

SHEAR VELOCITY PROFILES OBTAINED FROM PASSIVE SEISMIC (MICROTREMOR) ARRAY DATA – NEWCASTLE, PROMINENT HILL, & TURKEY

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OUTLINE

Microtremor or ambient noise

H/V single station measurements

Array measurements

SOURCES OF MICROTREMORS (also MICROSEISMS)

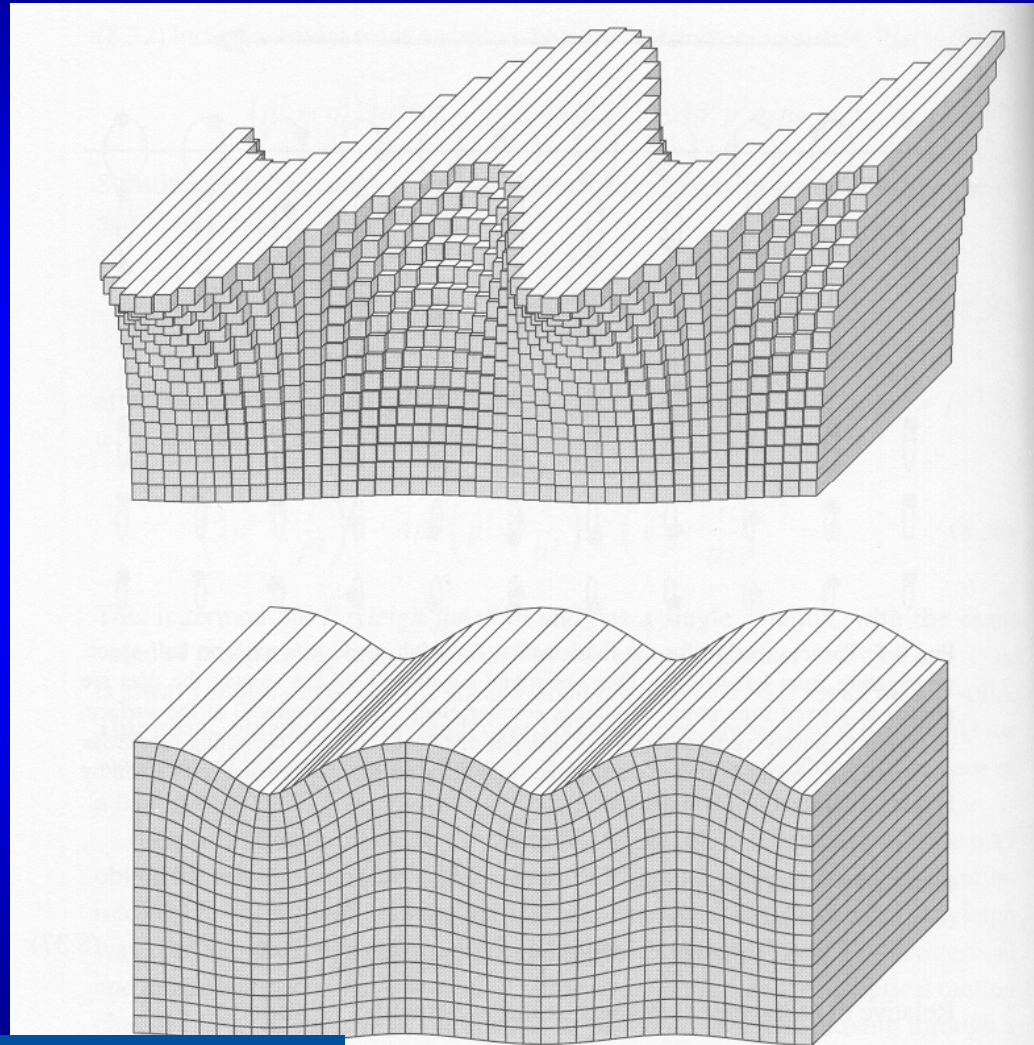
Wave propagation principally as surface waves

- 0.05-0.5 Hz : Meteorological -
(eg wave action)
- 1-30 Hz : Cultural -
vehicles, trains, machinery

TYPES OF SURFACE WAVES

- Rayleigh waves (P-SV particle motion) - solid or water free surface
- Love waves (SH particle motion) - solid layer(s) over half-space

Surface wave particle motion



SH motion

Love wave

P-SV motion

Rayleigh wave

INFORMATION CONTENT OF MICROTREMORS

- H/V spectral maxima indicate resonances which may be earthquake risks – can map relative thickness
- phase velocity gives thickness and shear-velocity profile of sediments

THE DUCK TUTORIAL ON MICROTREMOR SURFACE WAVE PROPAGATION



THE DUCK TUTORIAL ON MICROTREMOR SURFACE WAVE PROPAGATION

- Wave velocity is depth sensitive



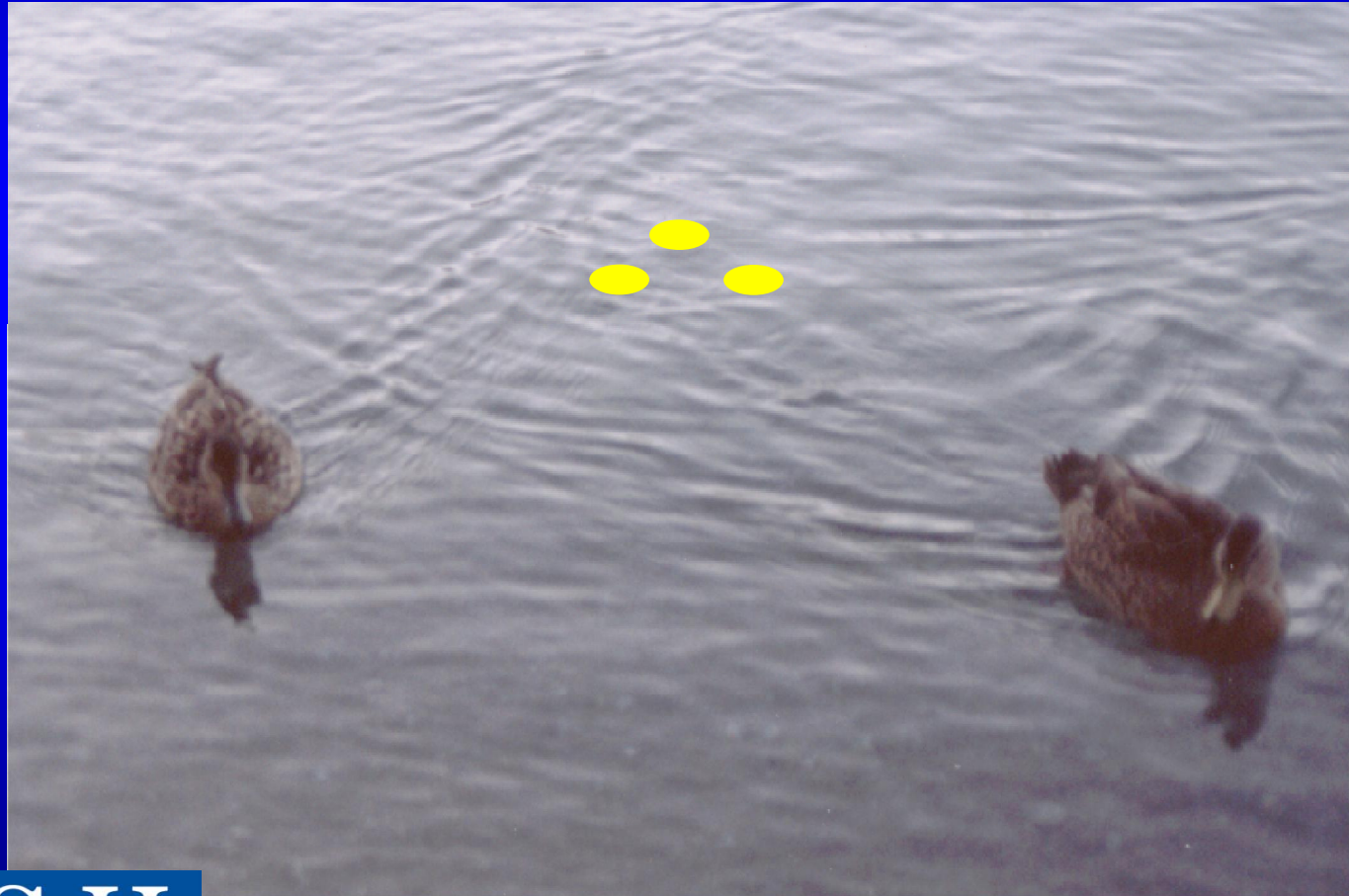
THE DUCK TUTORIAL ON MICROTREMOR SURFACE WAVE PROPAGATION

- Wave velocity is depth sensitive
- Can measure phase velocity with two detectors



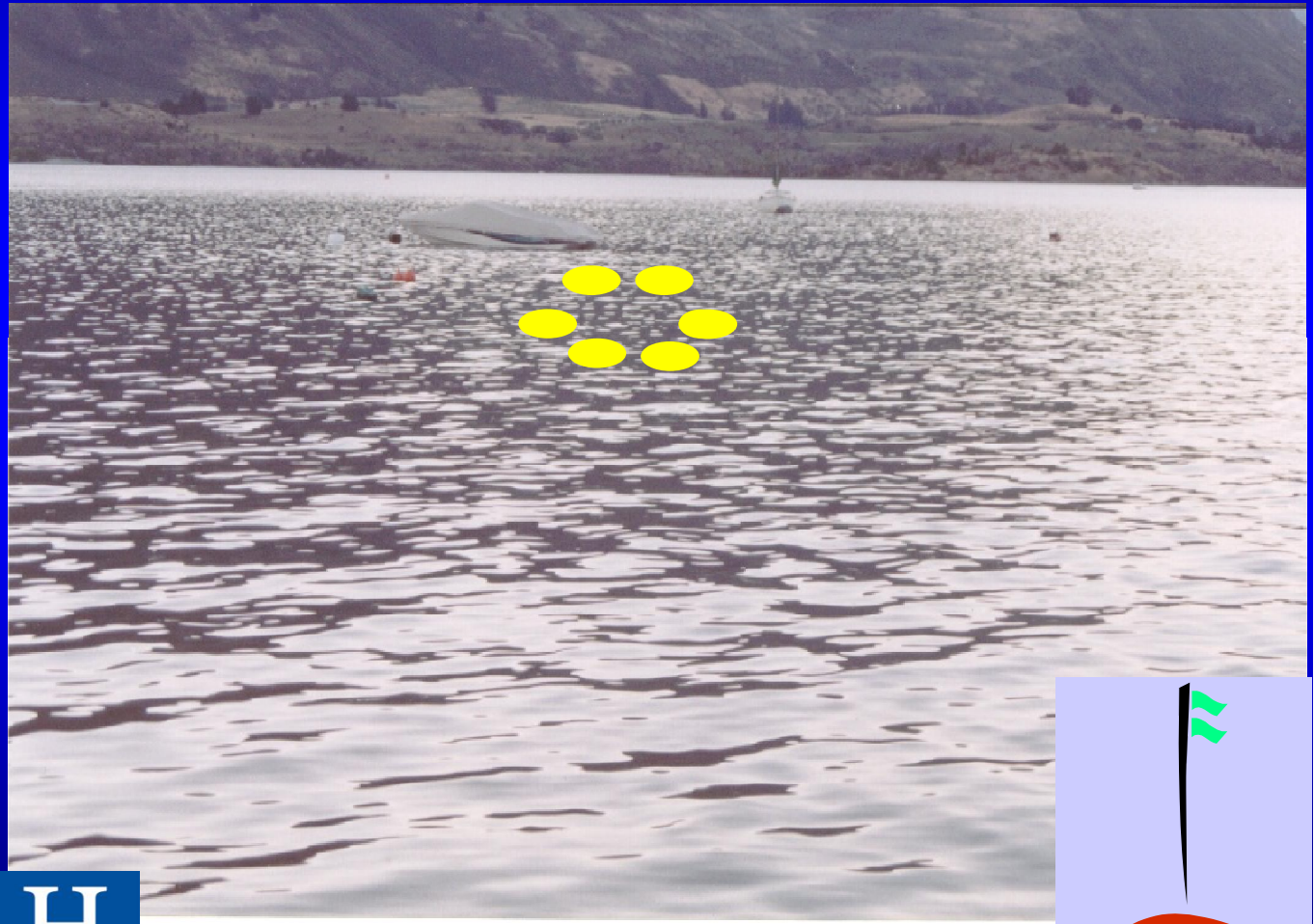
THE DUCK TUTORIAL ON MICROTREMOR SURFACE WAVE PROPAGATION

- Two sources give summation of waves- need array of detectors



THE DUCK TUTORIAL ON MICROTREMOR SURFACE WAVE PROPAGATION

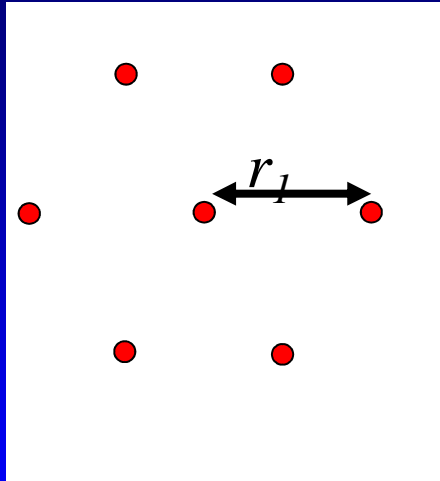
- multiple sources give apparent chaos BUT wave velocity still governed by physics



SOURCES OF MICROTREMORS (also MICROSEISMS)

Wave propagation principally as surface waves

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(eg wave action)
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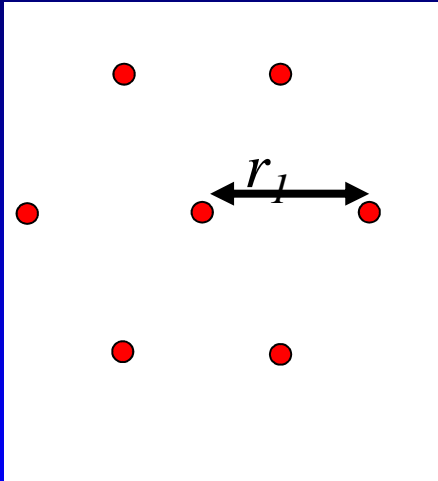
Spatial auto-correlation (SPAC)

- good for omni-directional sources

For a plane wave passing pairs of stations, *averaged in azimuth ϕ* , gives

$$\rho(f) = e^{i k \cdot r} \quad (\text{one pair})$$

where $k = 2 \pi f / C(f)$



Spatial auto-correlation (SPAC)

- good for omni-directional sources

For a plane wave passing pairs of stations, *averaged in azimuth ϕ* , gives

$$\overline{\rho}(f) = \int e^{i k \cdot r} d\phi = J_0(k \cdot r),$$

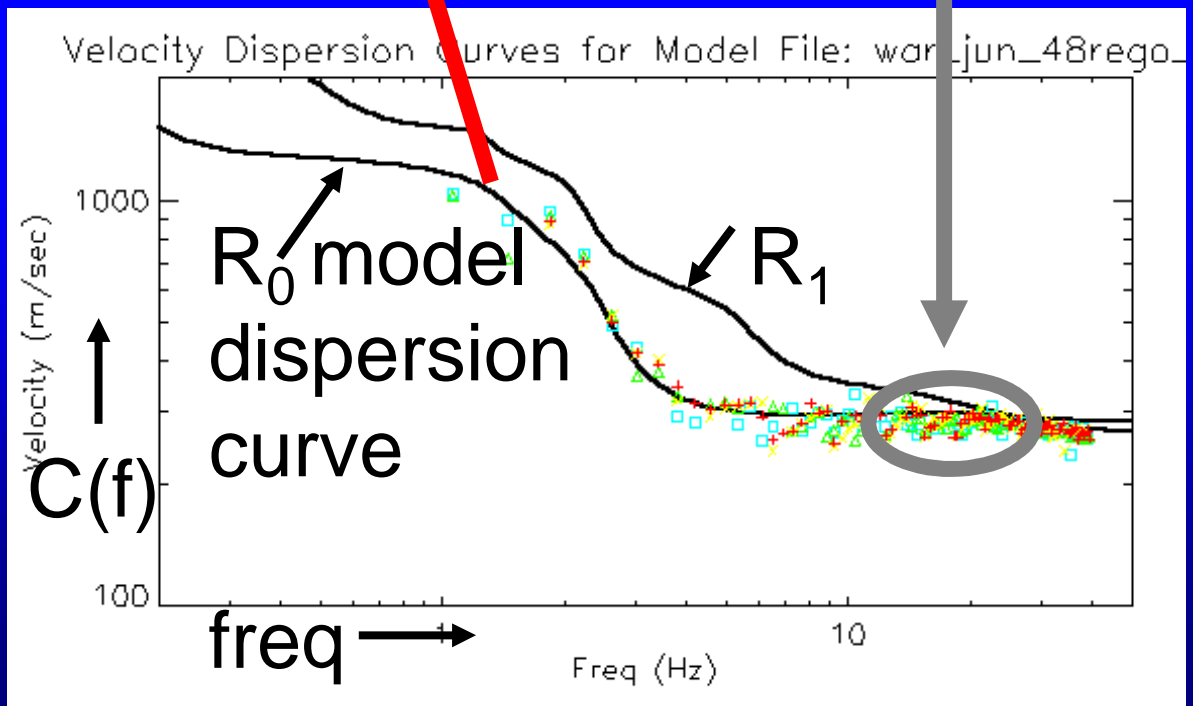
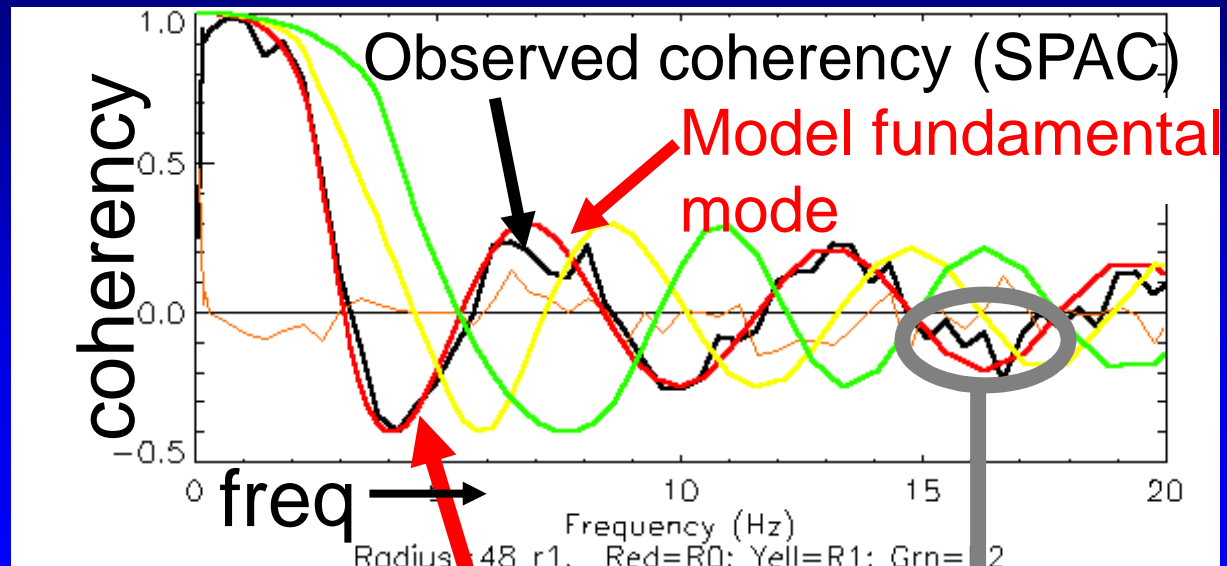
where $k = 2\pi f / C(f)$

MultiMode MMSPAC ADVANTAGES

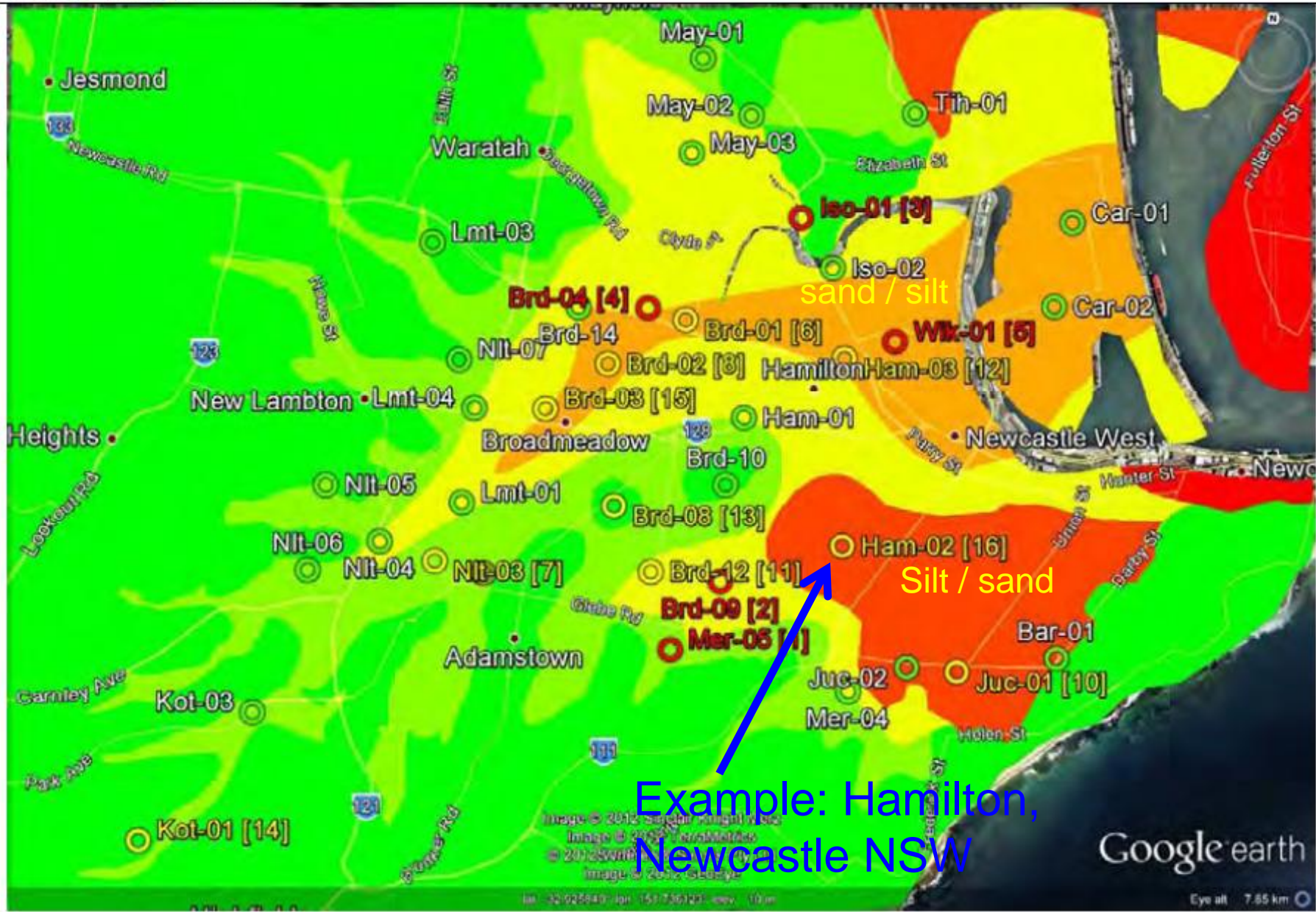
Fit data and
model in
coherency
space

Extended
wavenumber
range

Data fit nearer
to Gaussian



SITE CLASSES



Example: Hamilton,
Newcastle NSW

NEWCASTLE WORKERS CLUB 28 DEC 1989

M=5.6



HAMILTON (NEWCASTLE) SHOP FRONT

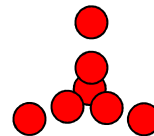
28 DEC 1989



LESSONS – A PRODUCTION-ORIENTED SURVEY

Effective array geometries

Use of Horizontal/Vertical spectral ratio for depth sensitivity

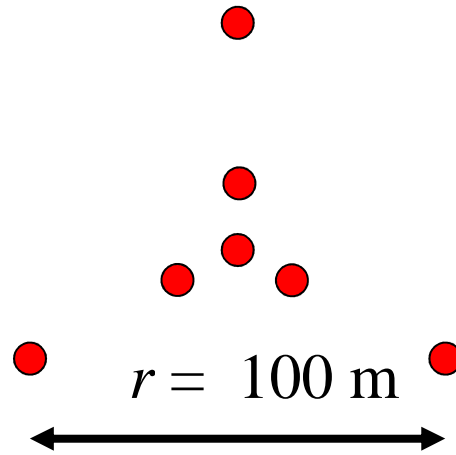


$r = 30 \text{ m}$



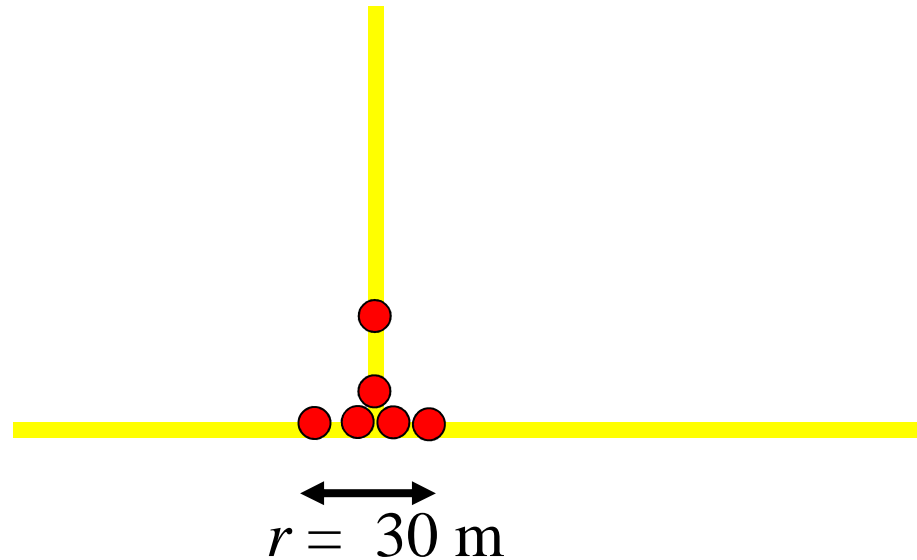
Nested triangle array
of seven stations

Good for use in
parkland



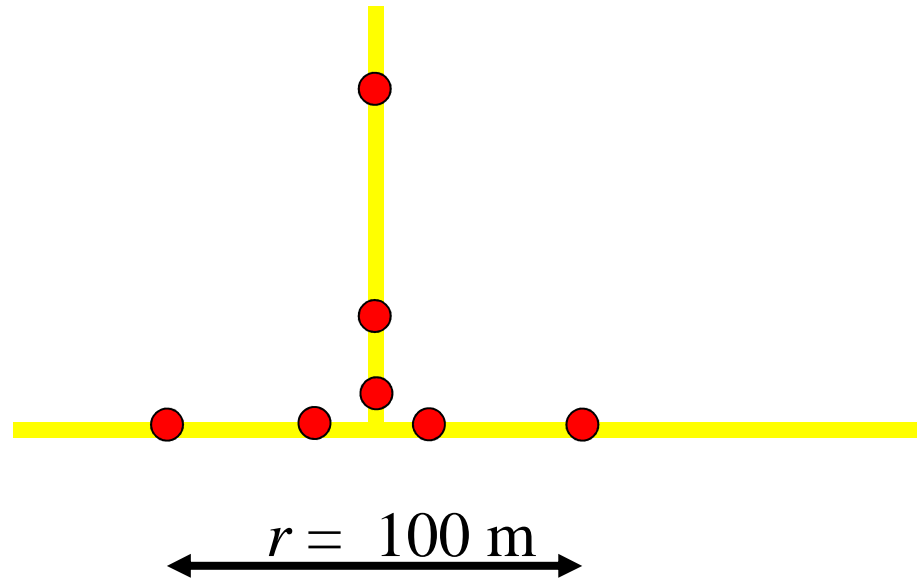
Nested triangle array
of seven stations

Good for use in
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Nested common-base
triangle array of seven
stations

Good for use on a T-
intersection



Nested common-base
triangle array of seven
stations

Good for use on a T-
intersection



National Soccer Ground,
Newcastle



2012.03.20 16:08

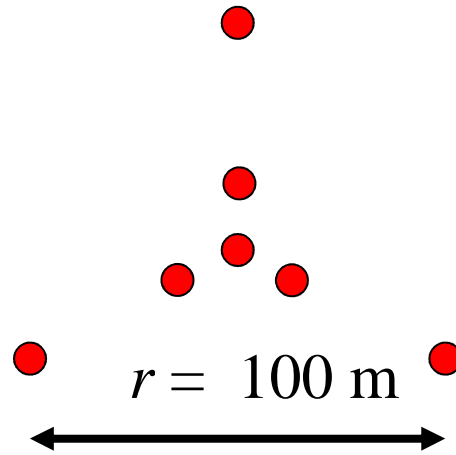


LESSONS – A PRODUCTION-ORIENTED SURVEY

Effective array geometries

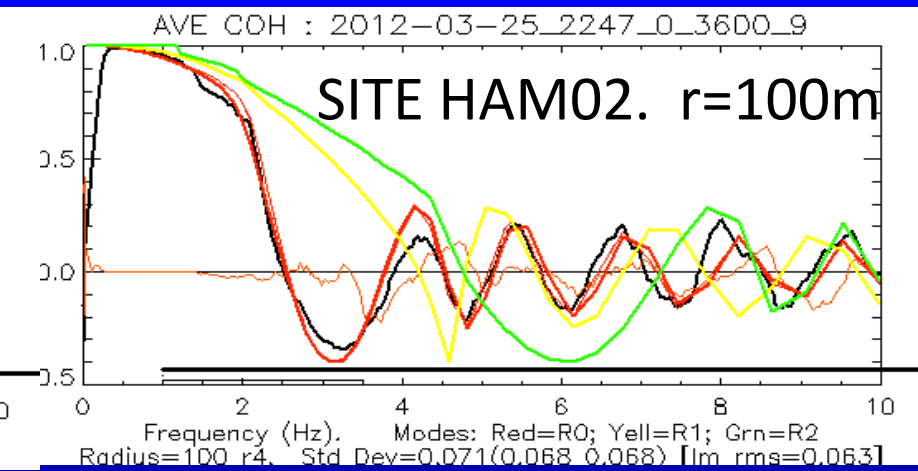
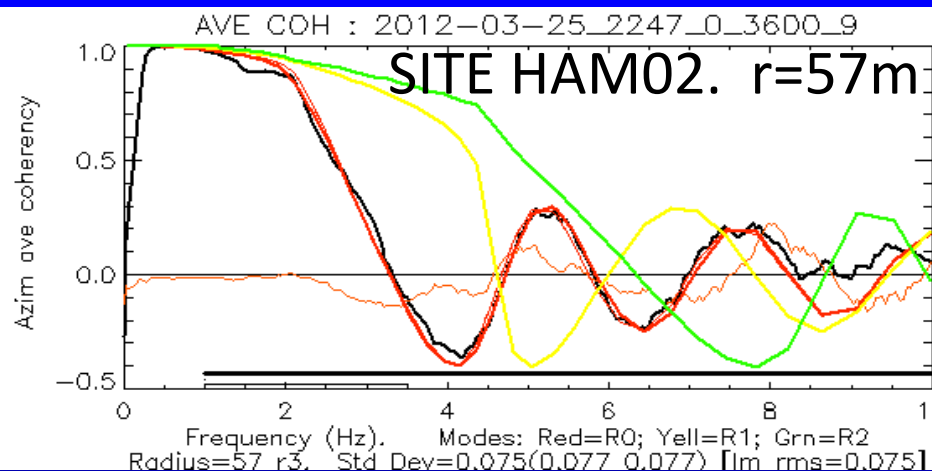
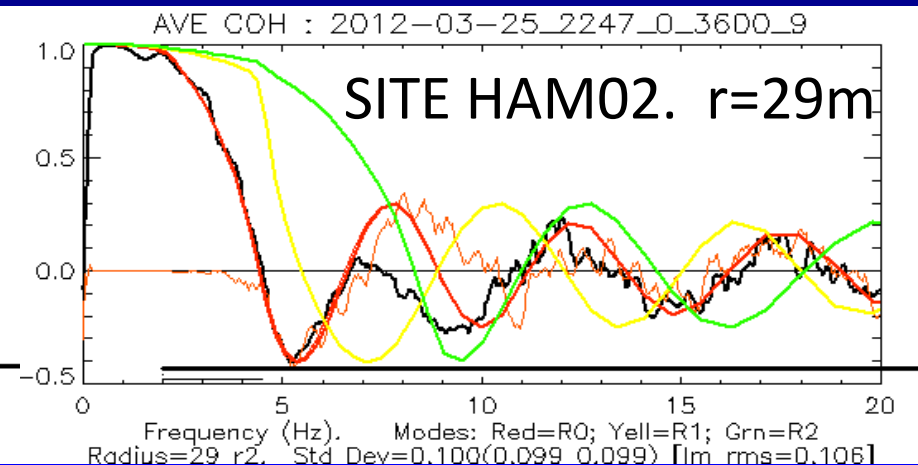
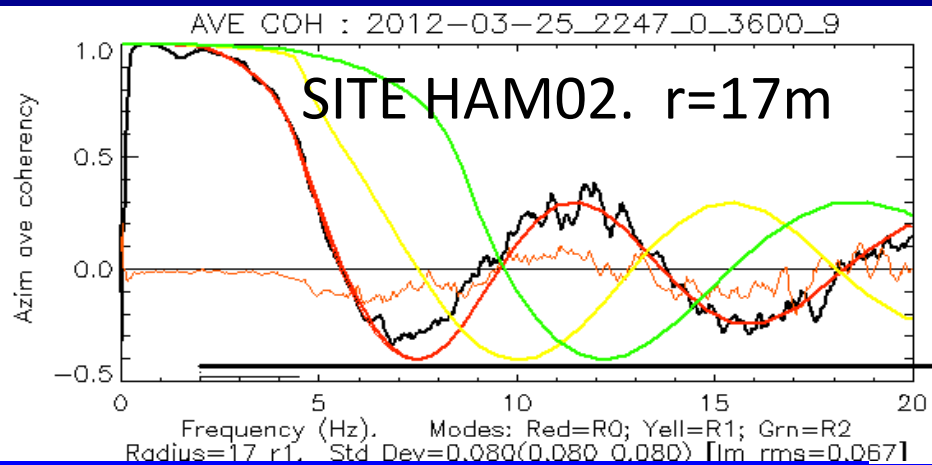
Use of Horizontal/Vertical spectral ratio for depth sensitivity

SITE HAM02



Nested triangle array
of seven stations

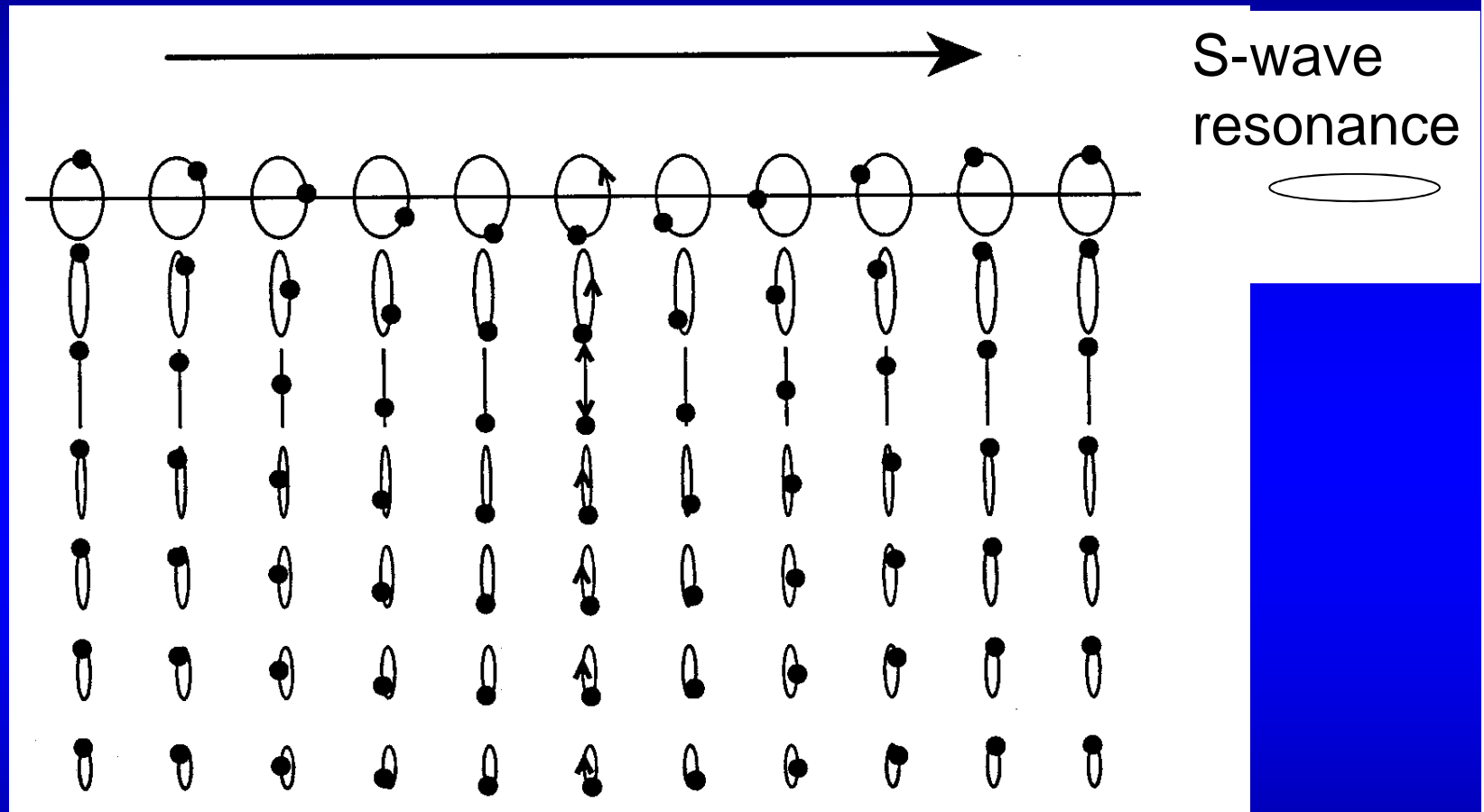
Good for use in
parkland

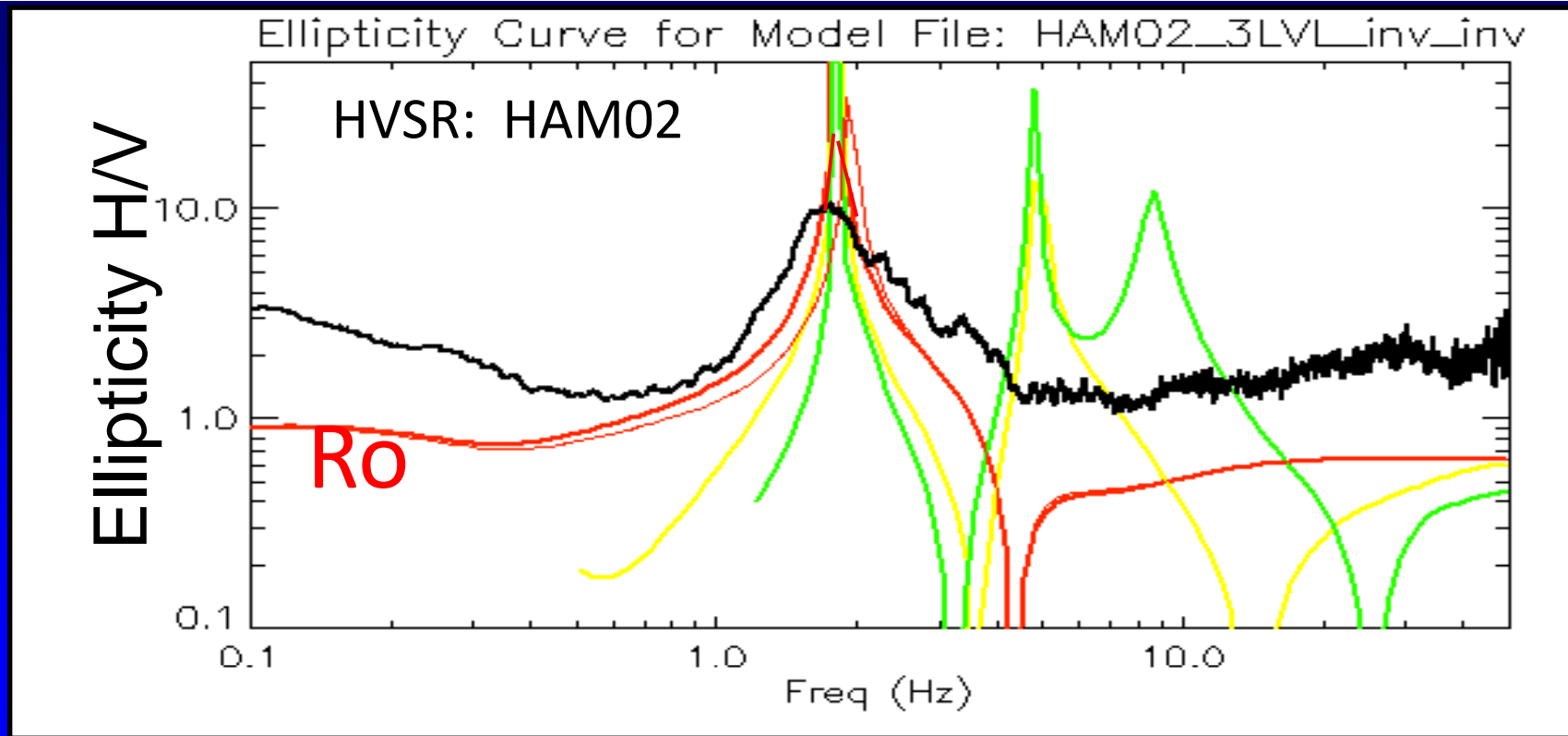


SITE HAM02: Black line – observed coherency spectrum

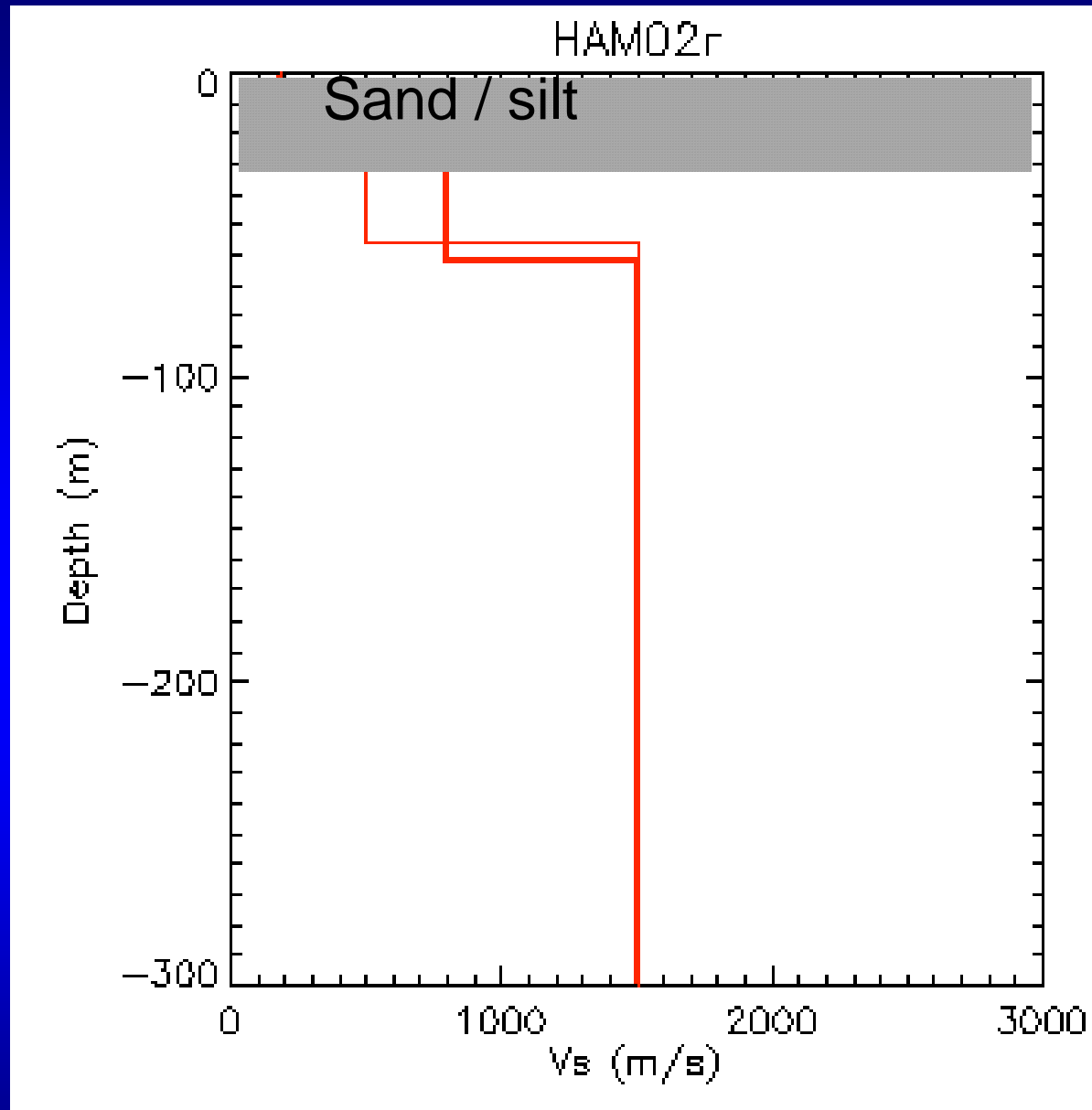
Red line: fitted model coherency spectrum, for best fit layered earth model.

Rayleigh wave particle motion



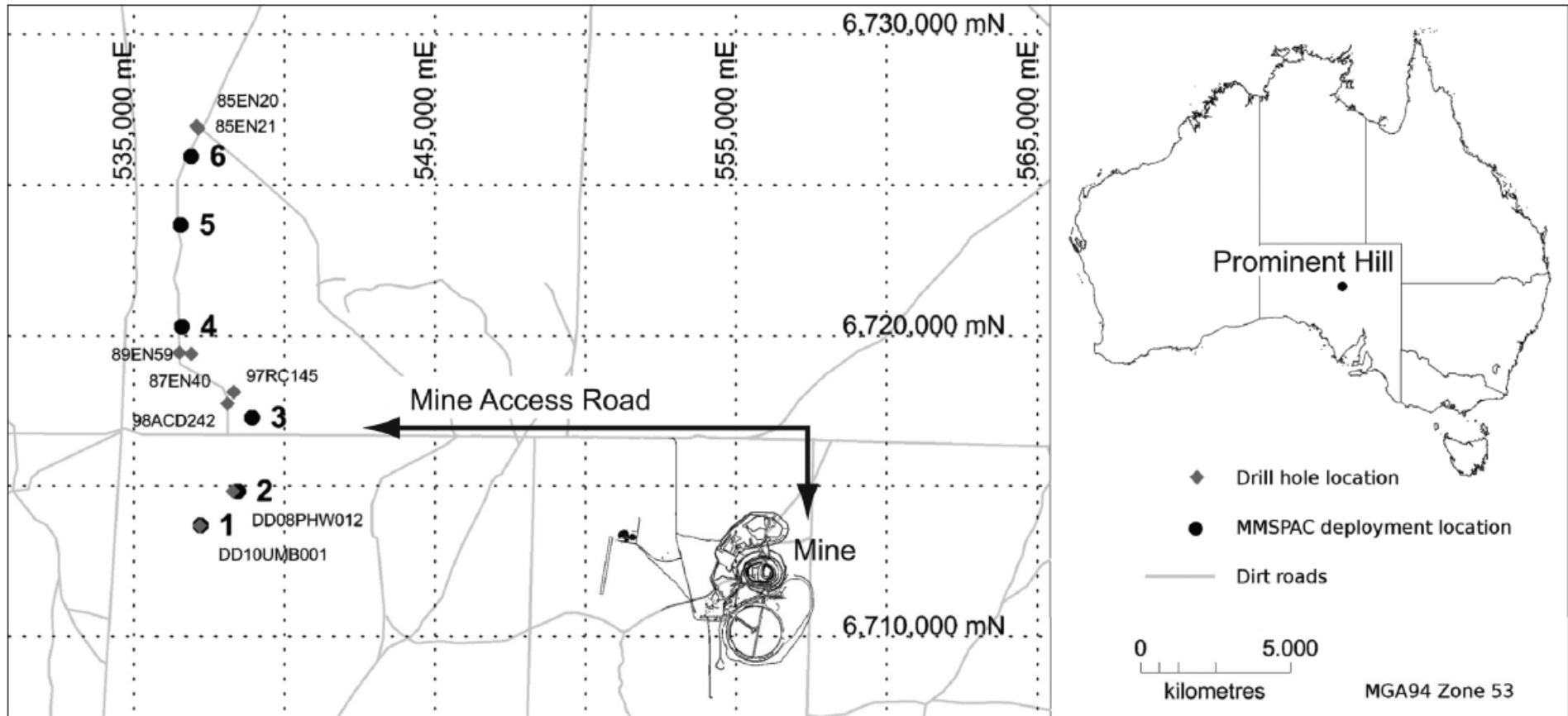


SITE HAM02: Black line – observed H/V spectrum
Red line: fitted model H/V spectrum, for best fit layered earth model.



SITE HAM02: Thick red line – preferred best fit model.
Thin red line – alternative model

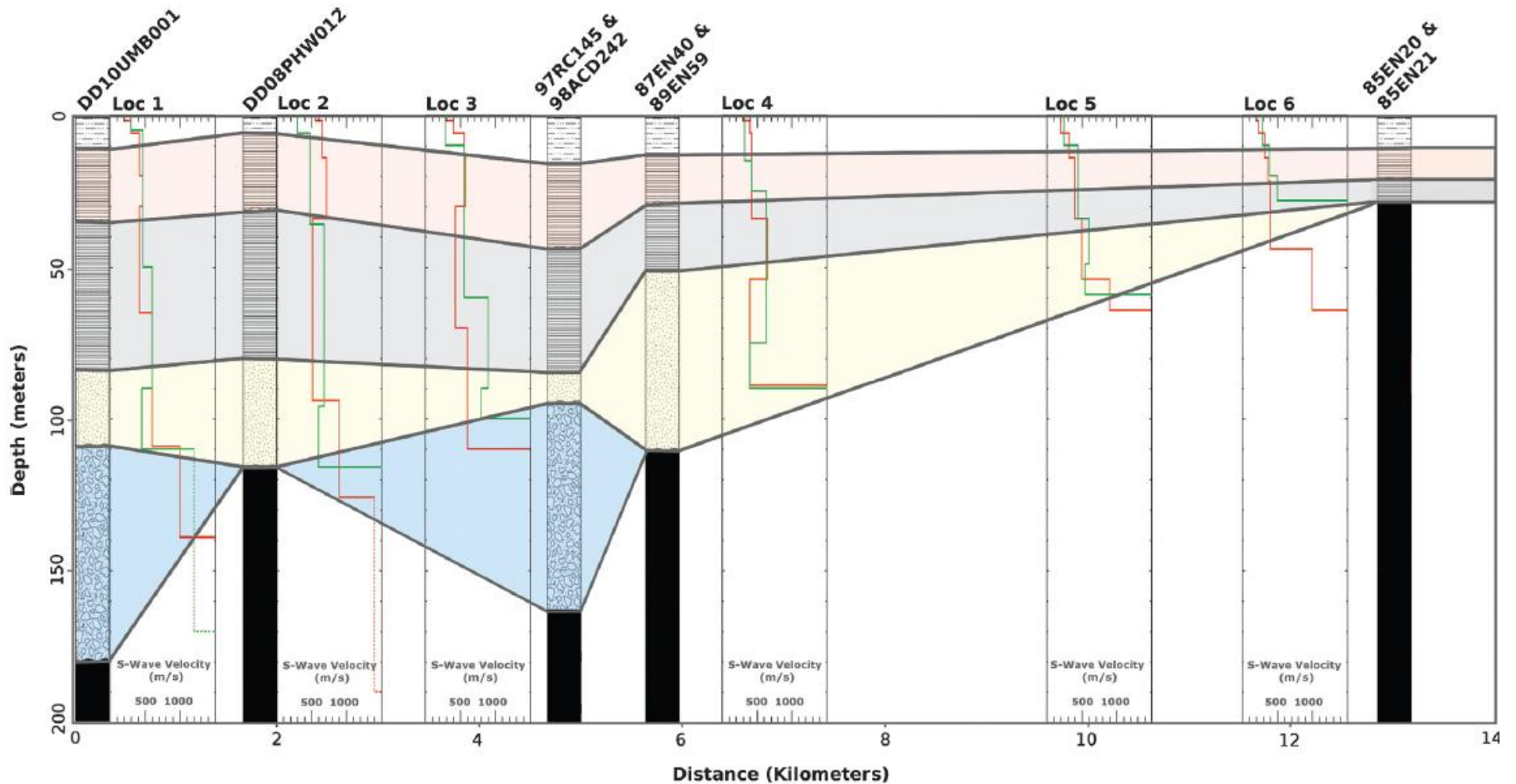
REGOLITH THICKNESS ESTIMATION AT PROMINENT HILL



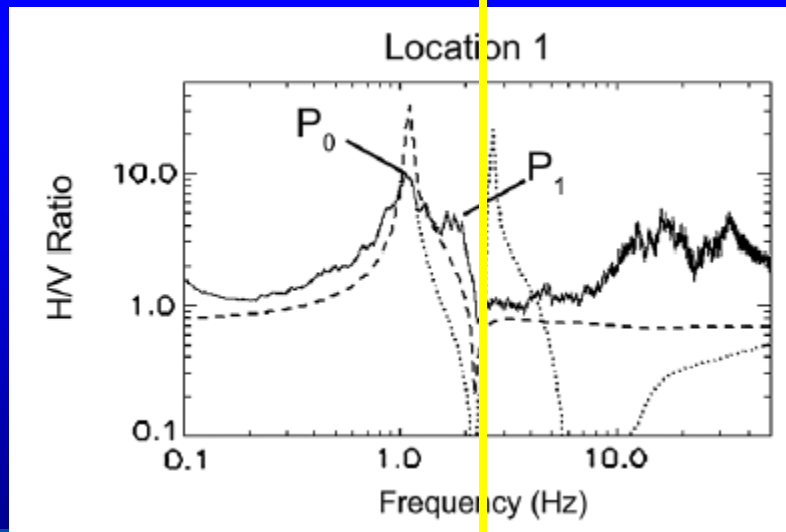
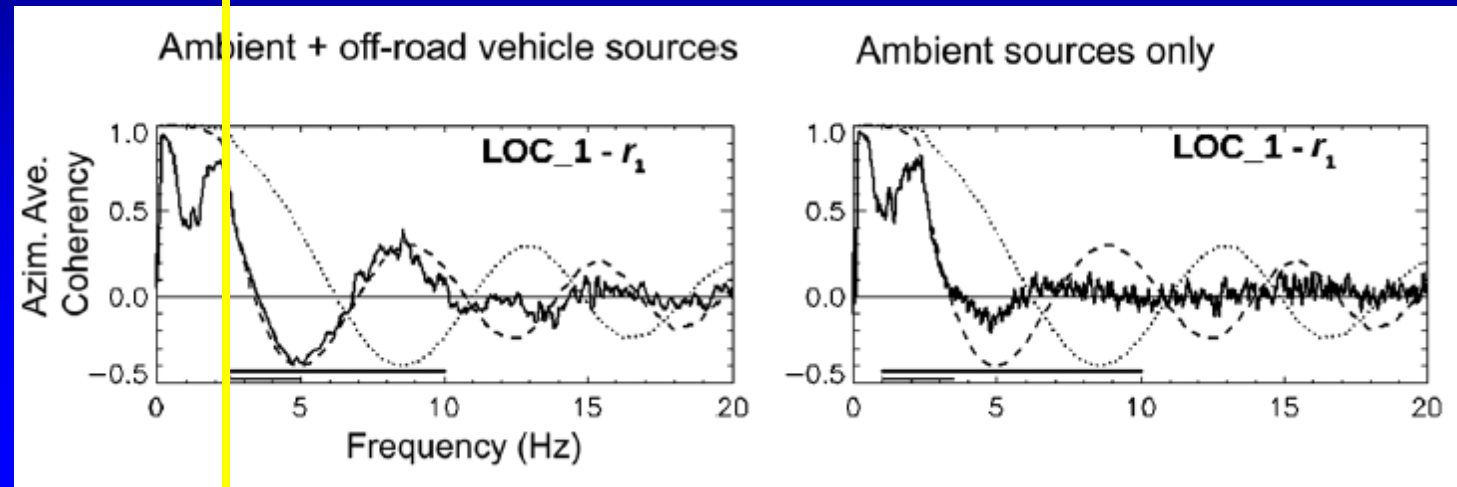




REGOLITH THICKNESS ESTIMATION AT PROMINENT HILL

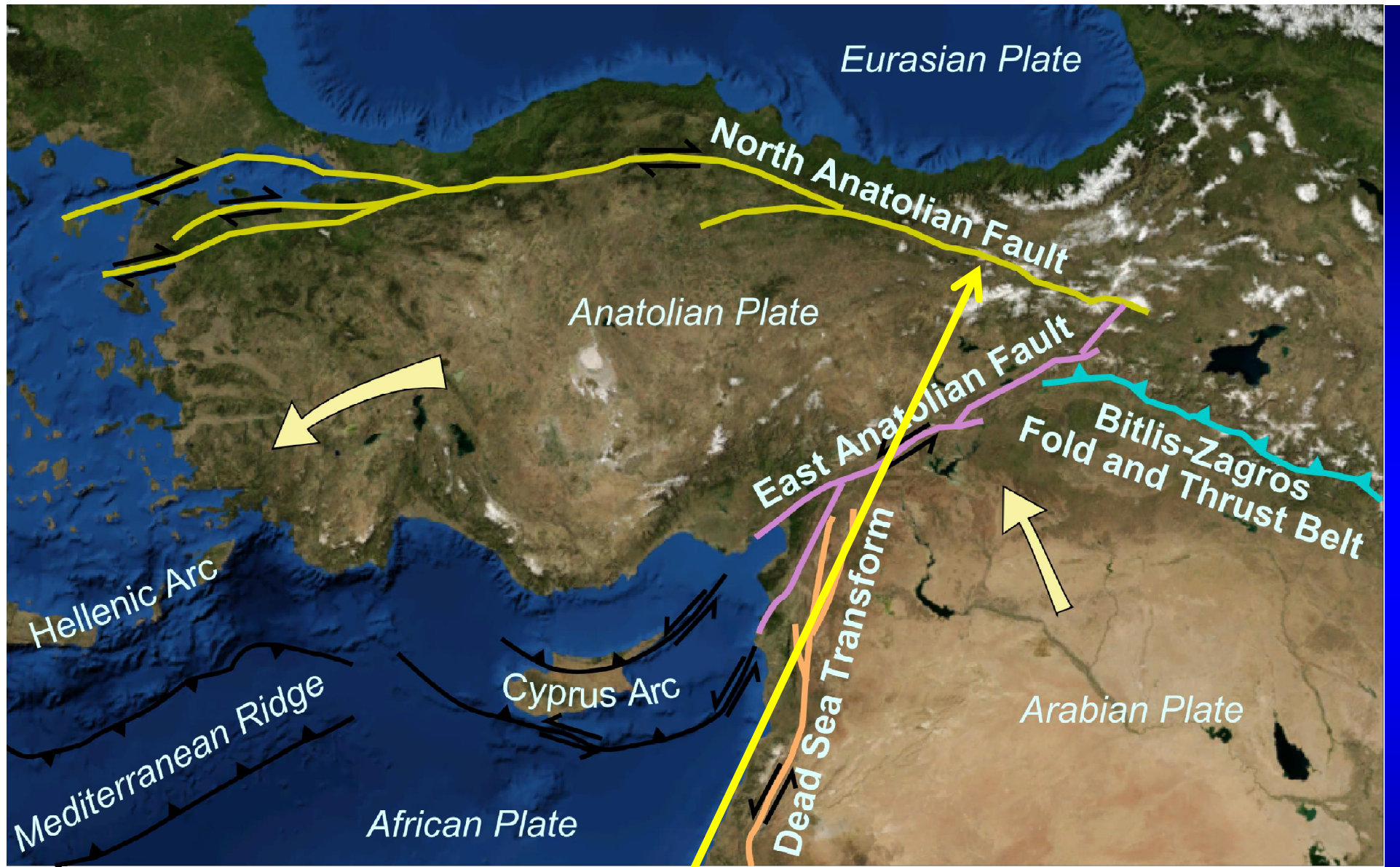


REGOLITH THICKNESS ESTIMATION AT PROMINENT HILL

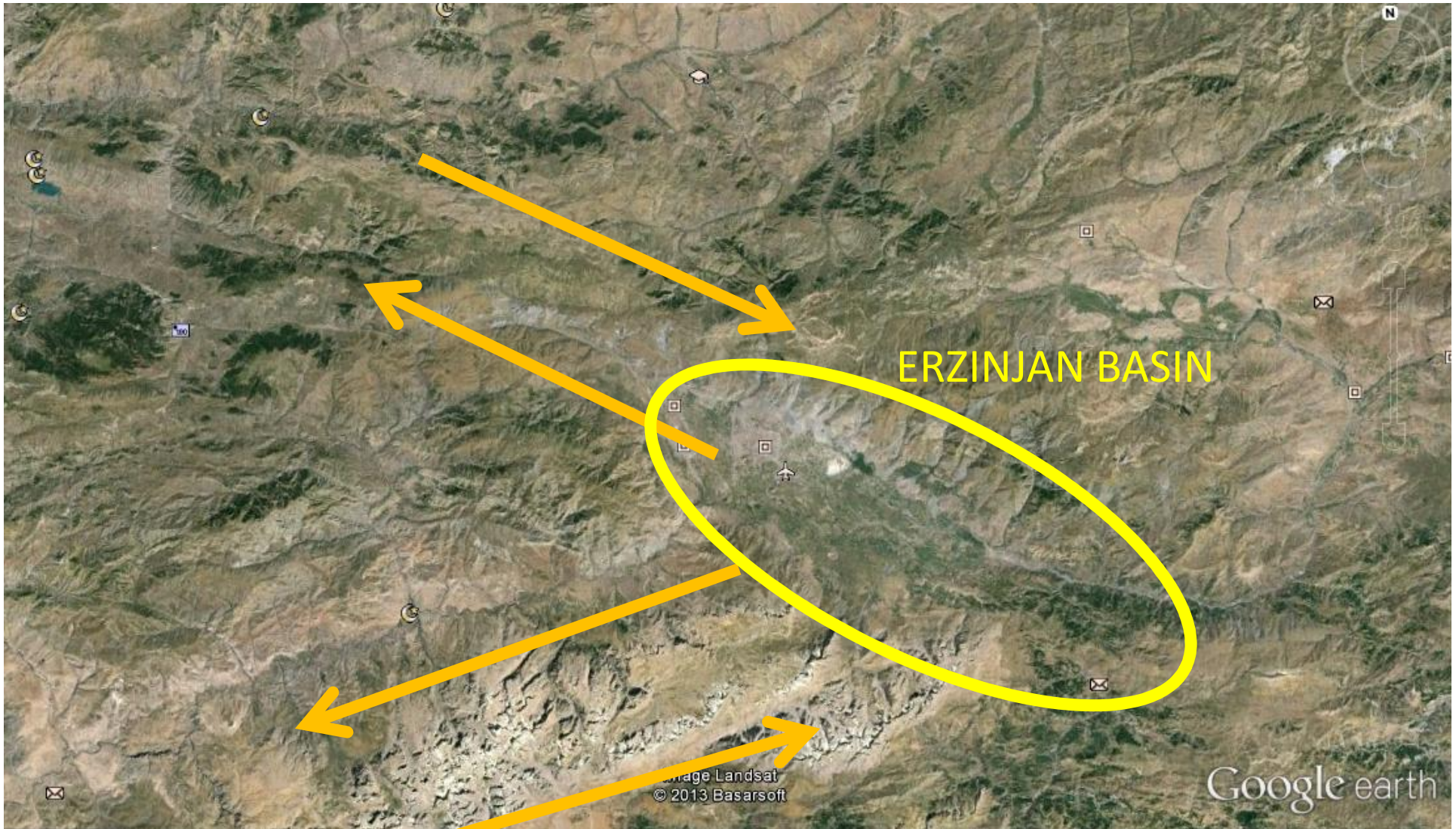


(from Smith et al, GEOPHYSICS, VOL. 78, NO. 5 (SEPTEMBER-OCTOBER 2013); P. B227-B242)





TECTONIC MAP OF TURKEY,
WITH ERZINJAN BASIN



25km



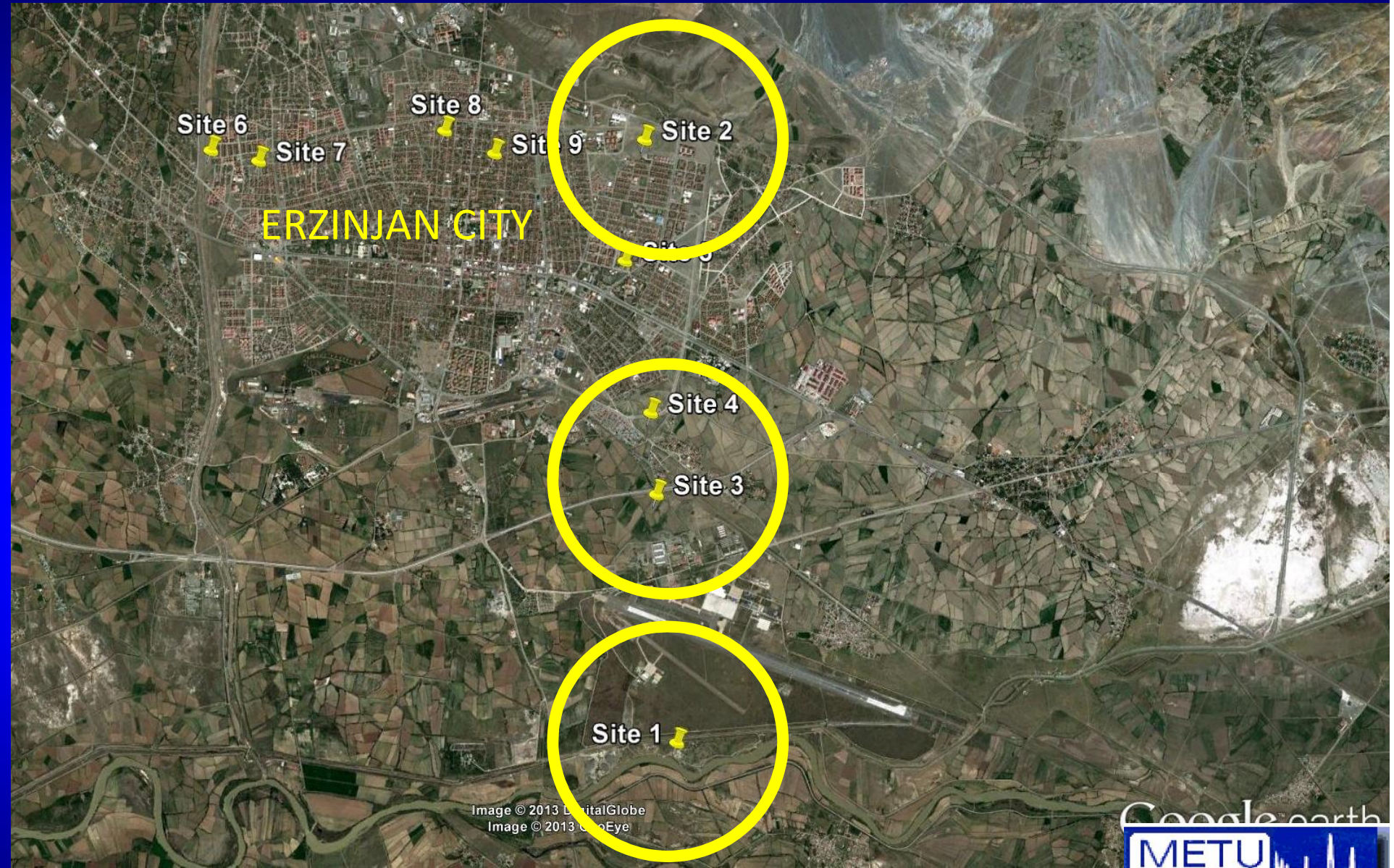
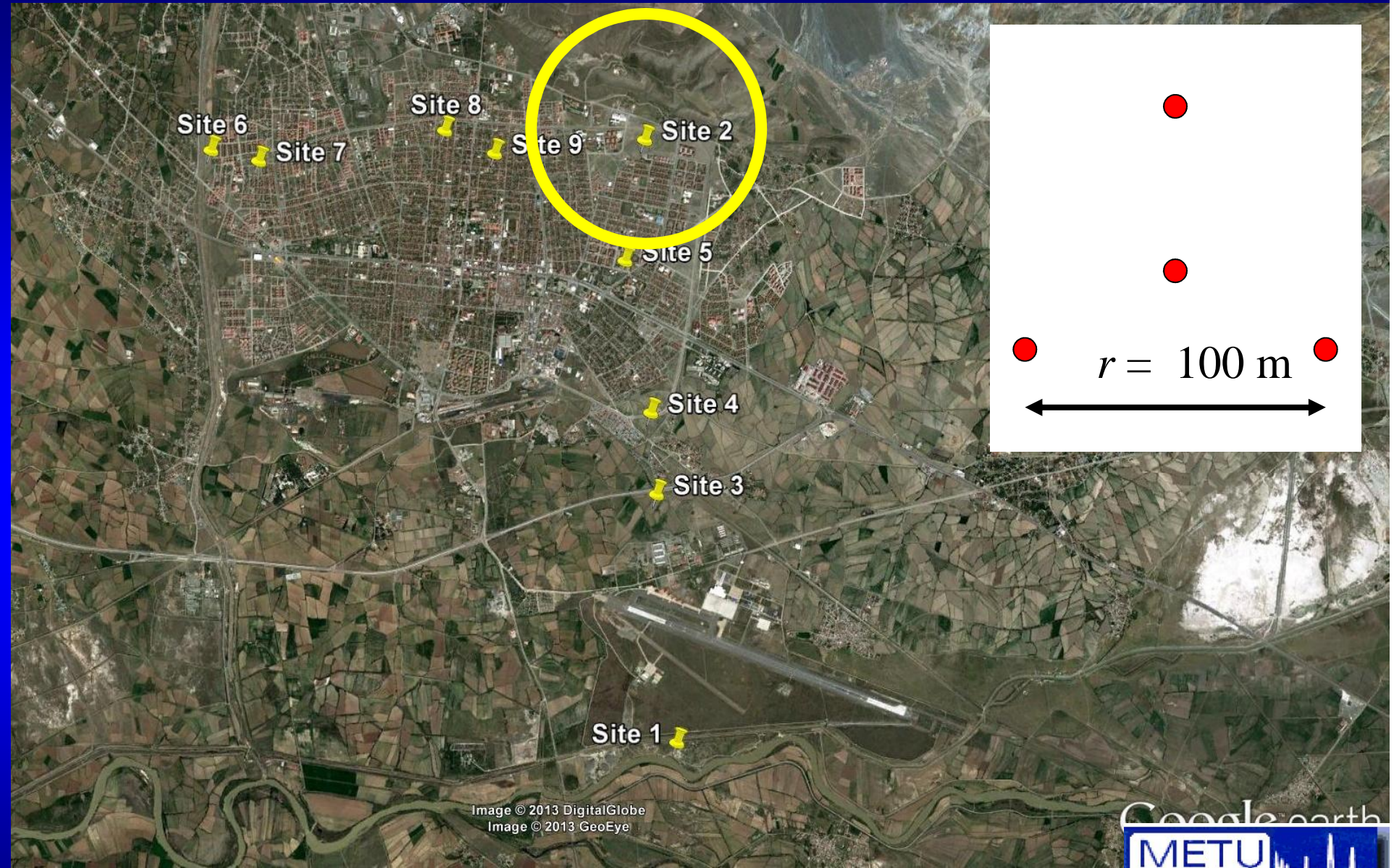


Image © 2013 DigitalGlobe
Image © 2013 GeoEye

Google earth







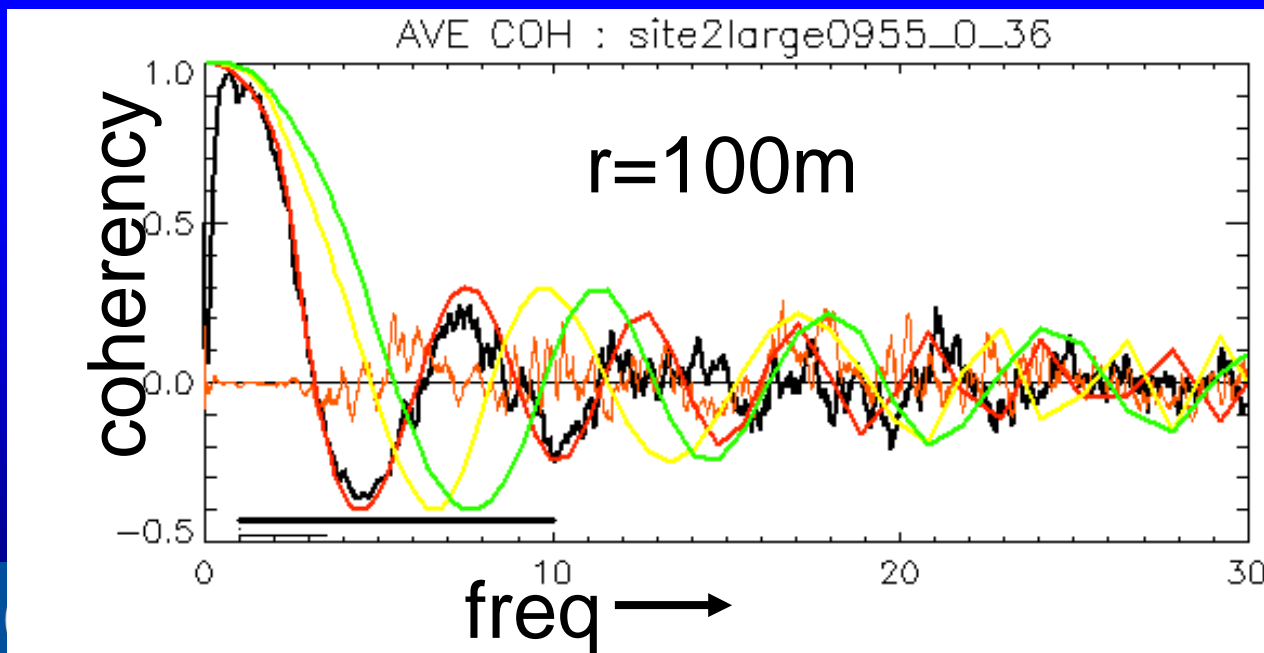
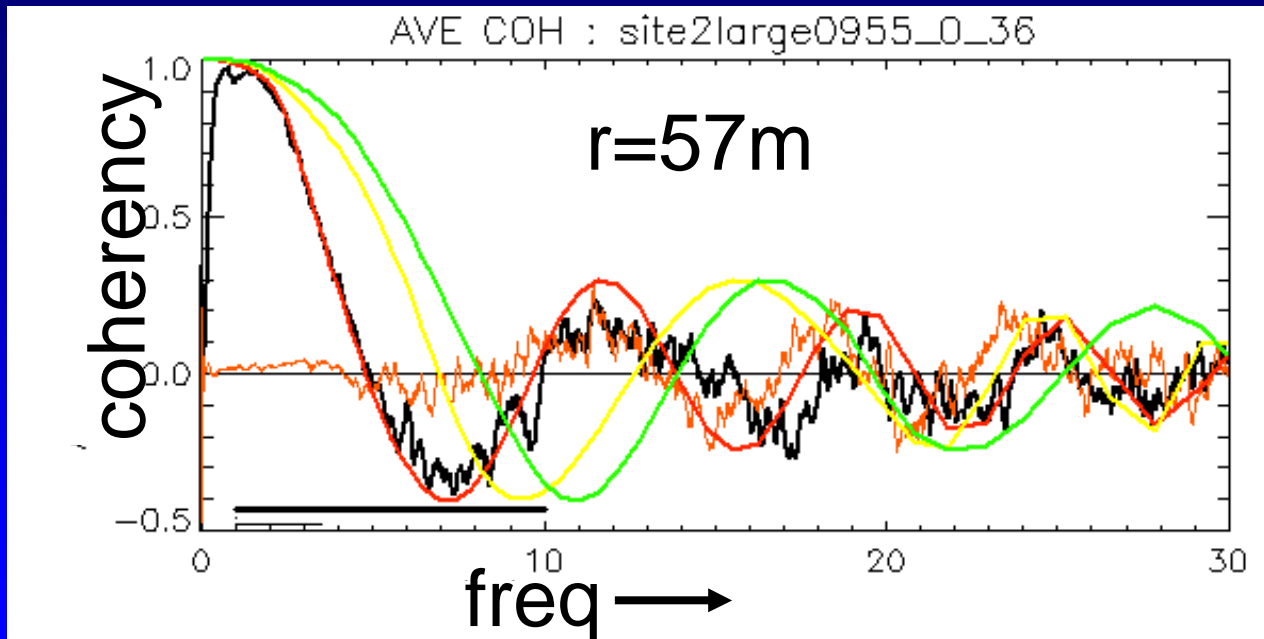


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UNIVER





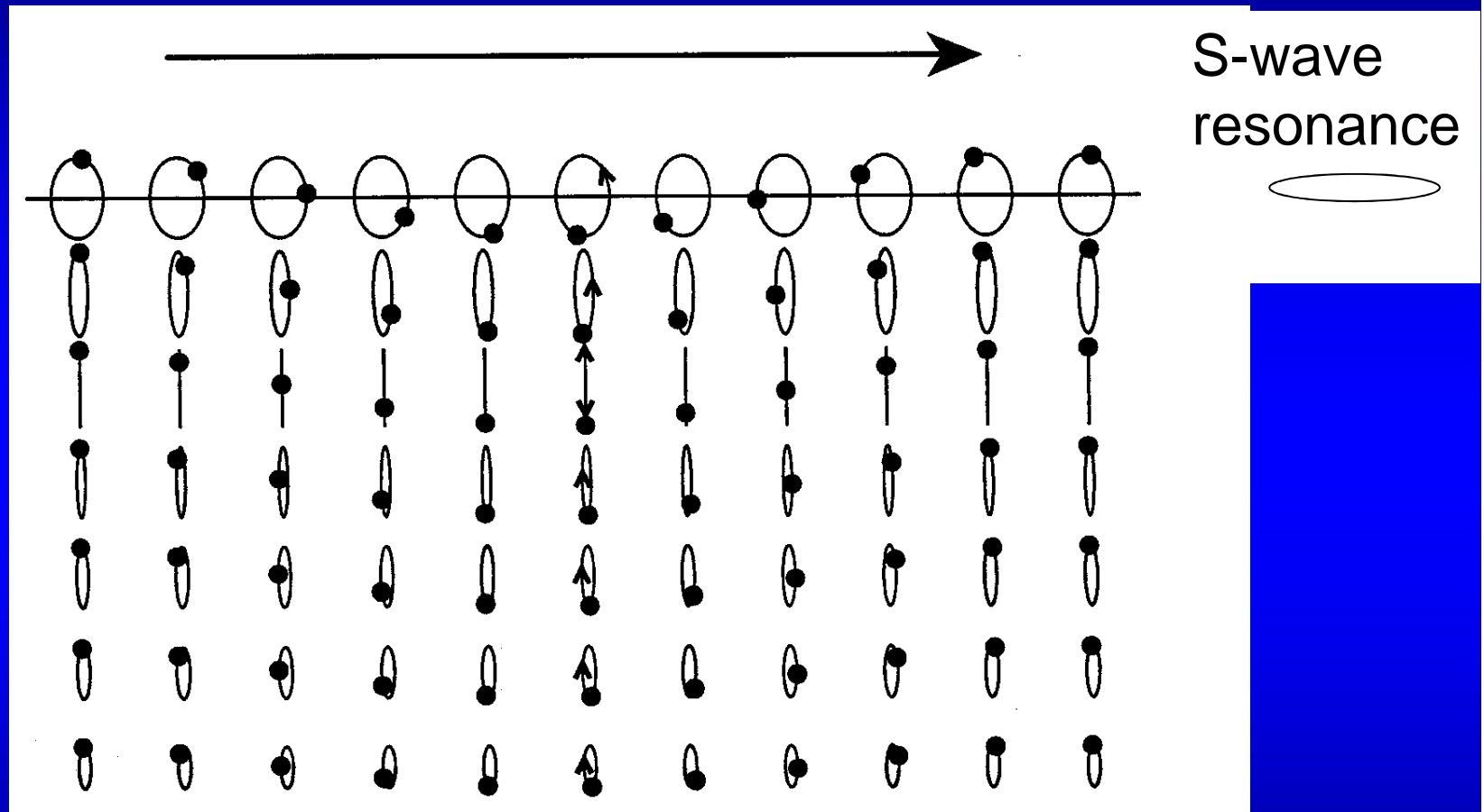
SPATIALLY AVERAGED COHERENCY

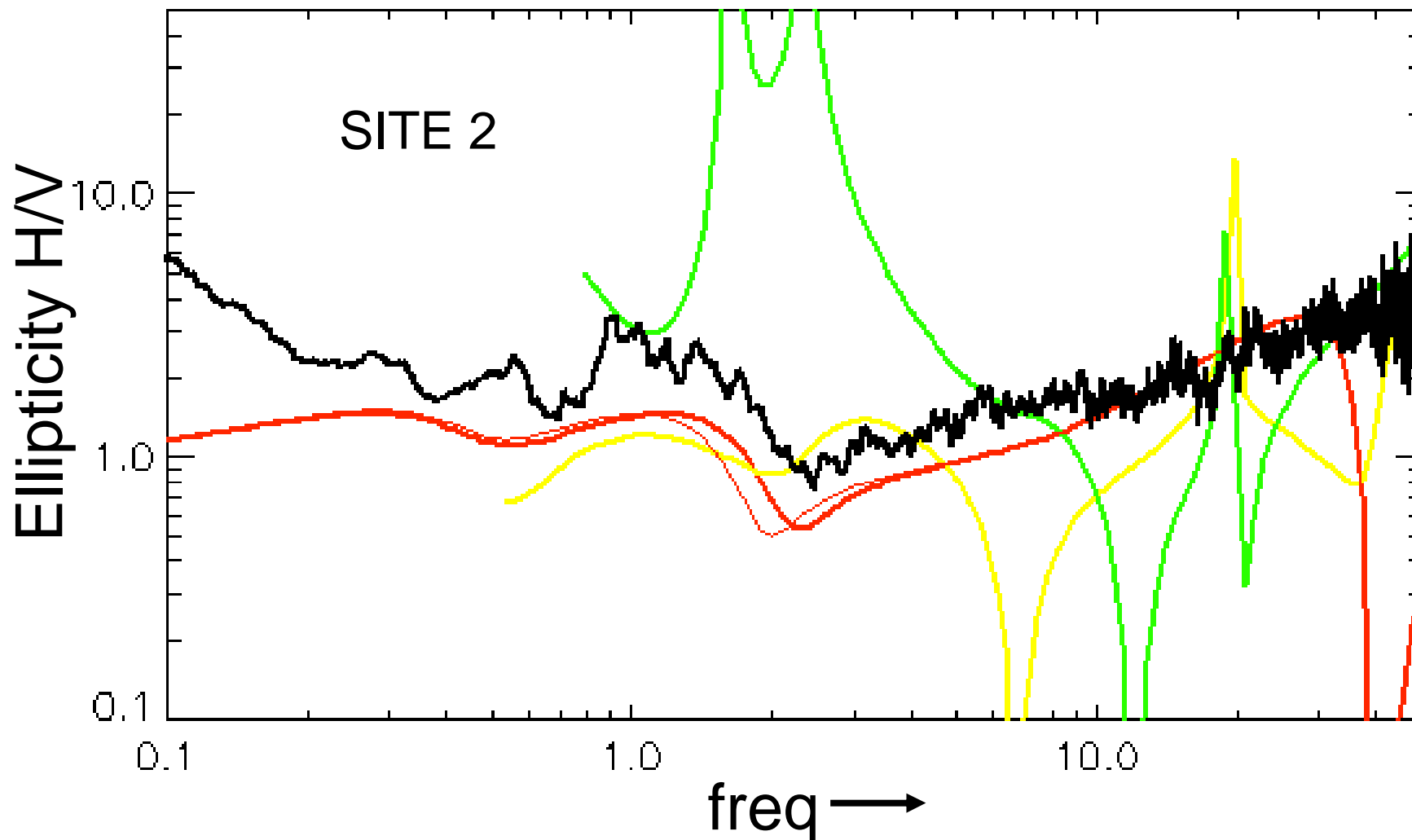
SITE 2
100 m triangle
array

Black line –
observed
coherency
spectrum

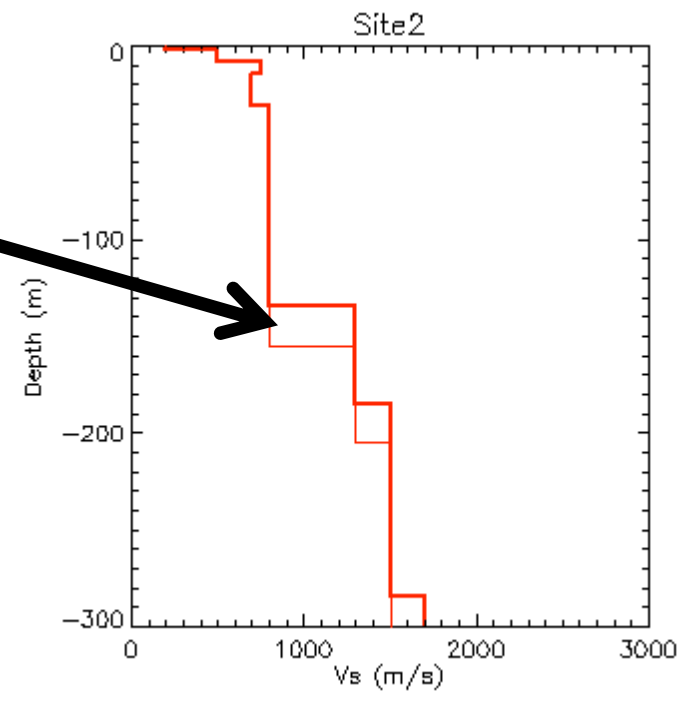
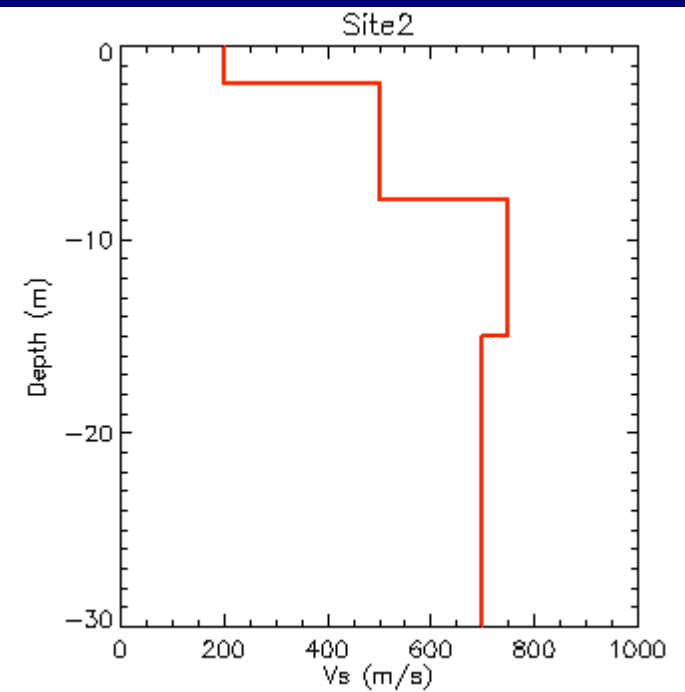
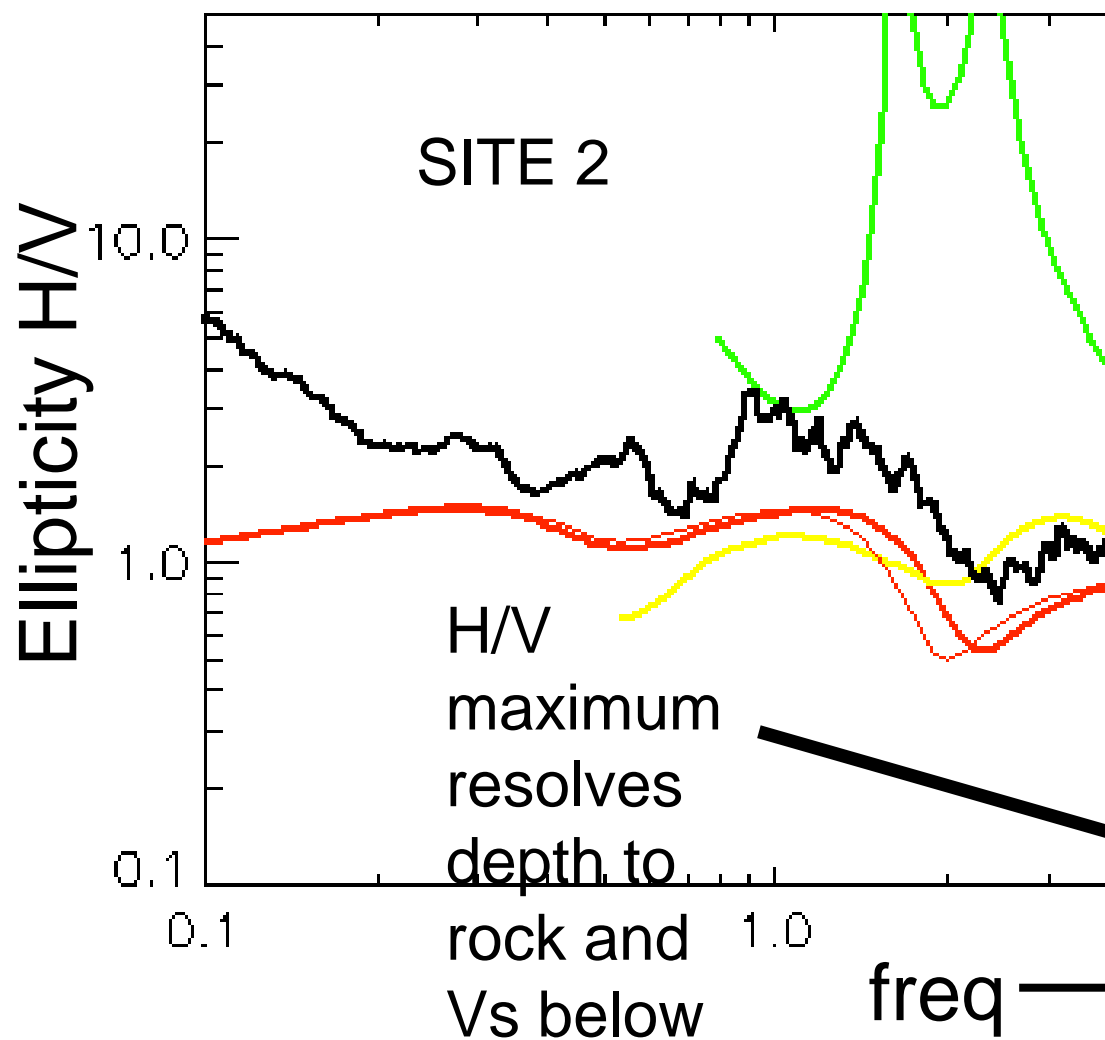
Red line: fitted
model coherency
spectrum, for best
fit layered earth
model.

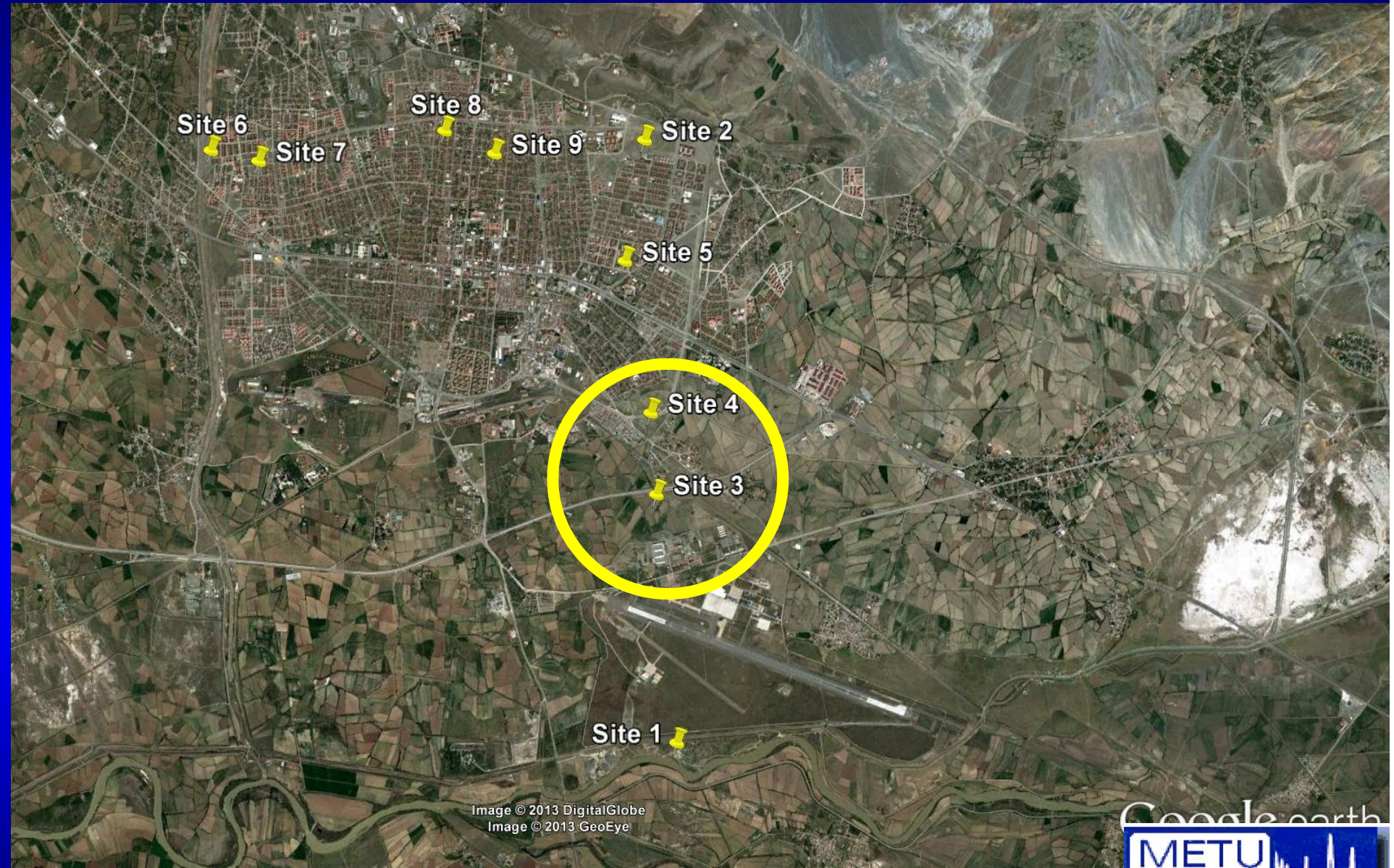
Rayleigh wave particle motion



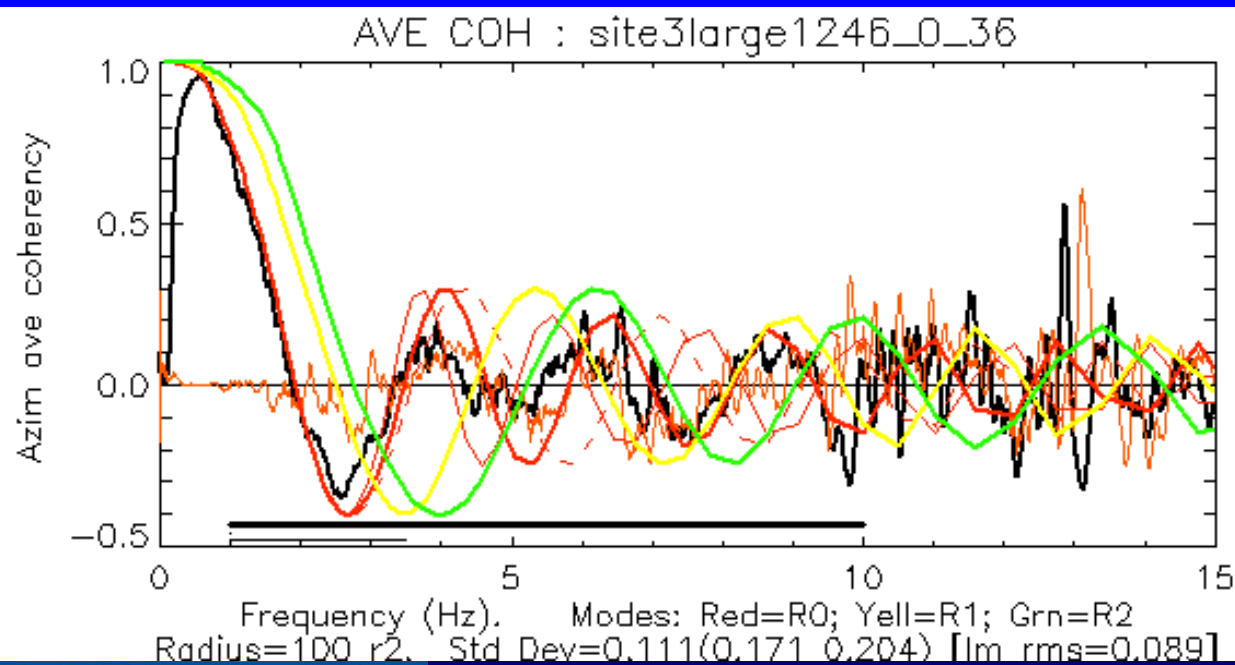
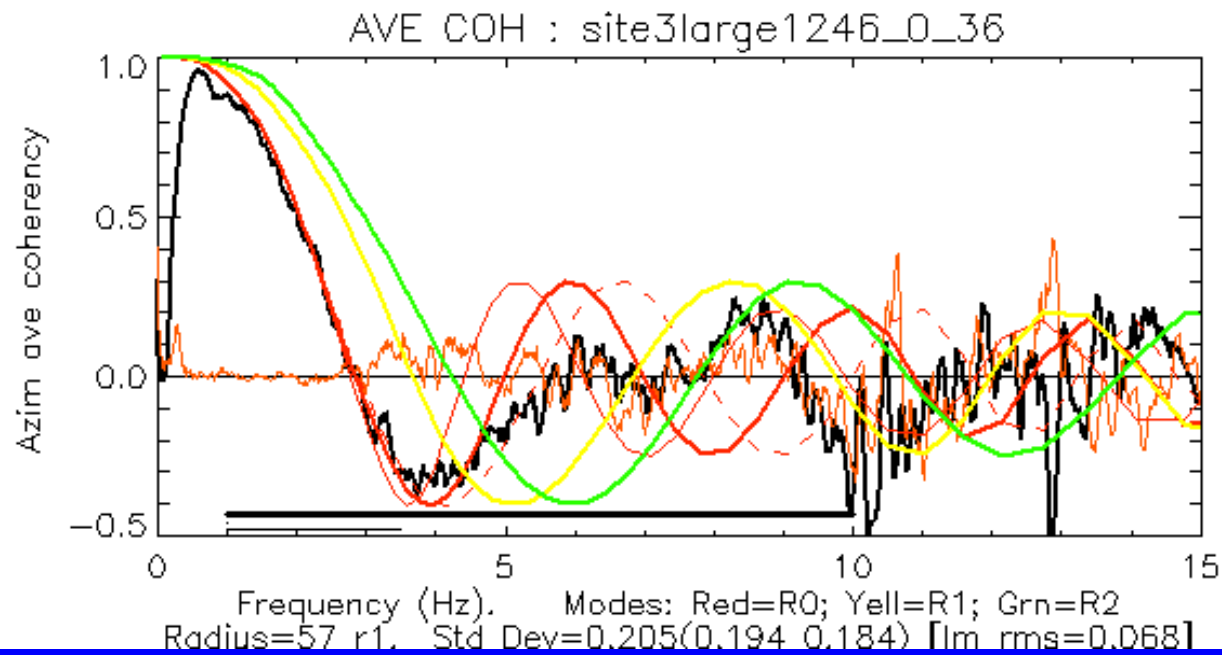


SITE 2: Black line – observed H/V spectrum
Red line: fitted model H/V spectrum, for best fit layered earth model.

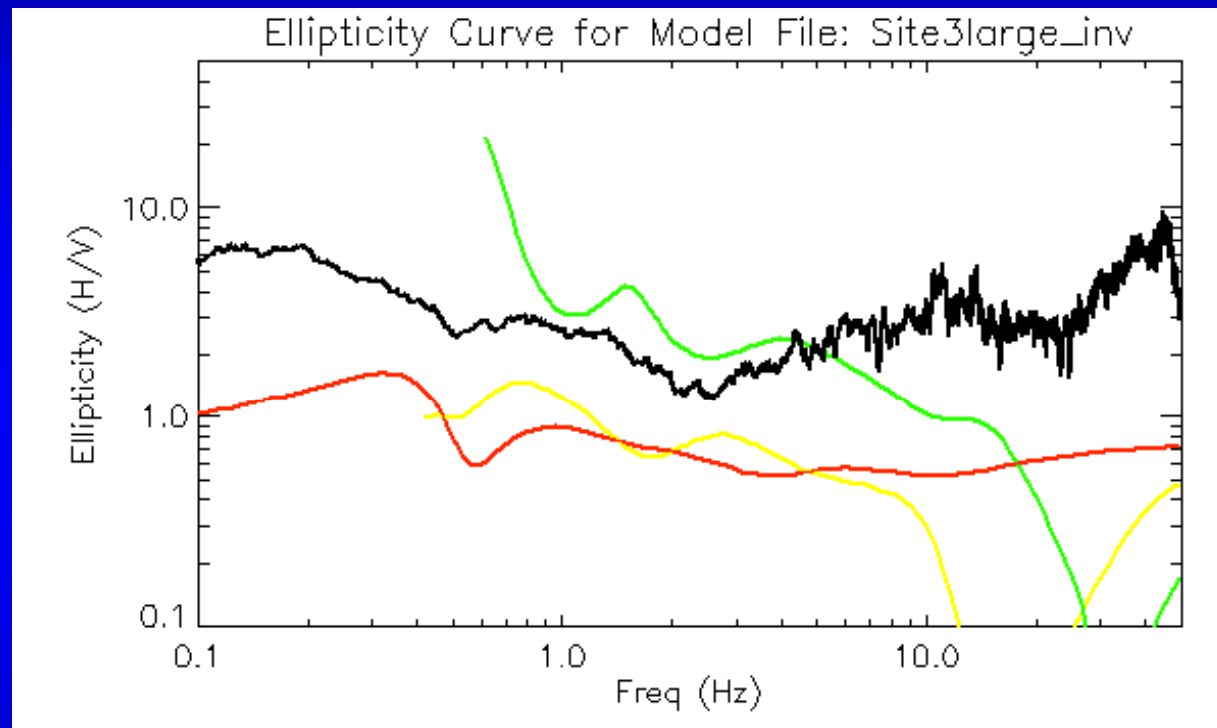




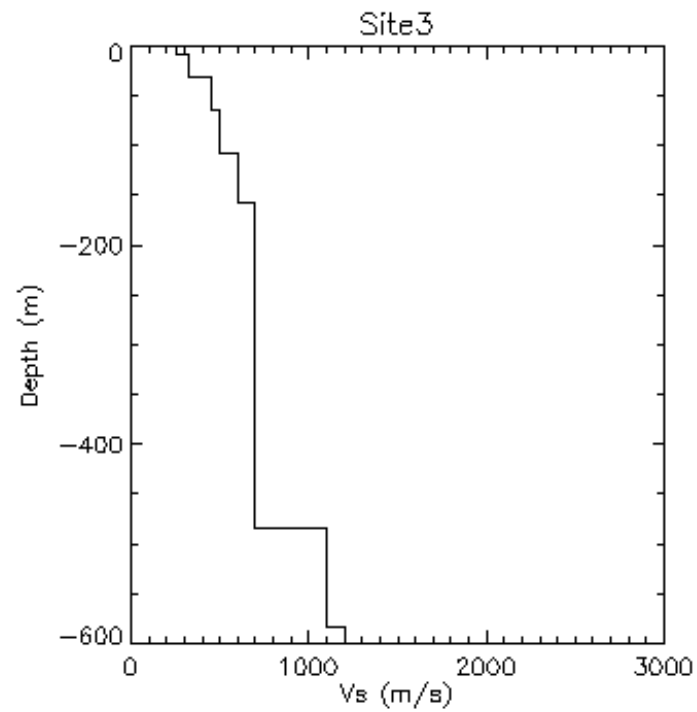
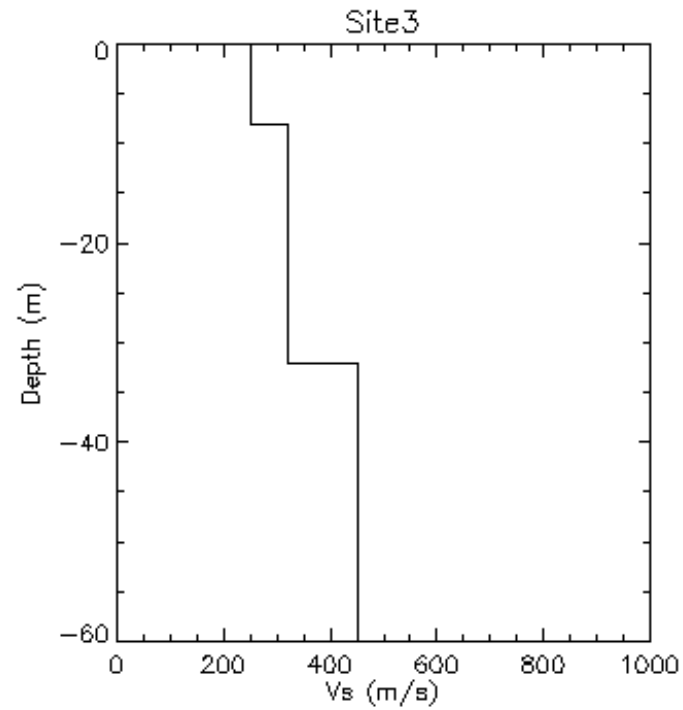
SITE 3
100m
triangle
array

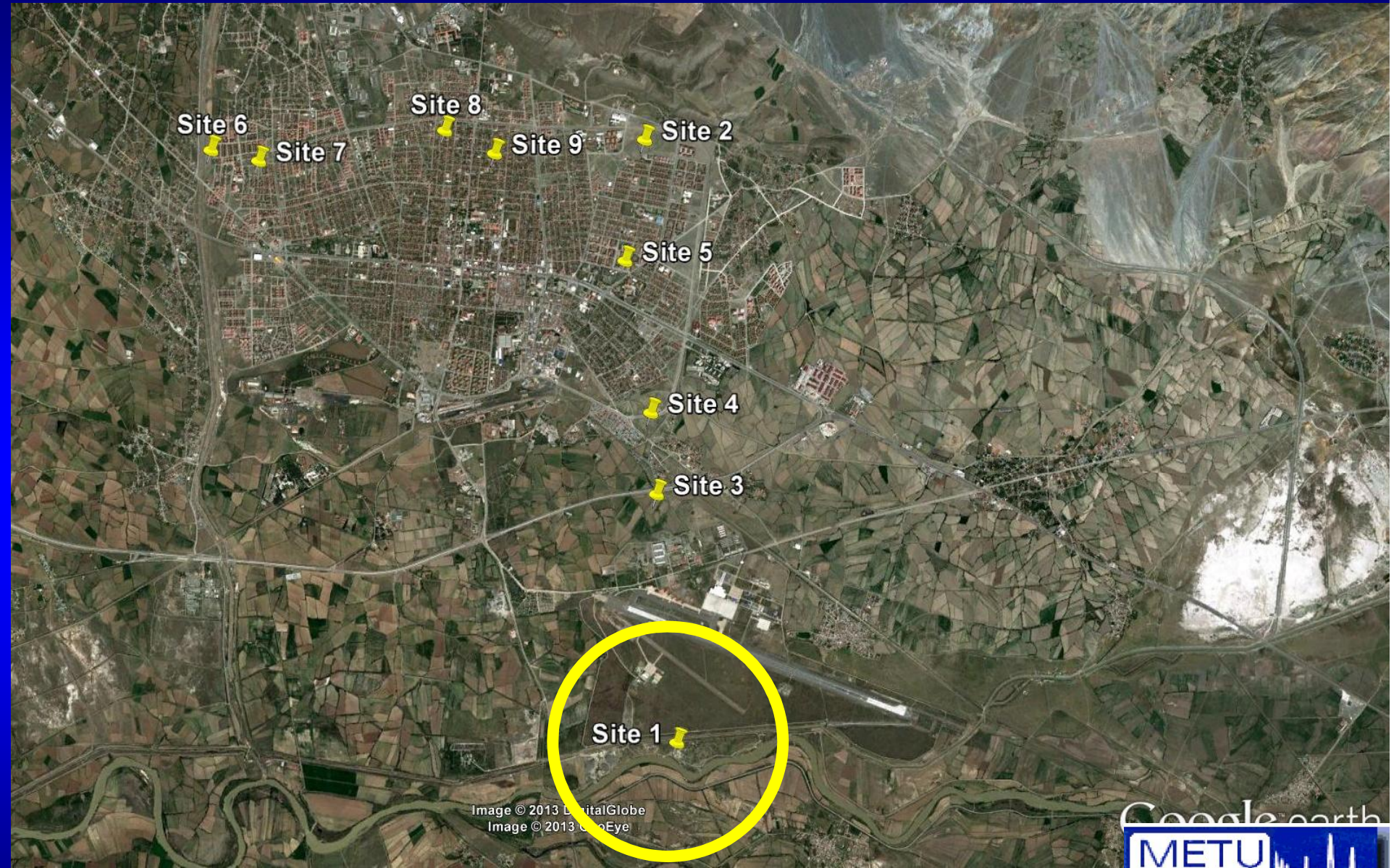


SITE 3



SITE 3





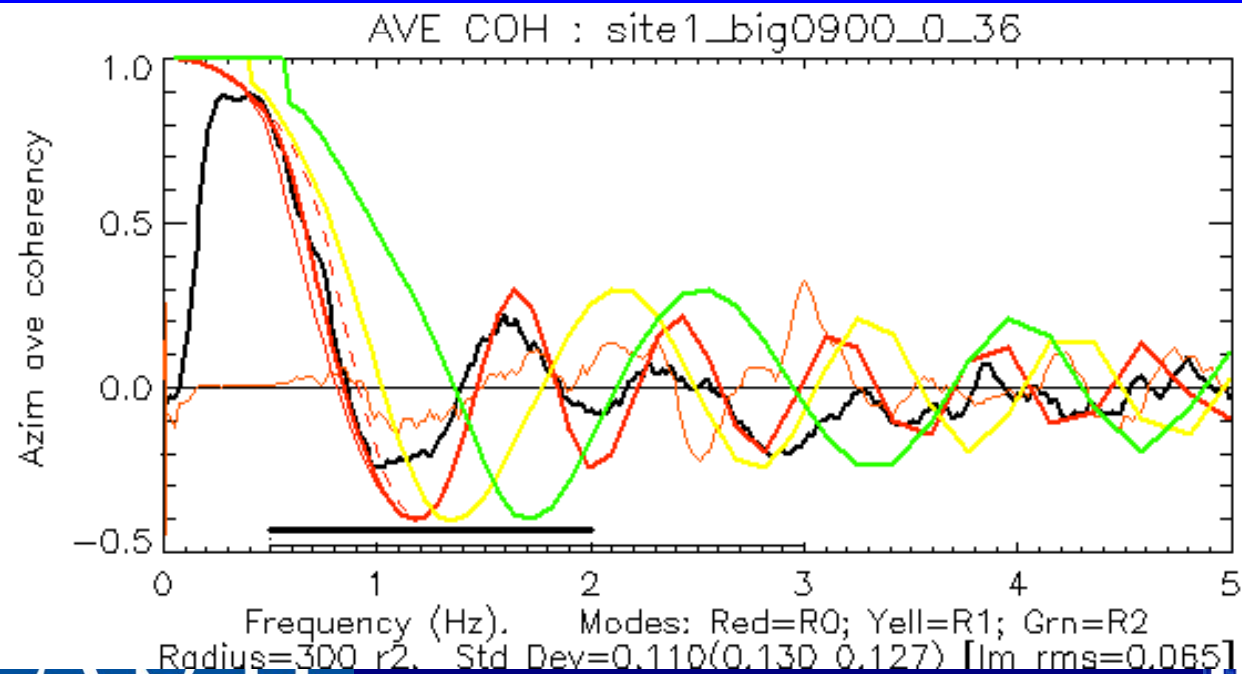
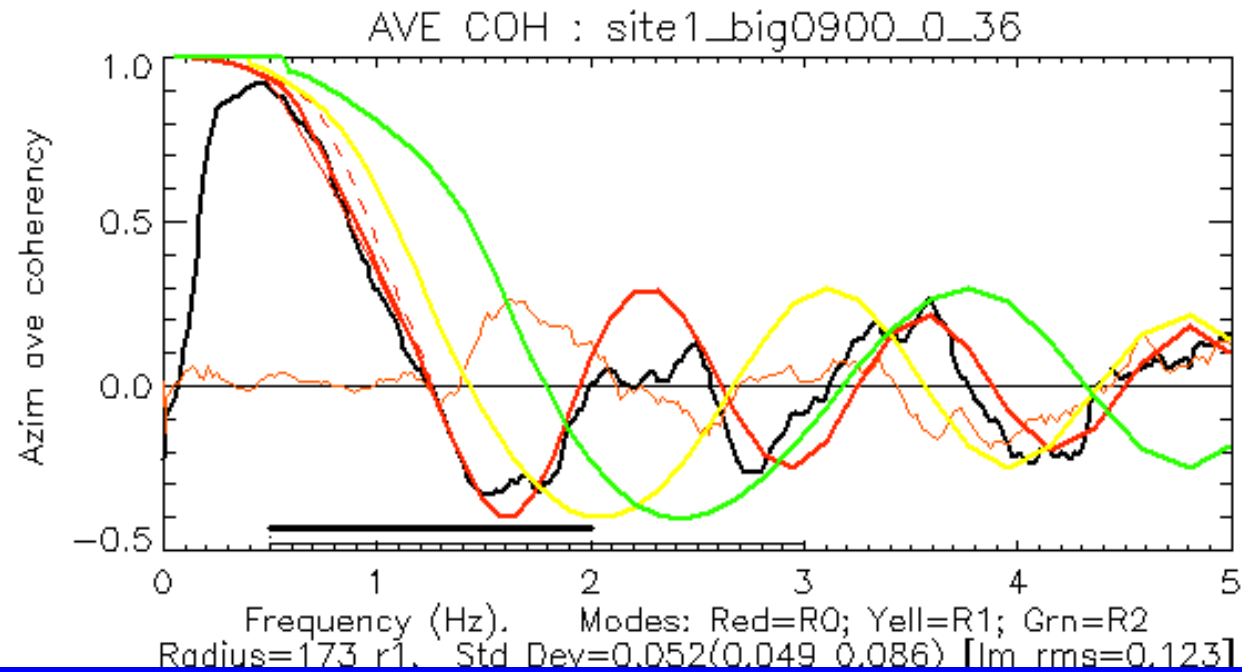


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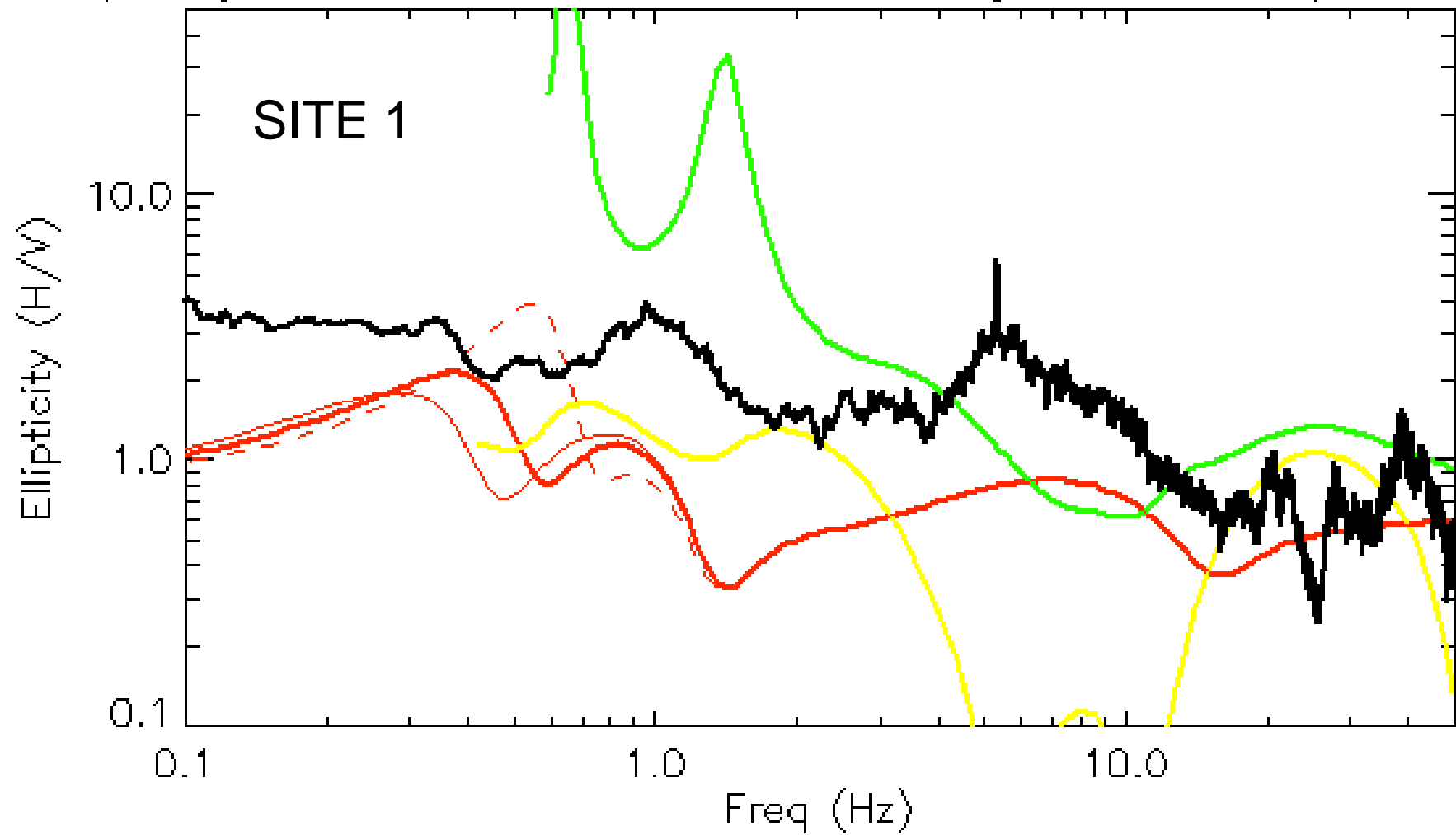


SITE 1

300m
triangle
array

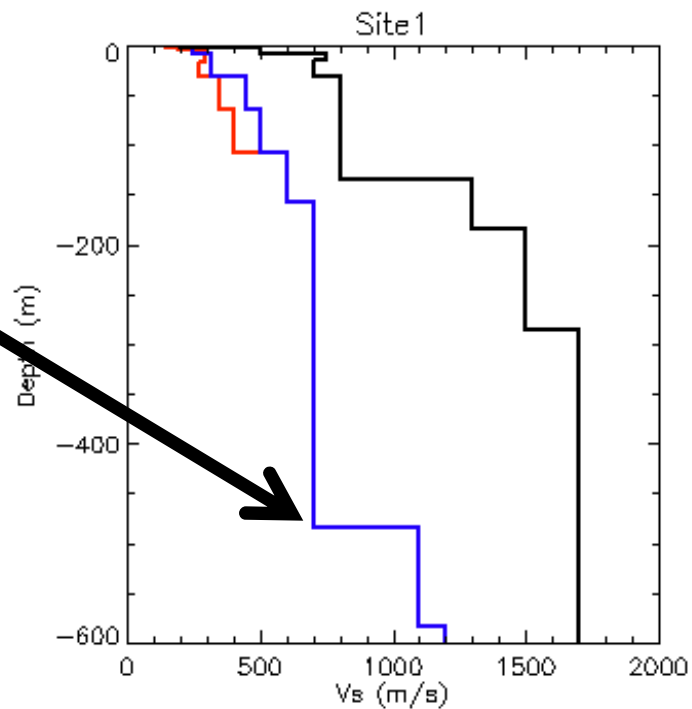
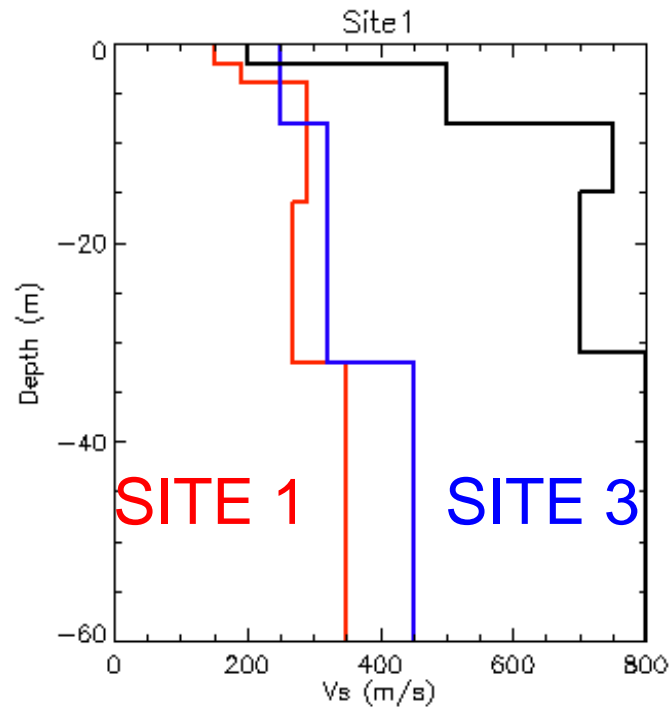


Ellipticity Curve for Model File: Site1bigto6DDm_3topMud_inv



SPAC 0.5
Hz
resolves
depth to
rock at
470m, and
Vs below
470m

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SITE 2



SUMMARY OF MICROTREMOR APPLICATIONS

NEWCASTLE: basement 20-100m depth

PROMINENT HILL: basement 100-200m
depth

Erzincan (Turkey): basement 470m depth