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HEADLINES:

Seeing Ahead for Natural Disasters: A Community-Based Approach for Monitoring Earthquakes

One natural disaster of great concern to people around the world is earthquakes. Whether large or small, earthquakes are an unsettling experience. Communities that have lived through the experience of a large earthquake are traumatized. They often become dedicated to creating more effective disaster response systems and dream of being able to predict the occurrence of earthquakes in order to give their families and friends time to respond.

Seeing ahead and preparing for natural disasters is the goal of the "Crustal Stress Community Awareness Network" or CSCAN . For the past three years, the Philippine Government and the United Nations have steadily developed the CSCAN system, which actively involves local communities in the forecasting of natural disasters.

With CSCAN , communities become involved in science and the networking of information at the local level to better monitor and prepare for natural disasters. It aims to provide community residents with information to enable them to make sound decisions and to act appropriately even before a disaster strikes. CSCAN starts with user-friendly advanced technologies to measure changes in the earth's crust. It is a network of instrumentation and community training designed to inform and alert communities in disaster-prone geographies.

This network, piloted in the Philippines, was built through partnerships among community residents in 12 municipalities/cities, public officials and scientists, directly involving the National Disaster Coordinating Council (NDCC), Dept. of National Defense (DND), Dept. of Interior and Local Government (DILG), Civil Service Commission (CSC), Philippine Institute of Volcanology and Seismology (PHIVOLCS), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Dept. of Social Welfare and Development (DSWD), Dept. of Education (DepEd), National

Food Authority (NFA), Dept. of Agriculture (DOA) and the Dept. of Public Works and Highways (DPWH).

To-date, CSCAN operates as a volunteer monitoring network of 10 communities in Luzon, the Philippines (UNDP Frontliner, Vol.1 No.2 2003). This community-based network has produced six forecasts, all of which have been followed by actual earthquakes. The six forecasts were submitted to the United Nations System (UNDP, UNGP-IPASD/DESA) before the forecasted time period of each occurrence.

While none of the forecasts were completely accurate, the forecasting results of this pilot effort are worth looking at. Just as in weather forecasting, where there is rarely a 100% accurate forecast, it is useful to consider a range of acceptable outcomes. Earthquakes are typically described using three parameters: time (T), magnitude (M) and location (L). What do the preliminary CSCAN research results tell us about ranges for these parameters?

The Crustal Stress Community Awareness Network in the Philippines, or CSCAN-Phils , has some capacity to see ahead for medium-sized earthquakes (about magnitude 5), in terms of days to just over a week (range in time), within one magnitude of the Richter scale (range in magnitude), and within several hundred down to under 100 kilometers in locating an earthquake epicenter (range in location).

Figures 1 –3 are two-dimensional (2D) plots, which provide greater detail to the above statements. In these 2-D images, stars represent the actual earthquakes which are spaced in horizontal time by their dates of occurrence. Circles represent the forecasts.

In Figure 1, star 5A-C represents a series of earthquakes which occurred shortly after Forecast 5 was issued. Forecasts 1-6 are shown as circles positioned above or below the corresponding numbered star quake. Circles below stars indicate that the actual quake occurred days before the forecasted date (in *italics*), while circles above the stars are for quakes which took place days after the forecasted date.

Figure 1 shows the difference in time between the forecasted date and the time of the actual quakes as ranging from two to nine days. In Figure 2, the difference between the forecasted magnitude and the actual quake magnitude is generally less than one magnitude on the Richter scale. These magnitude estimates are surprisingly accurate, considering that, for the earthquake databases of the United States, the Philippines and China, there is a scatter in magnitude values for earthquakes that have already occurred of half a Richter magnitude. This widely accepted scatter in earthquake magnitudes is represented by the shaded area in Figure 2 .

Determining the location of an eventual earthquake is very challenging. Figure 3 shows the CSCAN-Phils 2002-2003 research record for forecasting the location of earthquakes in the region of Luzon. The distance between the forecasted location and the actual earthquake epicenter is plotted and

labeled in kilometers. Note that the last four forecasted locations (for quakes 3, 4, 5A-C and 6) differ by less than 100km from the location of the actual earthquakes.

The forecasting research results of CSCAN-Phils are encouraging. However, can communities use such results constructively to better prepare for earthquakes? What has kept social and physical scientists at bay in looking seriously at forecasting research is the complex way in which the three earthquake parameters (Time, Magnitude, Location) interrelate and weave a pattern for communities to recognize as socially useful. Simply knowing the time or magnitude or location of an event, or even two of the three seismic parameters, is insufficient information for community leaders to decide whether or not to alert their people.

Figure 4 is a three-dimensional (3D) graph which provides a visual image of all the six forecasts made by CSCAN-Phils in 2002 and 2003. The star centered at the origin of this graph represents the actual earthquakes. Any forecast of any earthquake that hits its target with 100% success will have zero variances ($\Delta T = 0$, $\Delta M = 0$, $\Delta L = 0$) and would sit at the origin with the star. Forecasts 1-6 are shown as numbered circles and their positions in 3D space are determined by the variance values of Table 1 (Research Record for Forecasts in 2002-2003 by CSCAN-Phils). These variance values are represented by the various sizes and shapes of the wedges.

Figure 4 provides a picture for us to see how close, in terms of time, magnitude and distance, each forecast is to the actual earthquake. It also allows us to compare between forecasts, as well as to comment on the social usefulness of the forecasts. For example, forecasts 1 and 2 are both off by several hundred kilometers from their target quakes. However, forecast 2 is much less ideal because it is also off in magnitude by 1.2M. Hence, forecast 1 contains more useful information than forecast 2.

For forecasts 3, 4, 5 and 6, the information contained in these forecasts is socially useful. All of the forecasts were within 100 km (see Figure 4: gray area between 0 - 100km), 0.6M and within one week of the actual quakes that occurred. Earthquakes of magnitudes in this study and greater are often felt over areas that are hundreds of kilometers in length. Therefore, forecasts 3, 4, 5 and 6, while not 100% accurate, do contain information that is probably valuable for community leaders and their disaster managers.

In overview, it is too early to say if CSCAN-Phils can predict. However, this community-based network does gather information that can be helpful to communities to better monitor and prepare for earthquakes.

Communities, public officials, and scientists can use illustrations like Figure 4 to show the results and capability of any earthquake forecasting technology, as well as to evaluate the social usefulness of any monitoring approach.

Finally, CSCAN-Phils, at its heart, is a community-based initiative to energize disaster monitoring at the local level. It is a network

managed and used by local communities which can strengthen grass roots preparedness and citizen involvement when coupled with disaster awareness and education campaigns. The CSCAN-Phils generated data provide signals to citizens to review their disaster readiness, check their vulnerabilities, monitor additional environmental changes and take measured actions corresponding to the degree of risk as assessed by the community itself and the network at large.

Table 1. Research Record for Forecasts in 2002-2003 by CSCAN-Phils*

Fore-cast No.	Forecast faxed to UN on	Forecast Details			Actual Earthquake Details**				Variance		
		Time	Ms	Location	Time	Ms	Location	Region Affected	ΔT day	ΔM	ΔL km
1	Feb 4 2002	Feb 15 2002	5.0	120.9E 15.8N	Feb 13 2002	5.0	121.2E 19.2N	Pasuquin, Ilocos Norte	2	0	379
2	Jun 7 2002	Jun 19 2002	5.5	121.2E 16.7N	Jun 24 2002	4.3	121.3E 19.1N	Pasuquin, Ilocos Norte	5	1.2	267
3	July 12 2002	Aug 1 2002	4.6	121.1E 14.6N	Aug 6 2002	4.5	120.3E 14.6N	30kms S63°W of Olongapo City (felt in Manila)	5	0.1	86
4	Sep 11 2002	Sep 20 2002	5.1	120.8E 13.7N	Sep 20 2002	4.5	121.6E 13.4N	Naujan, Puerto Galera, Lipa and Batangas City	0	0.6	93
5	Nov 8 2002	Nov 19 2002	5.4	121.4E 13.8N	Nov 10 2002 (A)	4.5	120.6E 13.4N		9	0.9 T	97
					Nov 11 2002 (B)	4.3	121.7E 14.4N	Infanta-Quezon, and Metro-Manila	8	1.1 T	74
					Nov 12 2002 (C)	4.7	120.7E 14.0N	45km WNW of Batangas City	7	0.7 T	79
6	Feb 18 2003	Feb 26 2003	4.9	122.0E 16.0N	Mar 3 2003	5.0	121.9E 15.5N	Palayan City 85km E of Cabanatuan City	5	0.1	57

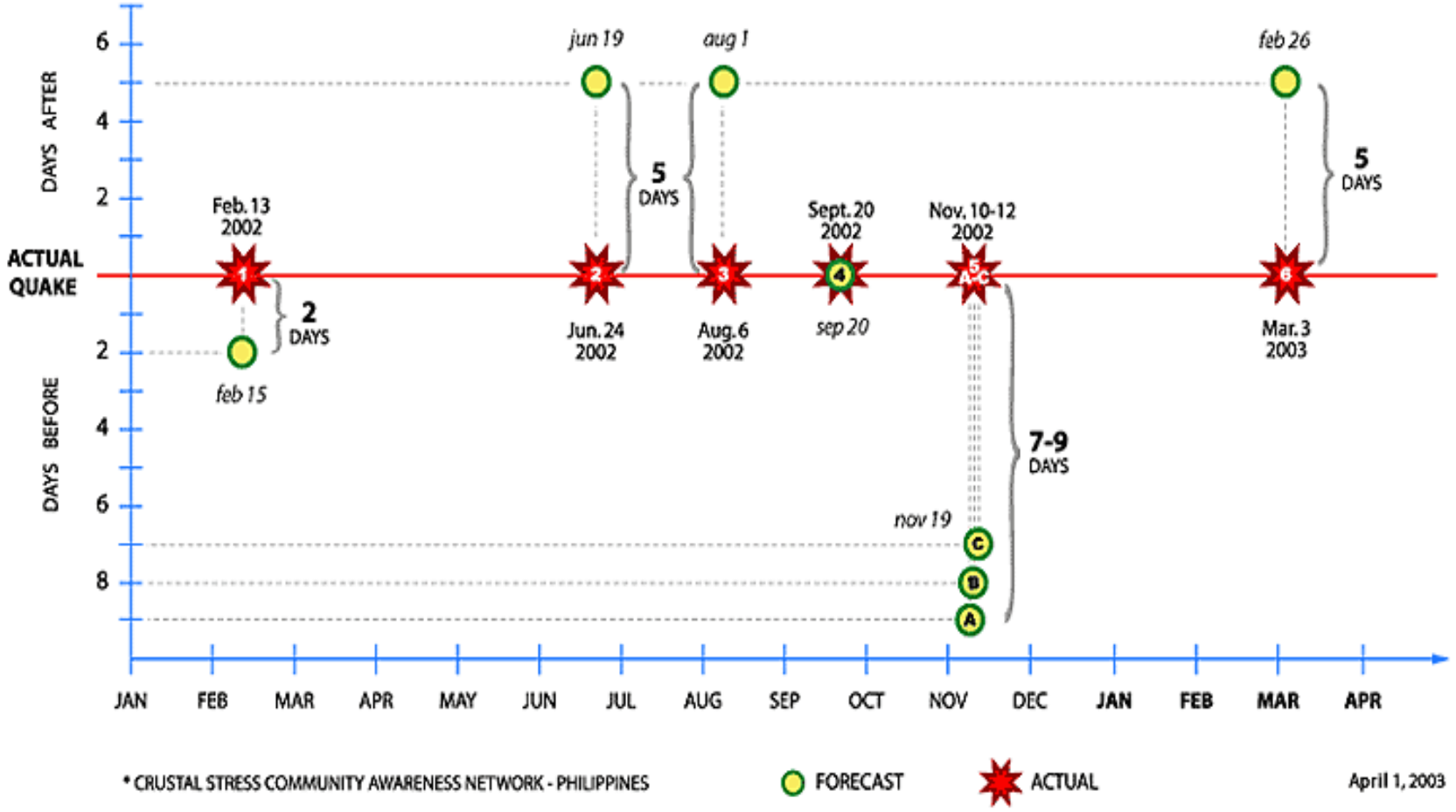
* Crustal Stress Community Awareness Network - Philippines

** U.S. Geological Survey Earthquake Database (USGS NEIC PDE)

April 1, 2003

ACCURACY IN DAYS FOR FORECASTS OF QUAKES 1-6
BY CSCAN-PHILS* FOR 2002 AND 2003

Figure 1



* CRUSTAL STRESS COMMUNITY AWARENESS NETWORK - PHILIPPINES

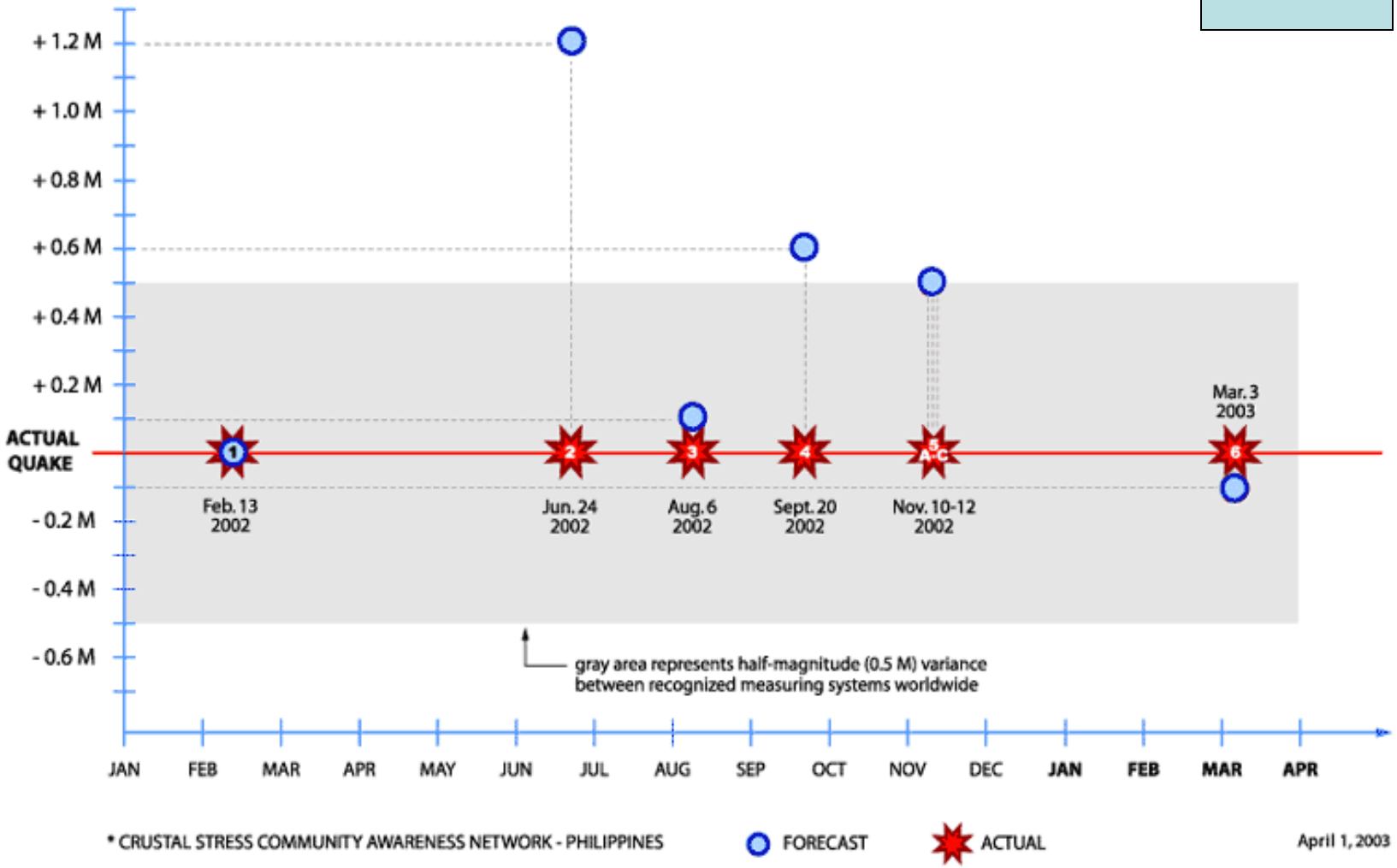
FORECAST ACTUAL

April 1, 2003

ACCURACY IN MAGNITUDE (M) FOR FORECASTS OF QUAKES 1-6
BY CSCAN-PHILS* FOR 2002 AND 2003

Figure 2

ΔM



* CRUSTAL STRESS COMMUNITY AWARENESS NETWORK - PHILIPPINES

FORECAST

ACTUAL

April 1, 2003

Figure 3

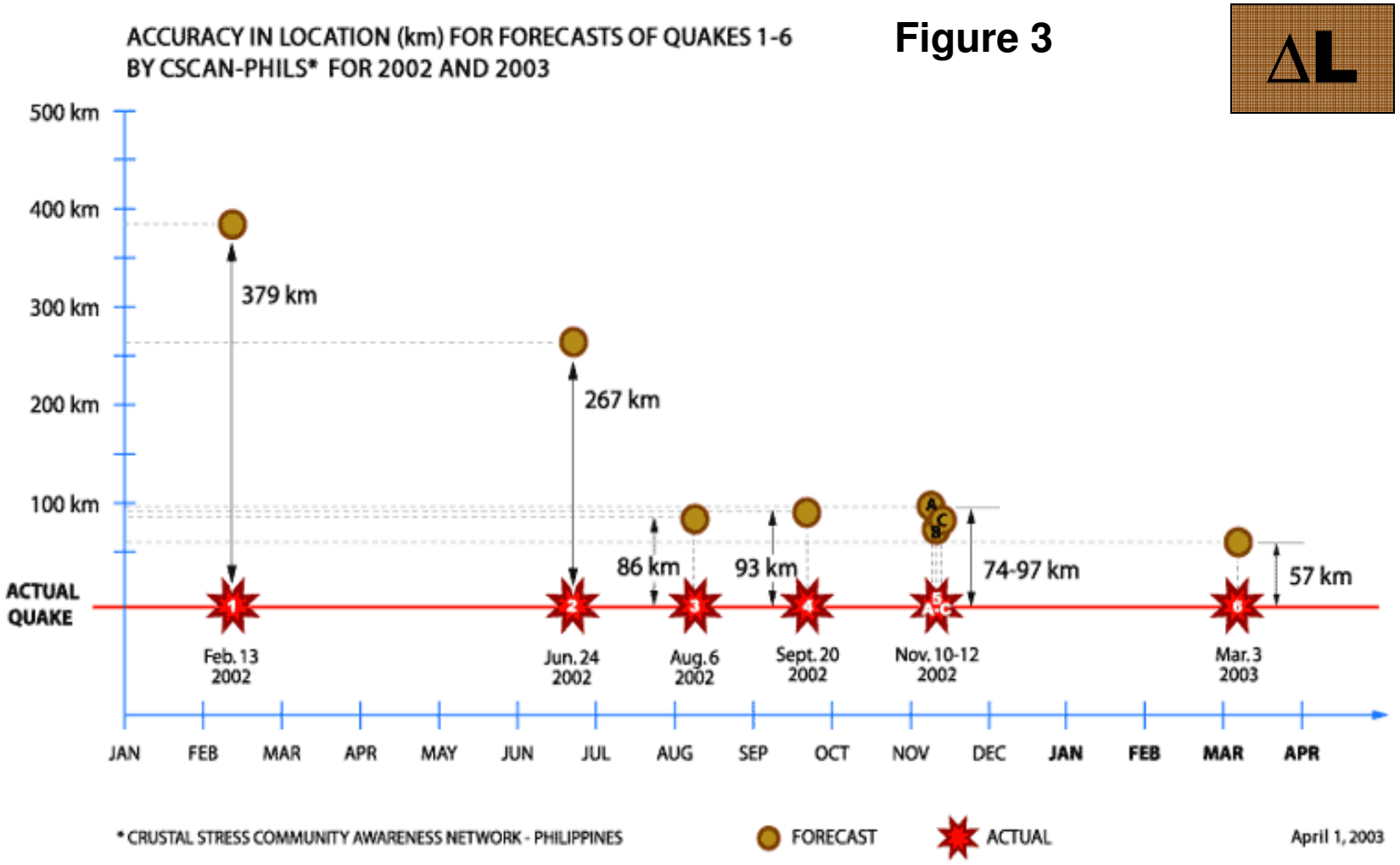
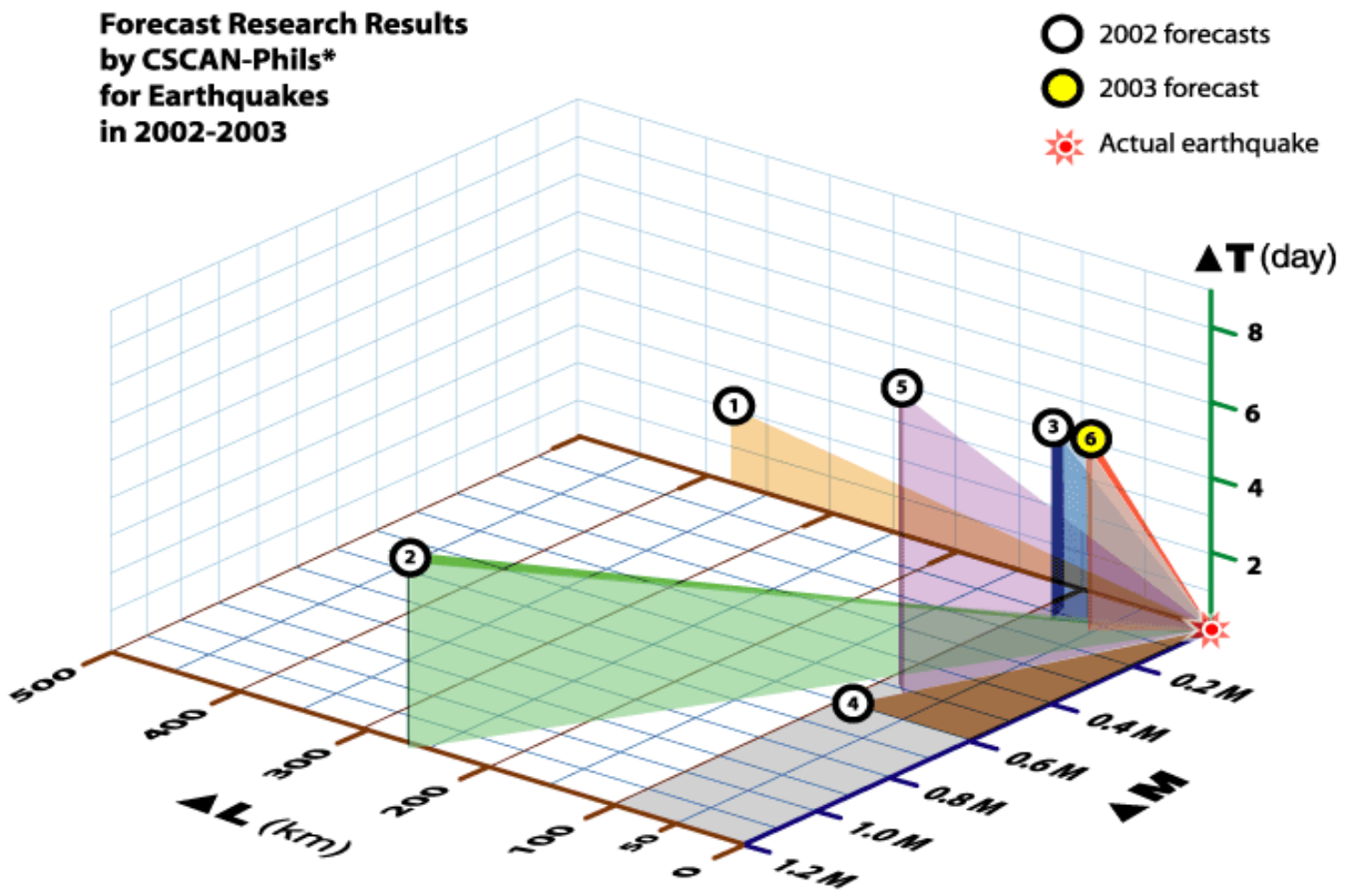

ACCURACY IN LOCATION (km) FOR FORECASTS OF QUAKES 1-6
BY CSCAN-PHILS* FOR 2002 AND 2003
500 km
400 km
300 km
200 km
100 km
379 km
267 km
86 km
93 km
74-97 km
57 km
ACTUAL QUAKE
1
2
3
4
5 A-C
6
Feb. 13 2002
Jun. 24 2002
Aug. 6 2002
Sept. 20 2002
Nov. 10-12 2002
Mar. 3 2003
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR
* CRUSTAL STRESS COMMUNITY AWARENESS NETWORK - PHILIPPINES
FORECAST
ACTUAL
April 1, 2003

Figure 4

Forecast Research Results by CSCAN-Phils* for Earthquakes in 2002-2003



*Crustal Stress Community Awareness Network - Philippines

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