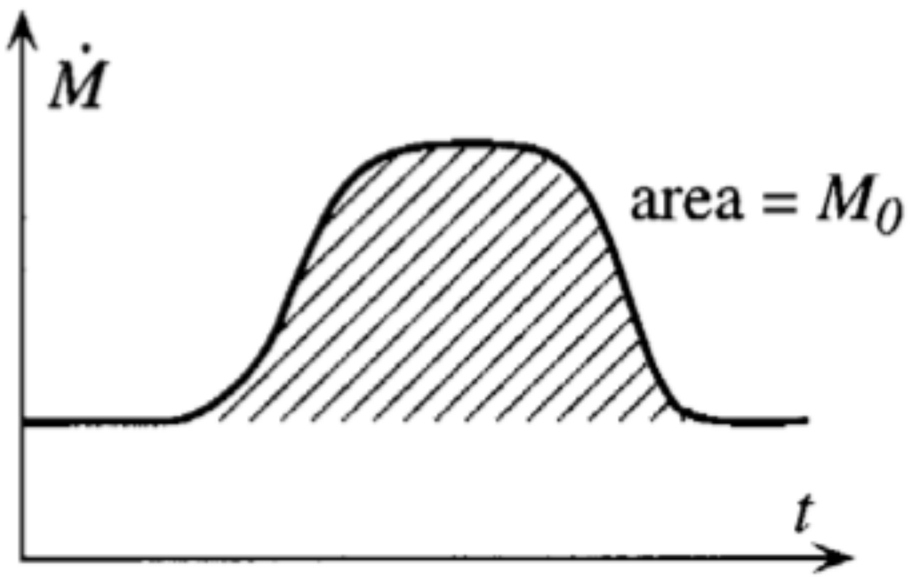
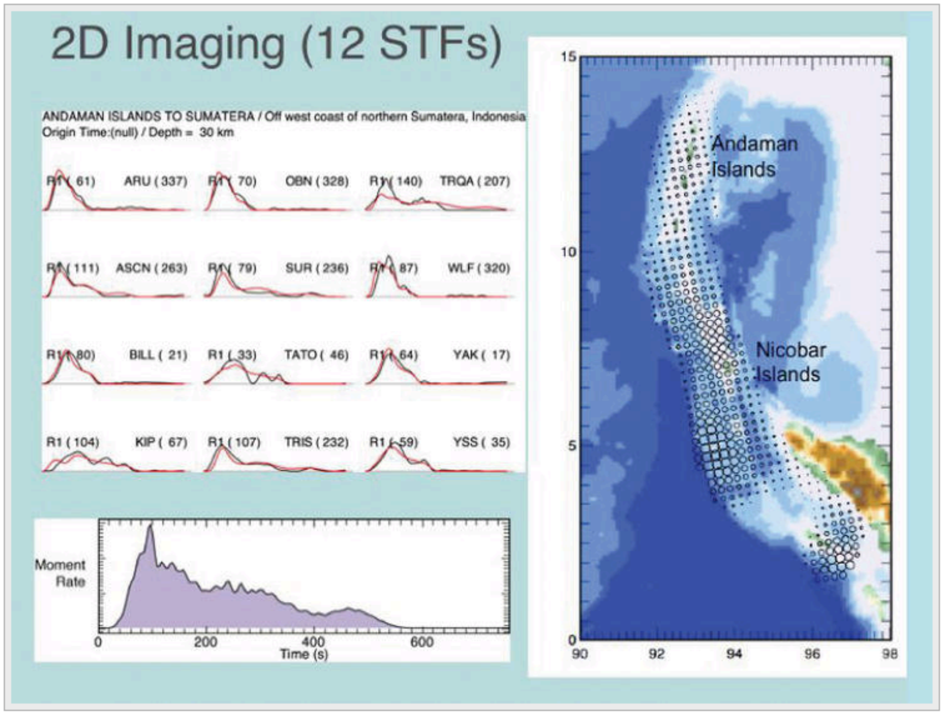
Mwp

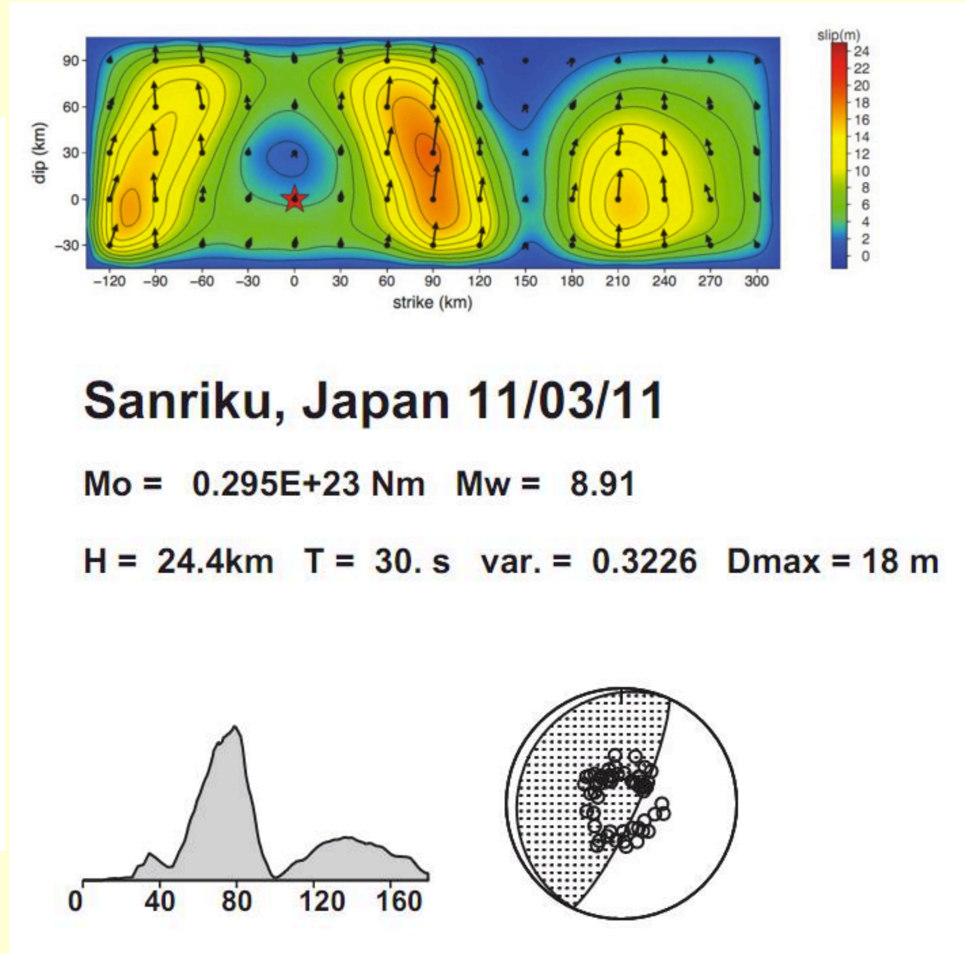
March, 2011
Antelope User Group Meeting
Bucharest, Romania

$$\dot{M}(t) = \mu \frac{\partial}{\partial t}[A(t)D(t)],$$



$$M_0 = \mu \overline{D} A,$$





Aka 2011 Tohoku Earthquake

Far Field Displacement for P wave in an infinite homogeneous medium

$$u(t) = \frac{\Gamma}{4\pi\rho\alpha^3 r} \mathring{M}_0(t)$$

$$M_0 = \frac{4\pi\rho\alpha^3 r}{\Gamma} \int u(t)dt$$

First proposed by Tsuboi, et al, 1995 for computation of total earthquake moment from P-arrivals only, known as Mwp

Traditional computations of Mwp

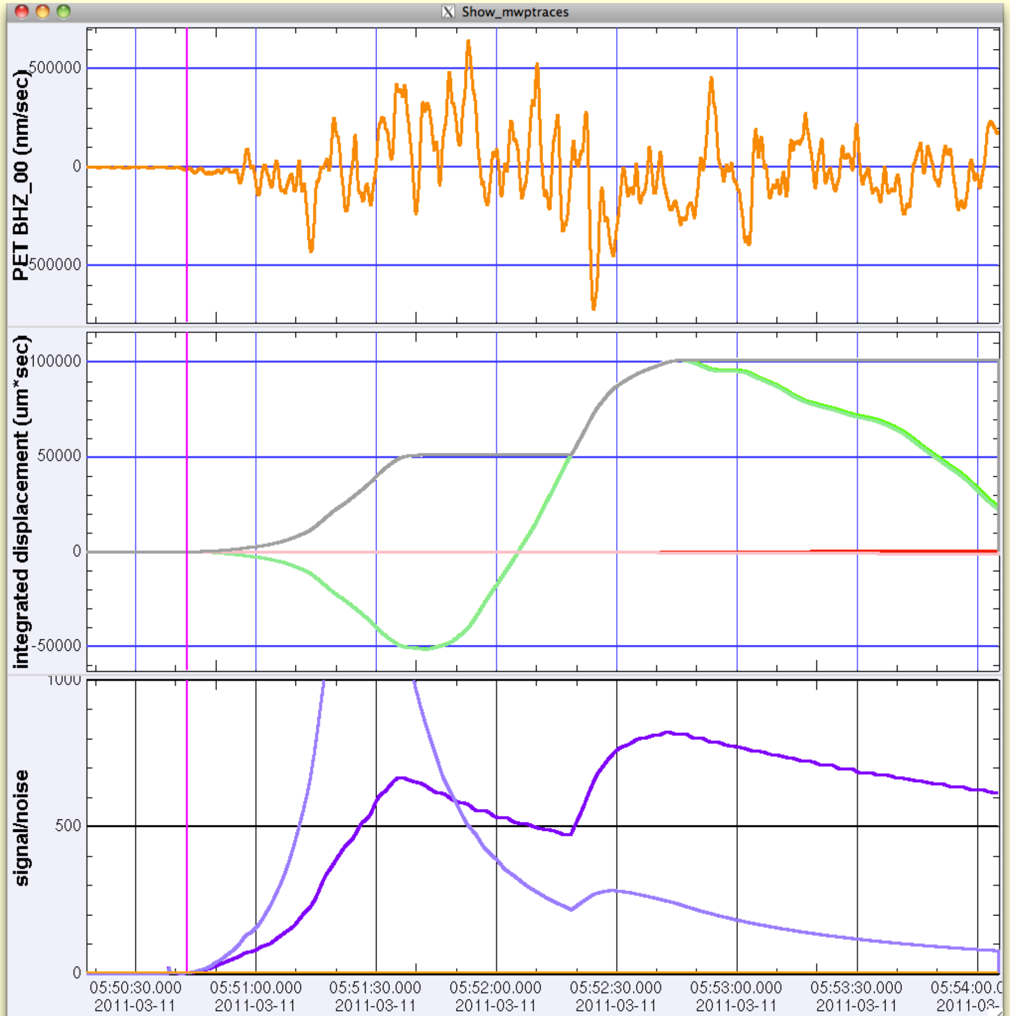
- Double integration of broadband velocity records
- Used very broadband vertical components only (STS-I used mainly)
- Ignored radiation gain and instrument responses
- Only use P wave train up to the S arrival
- Since double integration of broadband velocity is highly unstable, a poorly described interactive analyst process was originally involved
- Used by PTWC and some variant by NEIC
- No published reliable method for doing this automatically

Automatic computation of Mwp

- Developed by group at Geoscience Australia with most of the work done by Dr. Marthijn de Kool
- Uses a number of automated tests of the stability of the double time integration to reject spurious cases without the need for direct human intervention
- Has proven to be quite reliable for earthquakes with Mw >= 6 when compared to the published Mw values from NEIC using only GSN data:
  - 179 events
  - Median difference = 0.07
  - Standard deviation = 0.15
- For 2011 Tohoku Earthquake Mwp = 9.1 produced completely automatically about 15 minutes after the origin time (compared to initial NEIC estimate of 7.9, revised to 8.9 several hours later and finally to 9.0 after about one day)

MwpA, how does it work?

- Compute a mean value using a time window that is 30 seconds prior to the P-arrival
- Subtract the mean from the seismogram
- Compute two double integrations of the demeaned seismogram starting at the P-arrival; one in the positive time direction (signal), the other in the negative time direction (noise)
- Find the largest signal value for which the corresponding signal/noise >= 3.0 up to the minimum value of the S-arrival time and the P-arrival time plus 10 minutes
- Compute the station Mwp using this largest signal value
- Repeat the entire procedure using a mean value computed over 300 seconds prior to the P-arrival. If the two Mwp estimates are different by more than 0.5, the station Mwp is rejected due to double integration instability

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redgarden% show_mwptraces gsn 101774 5.0 10.0
sta=PET chan=BHZ_00 time= 3/11/2011   5:50:37.811 phase=P delta=18.5 depth=54.0 S-P=207.5 mb=7.30 prefor=208646
Best integrated displacement for 300 s mean = 101684.865 um*s, m0=8.81525e+21, mwp=8.94
Best integrated displacement for  30 s mean = 101131.866 um*s, m0=8.76731e+21, mwp=8.93
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BRTT

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Automatic computation of Mwp: caveats

- Need very broadband data, preferably STS-I
- Only works for Mw >= 6.0
- Need data where rupture duration is less than S-P duration
- Need a good distribution of stations in azimuth and distance