Wave refraction analyses at the coast of Norway for offshore applications

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SEEING THINGS DIFFERENTLY

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OBJECTIVES

Introduction: what is wave refraction?

                    why study wave refraction?

Methods: how to calculate wave propagation paths?

Application: effect of current induced refraction on rays reaching the coastal regions off Norway

WAVE REFRACTION

Change in propagation direction due to a change in its transmission medium

Current and depth induced refraction

RELATION TO OFFSHORE WIND ENERGY

Wave load: where will wave energy propagate?

Wave load: winds and waves misaligned, bending moment of the mast increases (Tarp-Johansen et al., 2009; Seidel, 2010).

METHODS - ASSUMPTIONS

Linear wave theory

Relative change in water depth over wavelength is small

Relative change in current velocity over wavelength and period is small

No temporal variations in current velocity

METHODS – RAY CURVATURE (MATHIESEN, 1987)

$$\kappa = \frac{\mu_z \cdot \left(\frac{d\,\mathbf{r}}{d\,t} \times \frac{d^2\,\mathbf{r}}{d\,t^2} \right)}{\left| \frac{d\,\mathbf{r}}{d\,t} \right|^3}$$

WAVE REFRACTION: COAST OF NORWAY

Depth induced refraction: Long waves, the topography affects the wave speed

H ~ 20 m (T ~8s)

Application to coastal area off Norway: only current induced refraction will be relevant

EXAMPLE – NO CURRENTS
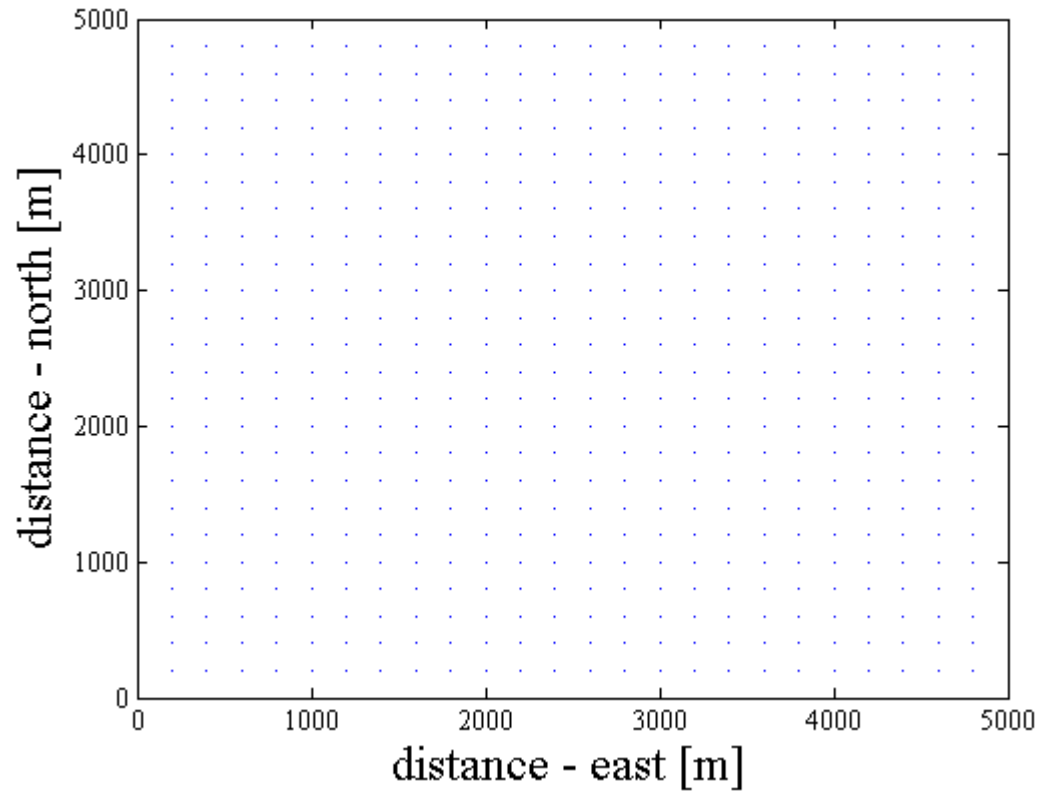
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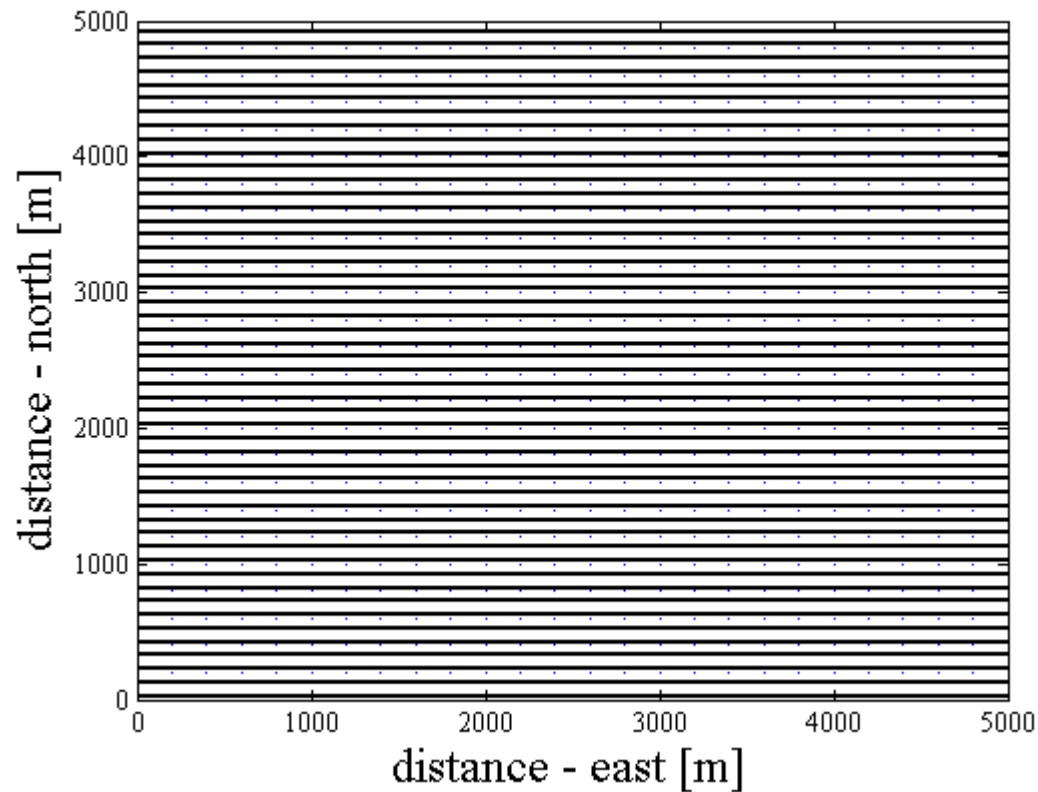
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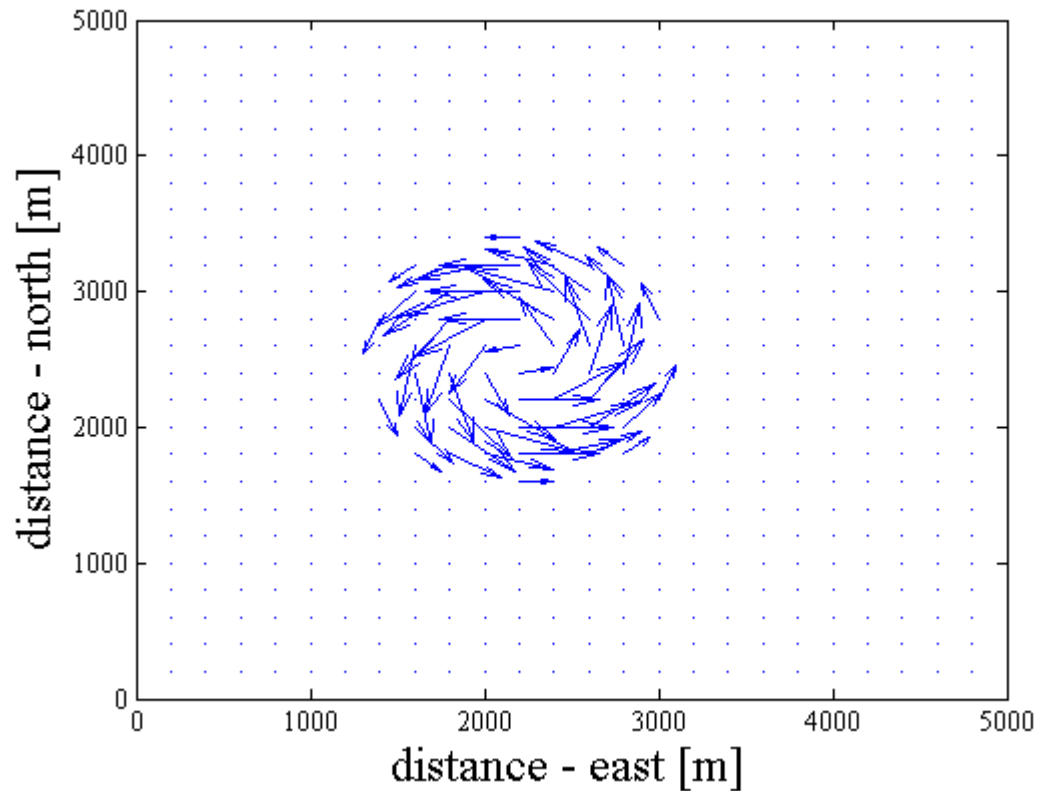
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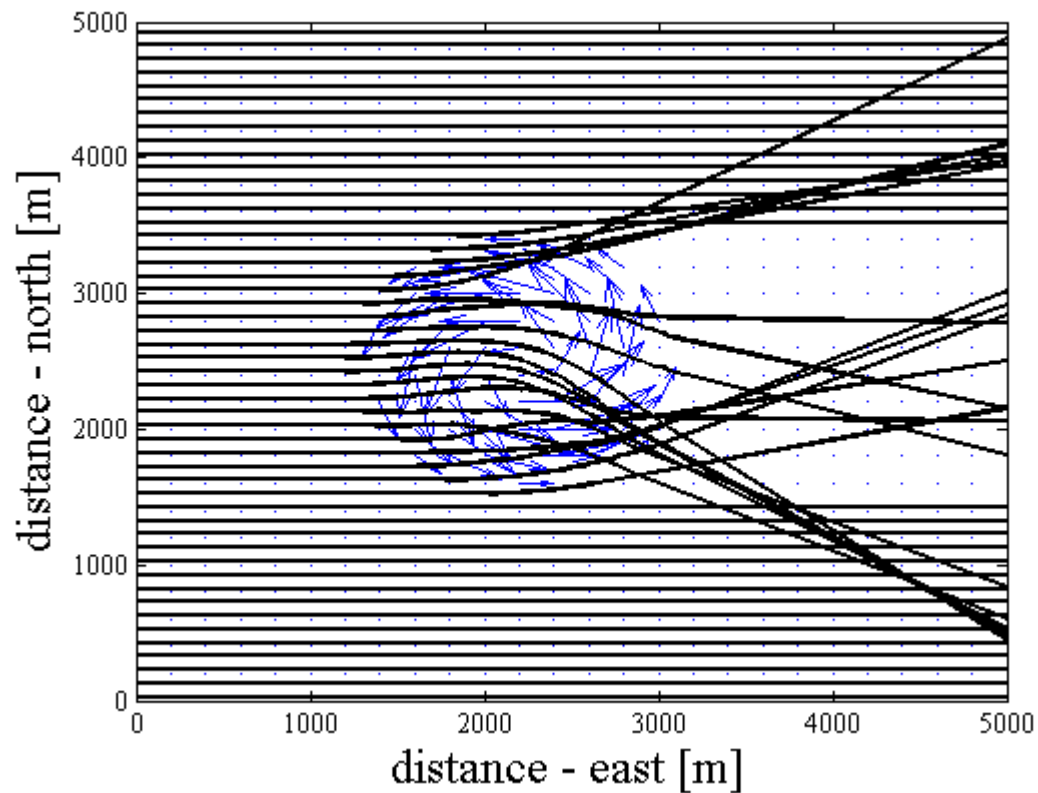
SURFACE VELOCITY

NorKyst800 (Albretsen et al., 2011)

Operational ocean model (Meterological inst., IMR, NIVA)

800 spatial m resolution

Daily averages since July 2012

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APPLICATION

For each current field: offshore wave propagation from 180° to 360°

Rays determined by eddies

All flow fields are representative for any wave propagation direction.

STUDY AREA AND SELECTED REGIONS
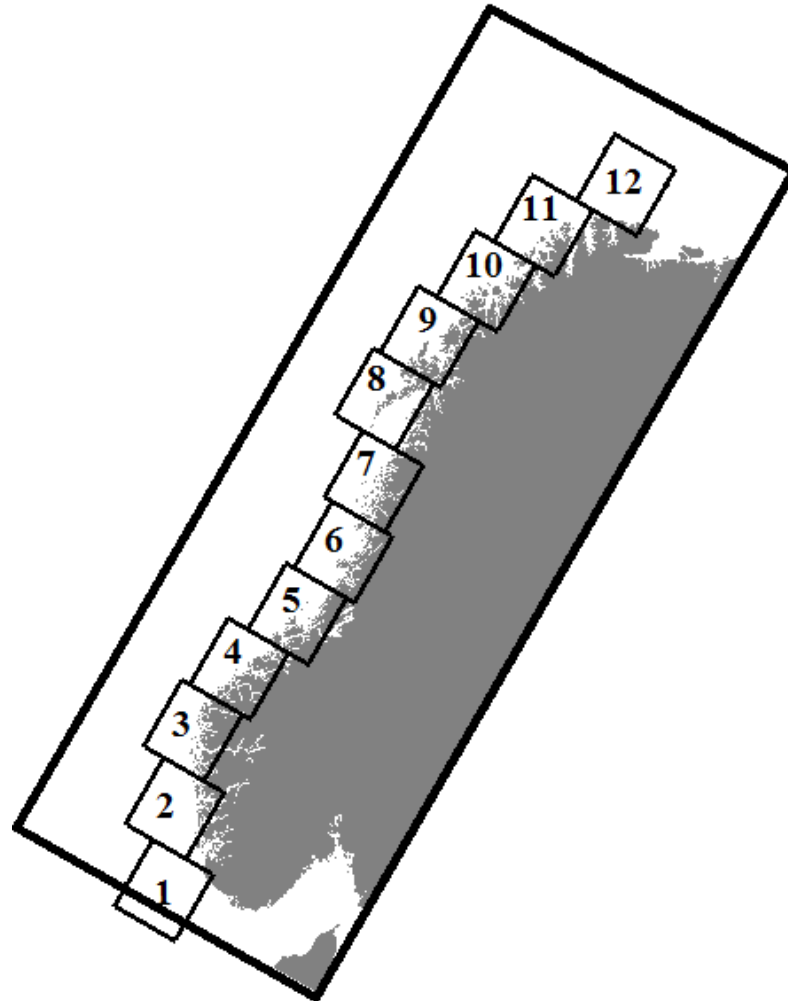
RAY DISTRIBUTIONS

RAY DISTRIBUTION
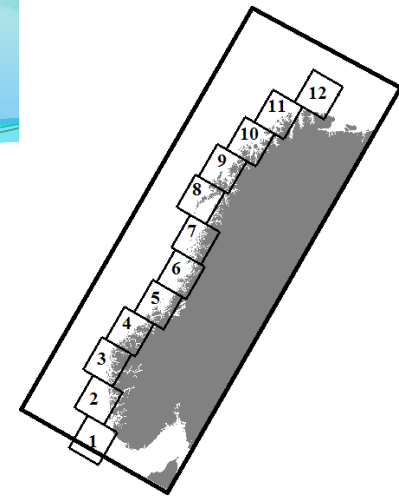
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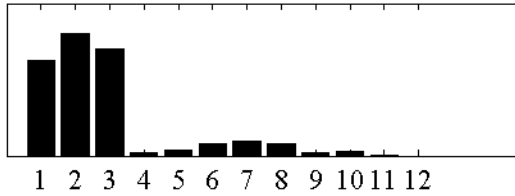
Offshore wave dir: 210°
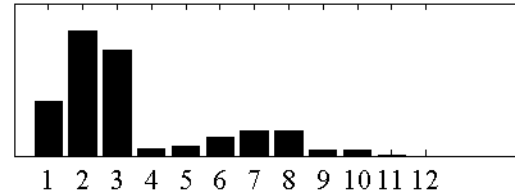
Offshore wave dir: 240°
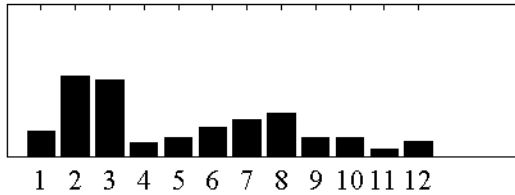
Offshore wave dir: 270°
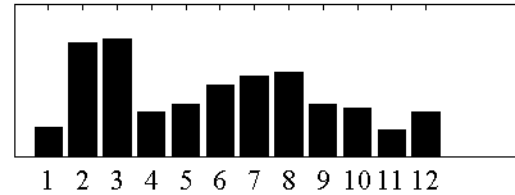
Offshore wave dir: 300°
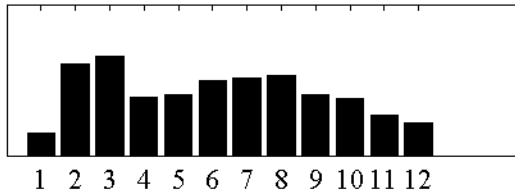
Offshore wave dir: 330°
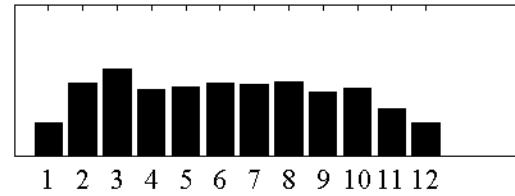
Offshore wave dir: 360°
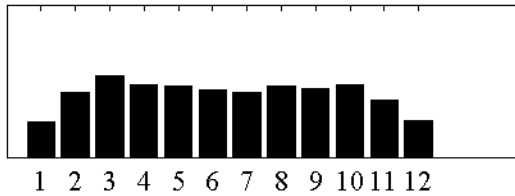
DEVIATION DISTRIBUTION-NORTHERLY WINDS
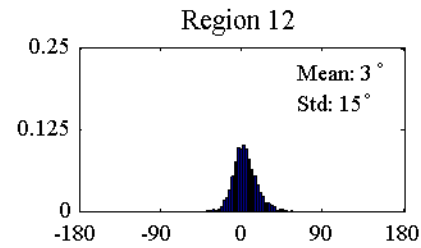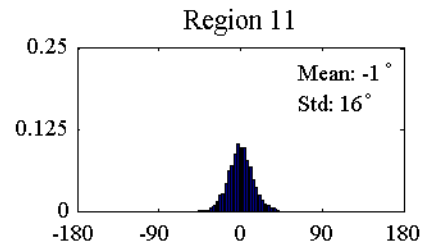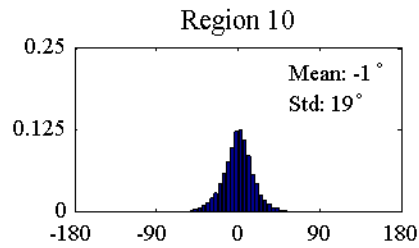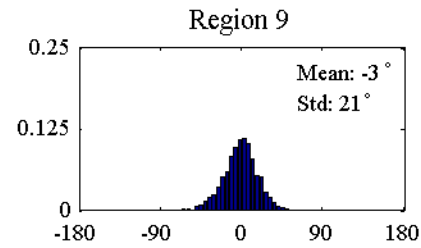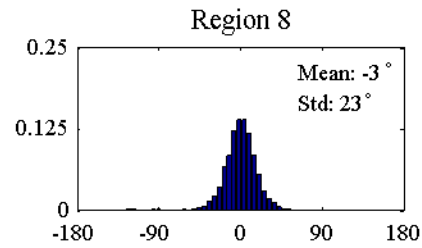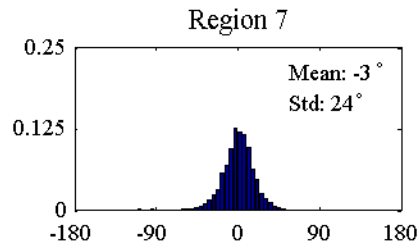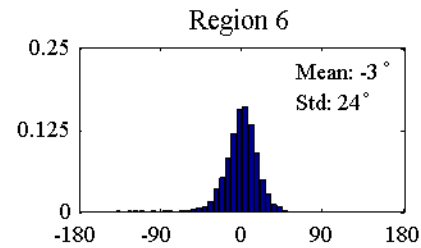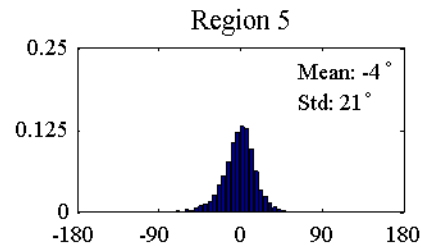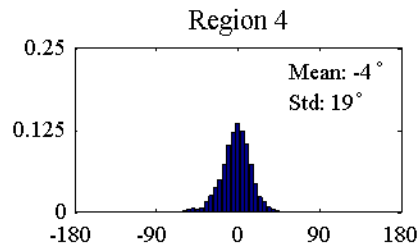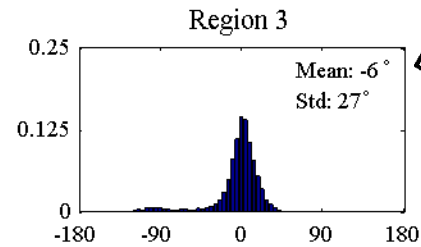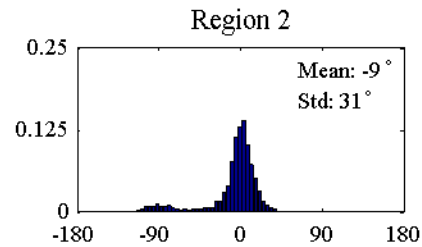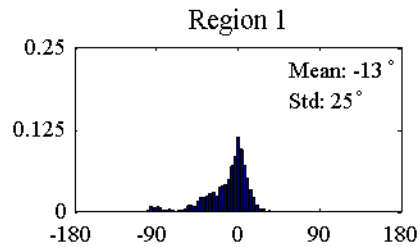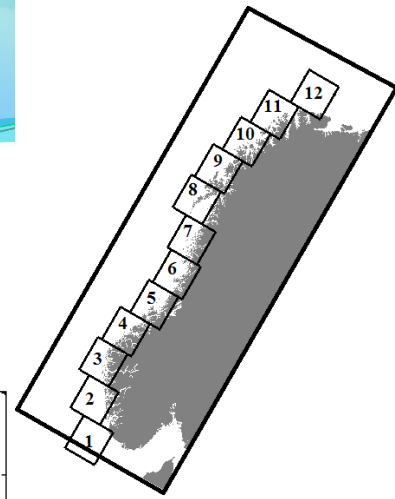
DEVIATION DISTRIBUTION-WESTERLY WINDS
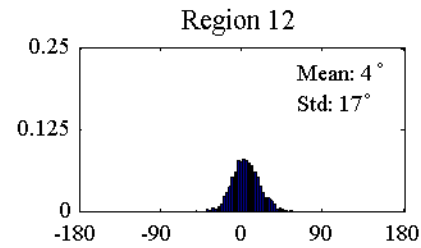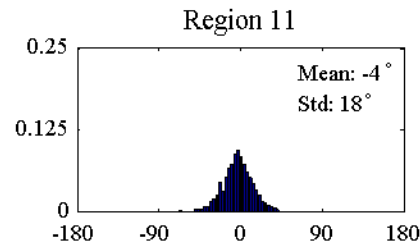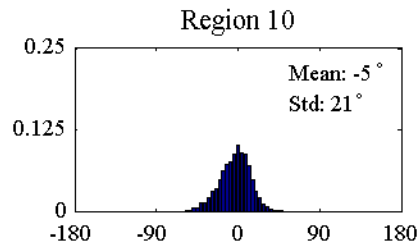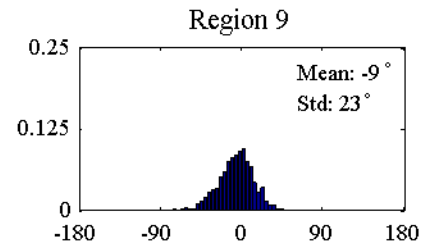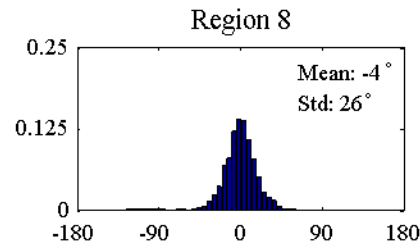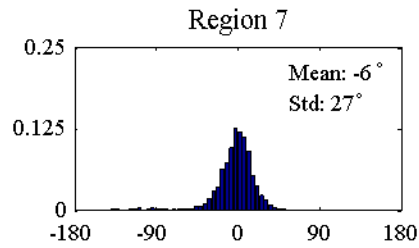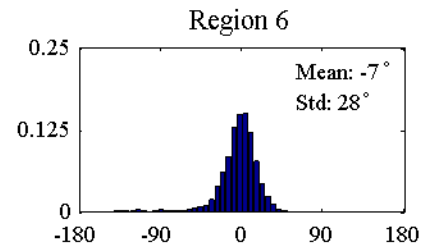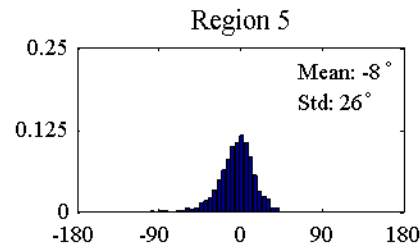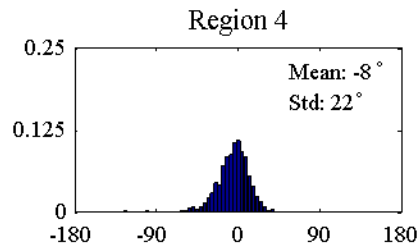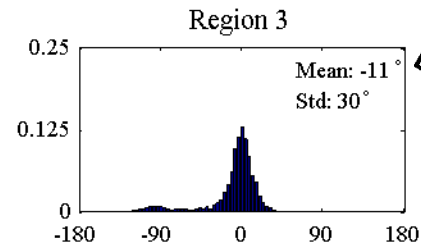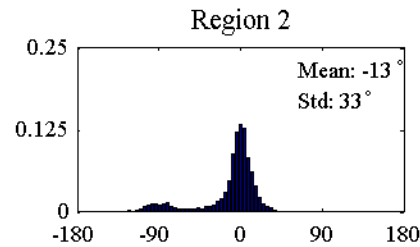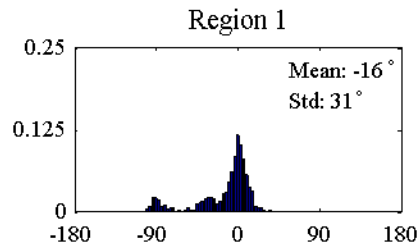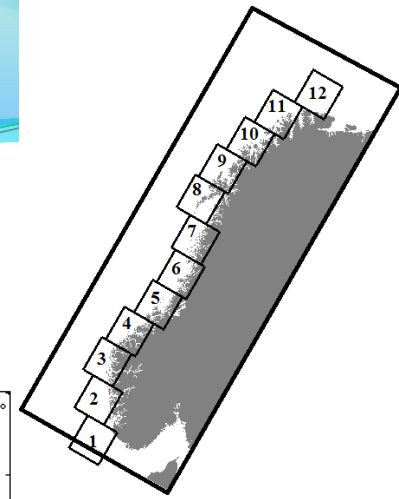
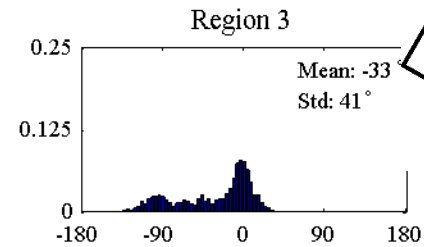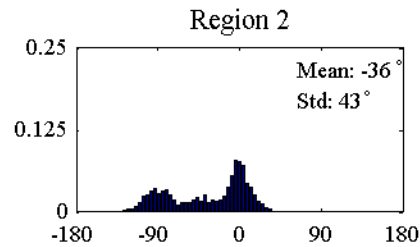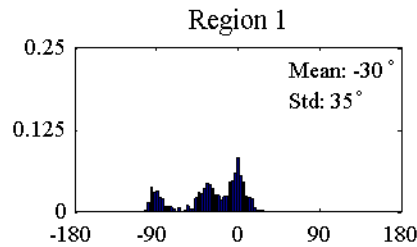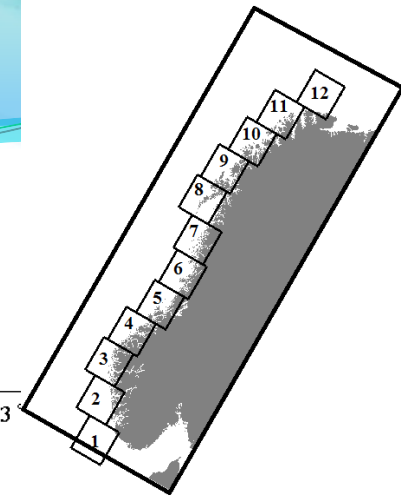# DEVIATION DISTRIBUTION-SOUTHERLY WINDS
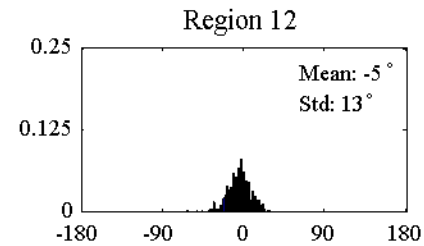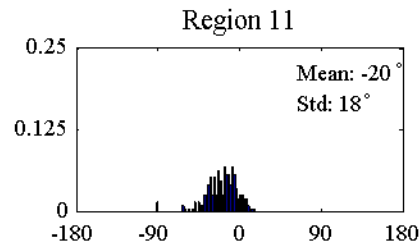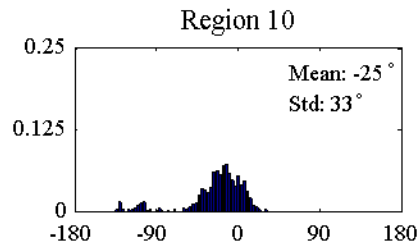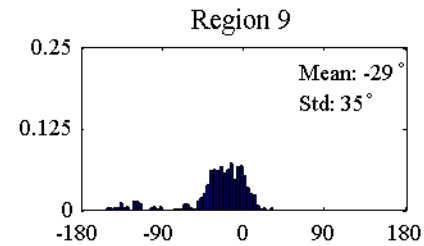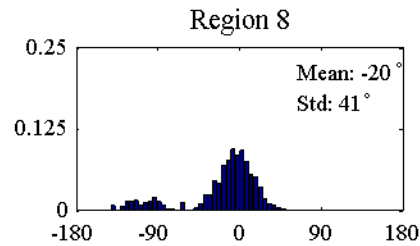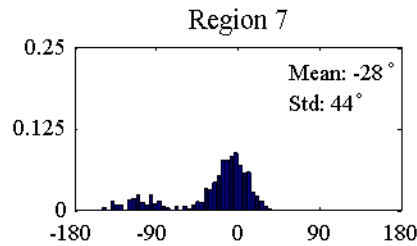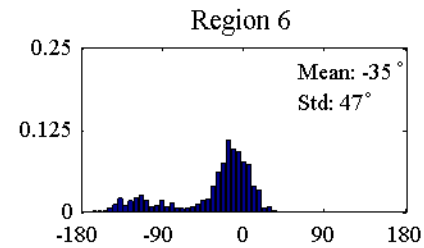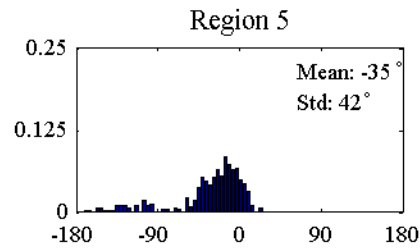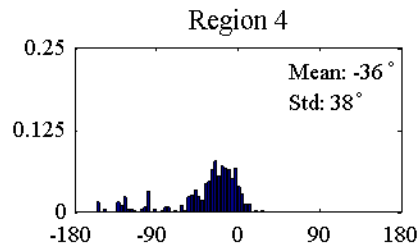
CONCLUSIONS

Southerly and westerly winds:

Convergence of wave energy at southwstern part of Norway

South of Lopphavet: Wave and wind are misaligned

Refraction effects may result in increased bending moment

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Thanks for your attention