The Relationship Between Sediment Properties & Sedimentation Patterns on a Macrotidal Gravel Beach over a Semi-lunar Tidal Cycle.

Daniel Buscombe & Gerhard Masselink.

School of Geography, & Centre for Coastal Dynamics and Engineering (C-CoDE),
University of Plymouth, UK.

American Geophysical Union Fall Meeting, December 2007;
San Francisco, USA.

Talk Outline

What can beach sedimentology tell us about morphodynamics?

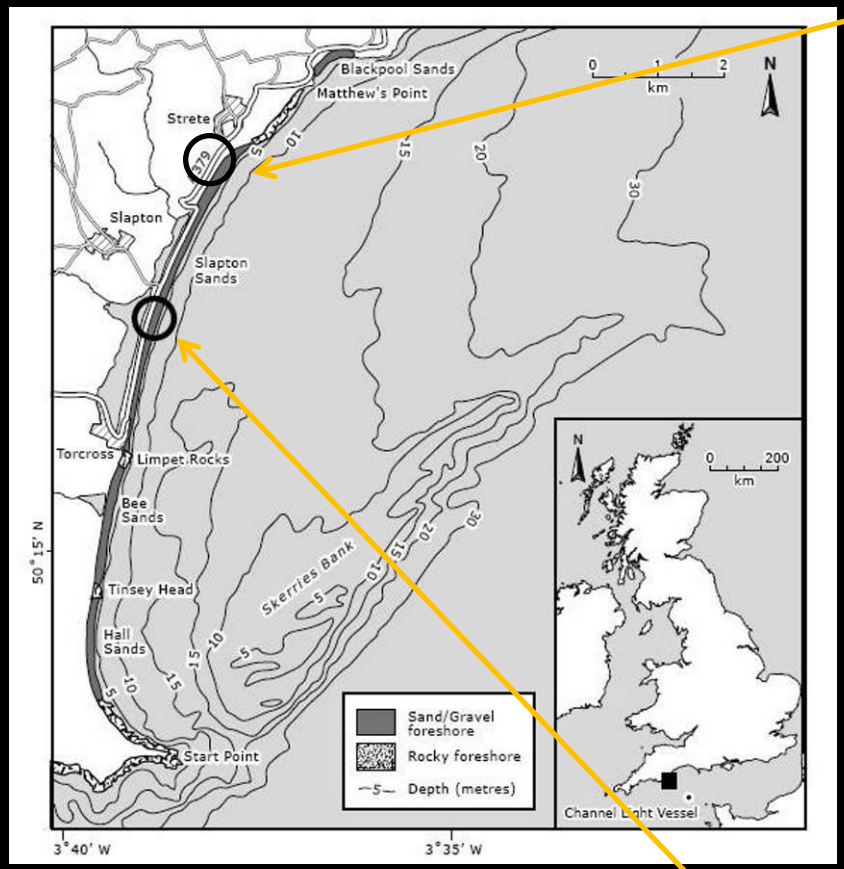
Does morphological and sedimentological change co-vary?

Not using linear statistics based on correlation → You have to use some relatively advanced techniques

Sedimentology of secondary morphological features & spatial differentiation of sedimentary properties on beaches is poorly understood

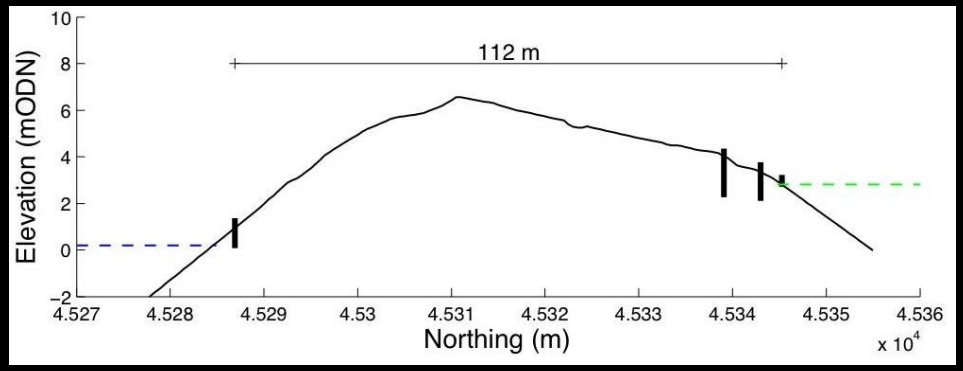
It is often assumed that changes in sedimentology are merely a by-product of morphodynamics

Two Field Sites & Data Sets.



Strete, 2 - 6 mm

Slapton, 4 - 10 mm



Two Field Sites & Data Sets.

1. Autumn 2005 - Slapton and Strete

profiles & surface samples

- every 0.5 m;
- 26 consecutive tides.

2. Spring 2007 - Strete

Profiles, surface & subsurface samples to depth of disturbance,

- every 1 m;
- 24 consecutive tides.

Strete, 2 - 6 mm

Slapton, 4 - 10 mm

Talk Outline

What can beach sedimentology tell us about morphodynamics?

Does morphological and sedimentological change co-vary?

A good data set has been collected with which to test the relationship

Not using linear statistics based on correlation

You have to use some relatively advanced techniques

No significant linear association between morphological change and sedimentological change ...

Morphological change

Sedimentological change

	σ_s	$\Delta\sigma_{si}$	$\Delta\sigma_{sm}$	$\Delta\sigma_{s1}$	σ_{ss}	$\Delta\sigma_{ssi}$	$\Delta\sigma_{ssm}$	$\Delta\sigma_{ss1}$
Slapton 2005 ΔZ_1	-0.05	0.03	0.07	0.05	-	-	-	-
Strete 2005 ΔZ_1	-0.08	0.05	-0.08	-0.05	-	-	-	-
Slapton 2005 ΔZ_i	0.15	-0.03	-0.04	-0.007	-	-	-	-
Strete 2005 ΔZ_i	0.15	-0.02	-0.07	-0.12	-	-	-	-
Strete 2007 ΔZ_1	0.15	0.02	-0.07	0.23	0.24	-0.04	-0.13	-0.02
Strete 2007 ΔZ_i	0.09	0.03	-0.07	0.03	0.06	0.11	0.06	0.08
Strete 2007 DOD	0.4	-0.003	0.05	0.29	0.46	-0.02	0.03	0.31
Strete 2007 DOD	-0.04	0.27	-0.05	-0.01	-0.03	0.26	0.02	-0.04

No significant linear association between morphological change and sedimentological change ...

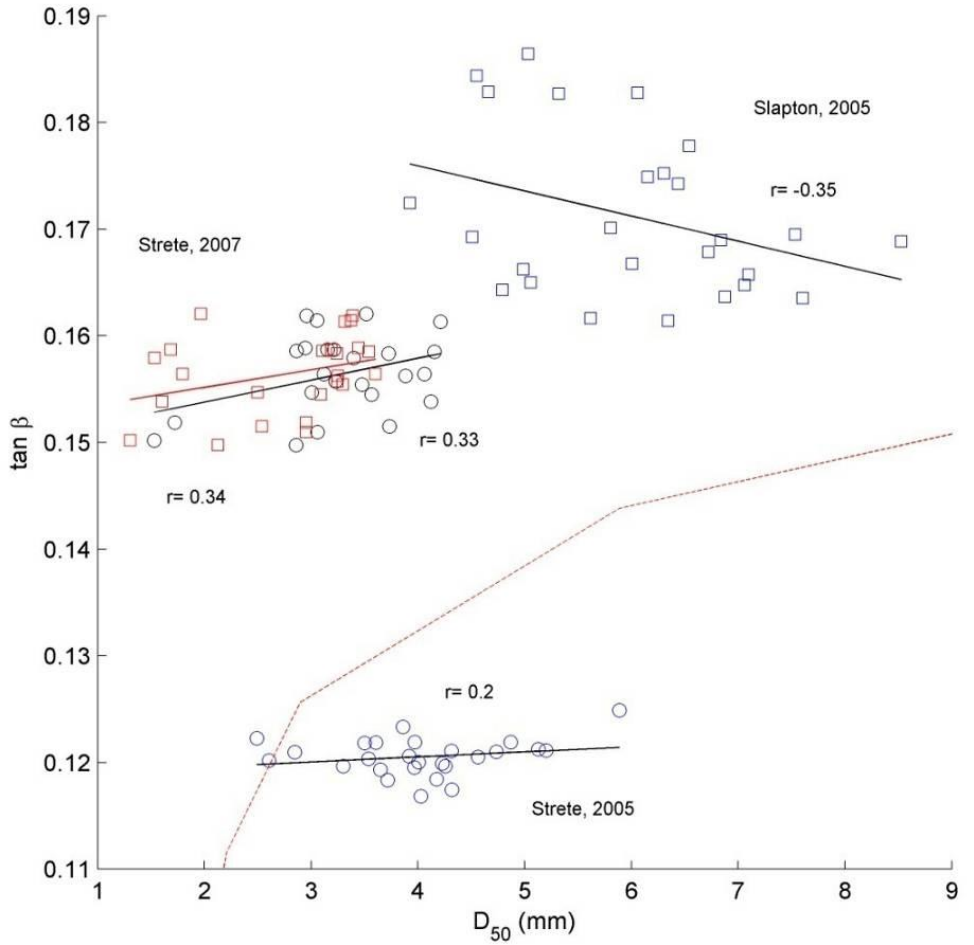
Morphological change

Sedimentological change

	σ_s	$\Delta\sigma_{si}$	$\Delta\sigma_{sm}$	$\Delta\sigma_{s1}$	σ_{ss}	$\Delta\sigma_{ssi}$	$\Delta\sigma_{ssm}$	$\Delta\sigma_{ss1}$
Slapton 2005 ΔZ_1	-0.05	0.03	0.07	0.05	-	-	-	-
Strete 2005 ΔZ_1	-0.08	0.05	-0.08	-0.05	-	-	-	-
Slapton 2005 ΔZ_i	0.15	-0.03	-0.04	-0.007	-	-	-	-
Strete 2005 ΔZ_i	0.15	-0.02	-0.07	-0.12	-	-	-	-
Strete 2007 ΔZ_1	0.15	0.02	-0.07	0.23	0.24	-0.04	-0.13	-0.02
Strete 2007 ΔZ_i	0.09	0.03	-0.07	0.03	0.06	0.11	0.06	0.08
Strete 2007 DOD	**0.4**	-0.003	0.05	**0.29**	**0.46**	-0.02	0.03	**0.31**
Strete 2007 DOD	-0.04	**0.27**	-0.05	-0.01	-0.03	**0.26**	0.02	-0.04

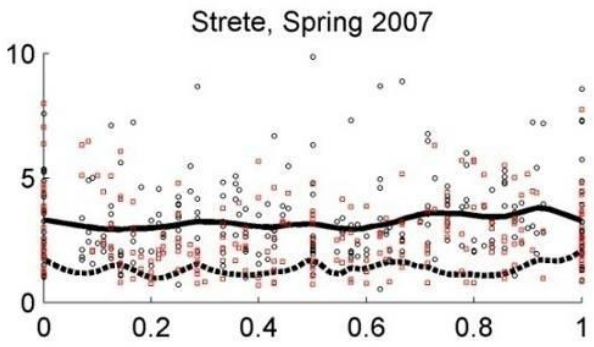
Size-slope relationships are not strong, not even to disturbance depth ...

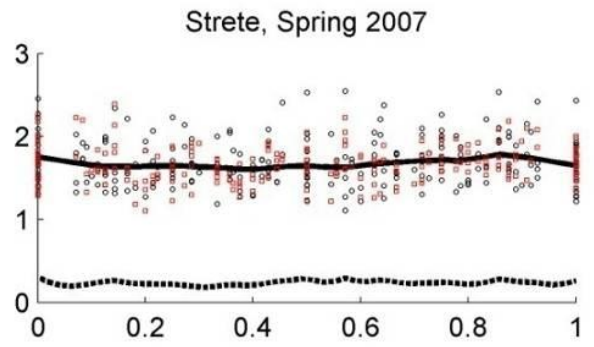
...and can be positive or negative.

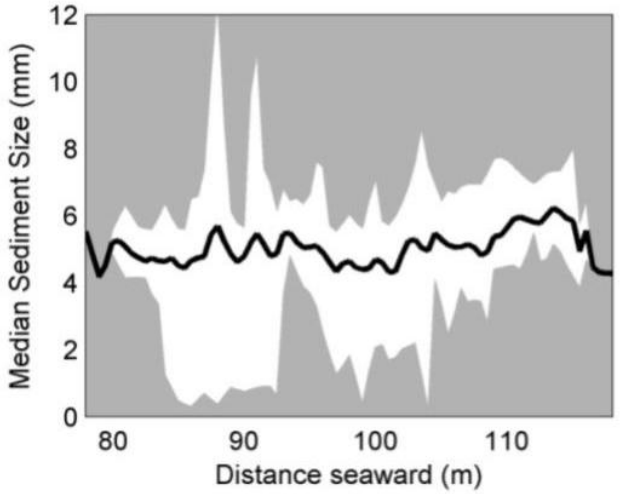


Partial correlation shows that sorting often influences the relationship.

Not even fluctuation around a ‘master’ grain size.

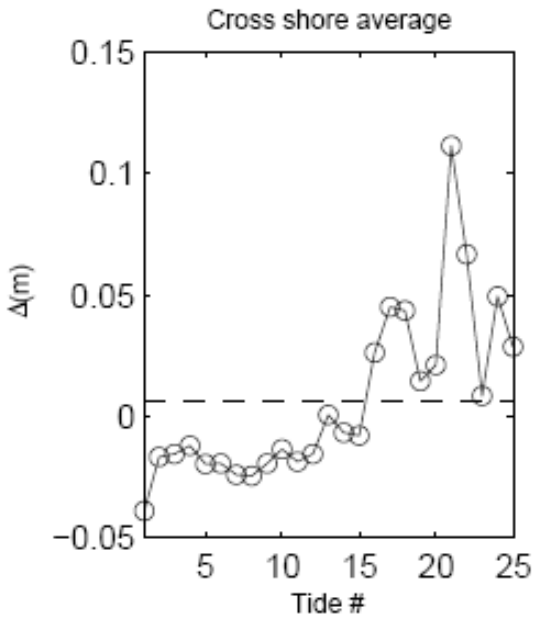


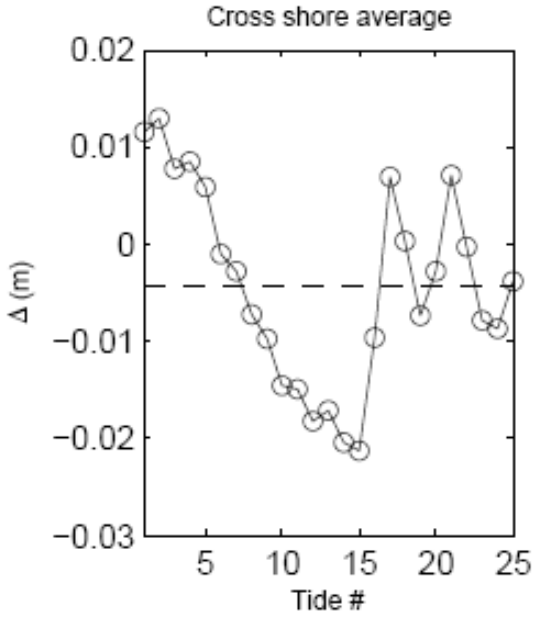




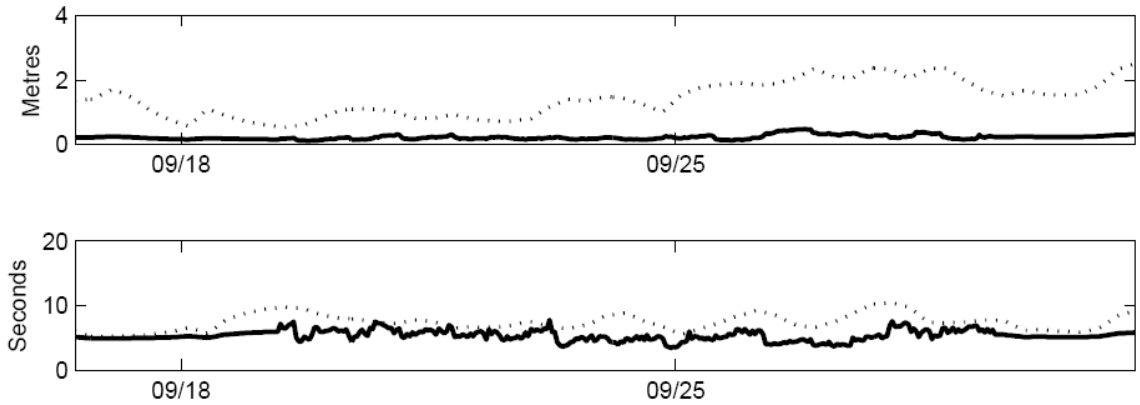
No cross-shore trends – fine beach or coarse beach, surface or sub-surface …

… spatial trends actually diminish the larger the scale over which one averages.





Inconsistent response between sites to similar synoptic wave conditions



... and between wave/tide & morphological response.

Talk Outline

What can beach sedimentology tell us about morphodynamics?

Does morphological and sedimentological change co-vary?

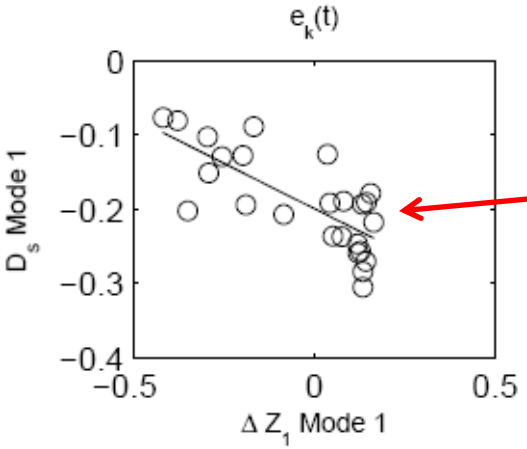
Not using linear statistics based on correlation

You have to use some relatively advanced techniques

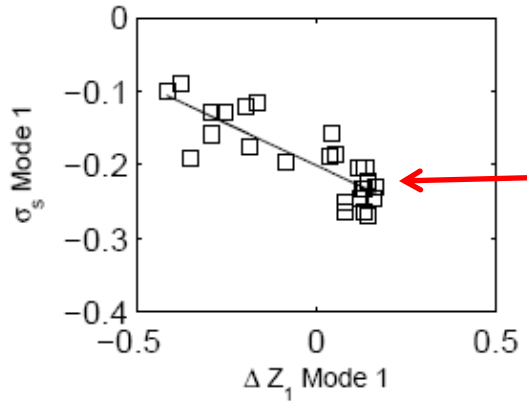
Gravel beach sedimentology, traditionally parameterised, is highly stochastic.

No spatial structure, little temporal trends.

Empirical Orthogonal Function analysis revealed modes of sediment size/sorting & morphological change with significant linear association.



Morph. change mode 1 vs D_{50} mode 1



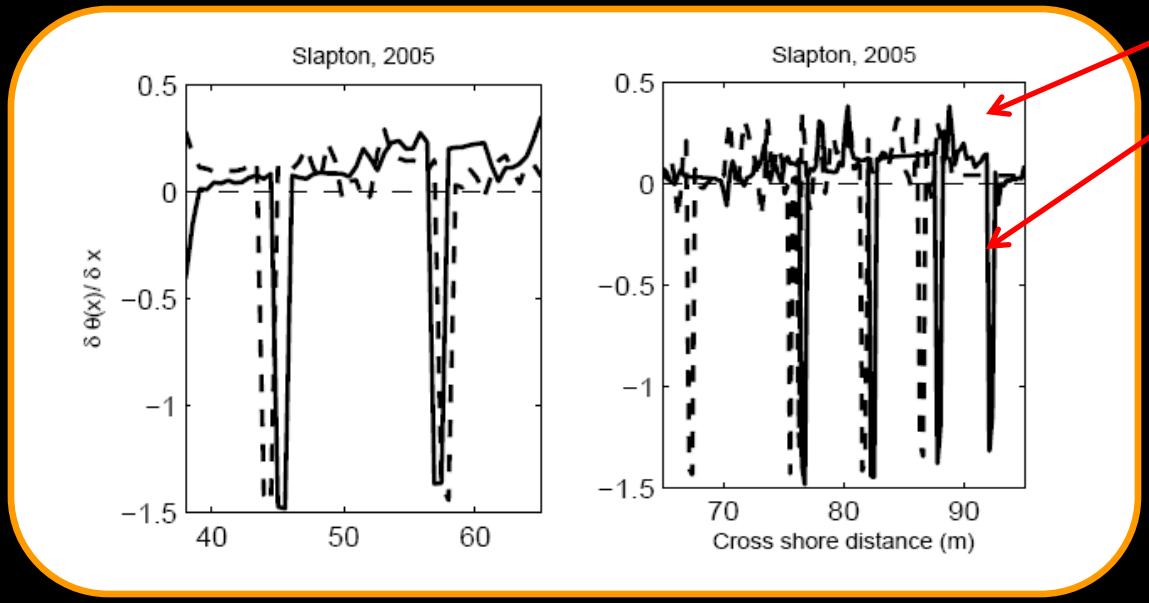
Morph. change mode 1 vs sorting mode 1

	D_s
EOFs, Slapton 2005	4
EOFs, Strete 2005	5
EOFs, Strete 2007	5

Also confirmed sorting less ‘noisy’ than size.

	σ_s
EOFs, Slapton 2005	3
EOFs, Strete 2005	4
EOFs, Strete 2007	2

Complex Empirical Orthogonal Function analysis revealed that propagating features present.



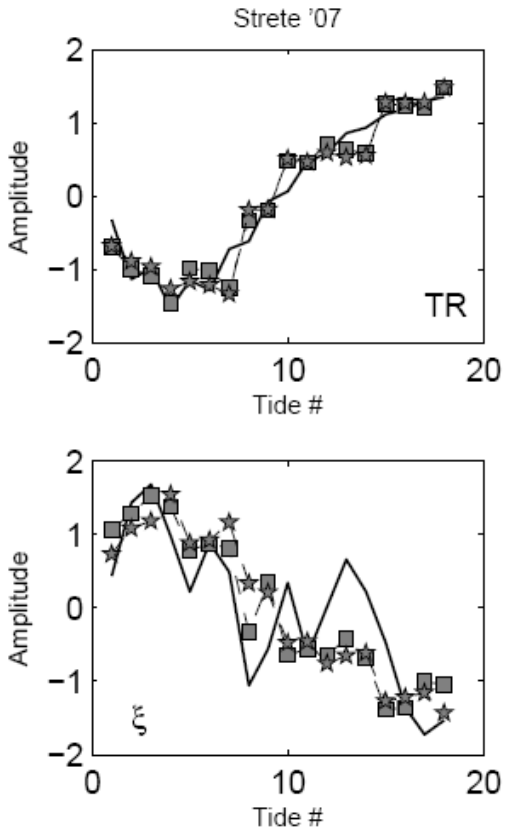
	D_s
CEOFs, Slapton 2005	5
CEOFs, Strete 2005	5
CEOFs, Strete 2007	6

	σ_s
CEOFs, Slapton 2005	3
CEOFs, Strete 2005	4
CEOFs, Strete 2007	4

Derivatives of spatial phase functions.

Possibly indicates sediment source and sink regions.

Canonical Correlation Analysis revealed morpho-sedimentary eigenmode pairs strongly related to hydrodynamic forcing.



... evidence that morpho-sedimentary change has some detectable cause.

Tidal range

Wave Height

Slapton	TR	ϵ_s	ϵ_w	H_s	T_s	$\overline{\theta}$	ξ	GF	ε
$[\Delta Z_1, 1; D_s, 1]$	0	0.88	0.16	0	0.74	0.83	0.81	0.3	0.97
$[\Delta Z_1, 1; D_s, 2]$	0	0.97	0.02	0	0.6	0.02	0.75	0.18	0.16
$[\Delta Z_1, 4; D_s, 2]$	0	0.07	0.052	0	0.36	0.01	0.2	0.84	0.52
$[\Delta Z_1, 1; \sigma_s, 1]$	0	0.83	0	0	0.8	0.1	0.81	0.16	0.94
$[\Delta Z_1, 1; \sigma_s, 2]$	0	0.95	0.042	0	0.67	0.06	0.8	0.29	0.28
$[\Delta Z_1, 4; \sigma_s, 1]$	0	0.052	0	0	0.58	0.07	0.41	0.07	1
$[\Delta Z_1, 4; \sigma_s, 2]$	0	0.07	0.02	0	0.41	0.02	0.24	0.53	0.77

Talk Outline

What can beach sedimentology tell us about morphodynamics?

Does morphological and sedimentological change co-vary?

Not using linear statistics based on correlation

You have to use some relatively advanced techniques

Identifying relationships between hydro-, morpho-, & sedimento- logical parameters possible…

…but may require dimensional-decomposition techniques

Sorting might be more useful than median size.

Thanks for listening.

Field Assistants:
Dr Martin Austin,
Isabelle Emmanuel,
Amaia Ruiz de Alegria,
David Dawson,
Tom Deacon,
Richard Hartley,
Dr Richard Charman,
Tamsin Watt.