

Coherence of off-shore steric height and island sea level

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European Geophysical Union
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**National
Oceanography Centre**

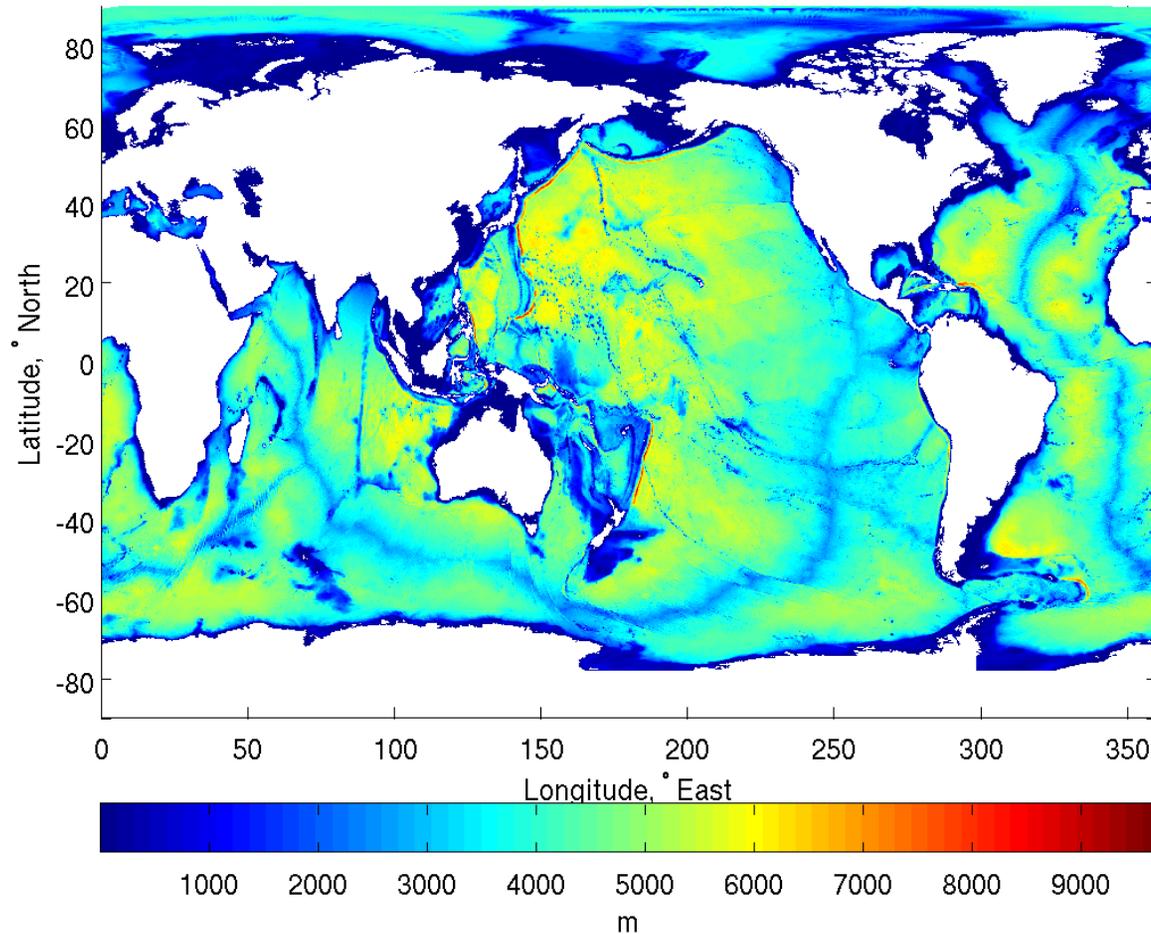
NATURAL ENVIRONMENT RESEARCH COUNCIL



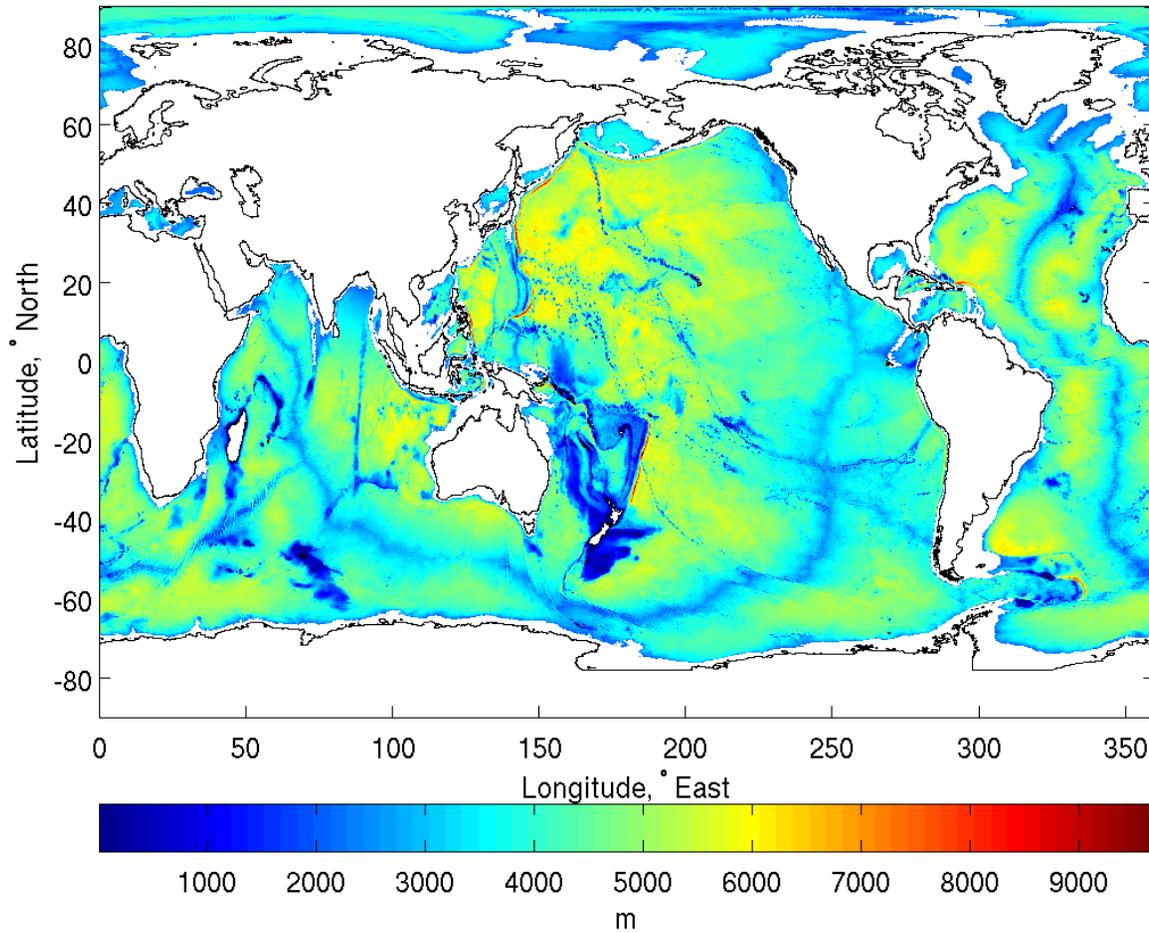
**NATURAL
ENVIRONMENT
RESEARCH COUNCIL**

EGU April 2012,
Vienna

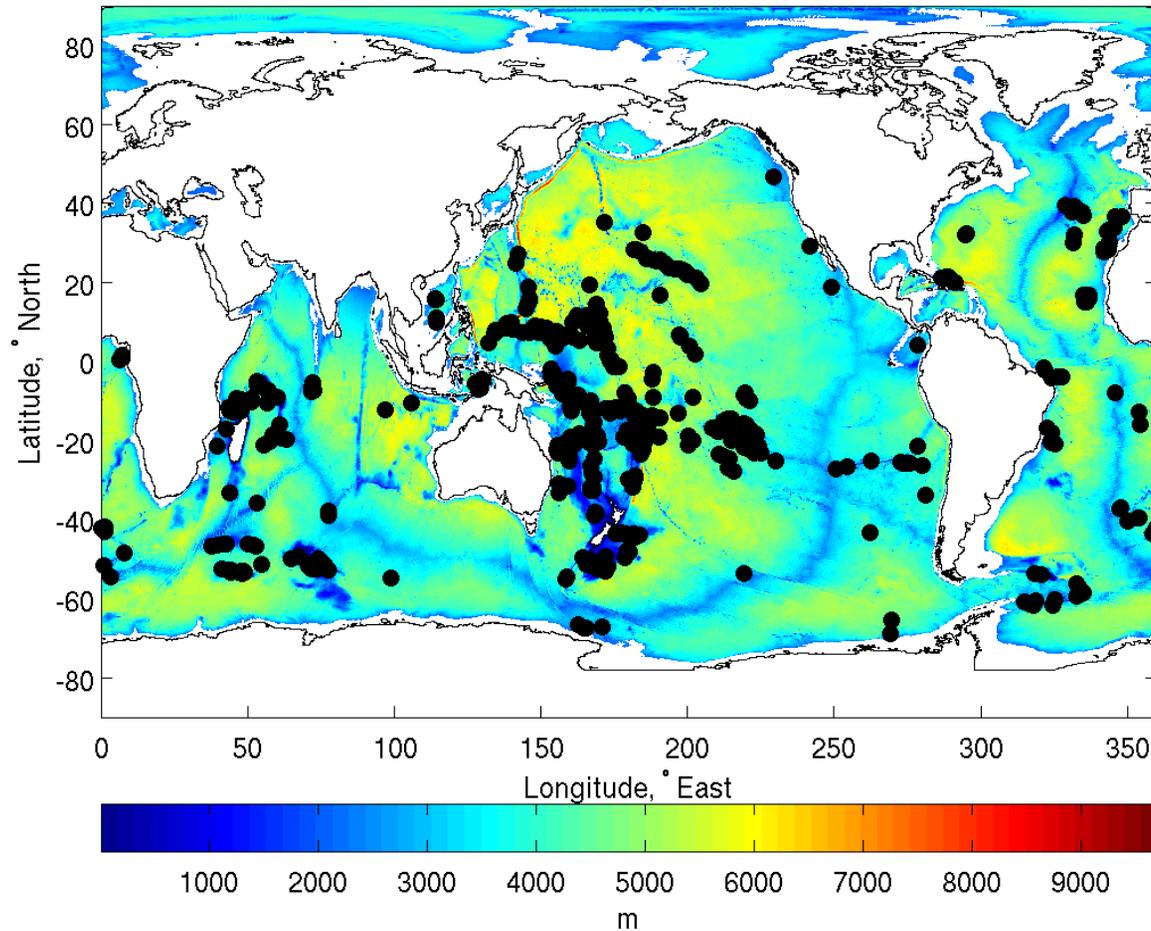
Bathymetry in the OCCAM 1/12 model

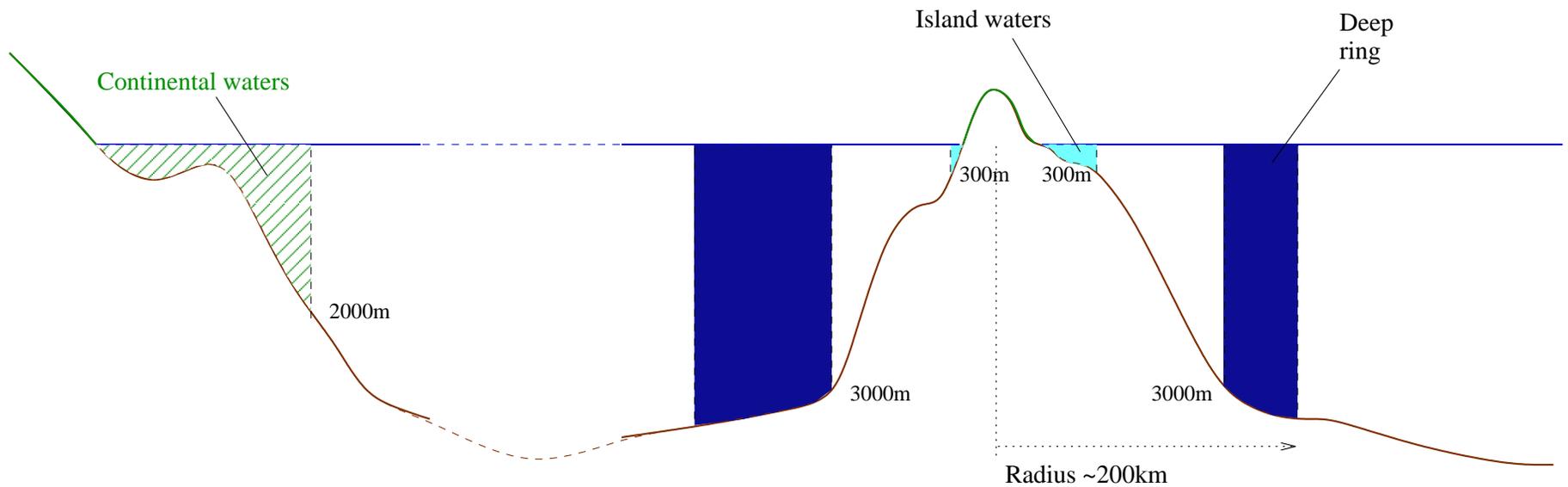


Excluding continental waters



Small, mid-ocean “islands”

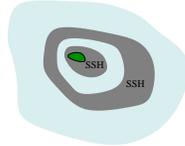




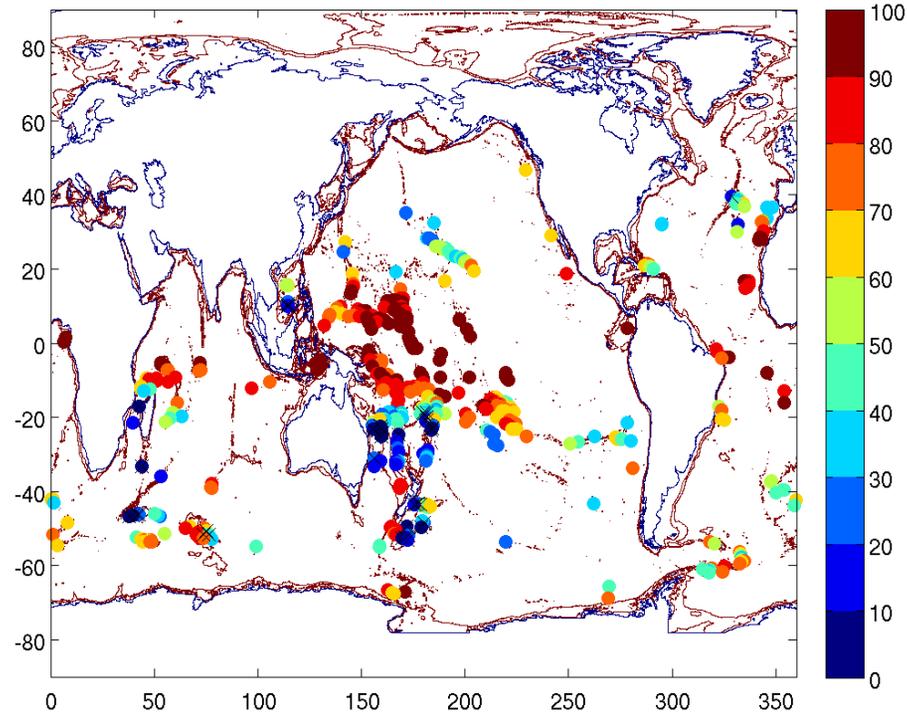
$$\% \text{ of variance} = 100 \frac{\text{var}(h_{island}) - \text{var}(h_{island} - Ah_{deep})}{\text{var}(h_{island})},$$

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

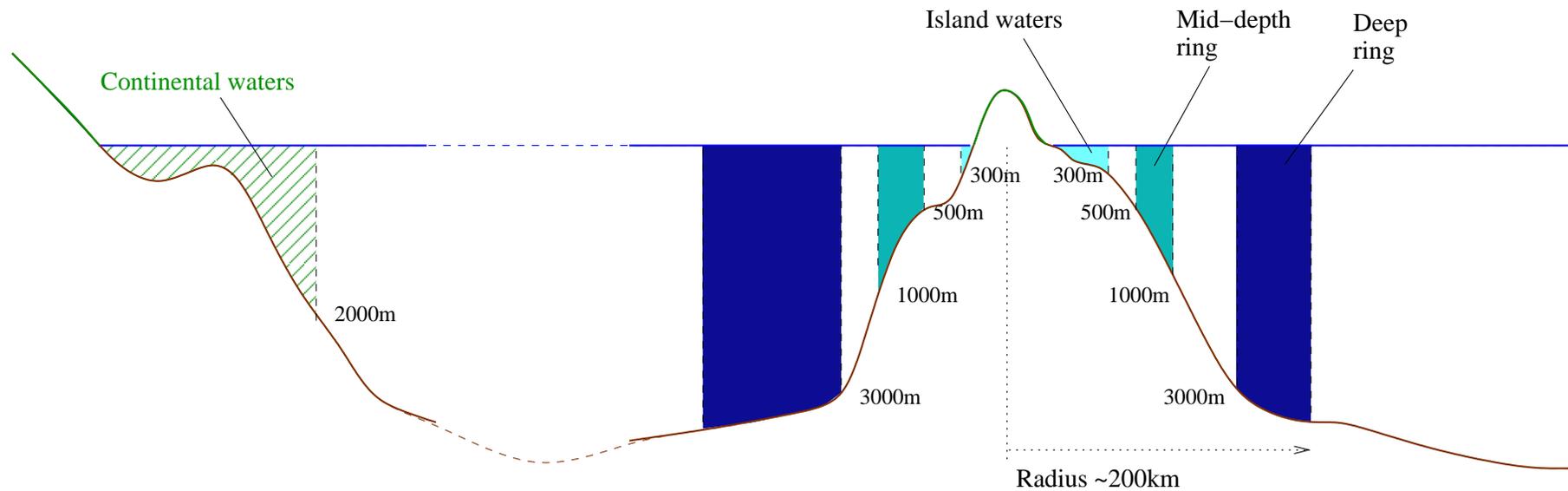
% variance of ssh at island explained by ssh in deep water



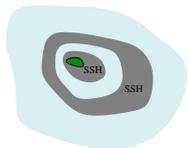
POV of ssh at island exp by ssh in deep water nearby,



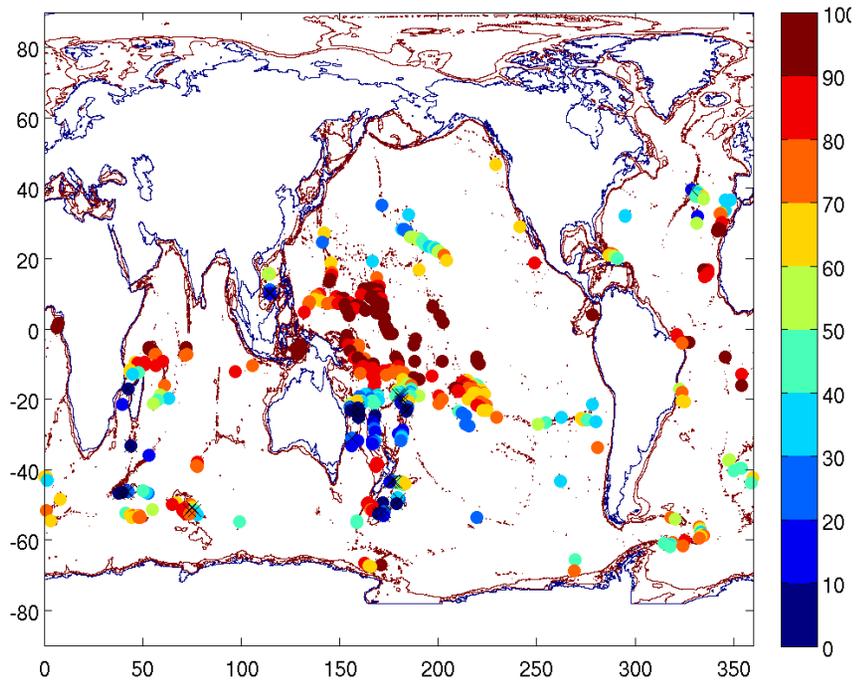
Effect of depth of ring



Effect of depth of ring

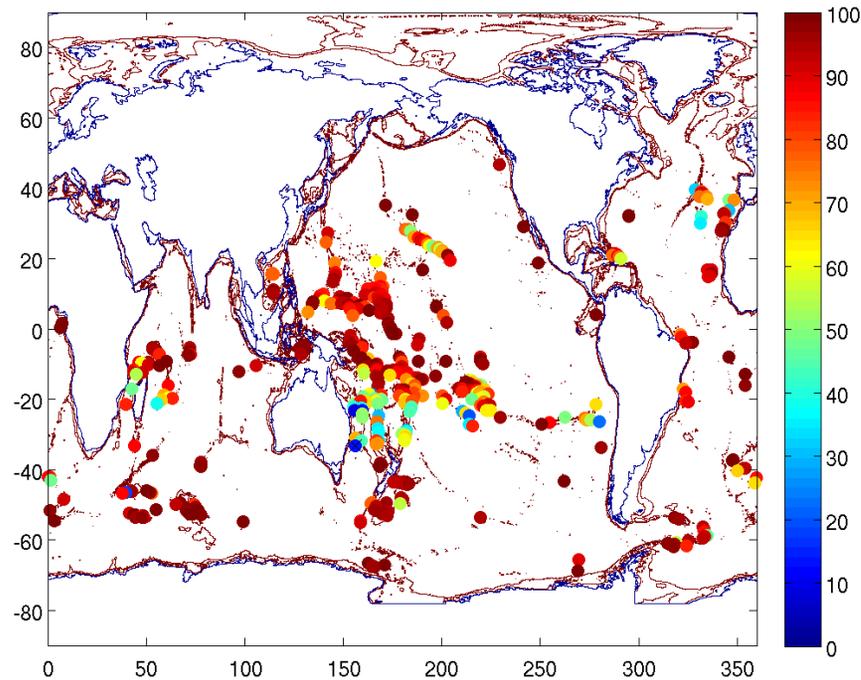


POV of ssh at island exp by ssh in deep water nearby,



(i) ssh by ssh deep

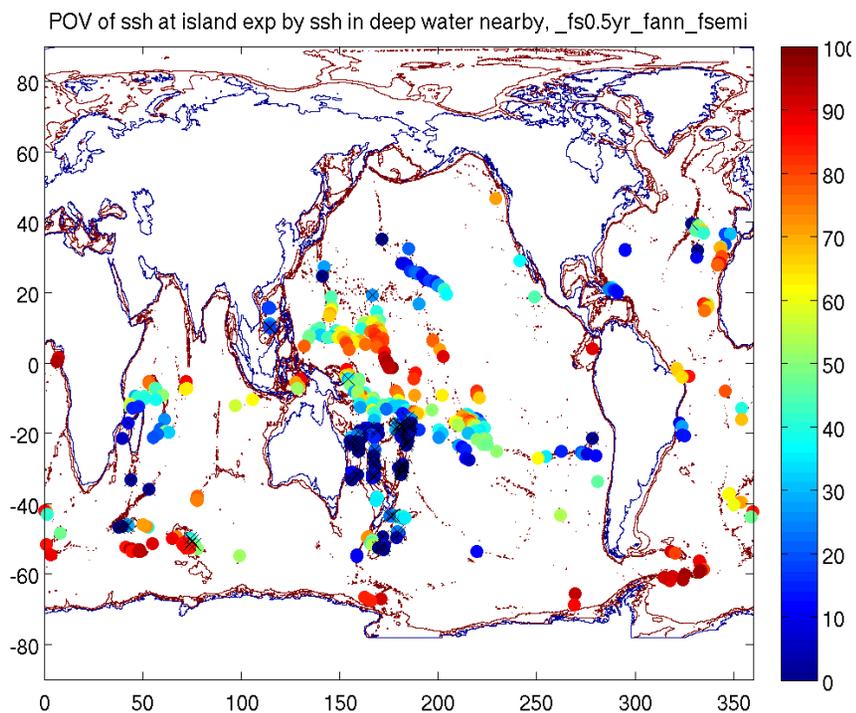
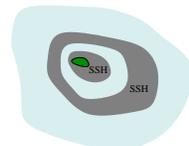
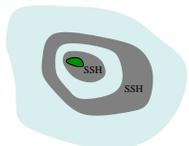
POV of ssh at island exp by ssh nearby,



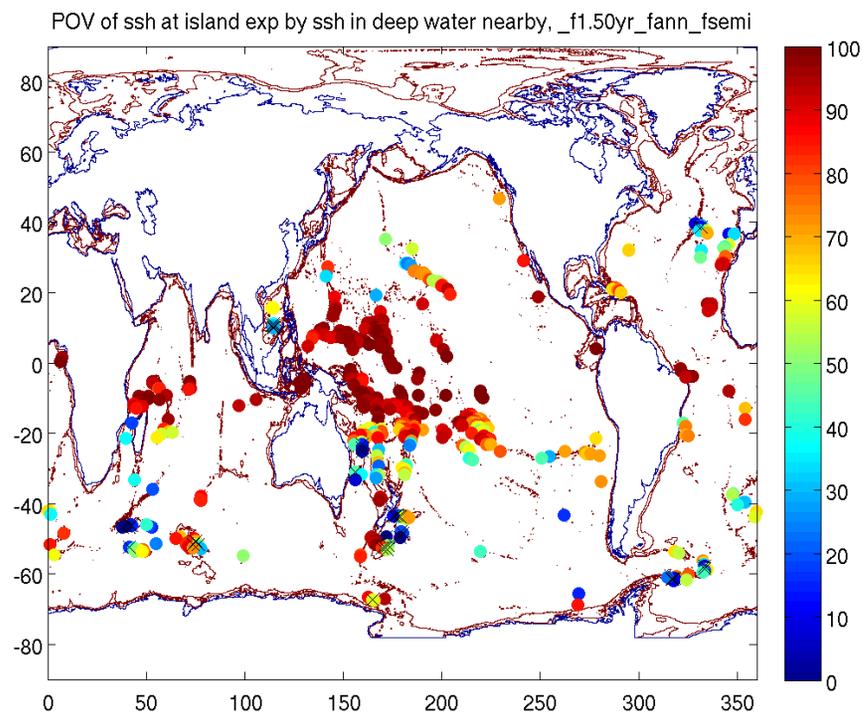
(ii) ssh by ssh mid-deep



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



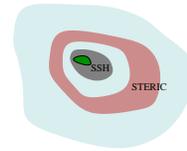
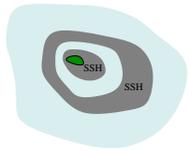
(i) 0–6 months



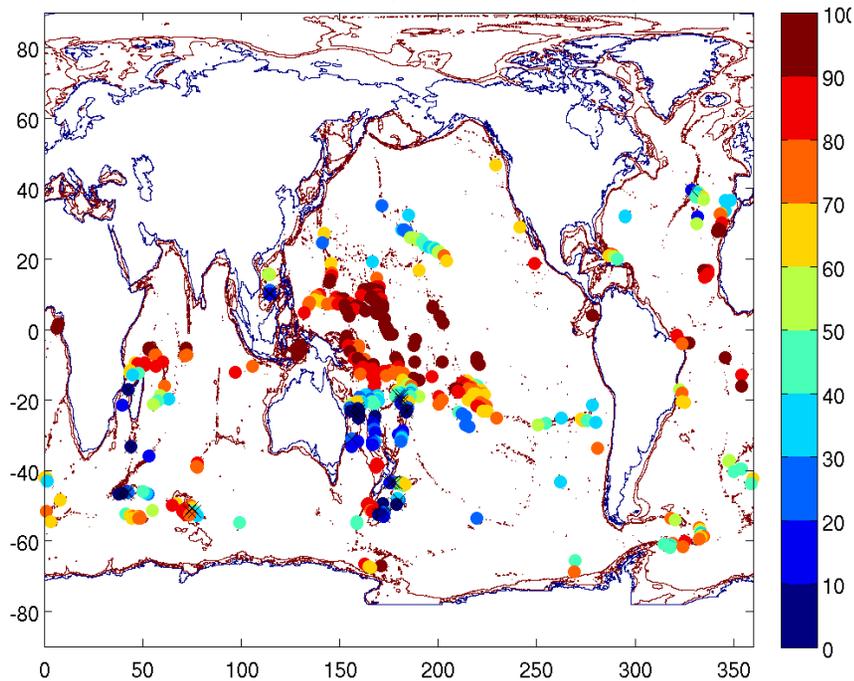
(ii) 18+ months



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

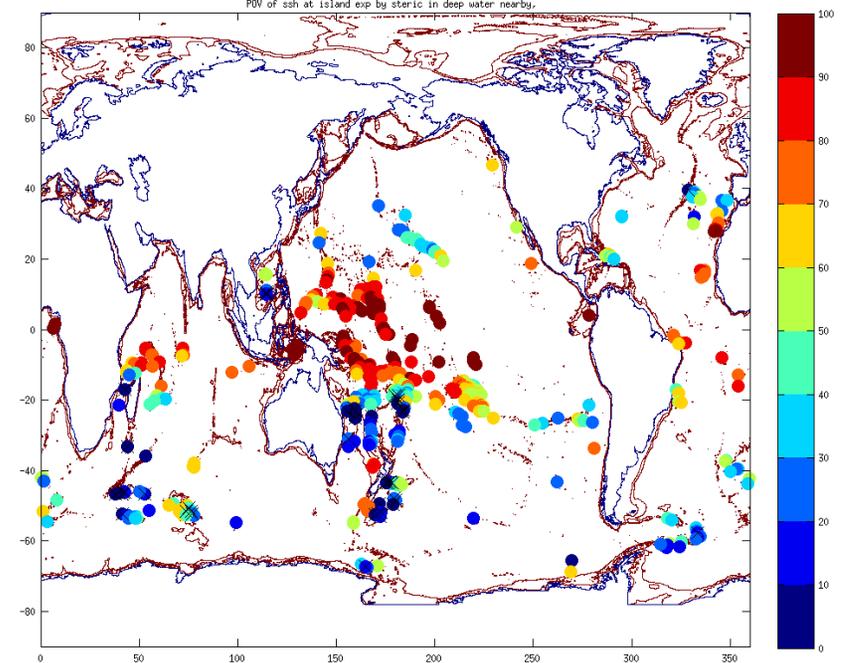


POV of ssh at island exp by ssh in deep water nearby,



(i) ssh by ssh deep

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

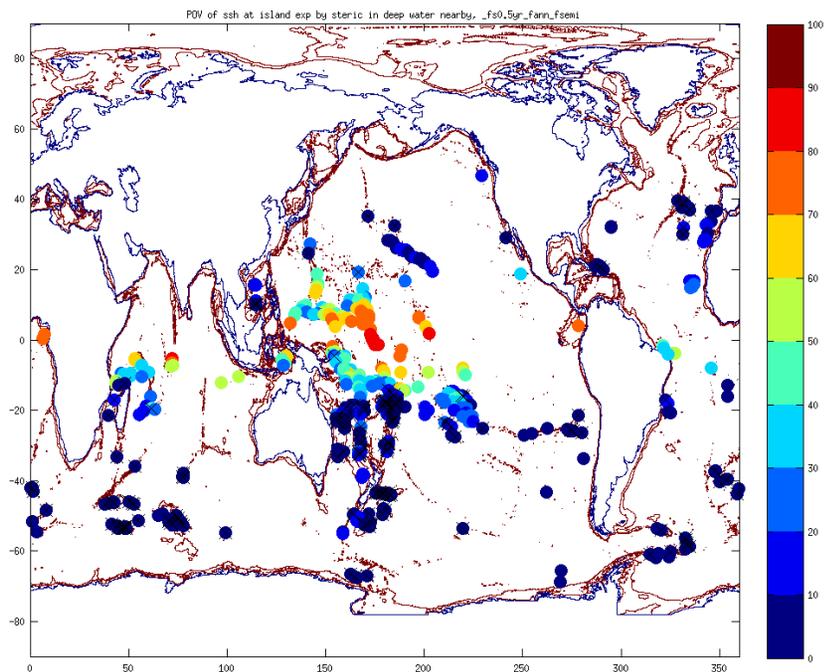
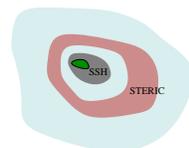
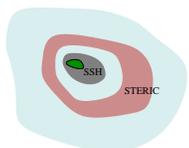


(ii) ssh by steric

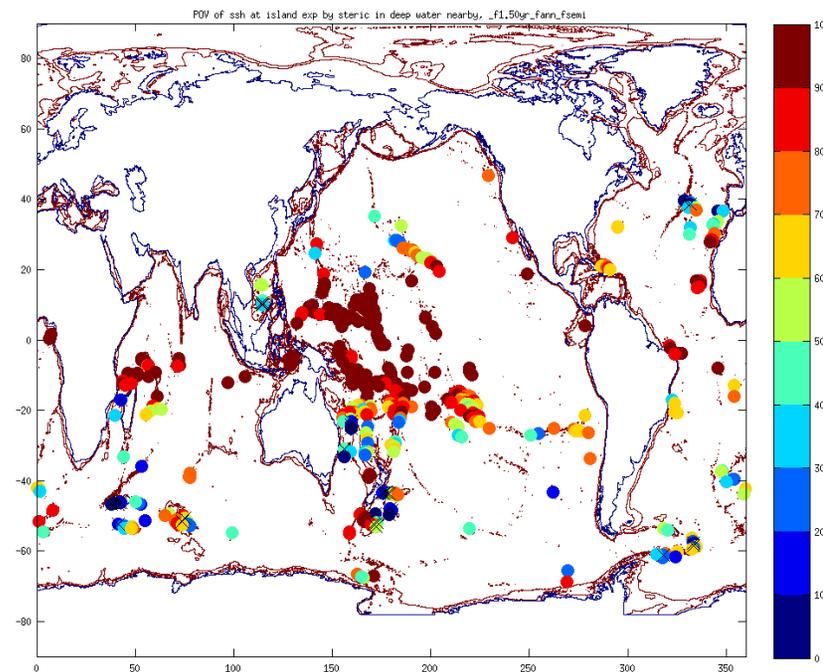
$$\underbrace{\rho_0 g \eta}_{\text{ssh}} = \underbrace{\int_{-H}^{\eta} \rho g dz}_{\text{bottom pressure}} - \underbrace{\int_{-H}^0 \rho g dz}_{\text{steric height}}$$



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



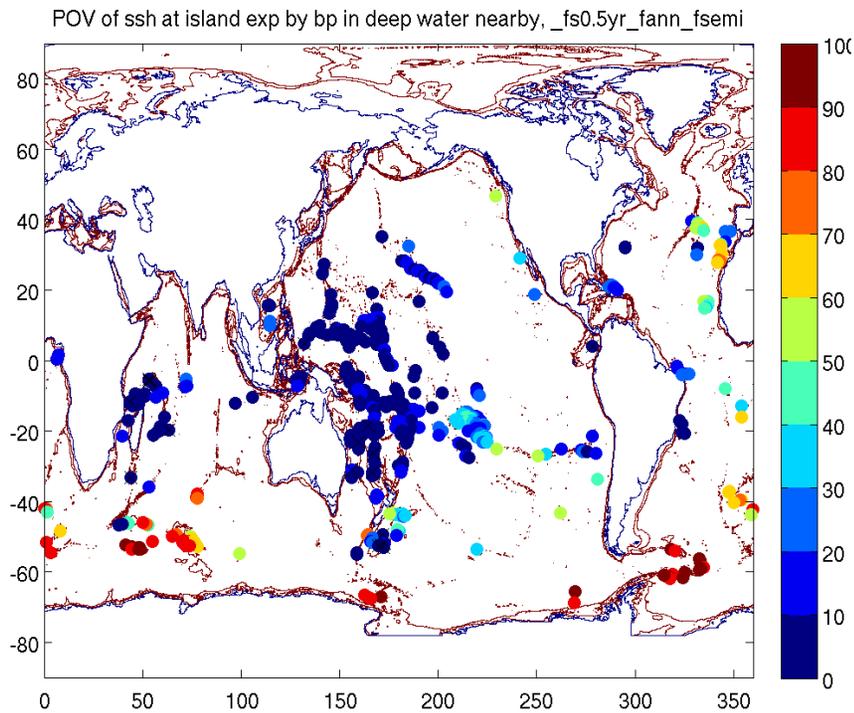
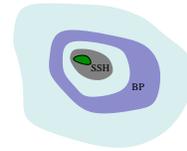
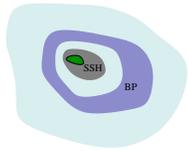
(i) 0–6 months



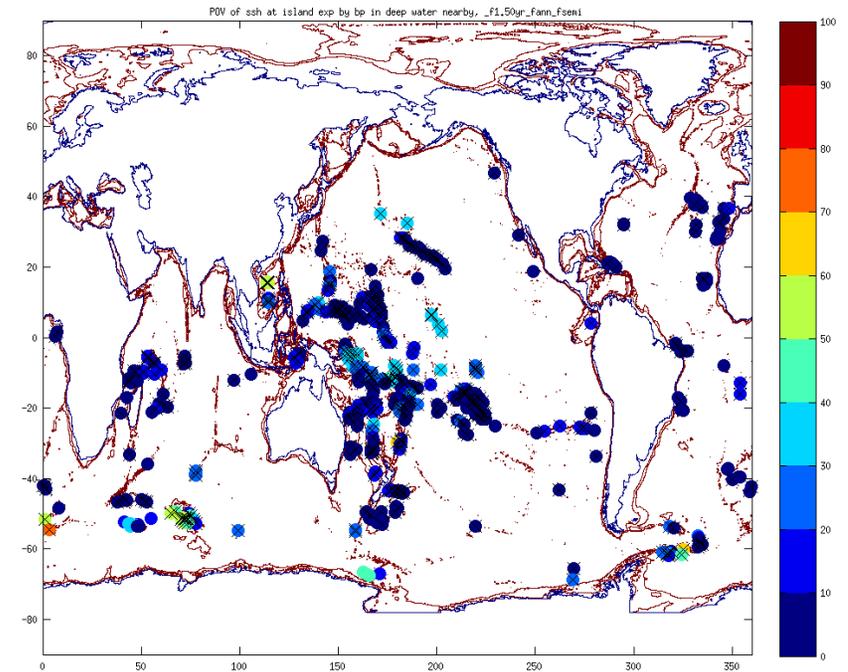
(ii) 18+ months



% 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:

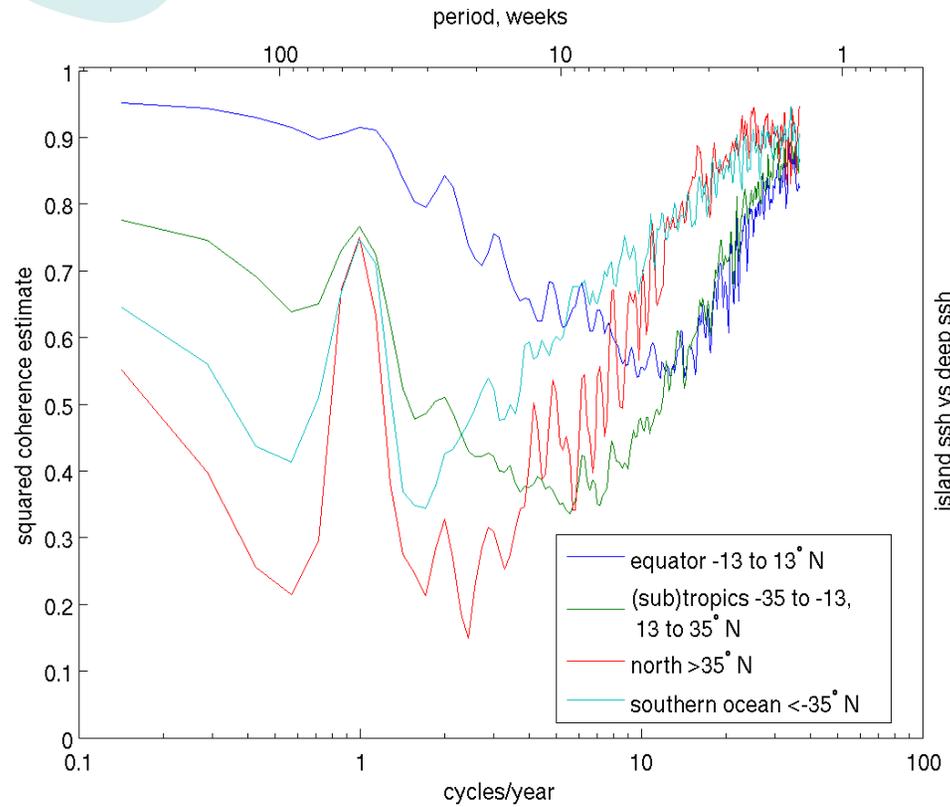
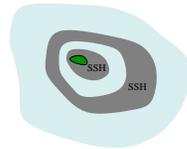
$$\gamma_{h\phi}(\sigma) = \frac{|S_{h\phi}(\sigma)|^2}{S_{hh}(\sigma)S_{\phi\phi}(\sigma)},$$

(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.



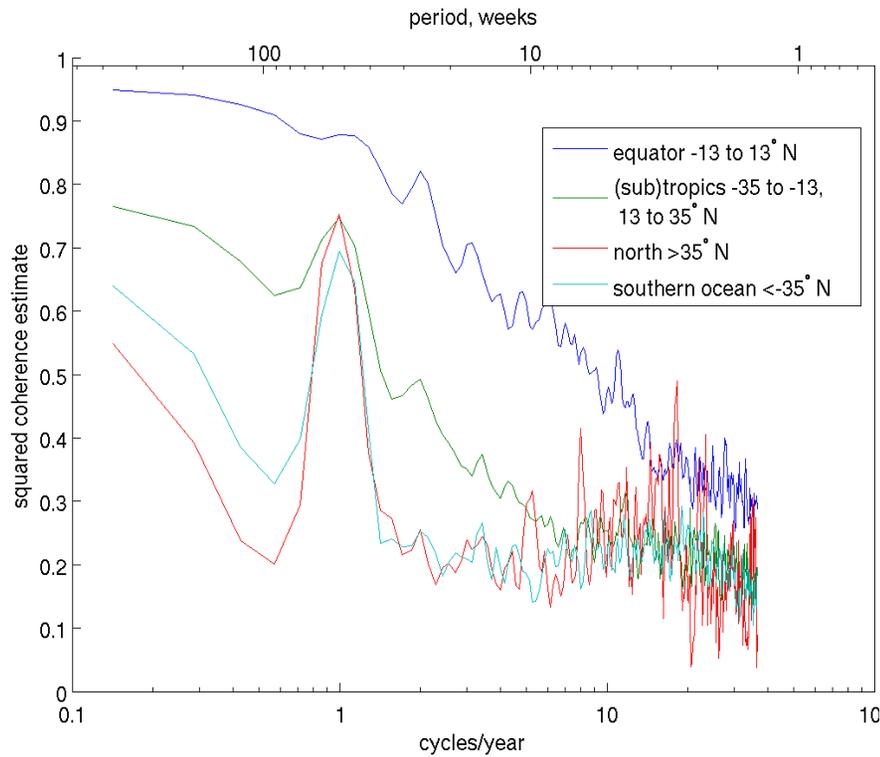
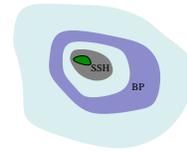
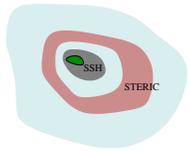
Frequency dependence of coherence



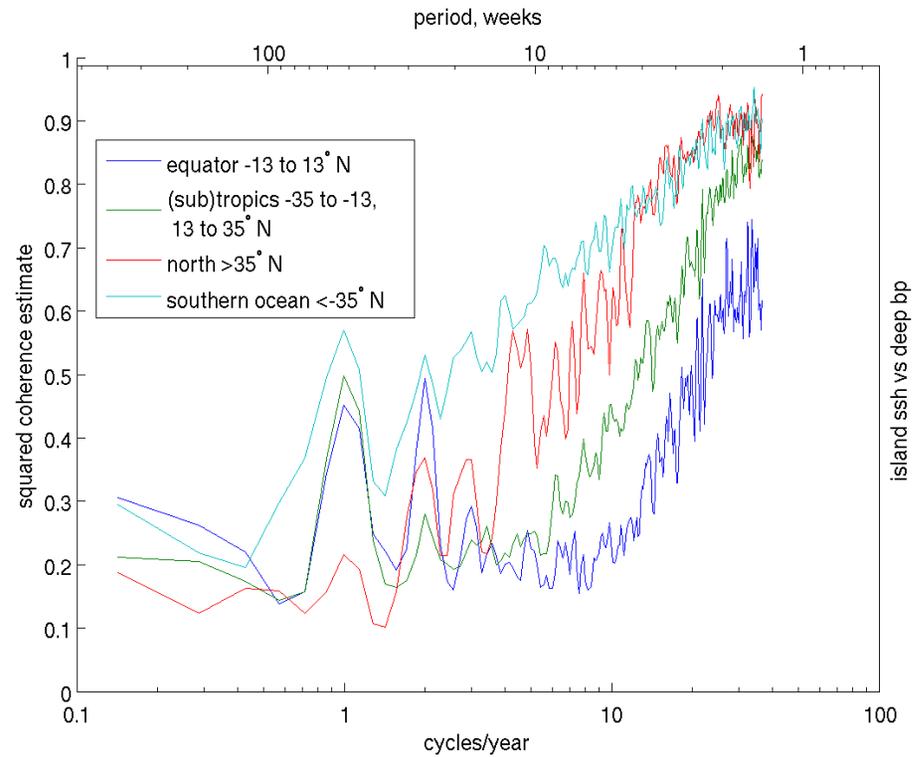
ssh by ssh deep



Frequency dependence of coherence



(i) ssh by steric deep

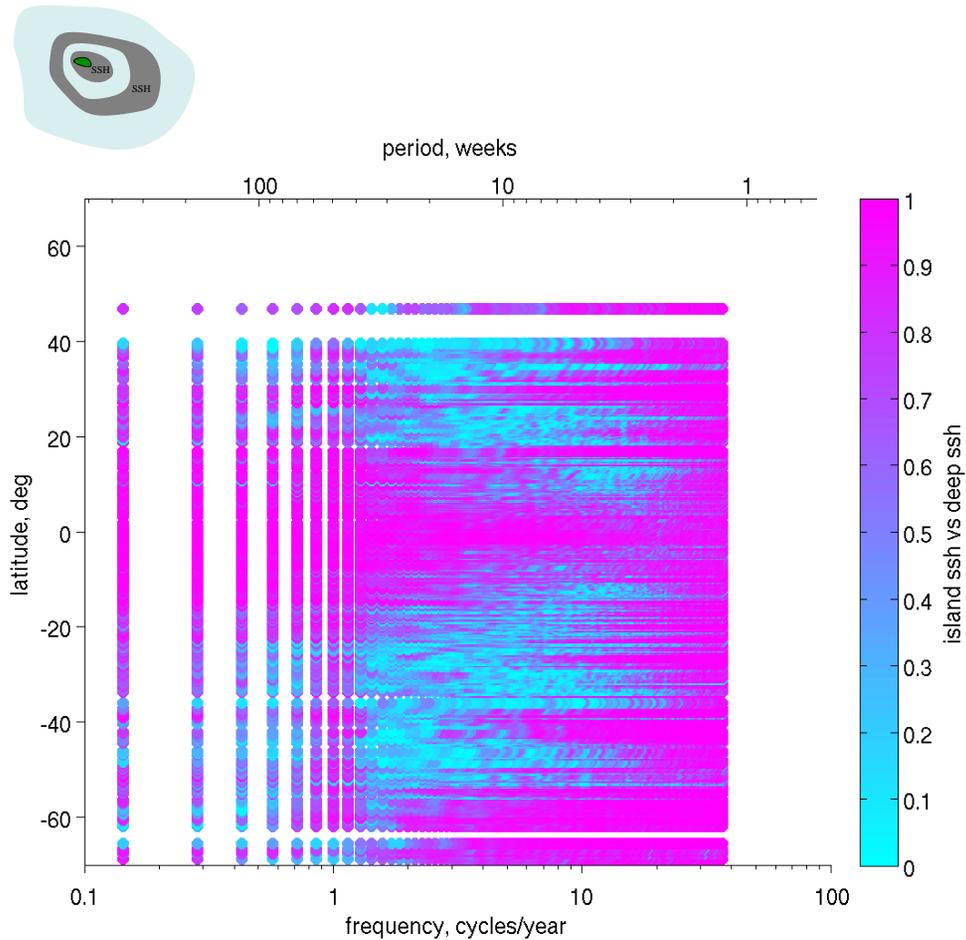


(ii) ssh by bp deep

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



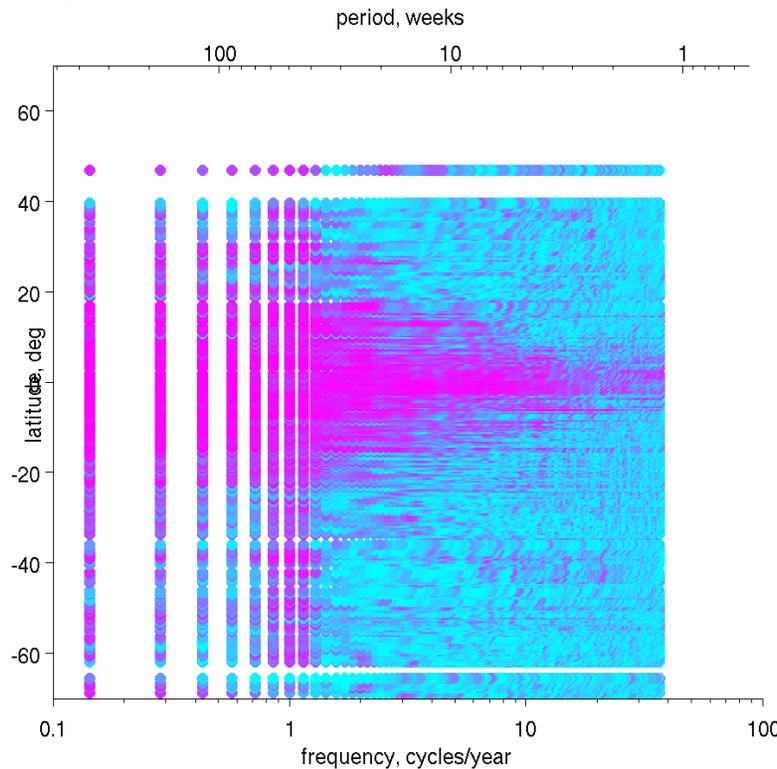
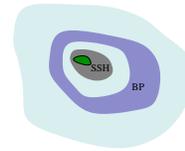
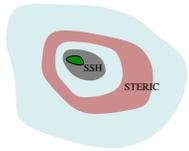
Frequency and latitude dependence of coherence



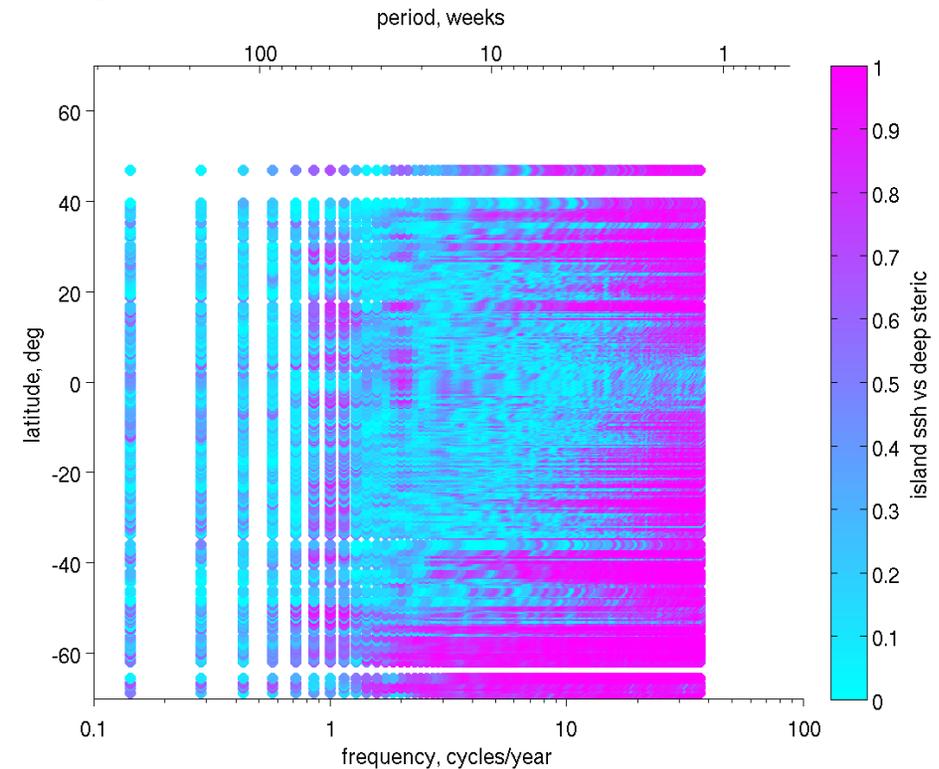
ssh by ssh deep



Frequency and latitude dependence of coherence



(i) ssh by steric deep

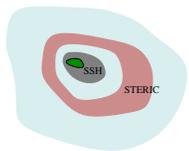


(ii) ssh by bp deep

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



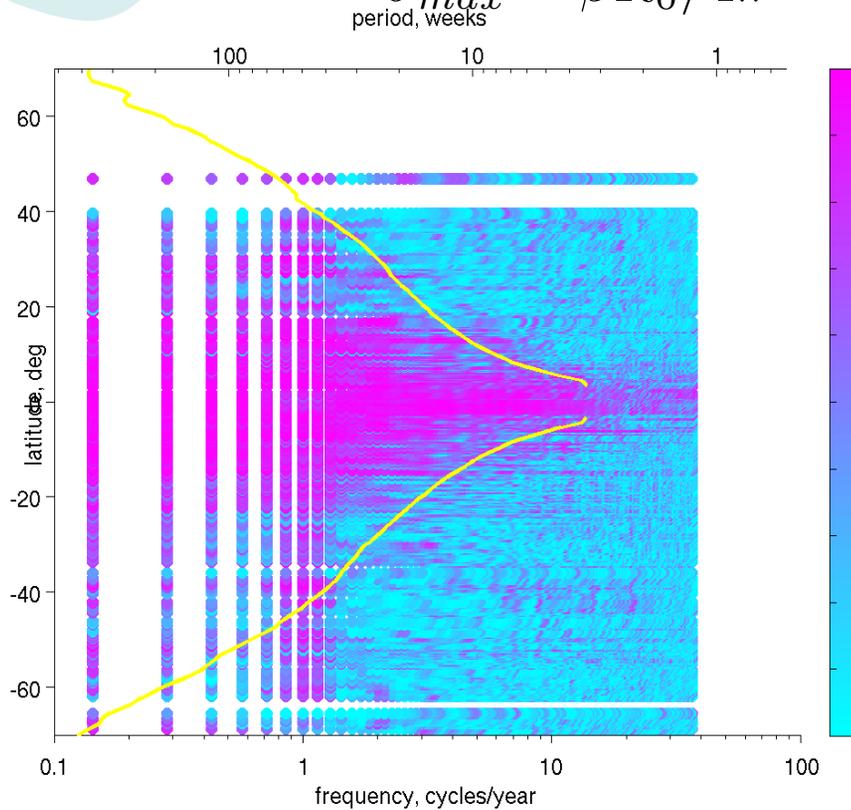
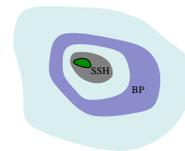
Frequency and latitude dependence of coherence



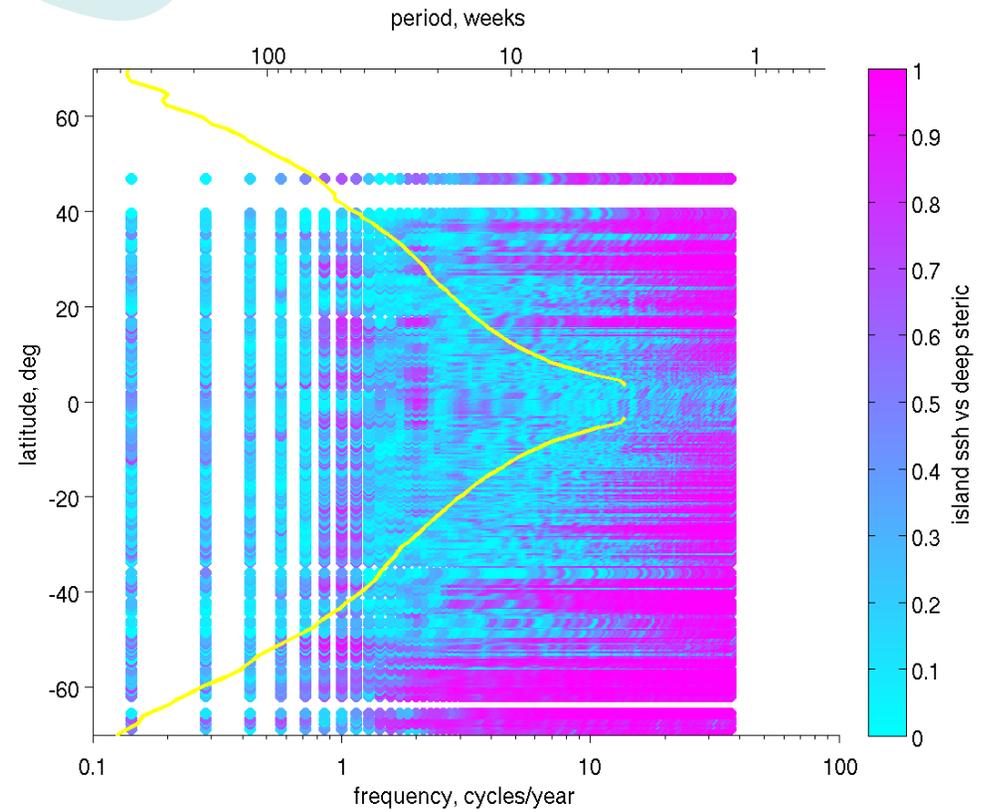
Baroclinic Rossby frequency

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

period, weeks



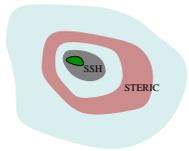
(i) ssh by steric deep



(ii) ssh by bp deep



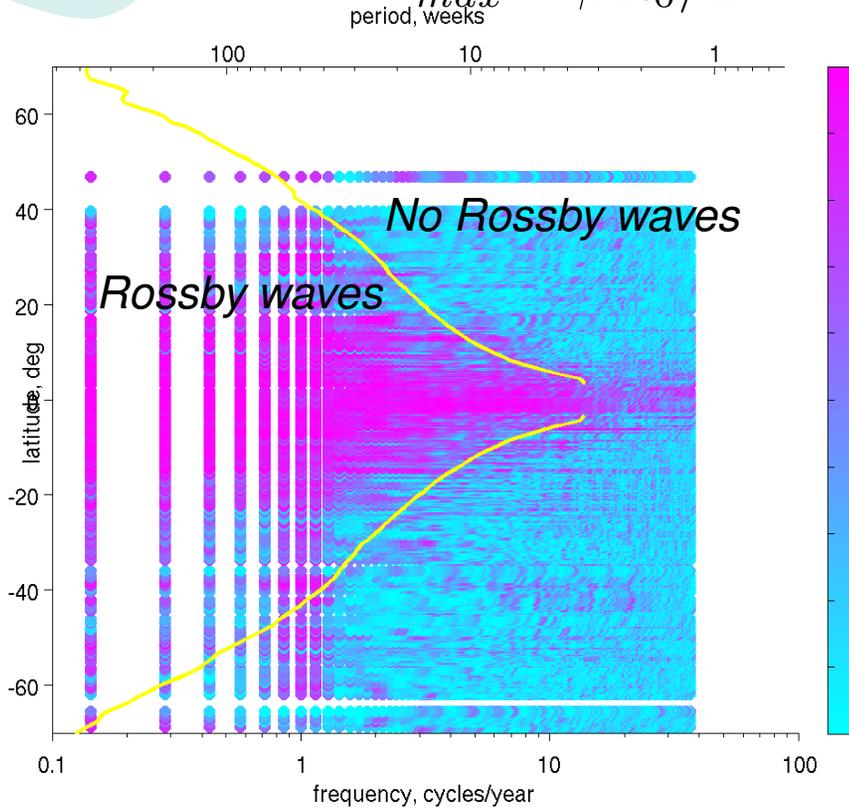
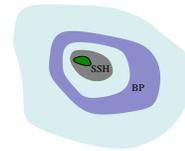
Frequency and latitude dependence of coherence



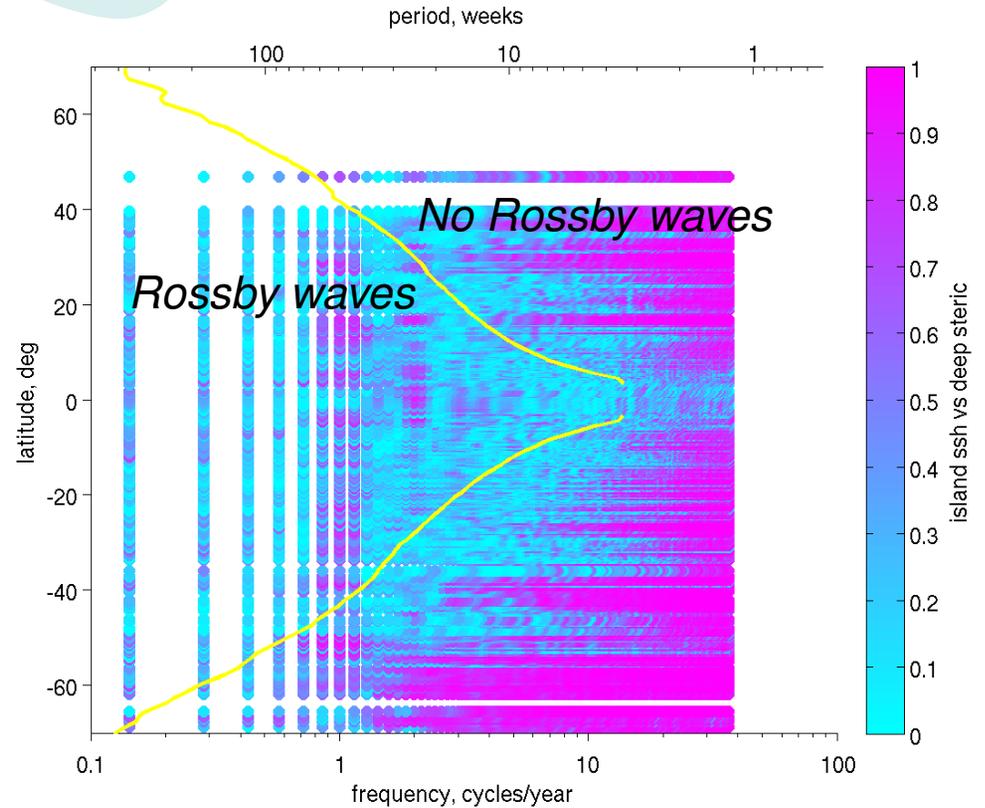
Baroclinic Rossby frequency

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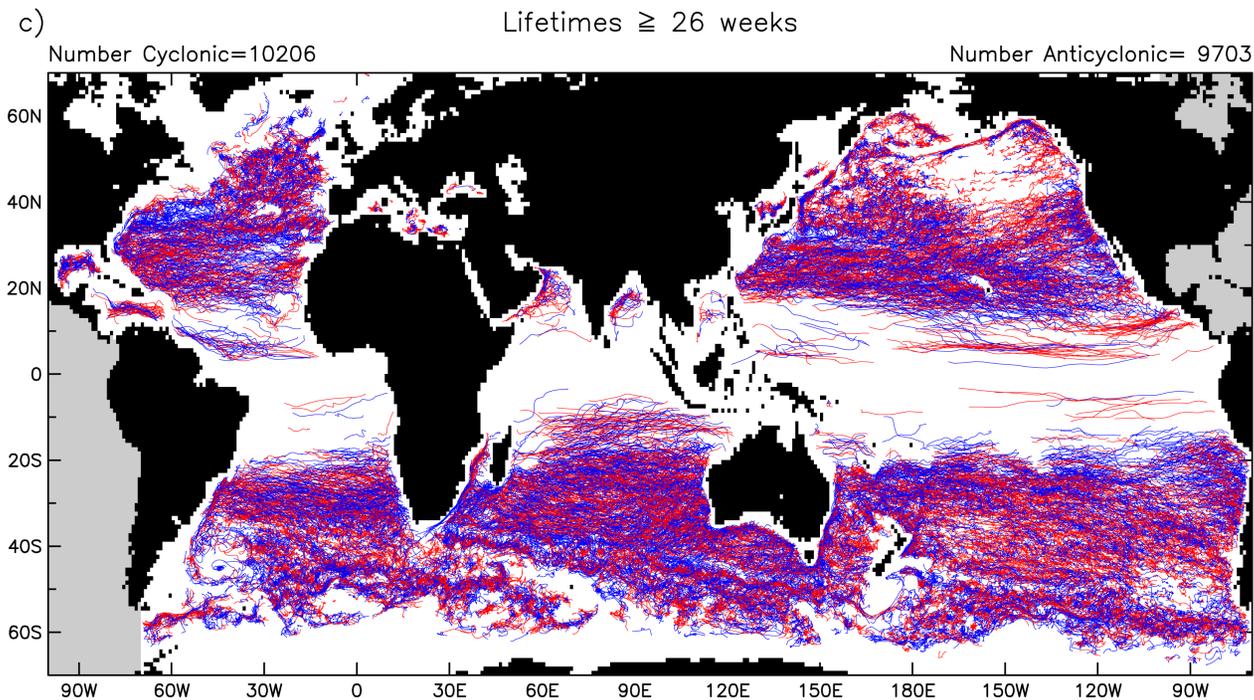


(i) ssh by steric deep



(ii) ssh by bp deep





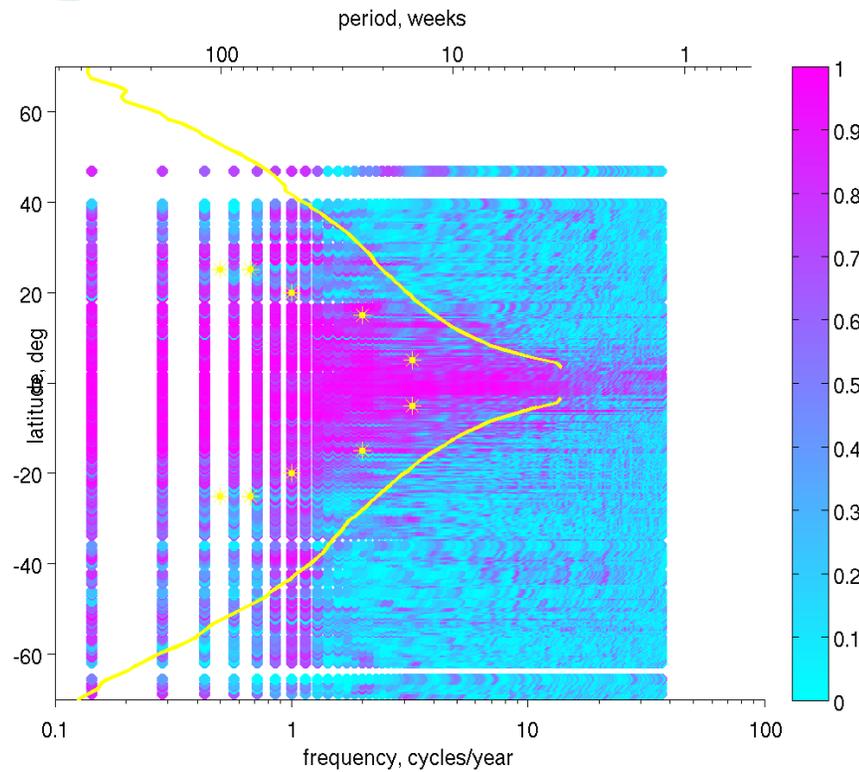
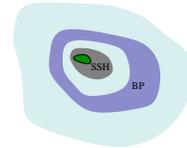
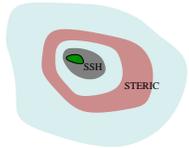
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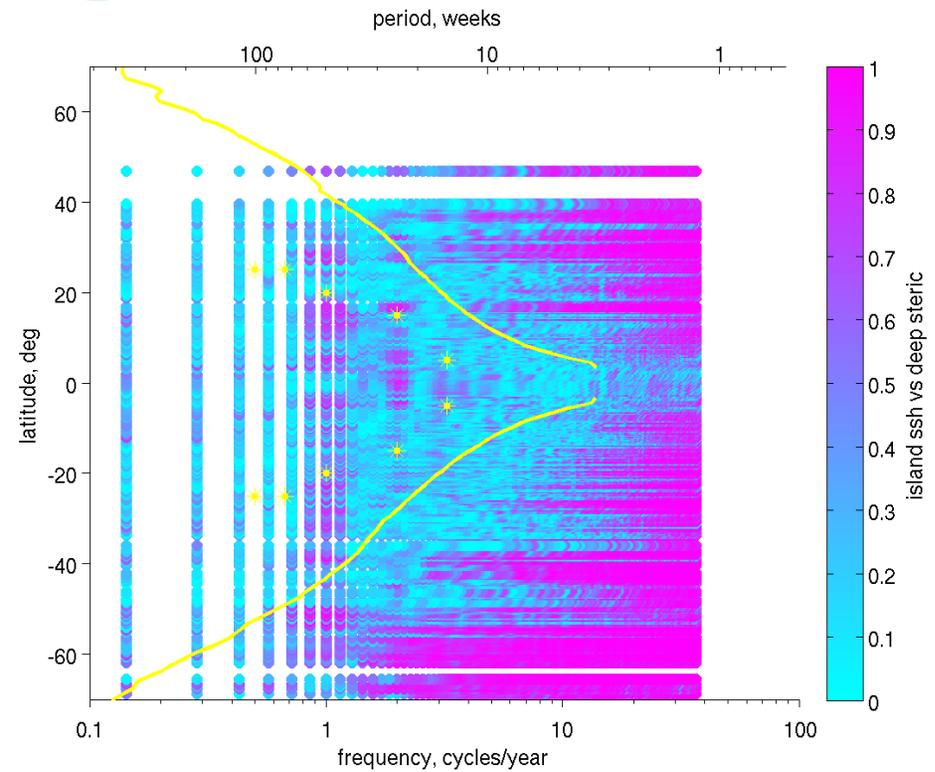
The trajectories of cyclonic (blue lines) and anticyclonic (red lines) eddies with lifetimes ≥ 26 weeks, seen in satellite altimetry over the 18-year period October 1992 – January 2011. *Chelton et al. 2011, Prog. Oceanogr. 91(2).*



Frequency and latitude dependence of coherence



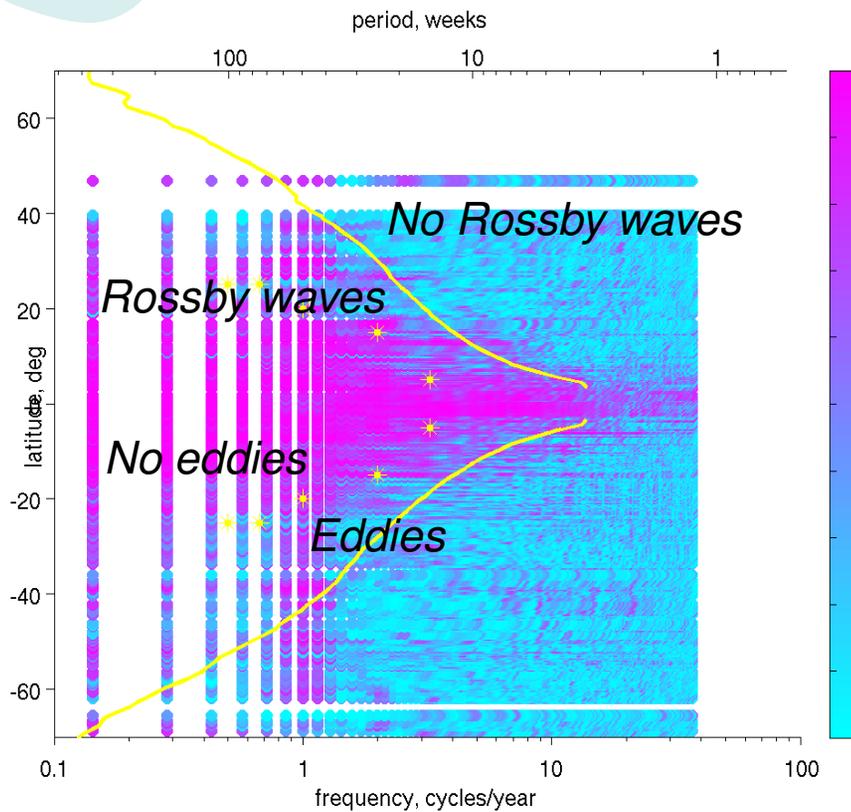
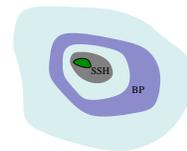
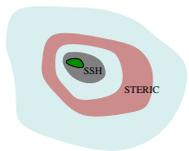
(i) ssh by steric deep



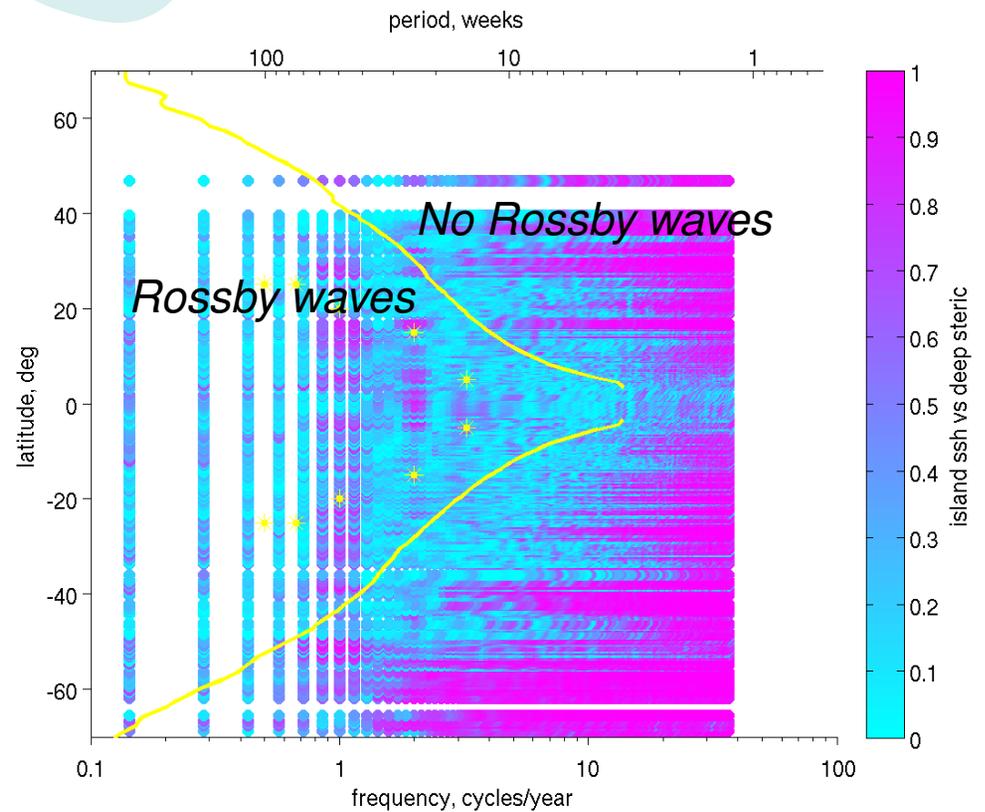
(ii) ssh by bp deep



Frequency and latitude dependence of coherence

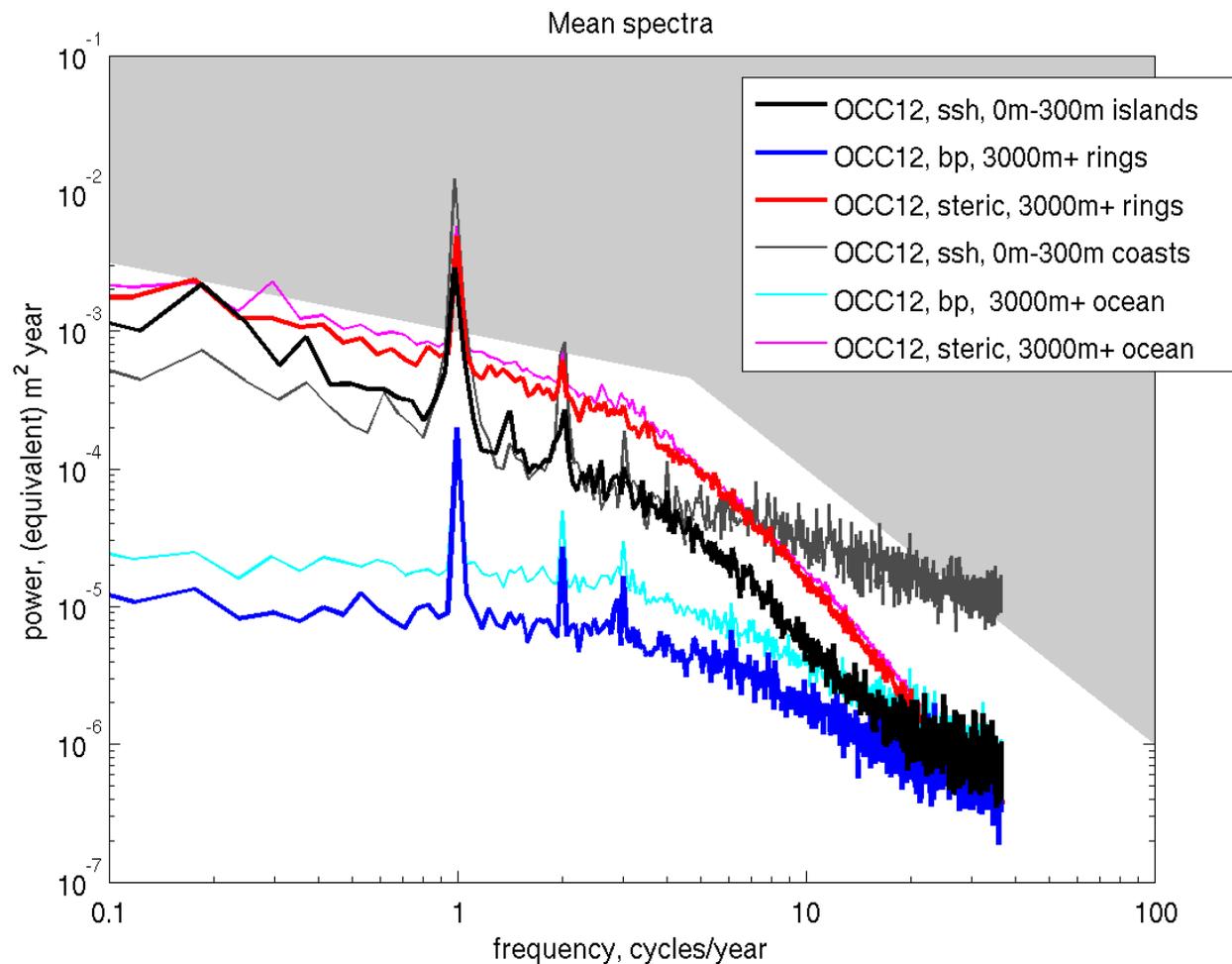


(i) ssh by steric deep



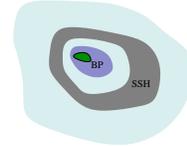
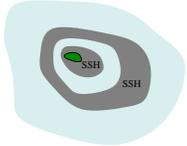
(ii) ssh by bp deep



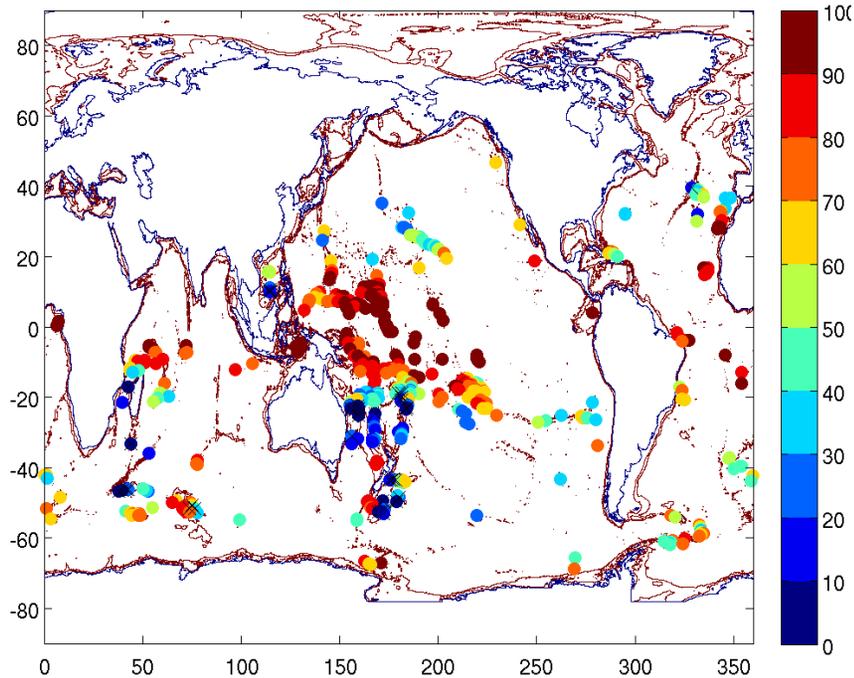


Spectra of ssh, steric or bp averaged across all islands or surrounding rings, all shallow coasts or all deep ocean. Polar regions are excluded.

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

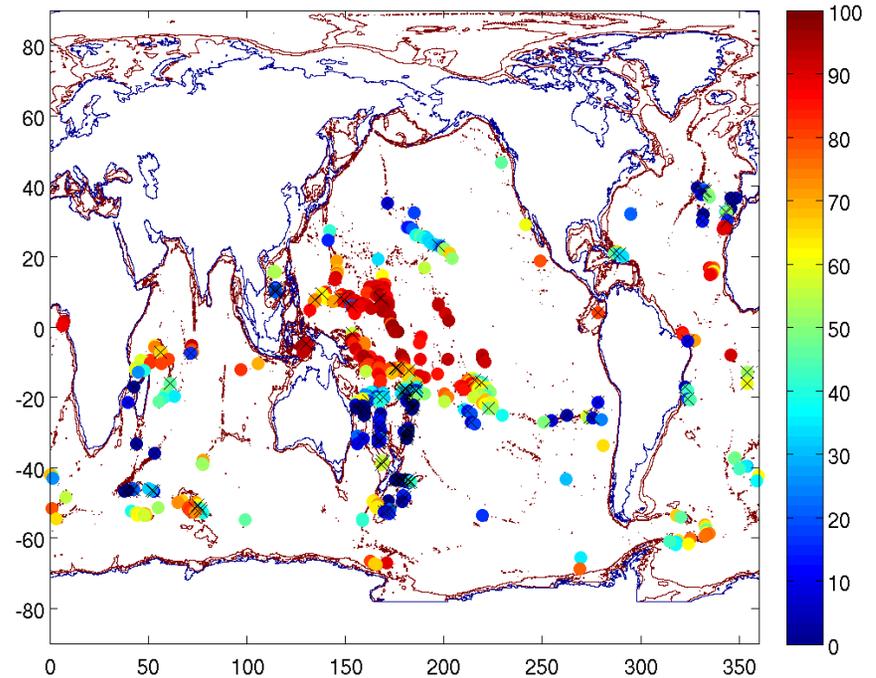


POV of ssh at island exp by ssh in deep water nearby,



(i) ssh by ssh deep

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



(ii) bp by ssh deep

