Wind Input Function

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Conclusions

Motivation

Scientific Objective:

(1) To understand why the wind generated waves don't always propagate in down wind direction, sometime the angle between wind and wave propagated directions can be very large, specially in the coastal region. These angles can significantly impact on the waves.

(2) Improving the wind input function by consider more physical terms, such as wave age, phase velocity.

Motivation

Wave input function is not fully understood, especially in the coastal region:

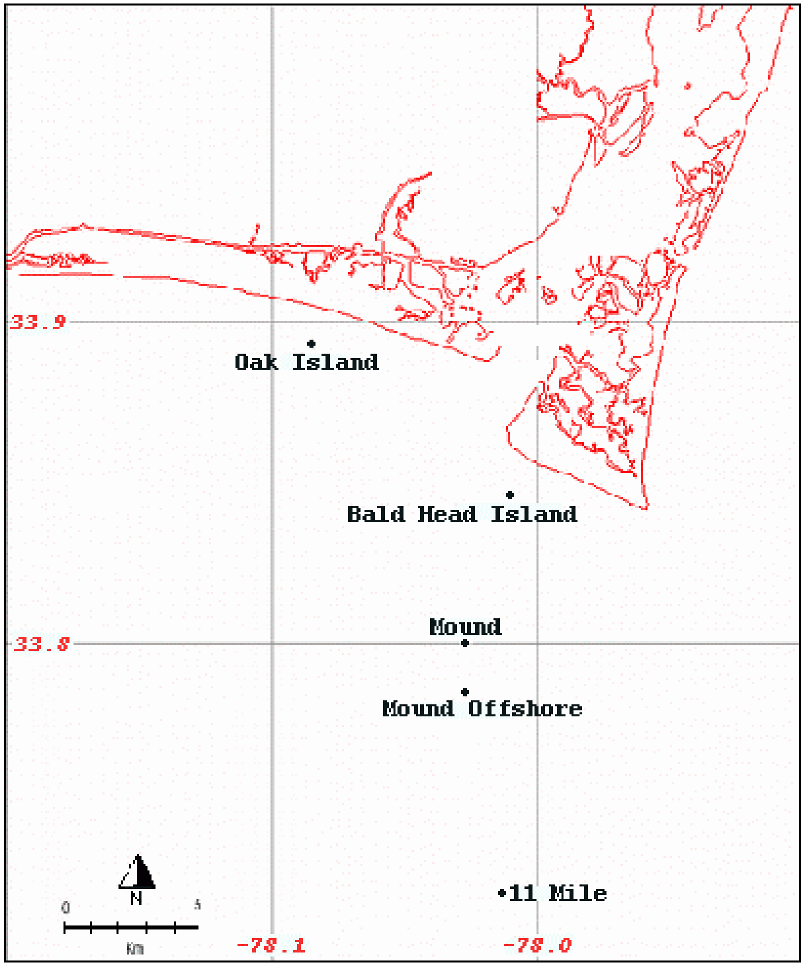
The theories:

- **Four wave interaction indirect cascades and direct cascades;**
- **Five wave interaction indirect cascades and direct cascades;**
- **Phillips mechanics.**

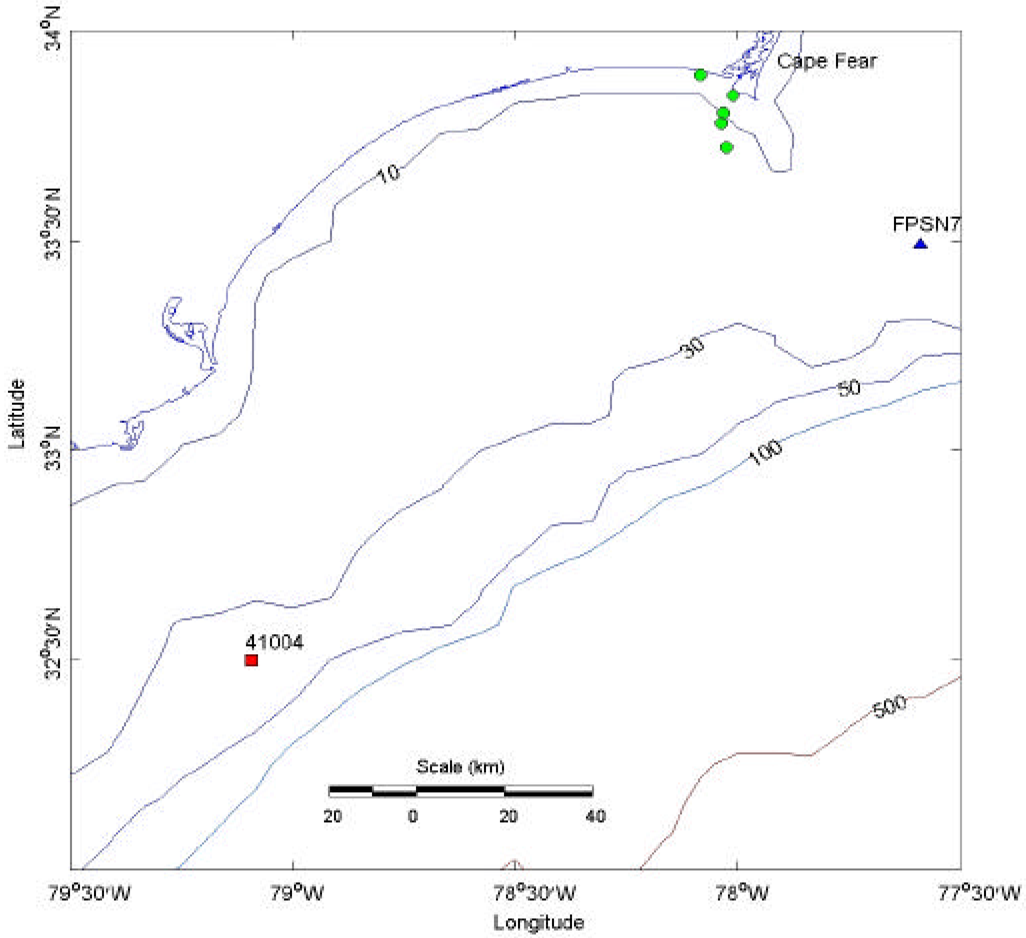
The new physical terms

- **Wave age;**
- **Phase velocity.**

Data location, Cape Fear



Location of two meteorological stations – Buoy 41004 (square) and Platform FPSN7 (triangle); also shown are directional wave gauges (green circles) and water depth contours in meters



Wind/Wave Station Information

Station	Water depth (m)	Data length
Oak Island	7	Sep 00 – May 03
Bald Head Island	5.8	Sep 00 – June 03
Mound Crest	7	July 01 – June 02
Mound Offshore	12.8	Aug 01 – July 02
Mile 11	12.8	Sep 00 – June 03
FPSN7	14	Nov 84 – present
Buoy 41004	38	June 78 – present

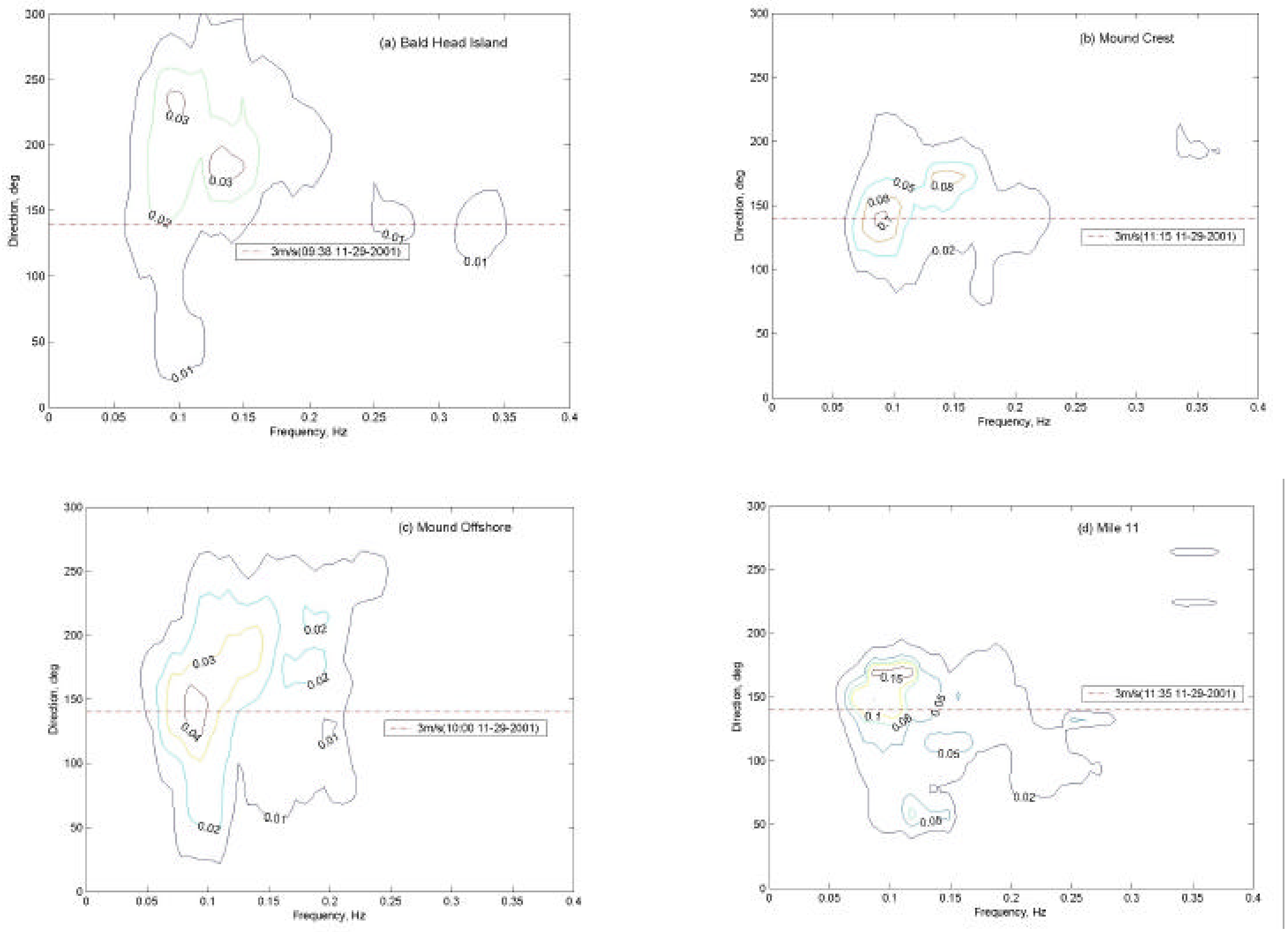
1) Action Conservation:

$$\frac{\partial A}{\partial t} + \frac{\partial[(c_{gx} + u)A]}{\partial x} + \frac{\partial[(c_{gy} + v)A]}{\partial y} + \frac{\partial[c_{gq} A]}{\partial q} + \frac{\partial[c_{gs} A]}{\partial s} = S_{in} + S_{dp} + S_{nl},$$

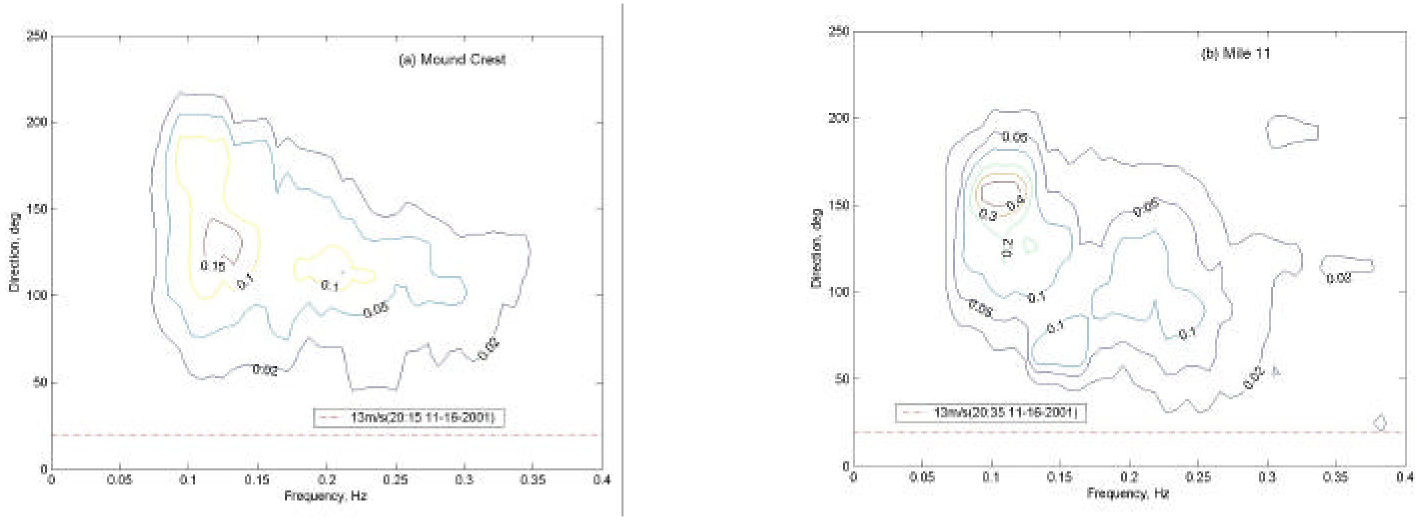
2) Phillips Mechanics

$$c_s < u_{wind} \quad if \qquad c_s \geq u_{wind} \quad if \qquad j = \begin{cases} \cos^{-1} \dfrac{c_s}{u_{wind}}, \\ 0, \end{cases}$$

$$c_s = \frac{s}{k}$$



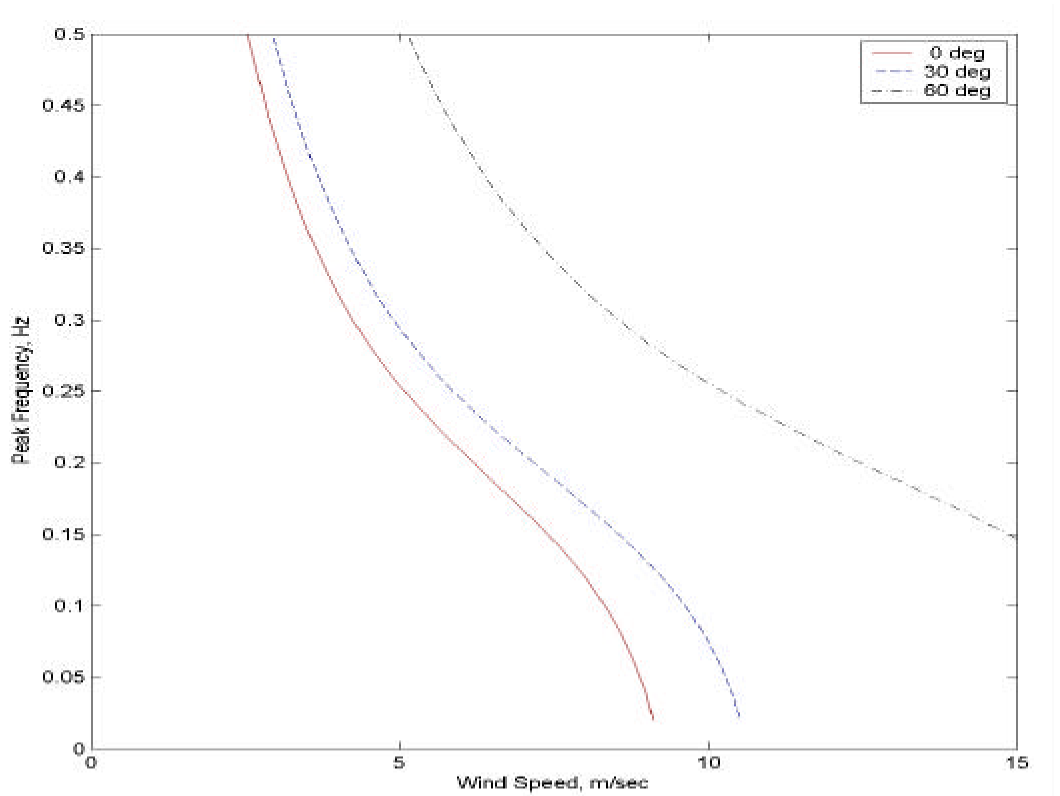
Measured directional wave spectra from (a) Bald Head Island, (b) Mound Crest, (c) Mound Offshore, and (d) Mile 11 between 09:38 and 11:35 GMT, November 29th, 2001 (wind speed is 3m/sec and wind direction is from 140°, shown as dash lines)

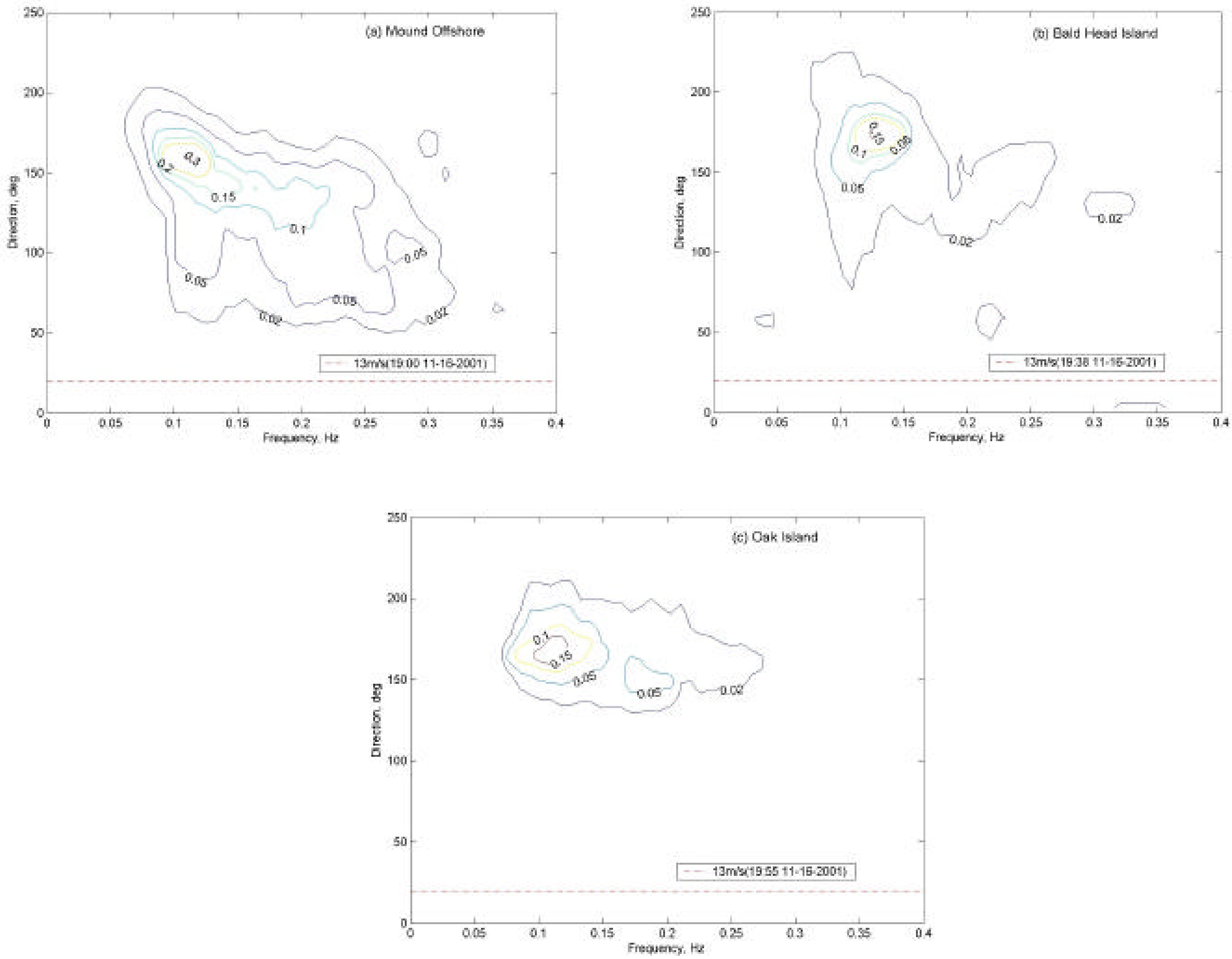


Measured directional wave spectra from (a) Mound Crest at 20:15 GMT and (b) Mile 11 at 20:35 GMT, November 16th, 2001 (wind speed is 13m/sec and direction is 20°, shown as dash lines)

For fully developed sea states in a finite depth, *h*, the peak frequency, s_{paek} can be approximated by (Graber and Madsen, 1988)

$$s_{peak} = \frac{g \tanh(k_{peak} h)}{u_{wind} \cos(q_{wind} - q_{wave})}$$





Measured directional wave spectra from (a) Mound Offshore at 19:00 GMT, (b) Bald Head Island at 19:38 GMT, and (c) Oak Island at 19:55, November 16th, 2001 (wind is 13m/sec from 20°, as dash lines)

New Wind Input Function

$$S_{in} = \frac{a_1 s}{g} F_1(\vec{u}_{wind} - \vec{c}_s)\, F_2\left(\frac{\vec{c}_s}{\vec{u}_{wind}}\right) E^*_{PM}(s)\Phi(q) +$$

$$\frac{a_2 s}{g} F_1(\vec{u}_{wind} - \vec{c}_s)\, F_2\left(\frac{\vec{c}_s}{\vec{u}_{wind}}\right)\, F_3\left(\frac{\vec{c}_s}{\vec{u}_{wind}}\right)\, E(s,q),$$

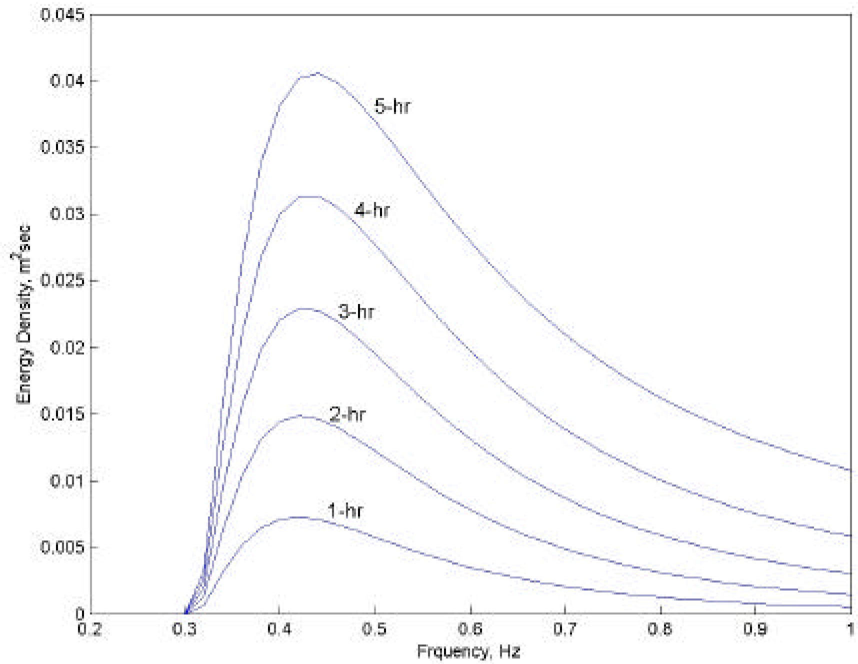
$$F_1(\vec{u}_{wind} - \vec{c}_s) = \begin{cases} |\vec{u}_{wind}|\cos(q_{wind} - q) - c_s(s,q), & \text{If } \vec{c}_s < \vec{u}_{win} \\ 0, & \text{if } \vec{c}_s \ge \vec{u}_{win} \end{cases}$$

$$F_2\left(\frac{\vec{c}_s}{\vec{u}_{wind}}\right) = \begin{cases} \cos j\,, & \text{If } \vec{c}_s < \vec{u}_{win} \\ 1, & \text{if } \vec{c}_s \ge \vec{u}_{win} \end{cases}$$

$$F_3\left(\frac{\vec{c}_s}{\vec{u}_{wind}}\right) = \begin{cases} \log_{10}\left[\left(\frac{c_s}{u_{wind}}\right)^{-1}\right], & \text{If } \vec{c}_s < \vec{u}_{win} \\ 0, & \text{if } \vec{c}_s \ge \vec{u}_{win} \end{cases}$$

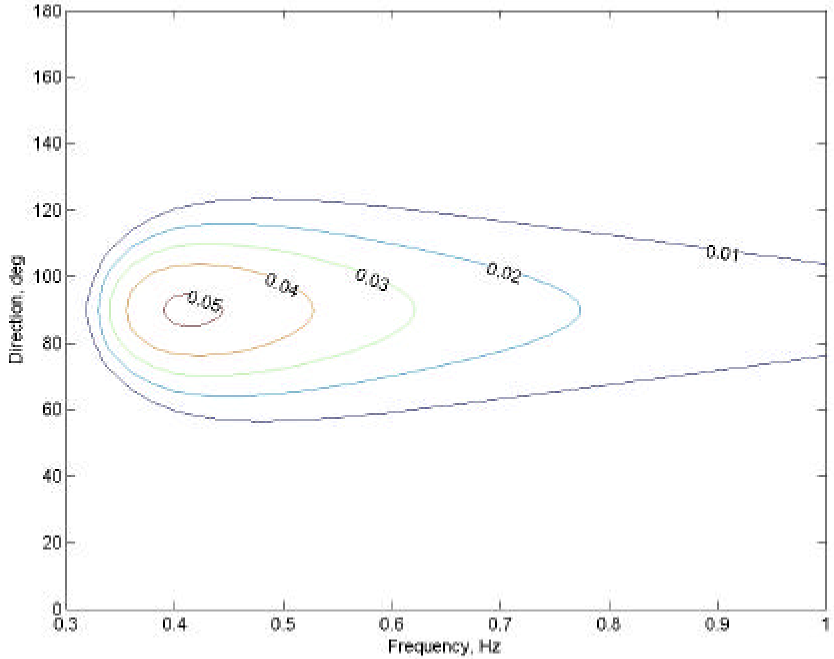
$$E^*_{PM}(s) = \frac{a_1 g^2}{s^5} \exp\left(-0.74\frac{s_0^4}{s^4}\right) \qquad \Phi(q) = \frac{8}{3p}\cos^4(q - q_{wind})$$

Numerical Results



Wave energy growth in the frequency spectrum for the first 5 hours under the steady wind condition (wind speed is 5 m/sec, from 90^o) over a calm sea in water depth of 18 m

Numerical Results



Directional wave spectrum (in the units of m^2sec/radian) from a 5-hour simulation under the steady wind condition (wind speed is 5 m/sec and direction from 90^o) over a calm sea in water depth of 18 m

Summary

1. In the case of a mild wind where the wind speed is less than the wave phase velocity of the spectrum, the wind wave propagation will be in the down wind direction.

2. The angle between wind wave are due to:

(a) Phillips' mechanics;

(b) the wind wave propagation direction is also affected by the initial spectrum and a new nonlinear four-wave interaction mechanics suggested by Lin and Perrie (1997b).

3. New physical terms:

(a) wave age;

(b) Wave phase velocity;

4. Included traditional terms in WAM.

5. Formulation is based on very limited data; our goal is intended to understand the fundamental physics