{27}$  corresponding to a moment magnitude of 9.1 (GCMT). The earthquake generated a tsunami that caused the most widespread destruction in the Pacific since the tsunami generated by the Chile earthquake of 1960. The vast majority of deaths, casualties, and damage occurred in Japan, yet few deaths and casualties occurred elsewhere in the Pacific because of the warnings issued by the Pacific Tsunami Warning Center (PTWC) and the West Coast and Alaska Tsunami Warning Center (WCATWC) and due to tsunami mitigation efforts by other agencies across the Pacific.

Despite Japan's vaunted earthquake and tsunami hazard mitigation efforts the earthquake and tsunami killed approximately 15,000 of its citizens, injured thousands more, and left hundreds of thousands homeless. Had Japan's warning system not been as capable as it was Japan may have suffered a far greater tragedy.

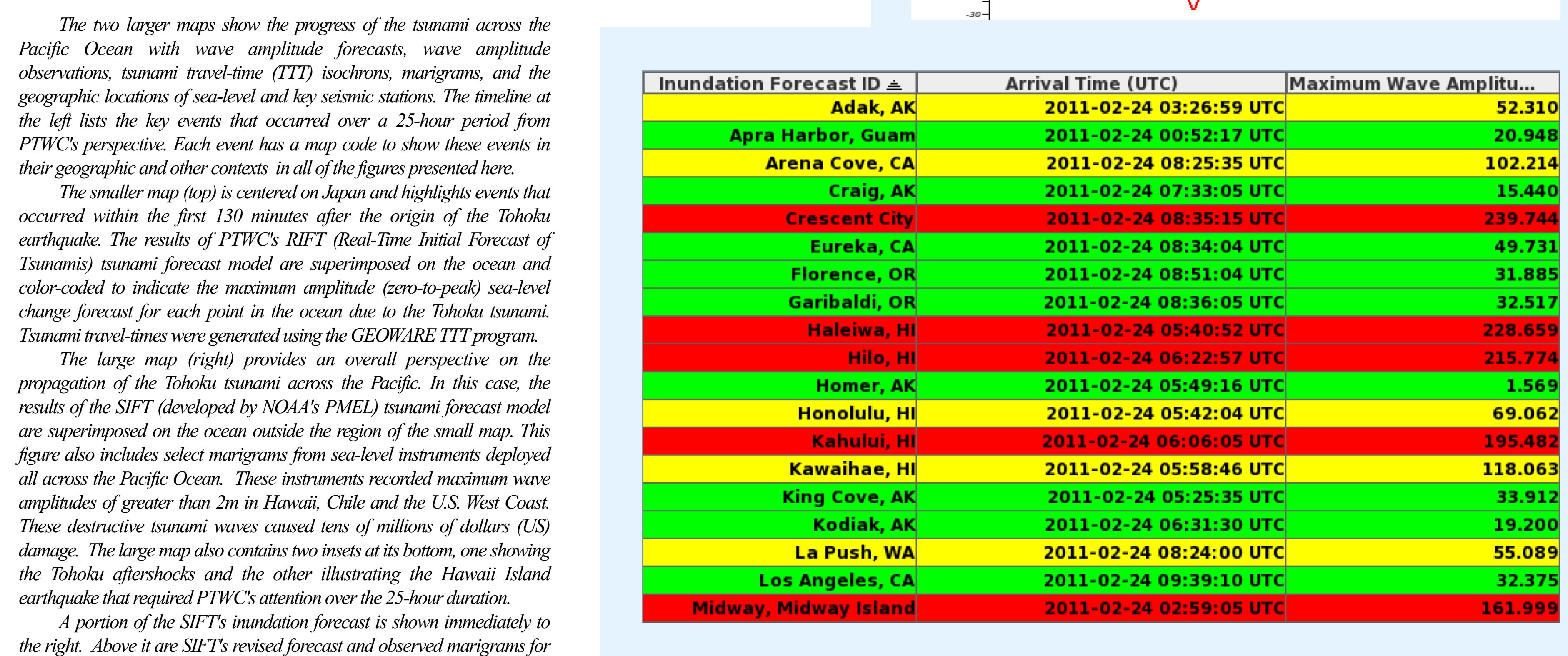
PTWC was first alerted to the Tohoku earthquake (A) by an alarm triggered by P-waves arriving at the seismometers ERM (Hokkaido) and MAJO (Hokkaido) 00:01:34 after origin (B). PTWC issued a preliminary earthquake message with a magnitude (Mwp) of 7.5 00:04:08 after the earthquake (C). The earthquake damaged the nearest coastal sea-level station reporting over the Global Telecommunications Service in Ofunato, Japan, before the tsunami arrived there (E). Because the earthquake occurred within JMA's area of responsibility as the Northwest Pacific Tsunami Advisory Center (NWPTAC), PTWC issued its first bulletin, a Regional Tsunami Warning/Watch to the Pacific Basin and a Tsunami Watch Bulletin to the State of Hawaii (F), using JMA's parameters, including a magnitude of 7.9, following receipt of JMA's first NWPTAC bulletin in accordance with international agreements. Within the next 20 minutes PTWC realized the true earthquake magnitude was at least 8.8 when it computed a centroid-moment tensor (CMT) magnitude (G) based on later-arriving W-phase waves detected by more distant seismic stations, and observed the first tsunami waves to arrive at the Sendai DART sensor (L). This sensor recorded an amplitude of over 2m, the largest sea-level change ever recorded in deep water (~1000m) due to a tsunami.

PTWC issued its second pair of bulletins (K) ~00:55:00 after origin using the 8.8 W-phase CMT magnitude. Over the next 40 minutes PTWC received sea-level data showing nearly 3m amplitude waves striking the coast of Hanasaki (L) to the North and 0.8m waves arriving at the DART station dtok (M,O). A second computation of the W-phase CMT, using a revised depth estimate, yielded an Mw of 9.0. PTWC then used the DART data and the new magnitude to revise its tsunami forecasts (P) before issuing its third pair of bulletins (Q), a Pacific Wide Warning Bulletin to the Pacific and a Tsunami Warning Bulletin to the State of Hawaii (R). After consulting with the PTWC of the State of Hawaii began to evacuate its coastlines ~02:12:00 after origin (S).

Tsunami waves first arrived in Hawaii at Hanalei Bay on Kauai Island ~07:08:00 after origin (Y). Many buildings were damaged in Kahului, Maui (Z) and along the Kona Coast of Hawaii Island. The tsunami also severely damaged the harbor in Kechee Lagoon on Oahu along with many boats. The tsunami also tripped a run-up detector in South Kona, indicating that it inundated this area more than 100m inland (CC). PTWC issued its Final Advisory Bulletin to the State of Hawaii after the tsunami threat to Hawaii had passed ~15:39:00 after origin and about 13 hours after the State of Hawaii evacuated its coastlines (JJ).

The tsunami crossed the whole of the Pacific Ocean to arrive in Iquique, Chile, ~21:15:00 after origin (KK). Over the next few hours the tsunami arrived at locations in Southern Chile. Finally, ~24:39:00 after origin, PTWC concluded its official responsibilities for the Tohoku tsunami when it issued its last bulletin, a Widespread Warning Cancellation to the Pacific Basin (MM). Chile and the WCATWC, however, would keep their warnings/advisories in place for several more hours.

During this event PTWC staff fielded hundreds of phone calls and emails from Hawaii and all over the Pacific and gave many interviews to the media in an effort to keep the public informed and out of harm's way. Over the next several months and up to the present day, NOAA's Tsunami Warning Center scientists have continued to respond to the hundreds of aftershocks that have occurred in the aftermath of the Tohoku earthquake.



## Progress of the Tsunami Across the Pacific Ocean

