

Coherence of off-shore steric height and island sea level

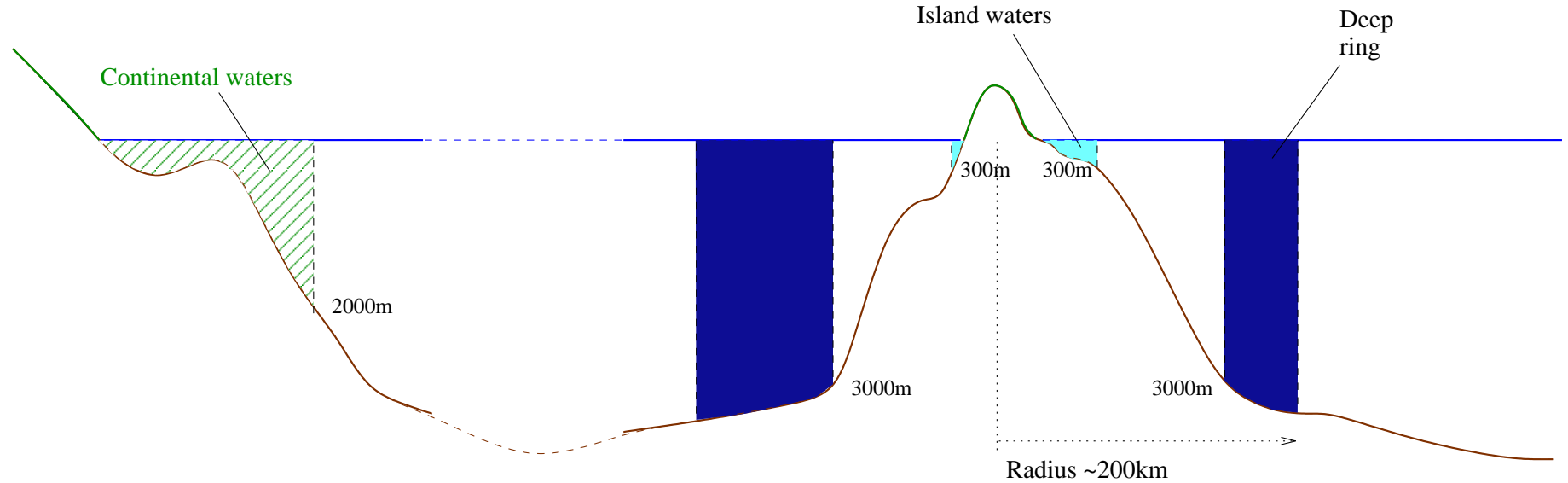
Joanne Williams, Chris W. Hughes

National Oceanography Centre, Liverpool, UK

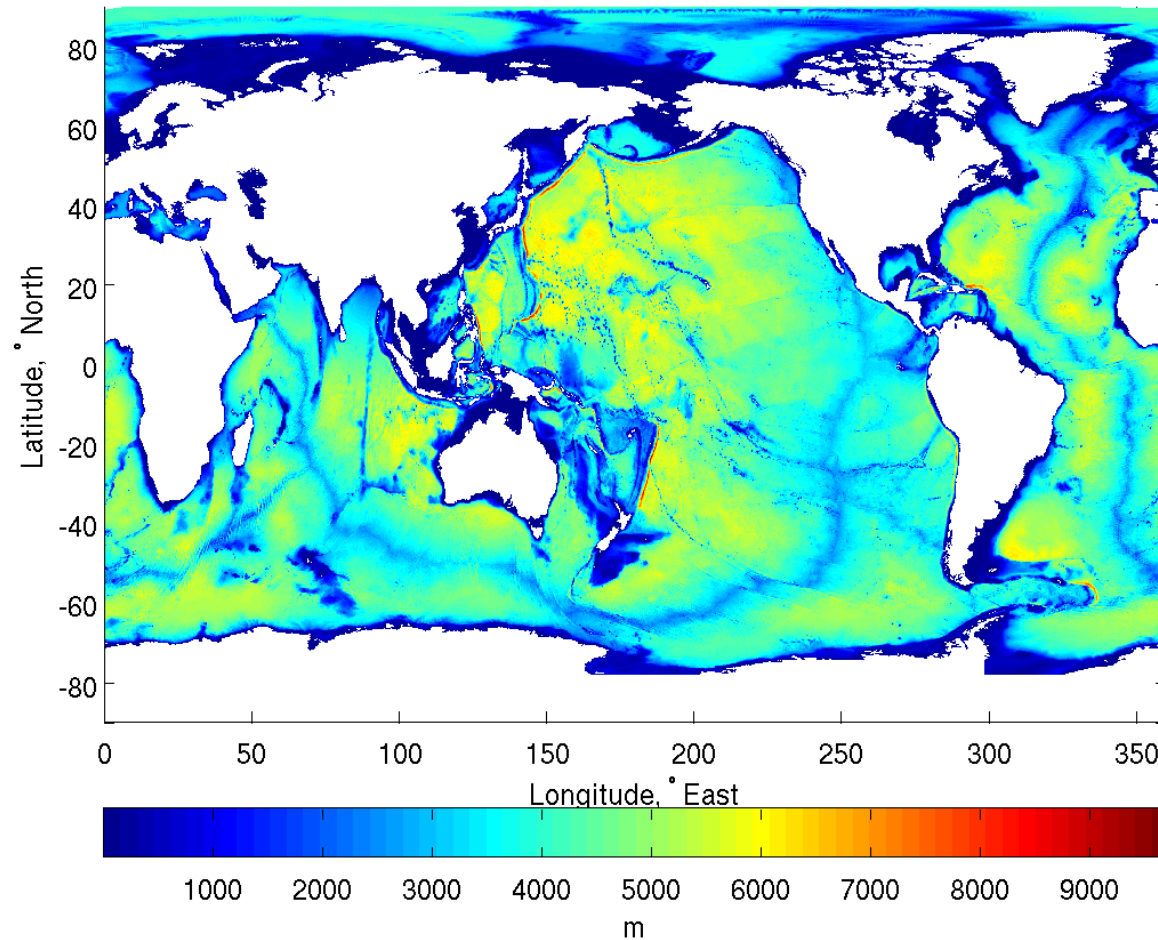
joll@noc.ac.uk

European Geophysical Union
April 2012

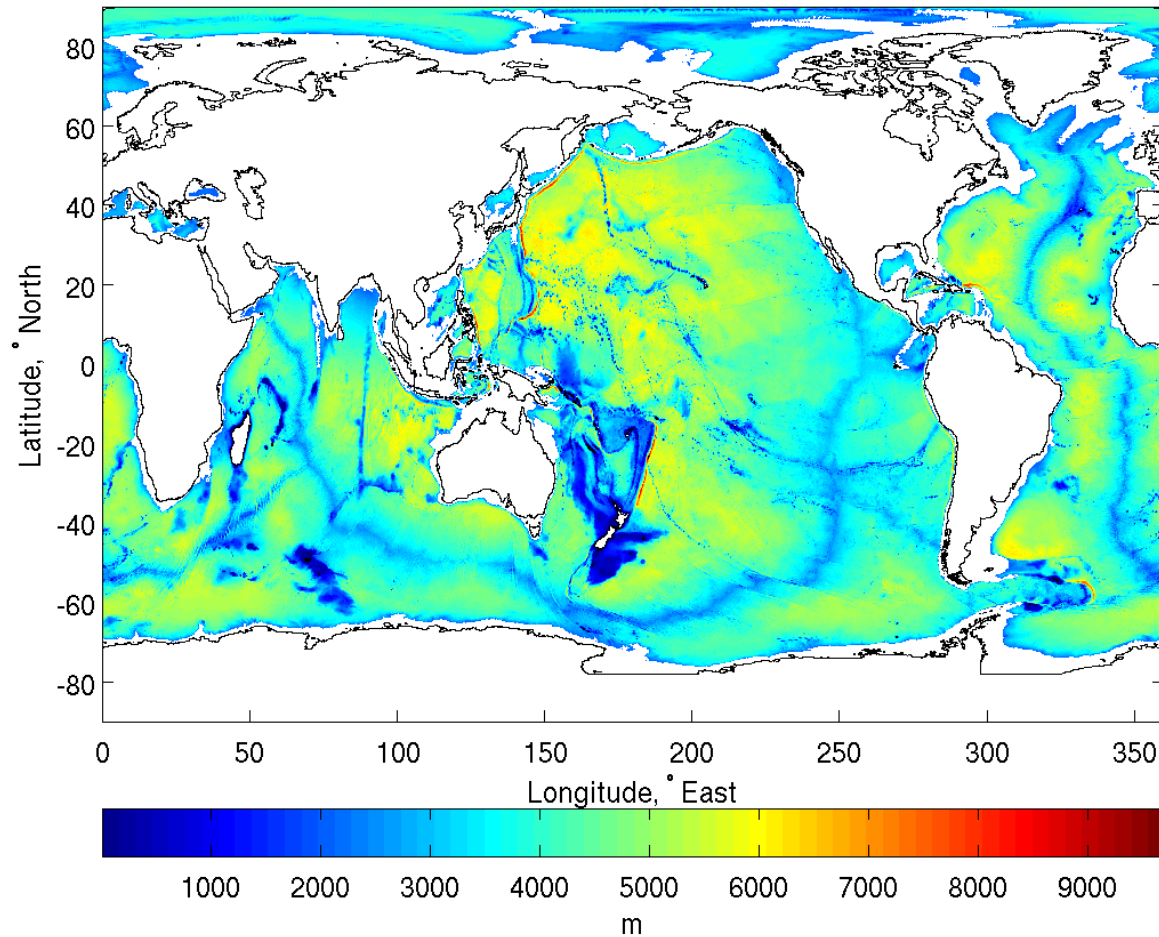
How does the sea-level (ssh) signal at a mid-ocean island relate to sea-level in deep water nearby?



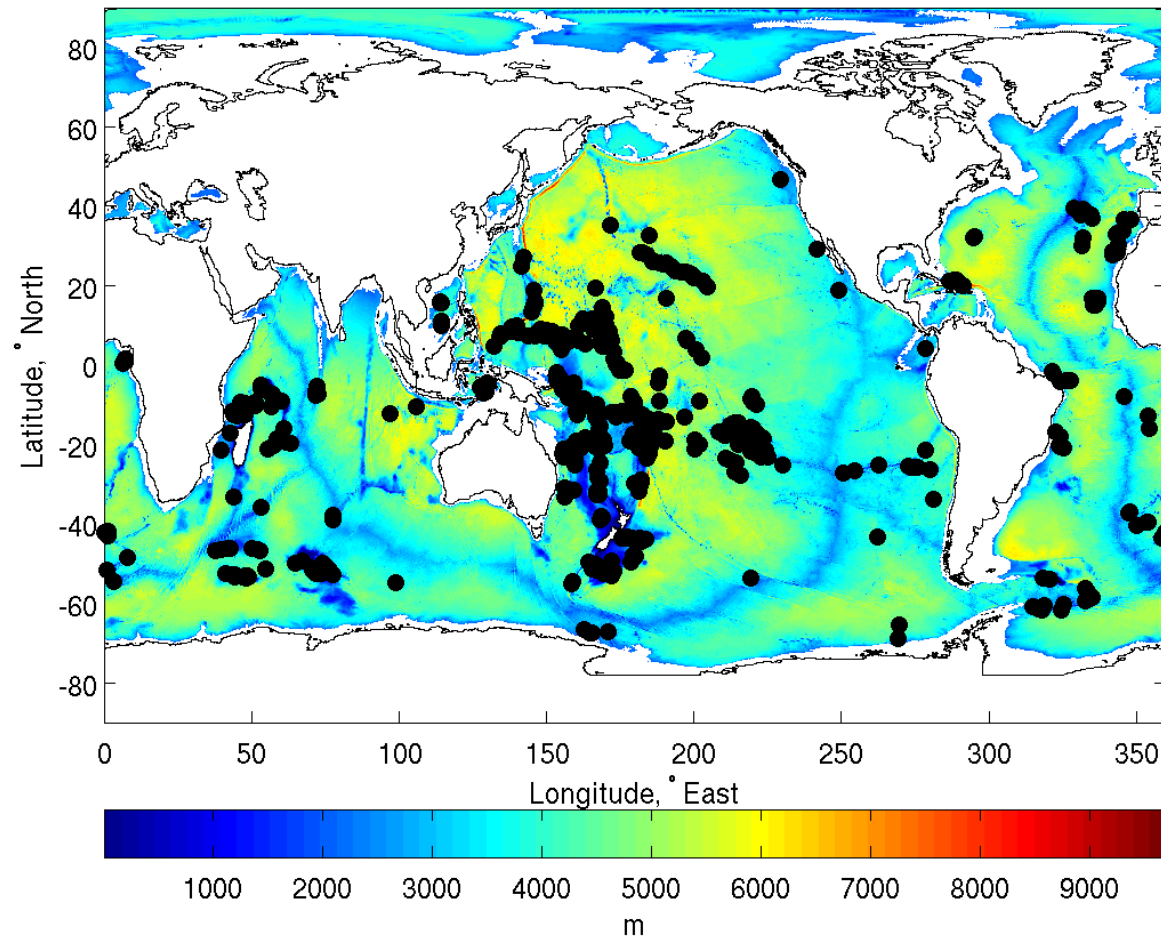
Bathymetry in the OCCAM 1/12 model

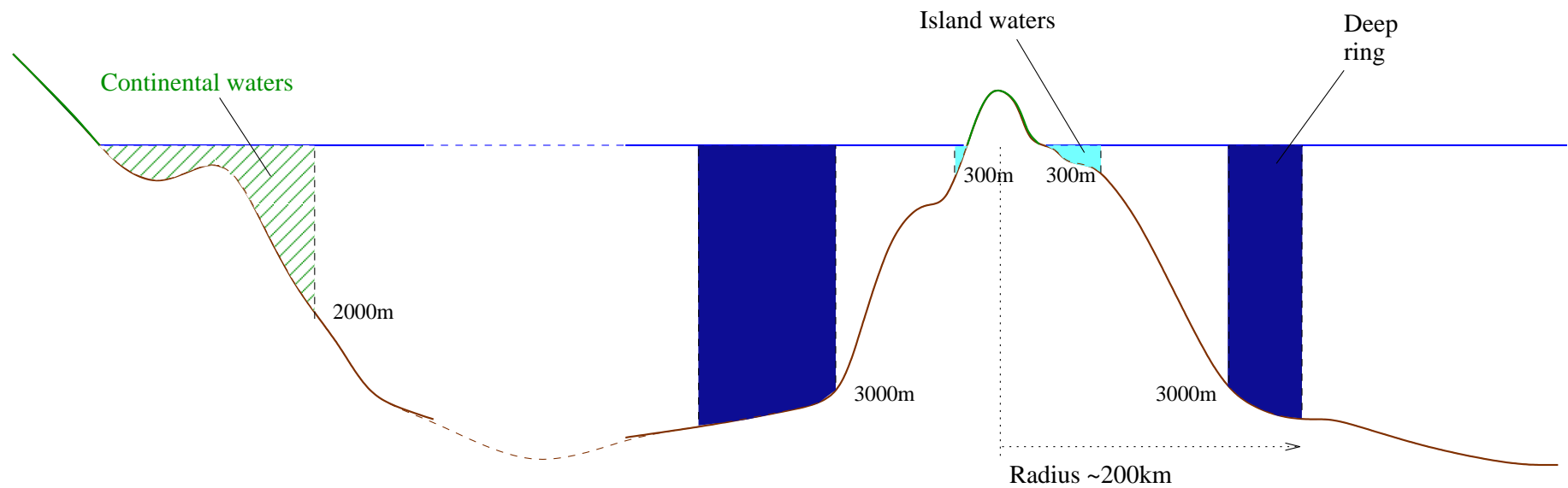


Excluding continental waters



Small, mid-ocean “islands”

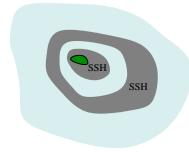




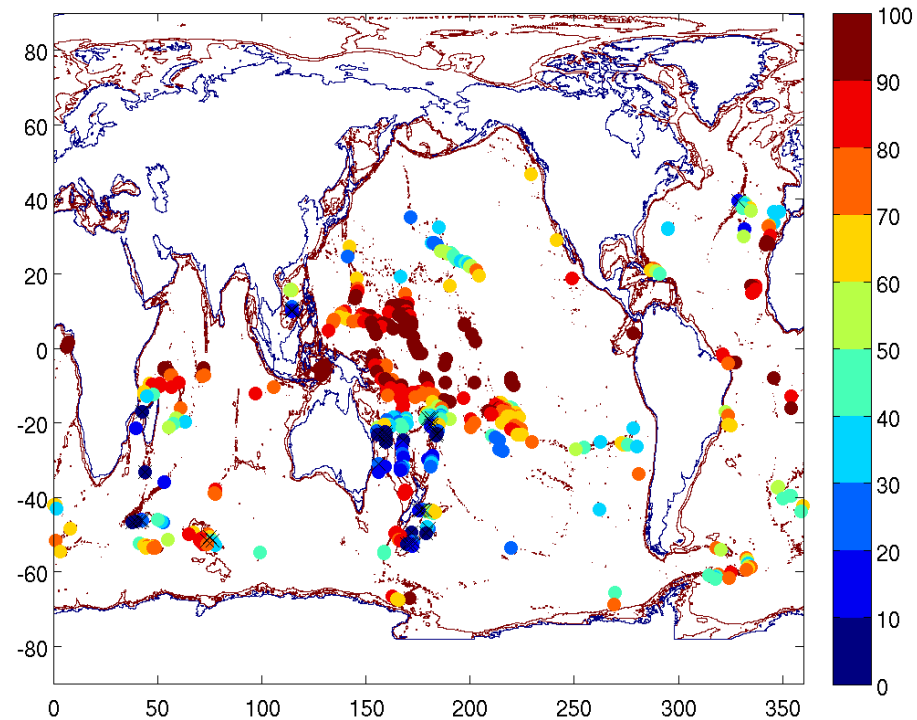
$$\% \text{ of variance} = 100 \frac{\text{var}(h_{\text{island}}) - \text{var}(h_{\text{island}} - Ah_{\text{deep}})}{\text{var}(h_{\text{island}})},$$

where A is regression coefficient obtained by regressing h_{island} onto h_{deep} .

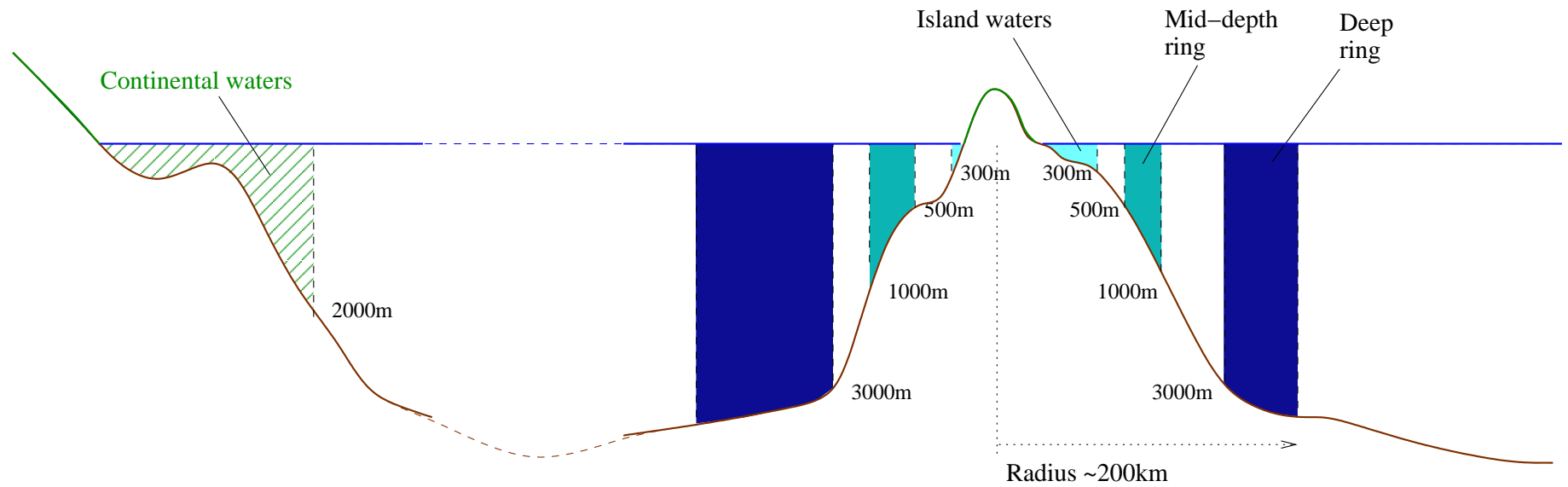
% variance of ssh at island explained by ssh in deep water



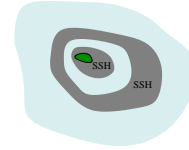
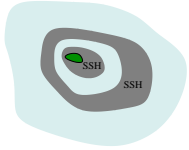
POV of ssh at island exp by ssh in deep water nearby,



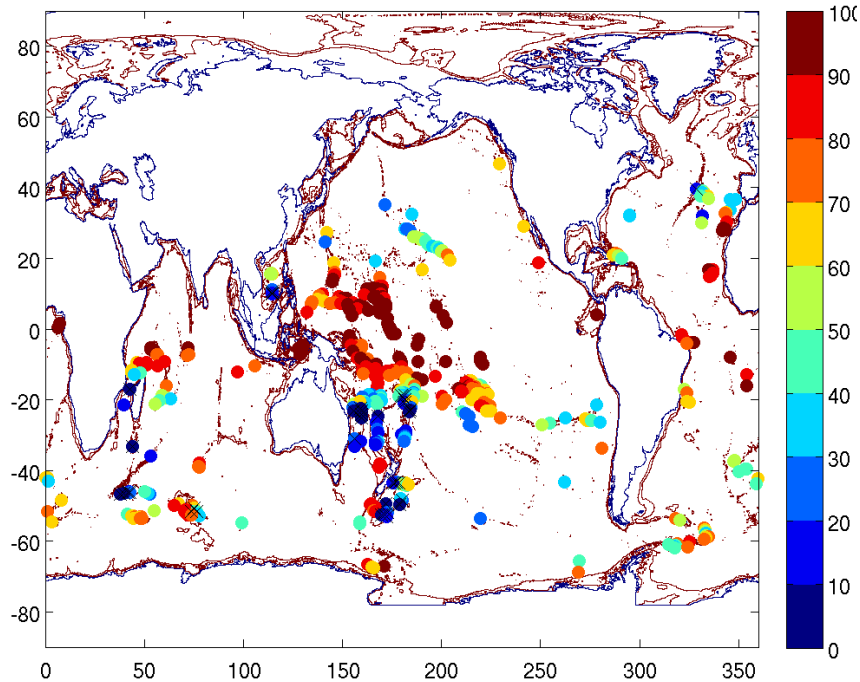
Effect of depth of ring



Effect of depth of ring

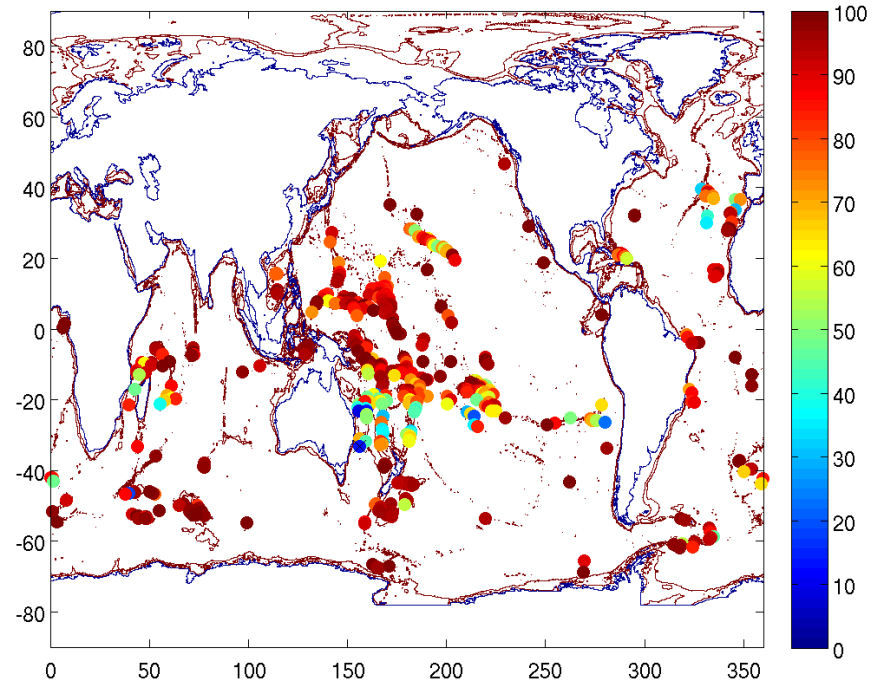


POV of ssh at island exp by ssh in deep water nearby,



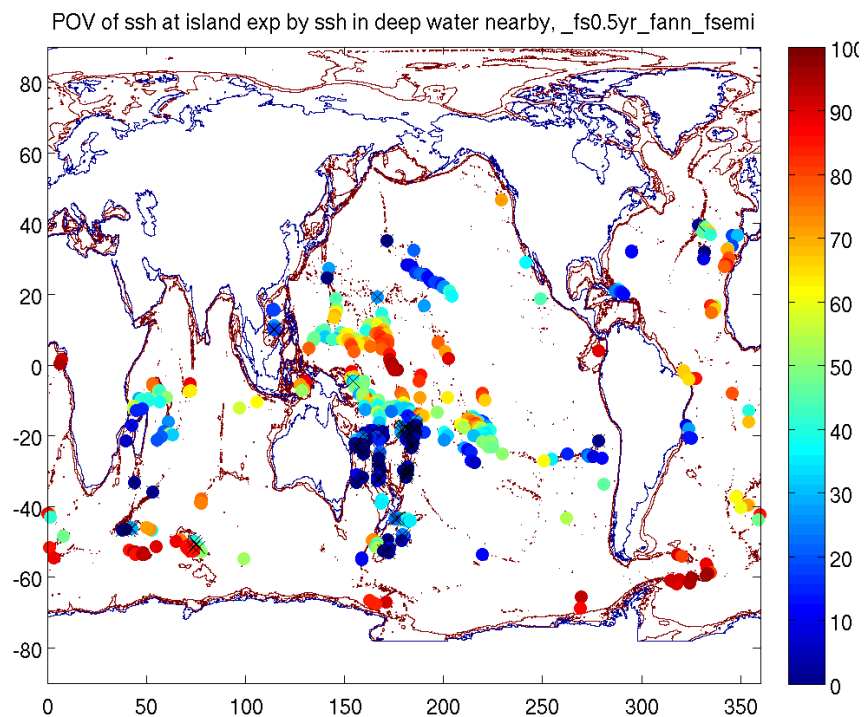
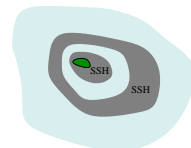
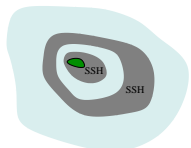
(i) ssh by ssh deep

POV of ssh at island exp by ssh nearby,

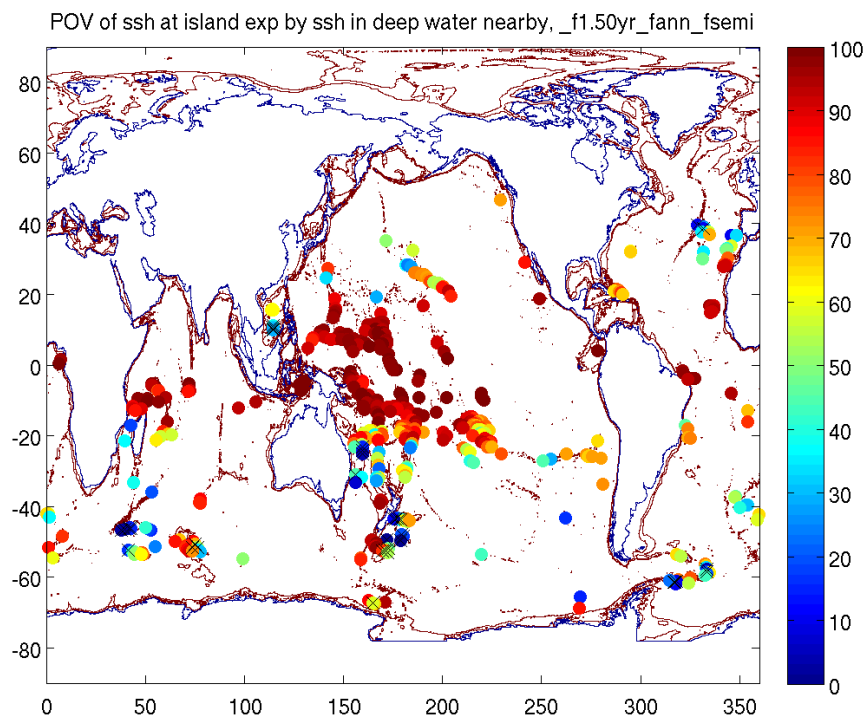


(ii) ssh by ssh mid-deep

% variance of ssh at island explained by ssh in deep water

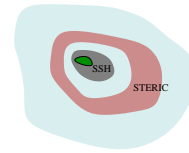
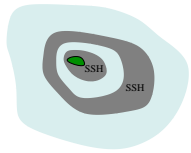


(i) 0–6 months

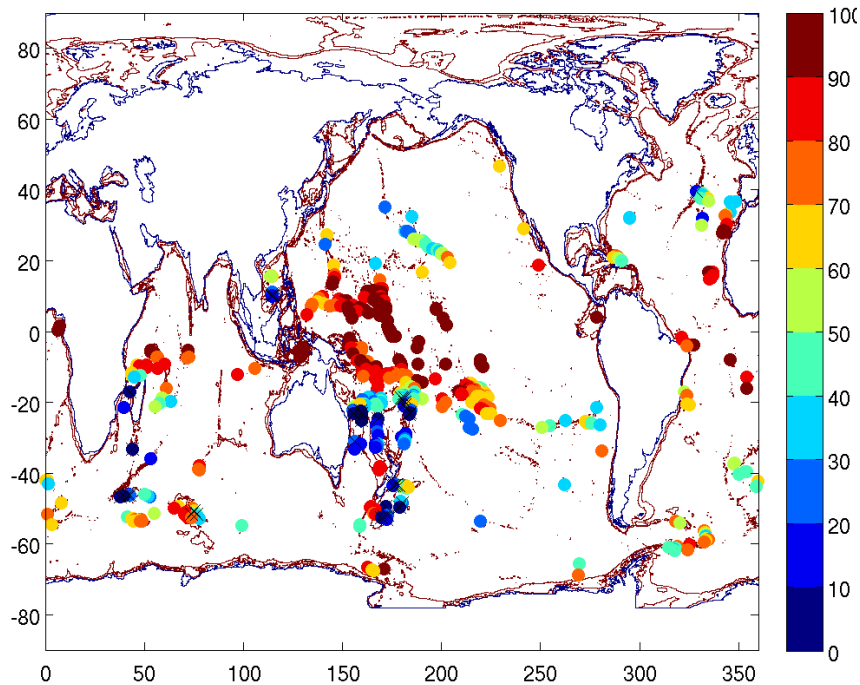


(ii) 18+ months

% variance of ssh at island explained by steric in deep water

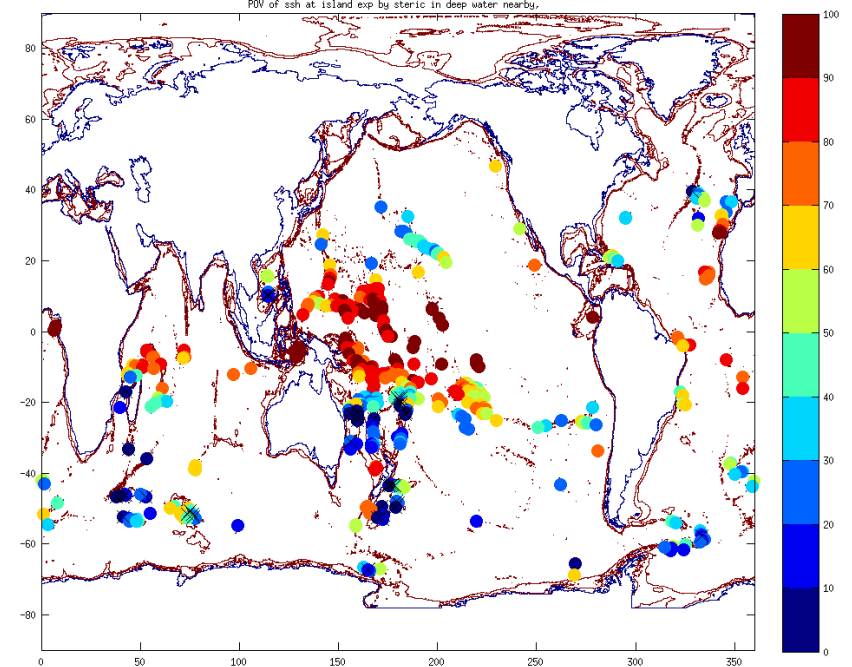


POV of ssh at island exp by ssh in deep water nearby,



(i) ssh by ssh deep

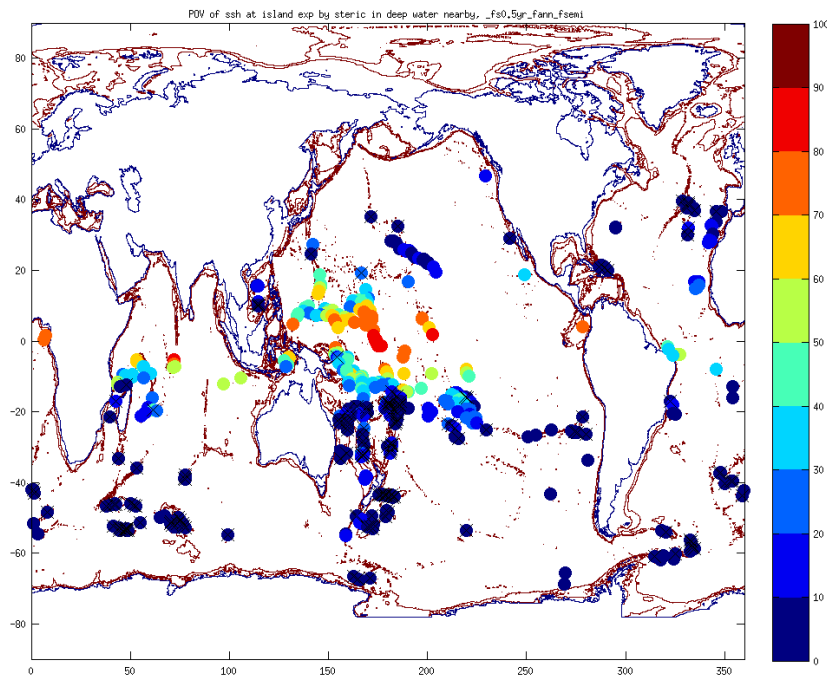
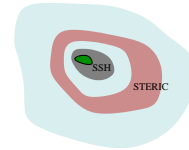
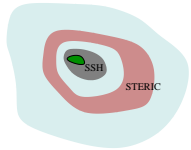
POV of ssh at island exp by steric in deep water nearby,



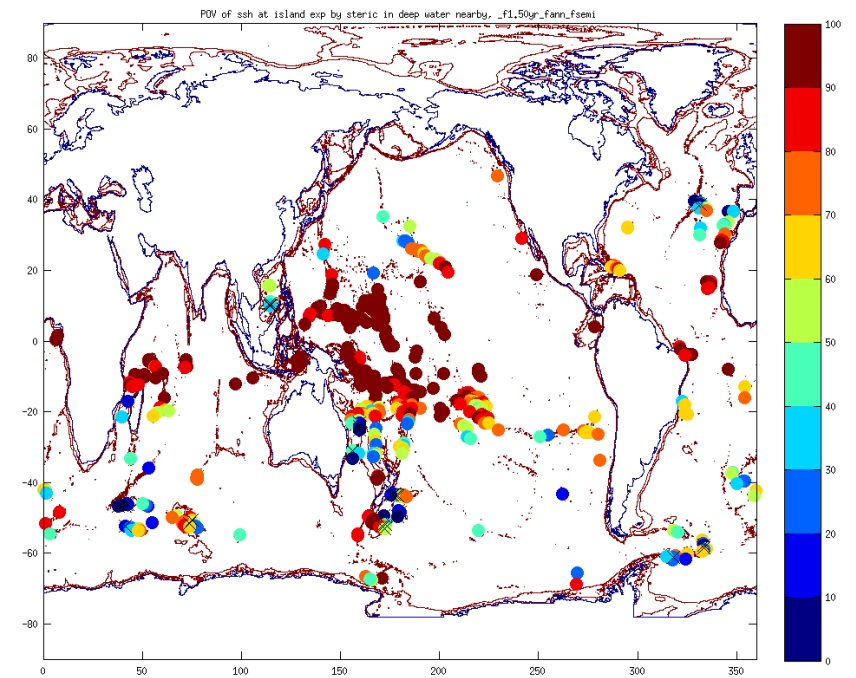
(ii) ssh by steric

$$\underbrace{\rho_0 g \eta}_{\text{ssh}} = \underbrace{\int_{-H}^{\eta} \rho g dz}_{\text{bottom pressure}} - \underbrace{\int_{-H}^0 \rho g dz}_{\text{steric height}}$$

% variance of ssh at island explained by steric in deep water

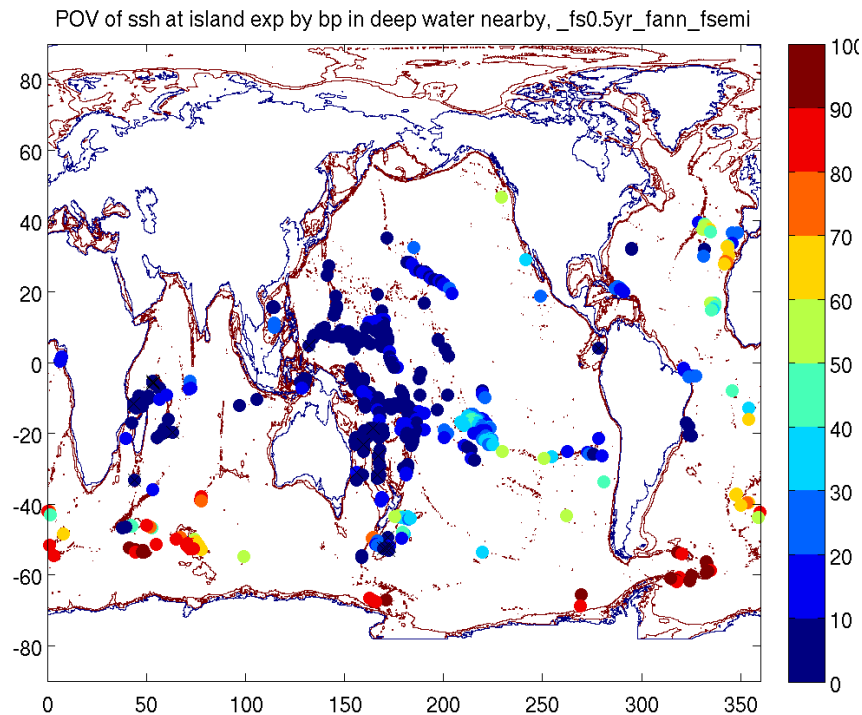
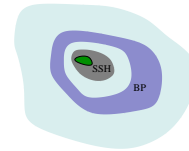
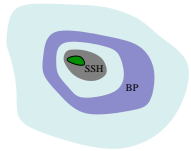


(i) 0–6 months

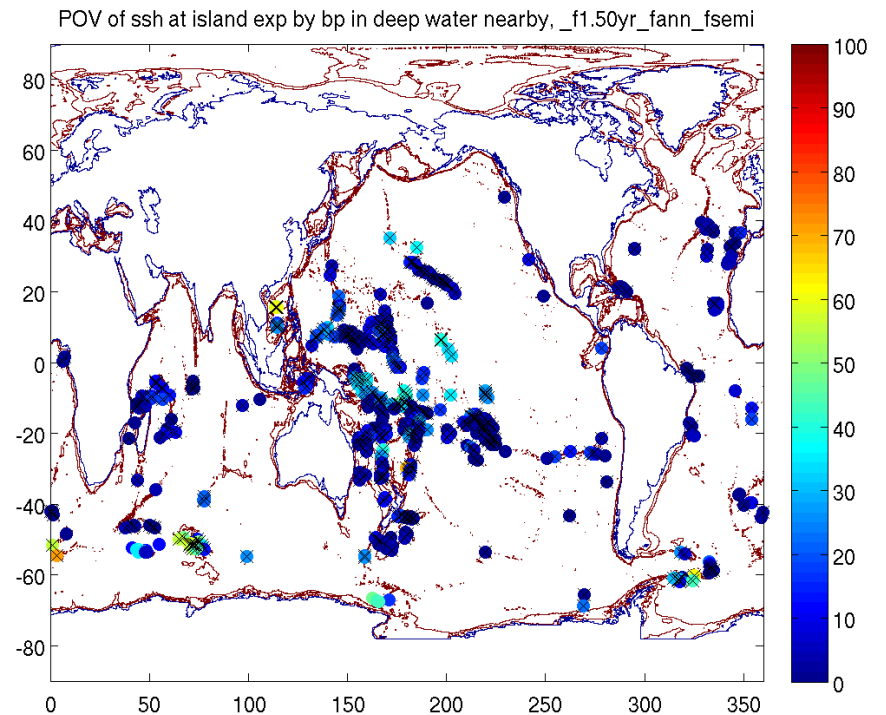


(ii) 18+ months

% variance of ssh at island explained by bp in deep water



(i) 0–6 months



(ii) 18+ months

Equivalent barotropic structure in Southern Ocean

Frequency dependence of coherence

Time series: $h(t)$ ssh at the island and $\phi(t)$ steric in the deep water.

Cross-correlation spectrum: $R_{h\phi} = E(\phi(t)h(t + \tau))$

Cross power spectral density: $S_{h\phi}(\sigma) = \sum_{m=-\infty}^{\infty} R_{h\phi}(m) \exp^{-jfm}$

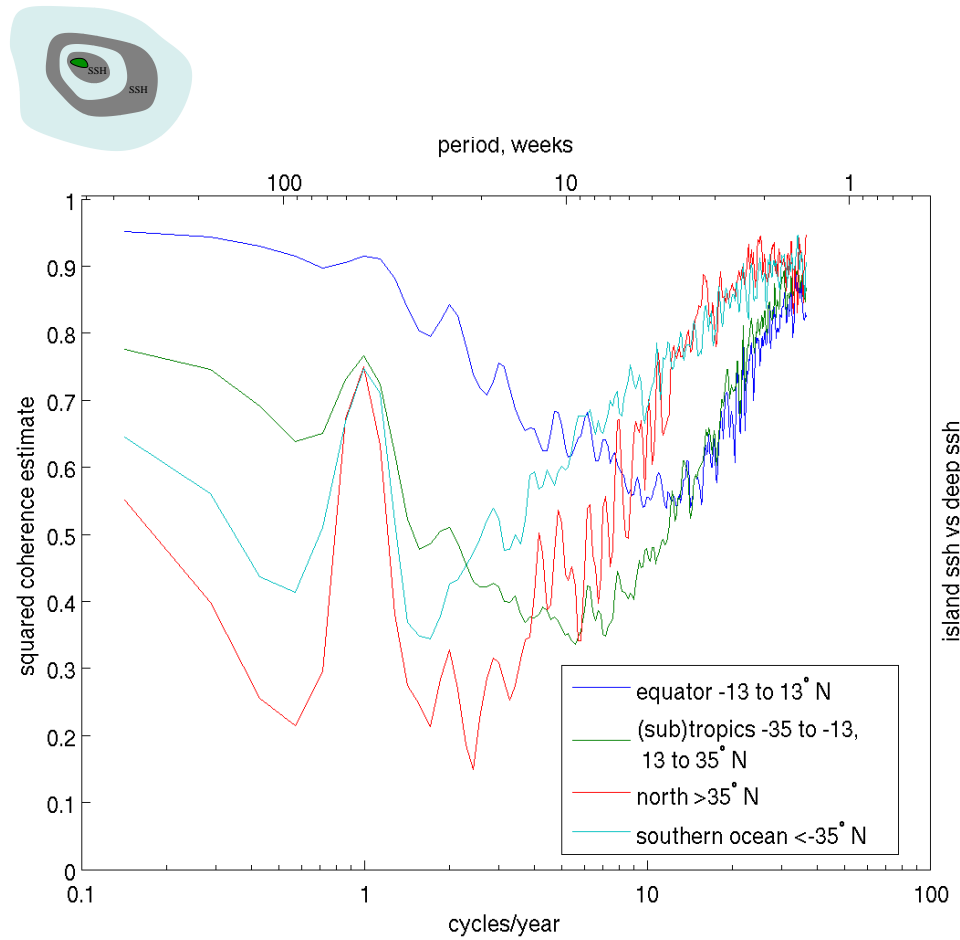
Magnitude squared coherence:

$$\gamma_{h\phi}(\sigma) = \frac{|S_{h\phi}(\sigma)|^2}{S_{hh}(\sigma)S_{\phi\phi}(\sigma)},$$

(Matlab function `mscohere.m`)

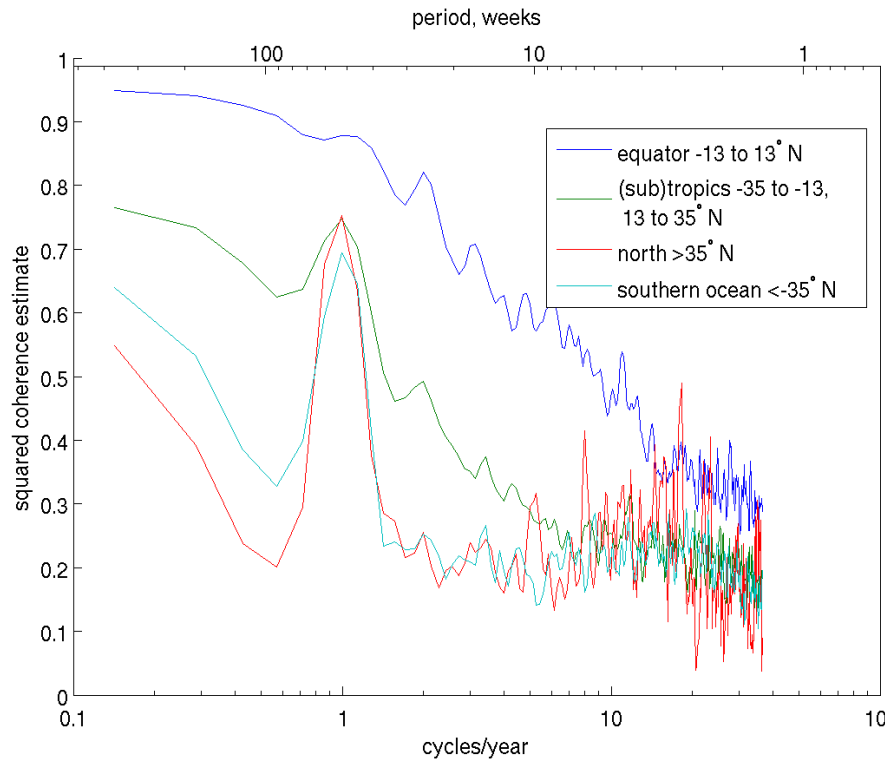
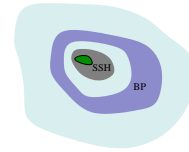
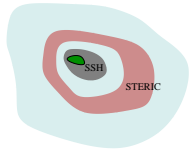
$\gamma_{h\phi}(\sigma)$ has values between 0 and 1 and indicates how well h , the signal at the island, corresponds to ϕ , the signal in deep water, at each frequency.

Frequency dependence of coherence

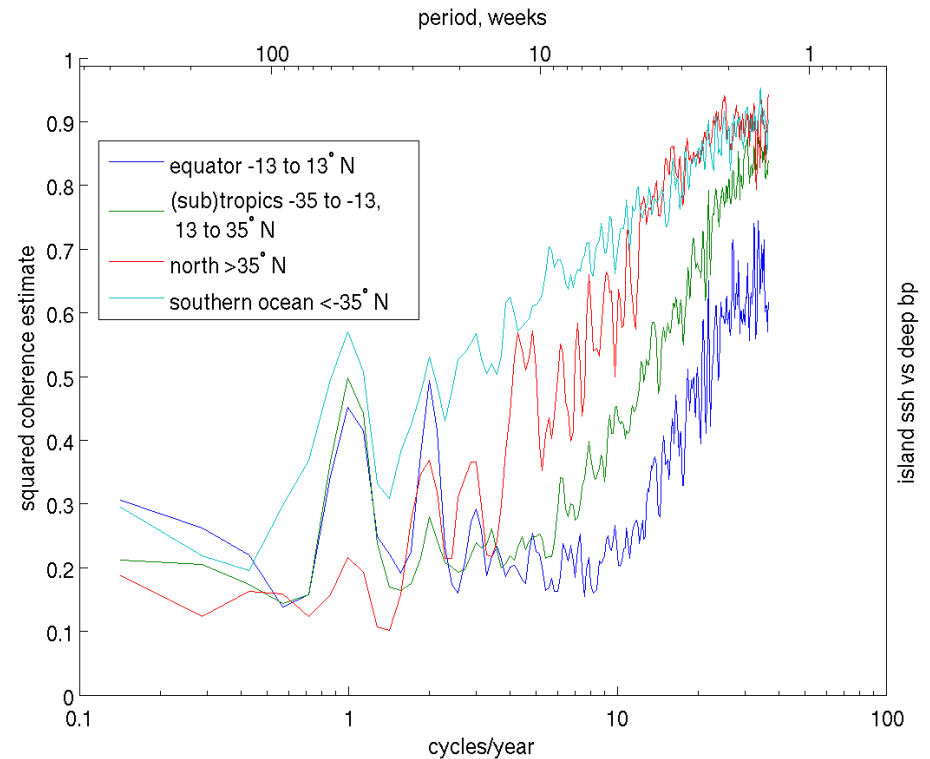


ssh by ssh deep

Frequency dependence of coherence



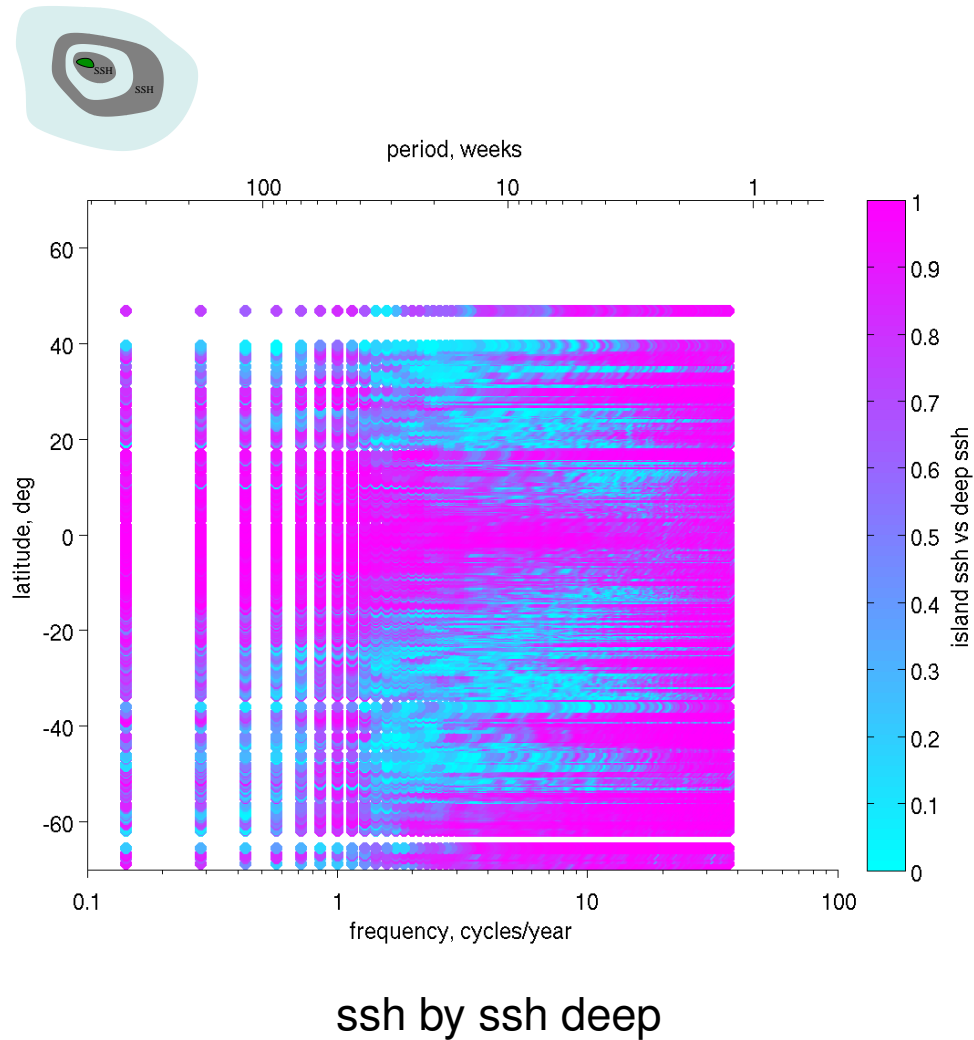
(i) ssh by steric deep



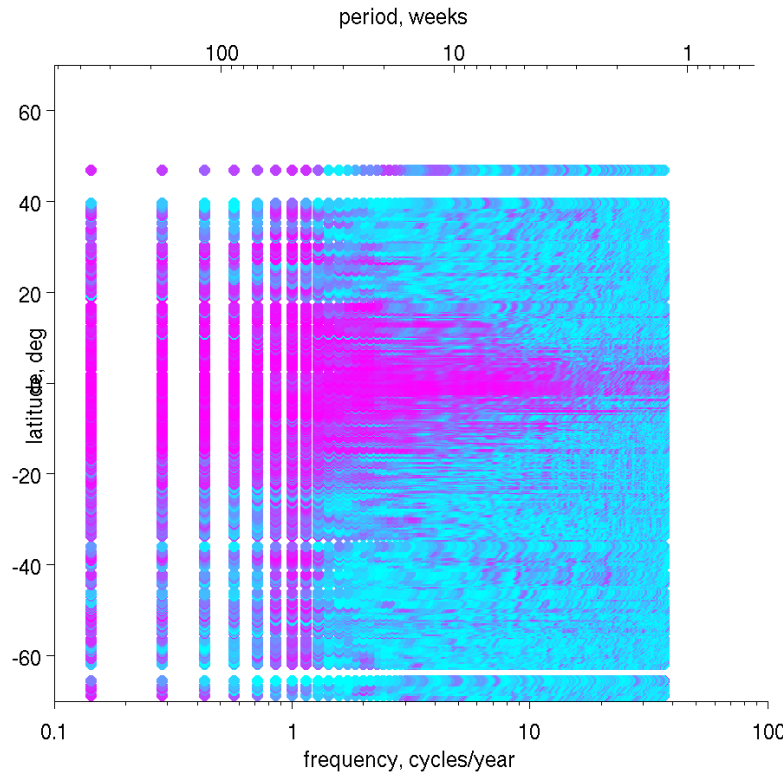
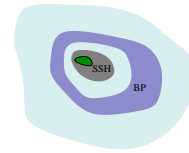
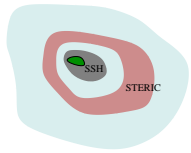
(ii) ssh by bp deep

$$\underbrace{\rho_0 g \eta}_{\text{ssh}} = \underbrace{\int_{-H}^{\eta} \rho g dz}_{\text{bottom pressure}} - \underbrace{\int_{-H}^0 \rho g dz}_{\text{steric height}}$$

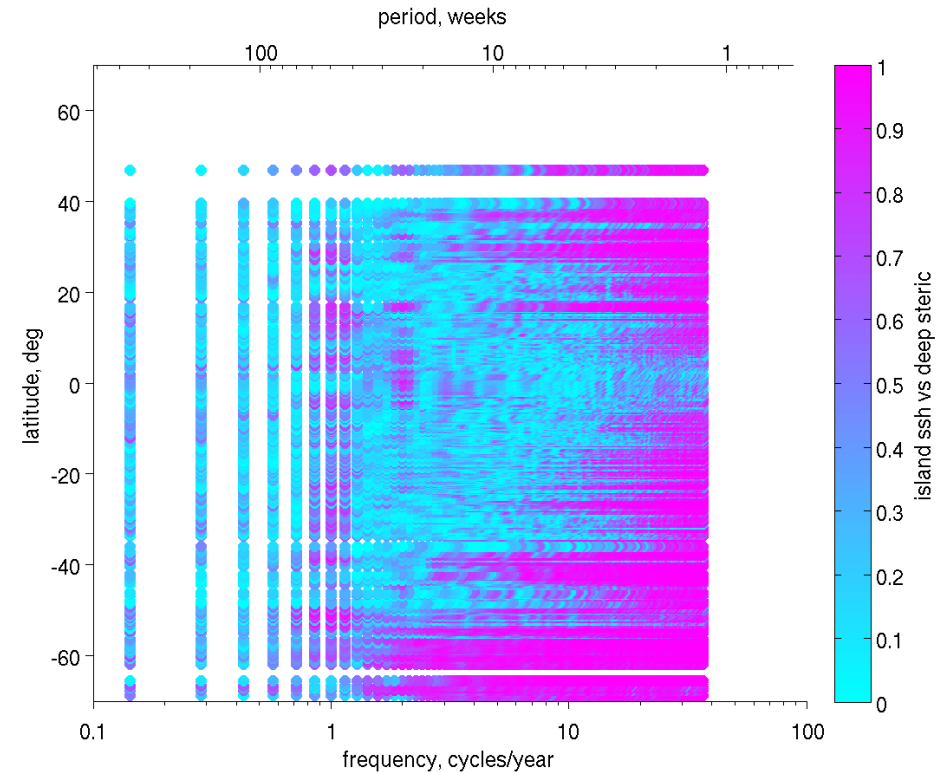
Frequency and latitude dependence of coherence



Frequency and latitude dependence of coherence



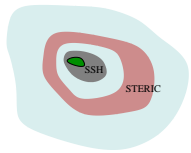
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(ii) ssh by bp deep

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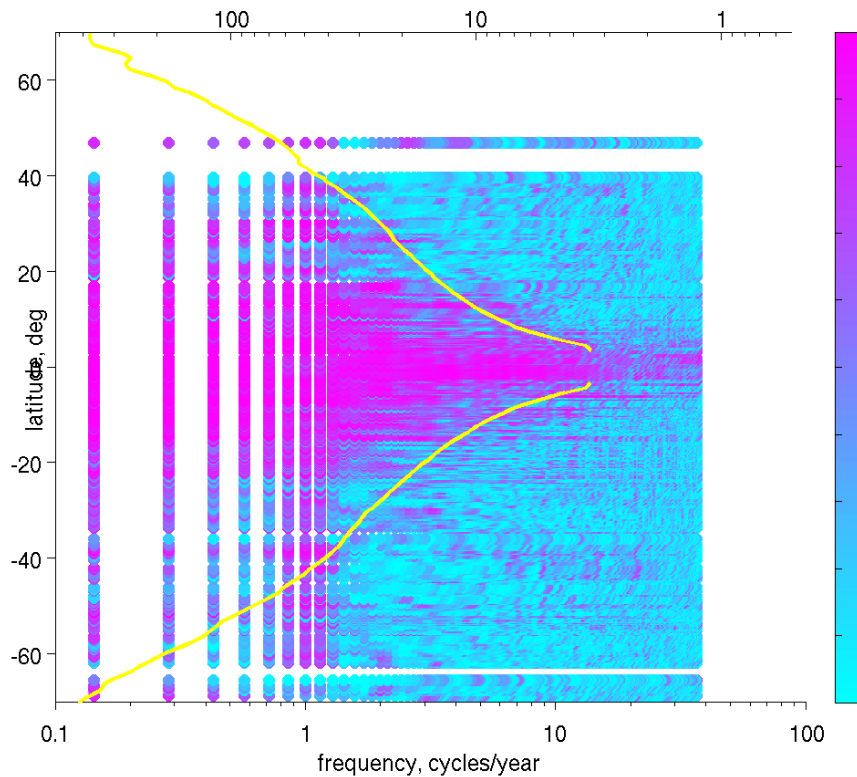
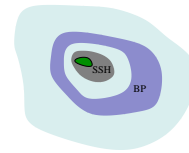
Frequency and latitude dependence of coherence



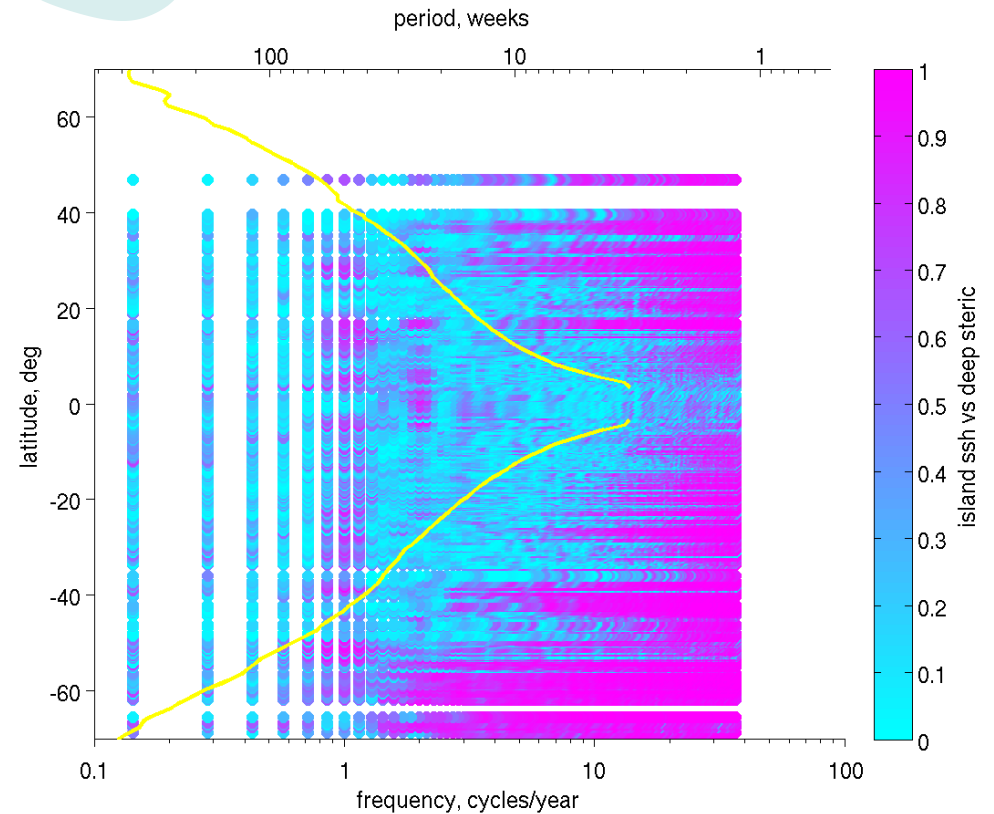
Baroclinic Rossby frequency

$$\sigma_{max} = \beta R_0 / 4\pi$$

period, weeks

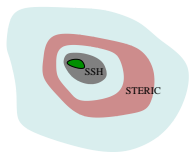


(i) ssh by steric deep



(ii) ssh by bp deep

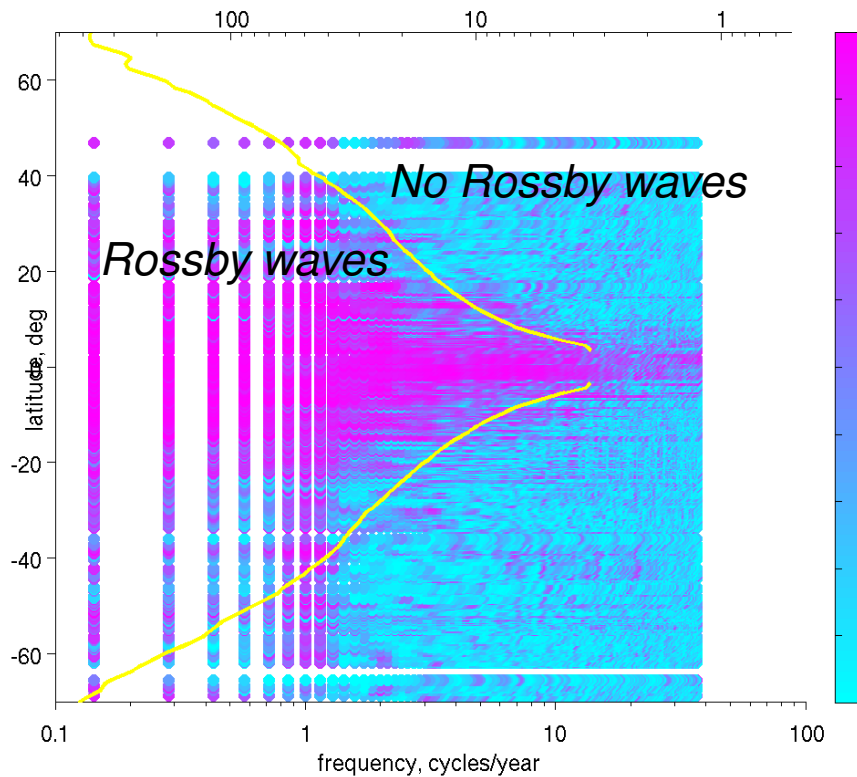
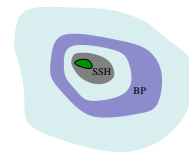
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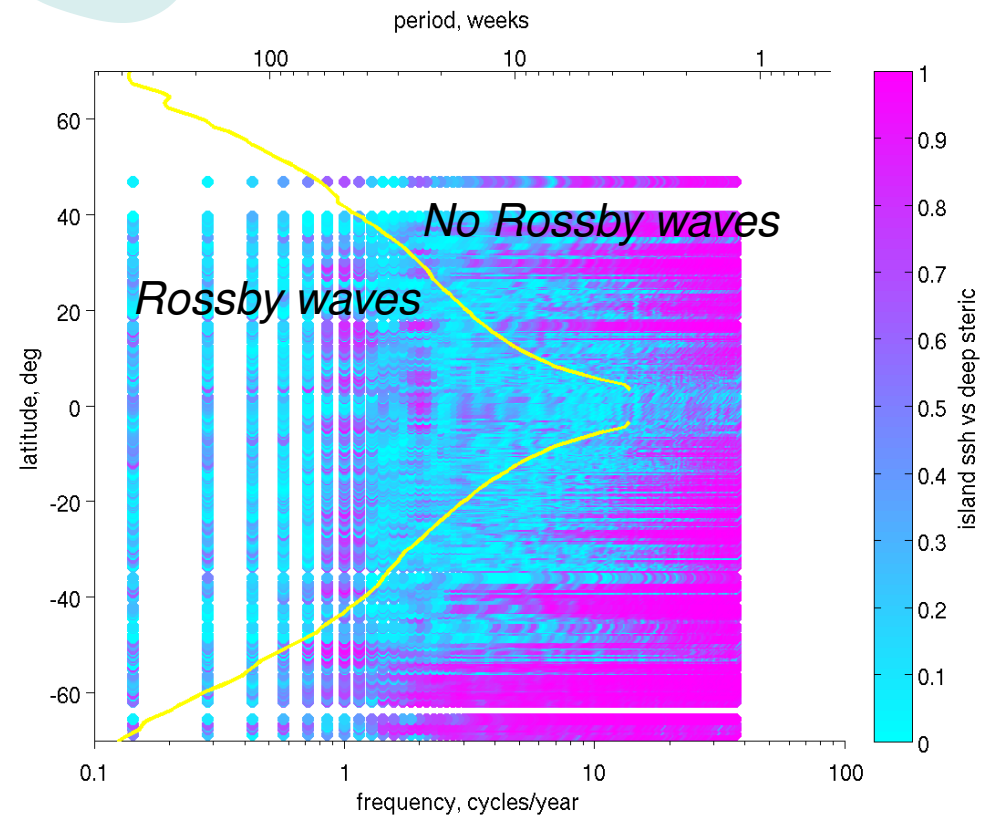
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(i) ssh by steric deep



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