Ocean Waves

2016년 해양구조물 실험 특론

정 광 효 교 수

부산대학교 조선해양공학과

Metocean parameters

Meteorology and Oceanography

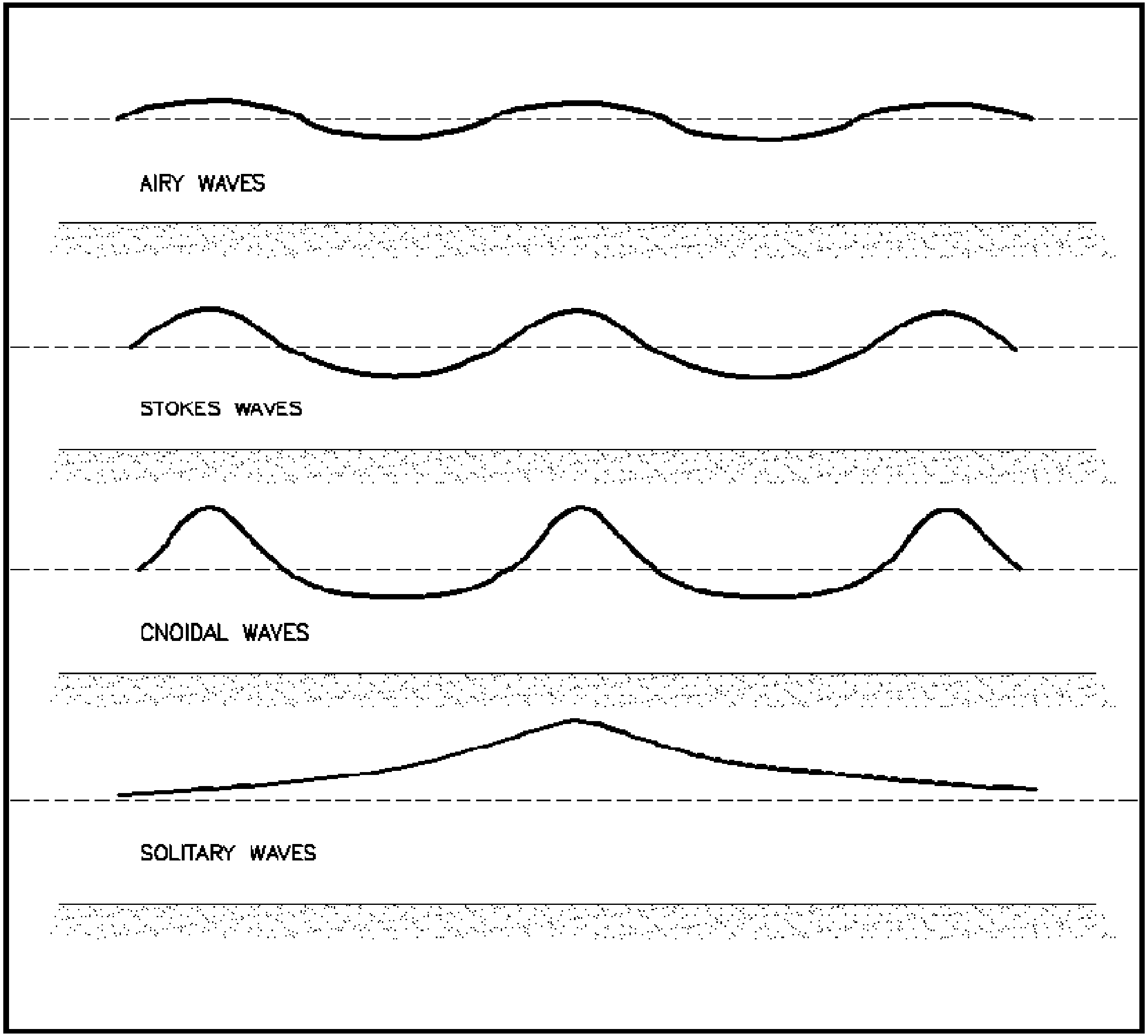
Parameter	Information
Winds	Extreme wind speed *
	Extreme wind speed by direction
	Frequency of occurrence of wind speed and direction *
	Persistence of sustained wind speeds above certain thresholds *
	Vertical profile
	Gust speeds and spectra
Waves	Extreme sea state *
	Extreme sea state by direction
	Cumulative frequency distribution of individual wave heights
	Joint probability of significant wave height and period *
	Joint probability of significant wave height and period by direction
	Wave energy spectra and directional spreading
	Persistence of storms and calms
Water levels	Chart datum water depth
	Extreme tidal rise and storm surge
	Extreme tidal, surge and wave crest elevation

Metocean parameters

Currents	Extreme current speed * Extreme current speed by direction Vertical profile with depth Fatigue design current speed
Temperatures	Maximum and minimum air temperatures * Maximum and minimum sea temperatures * Vertical profile of sea temperature with depth
Ice and snow	Maximum thickness and density of snow Maximum thickness and density of ice Occurrence of sea ice and icebergs
Marine growth	Type and thickness of growth
Other meteorological information	Precipitation, fog, wind chill, occurrence and forecastability of storms
Seabed information	Slope (including direction) of seabed Soil conditions
Salinity	Per cent

Water Waves

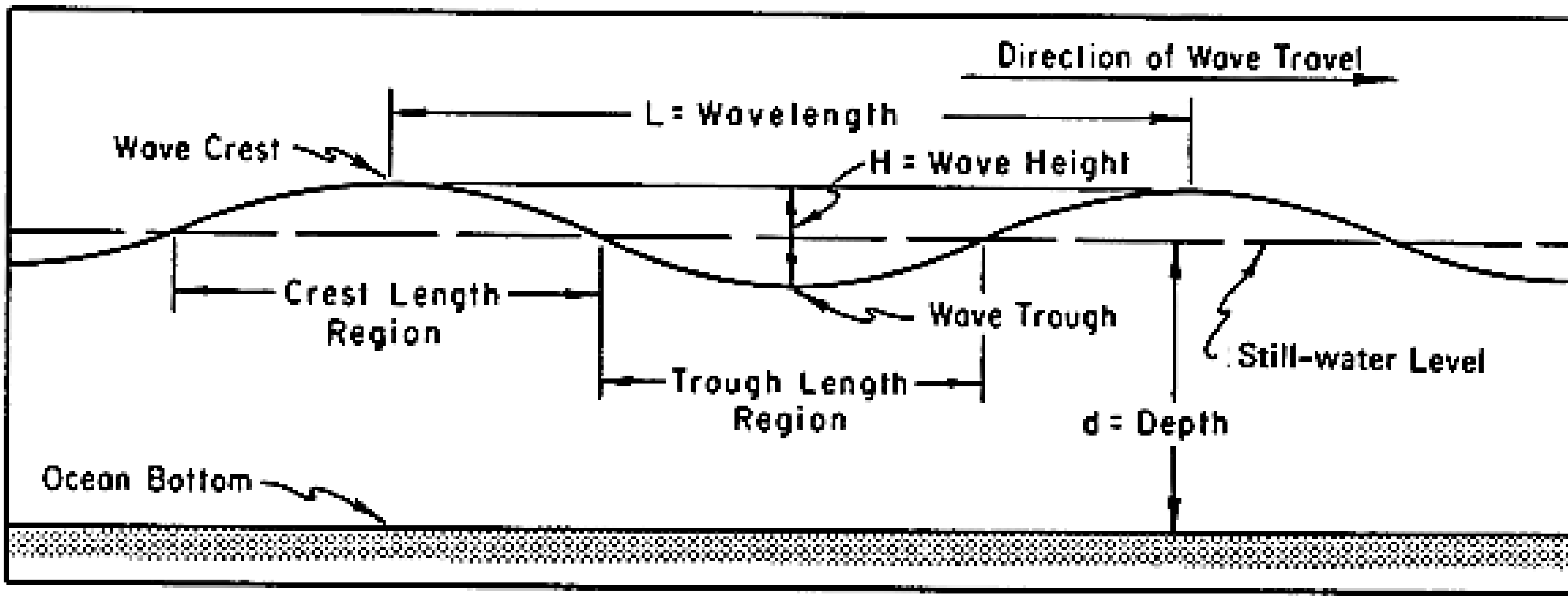
- Water waves on the free surface of the ocean with periods of 3 to 25 s are primarily generated by wind.
- Regular Waves : Waves of constant height and period
- Irregular Waves : Successive waves differing periods and heights
- Linear wave theory : The first-order Stokes, small-amplitude, or Airy wave theory
- Nonlinear wave theories : Cnoidal, Solitary, and Stokes theories


AIRY WAVES
STOKES WAVES
CNOIDAL WAVES
SOLITARY WAVES

Regular waves

- Wave height **H**
- Wave period **T**
- Wavelength **L**
- Water depth **d**
- Angular or radian frequency $\boldsymbol{\sigma = 2\pi/T}$
- Wave number $\boldsymbol{k = 2\pi/L}$
- Relative wave height **H/d**
- Phase velocity or wave celerity $\mathbf{C = L/T = \boldsymbol{\sigma}/k}$
- Still Water Level (SWL), Mean Water Level (MWL), Mean Sea Level (MSL)

Regular waves



Regular waves

Governing Equation: $\nabla^2 \emptyset = 0$

Boundary Condition

- Free Surface Boundary Condition kinematic B.C. ;
  - ✓ Kinematic FSBC : Retated with water particle kinematics
  - ✓ Dynamic FSBC : Pressure is uniform on the free surface be uniform along the wave form
- Bottom Boundary Condition
- Lateral Boundary Condition

Regular waves

Kinematic FSBC

$\zeta = \eta\,(x, y, t)$

$F(x, y, \zeta, t) = \zeta - \eta\,(x, y, t) = 0$ at the free surface.

$$\frac{DF}{Dt} = \frac{DF}{Dt} + \vec{v} \cdot \nabla F = \frac{\partial F}{\partial t} + u\frac{\partial F}{\partial x} + v\frac{\partial F}{\partial y} + w\frac{\partial F}{\partial \zeta}$$
$$= \frac{\partial F}{\partial t} + \frac{\partial \phi}{\partial x}\frac{\partial F}{\partial x} + \frac{\partial \phi}{\partial y}\frac{\partial F}{\partial y} + \frac{\partial \phi}{\partial \zeta}\frac{\partial F}{\partial \zeta}$$
$$= -\frac{\partial \eta}{\partial t} - \frac{\partial \phi}{\partial x}\frac{\partial \eta}{\partial x} - \frac{\partial \phi}{\partial y}\frac{\partial \eta}{\partial y} + \frac{\partial \phi}{\partial \zeta} = 0$$

$$\therefore \frac{\partial \phi}{\partial \zeta} = \frac{\partial \eta}{\partial t} + \frac{\partial \phi}{\partial x}\frac{\partial \eta}{\partial x} + \frac{\partial \phi}{\partial y}\frac{\partial \eta}{\partial y}, \text{ at } \zeta = \eta\,(x, y, t)$$

Regular waves

Dynamic FSBC

As DFSBC is a requirement that the pressure on the free surface be uniform along the wave form, the Bernouli equation with p_μ = C is applied on the free surface , $\zeta = \eta(x, y, t)$

$$\frac{\partial \emptyset}{\partial t} + \frac{1}{2}|\nabla\emptyset|^2 + \frac{p_\eta}{\rho} + g\zeta = C(t)$$

where p_μ is a constant and usually taken as gage pressure ($p_\mu = 0$)

Regular waves

Botton boundary condition (B.B.C)

$\zeta = -h(x,y)$, Impermeable, Bottom does not move with time

F= $\zeta + h(x,y) = 0$, at ζ=-h

$\frac{DF}{Dt}$=0 at ζ=-h

$$\frac{DF}{Dt} = \frac{\partial \emptyset}{\partial x}\frac{\partial h}{\partial x} + \frac{\partial \emptyset}{\partial y}\frac{\partial h}{\partial y} + \frac{\partial \emptyset}{\partial \zeta} = 0$$

$$\therefore \frac{\partial \emptyset}{\partial \zeta} = -\frac{\partial \emptyset}{\partial x}\frac{\partial h}{\partial x} - \frac{\partial \emptyset}{\partial y}\frac{\partial h}{\partial y}$$

Regular waves

Periodic lateral B.C. (PLBC)

Wave is periodic in space and time

$$\emptyset(\mathrm{x}, \mathrm{t}) = \emptyset(\mathrm{x} + \mathrm{L}\,, \mathrm{t})$$

$$\emptyset(\mathrm{x}, \mathrm{t}) = \emptyset(\mathrm{x}, \mathrm{t} + \mathrm{T})$$

Regular waves

$$\nabla^2\emptyset = \frac{\partial^2\emptyset}{\partial x^2} + \frac{\partial^2\emptyset}{\partial \zeta^2} = 0 : 0 \le X < L, \quad -h \le \zeta \le \eta$$

KSFBC : $\frac{\partial\emptyset}{\partial\zeta} = \frac{\partial\eta}{\partial t} + \frac{\partial\emptyset}{\partial x}\frac{\partial\eta}{\partial x}$ at $\zeta = \eta$, $\quad \boldsymbol{\frac{\partial\emptyset}{\partial\zeta} - \frac{\partial\eta}{\partial t} = 0}$ **at** $\boldsymbol{\zeta = 0}$

DSFBC : $\frac{\partial\emptyset}{\partial t} + \frac{1}{2}|\nabla\emptyset|^2 + g\zeta = 0$ at $\zeta = \eta$, $\quad \boldsymbol{\frac{\partial\emptyset}{\partial t} + g\eta = 0}$ **at** $\boldsymbol{\zeta = 0}$

BBC : $\frac{\partial\emptyset}{\partial\zeta} = 0$ at $\zeta = -h$

PLBC : $\emptyset(x + L, t) = \emptyset(x, t)$

$\emptyset(x, t + T) = \emptyset(x, t)$

Regular waves

Dispersion Relation

$$\boldsymbol{\sigma}^2 = \boldsymbol{gk} \tanh \boldsymbol{kh}$$

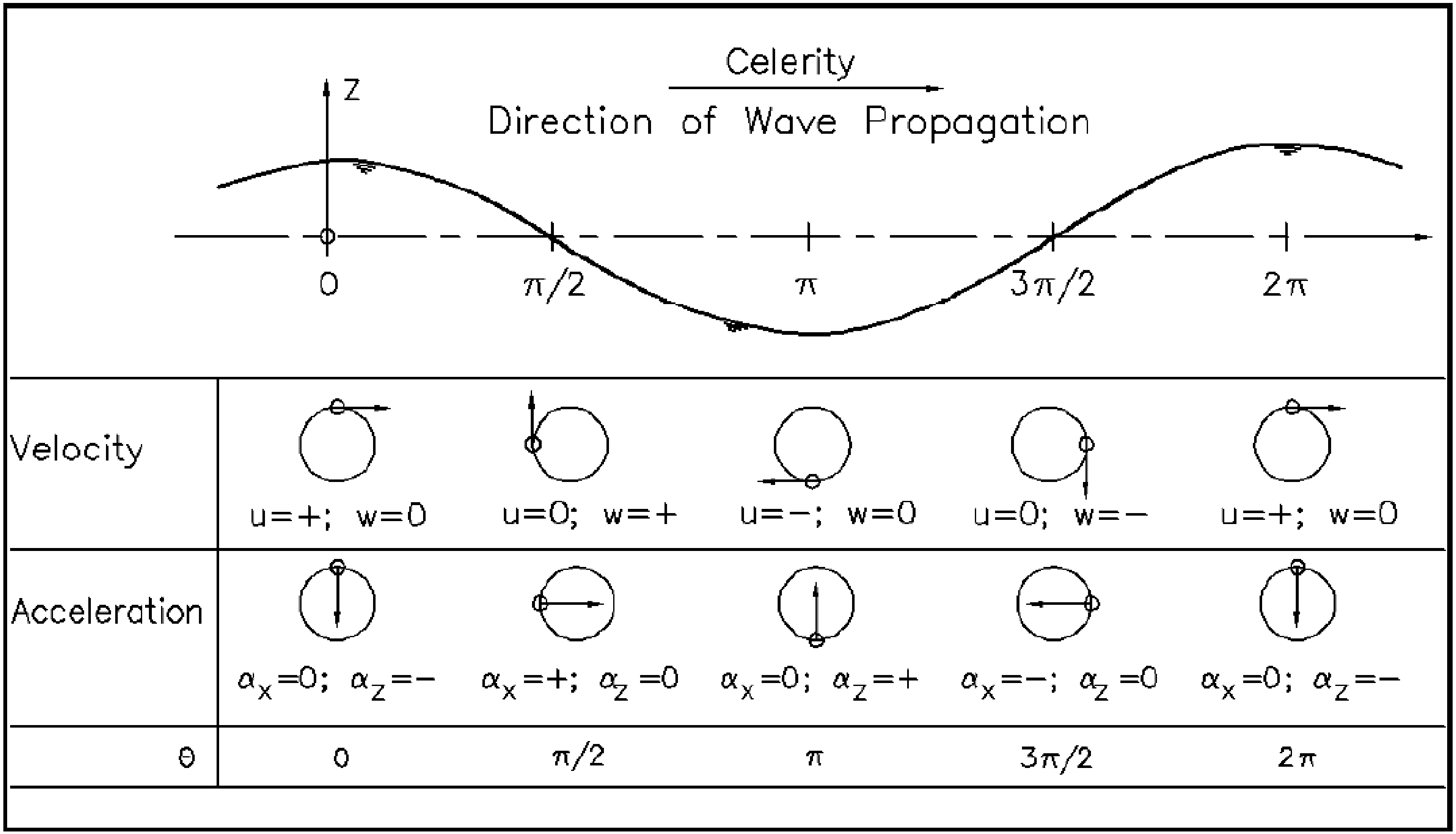
Wave Velocity Potential

$$\emptyset = \frac{\boldsymbol{H}}{\mathbf{2}} \frac{\boldsymbol{g}}{\mathbf{2}} \frac{\boldsymbol{cosh}[\mathbf{k}(\boldsymbol{\zeta} + \boldsymbol{h})]}{\mathbf{cos\ h}\ \boldsymbol{kh}} \boldsymbol{sin}(\boldsymbol{kx} + \boldsymbol{\sigma t})$$

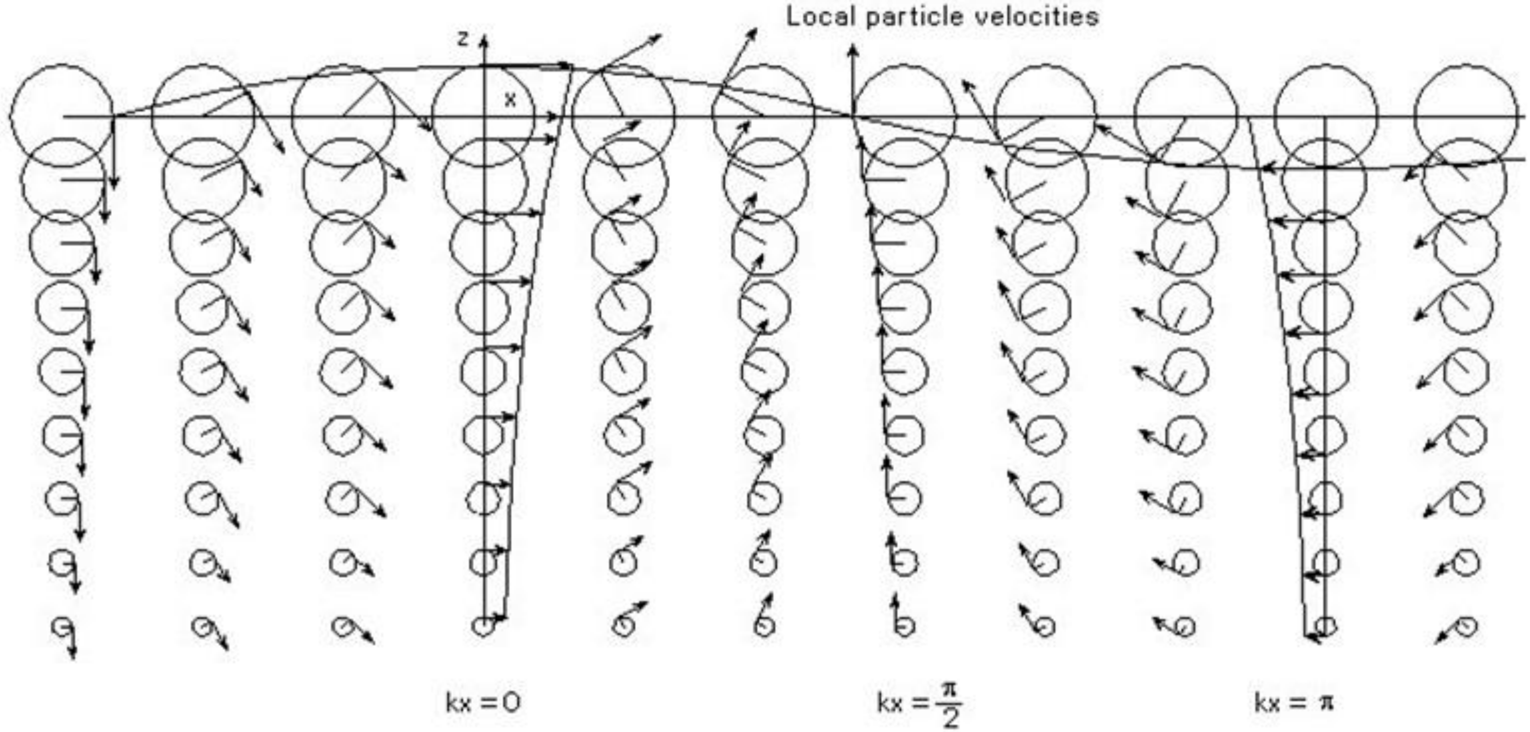
Wave Elevation

$$\eta = \frac{\mathrm{H}}{2} \cos(kx + \sigma t)$$

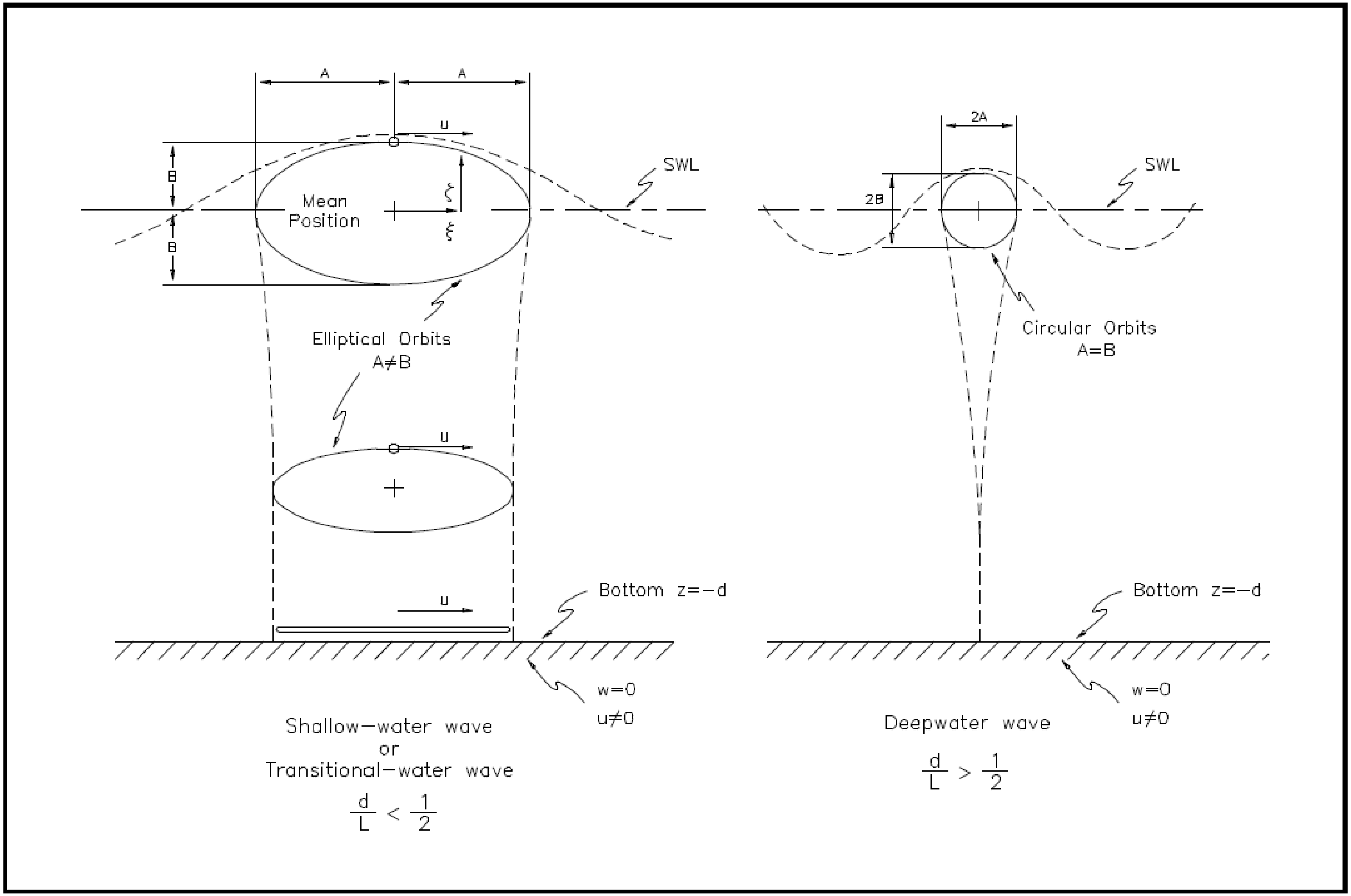
Regular waves



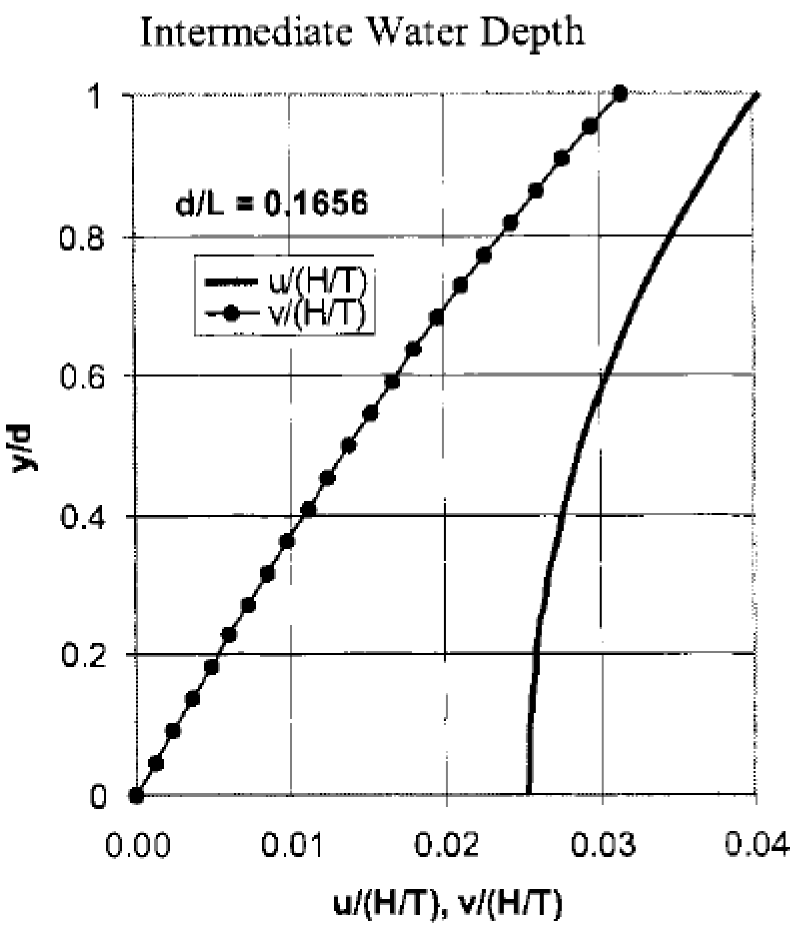
Wave Water Particle Trajectory

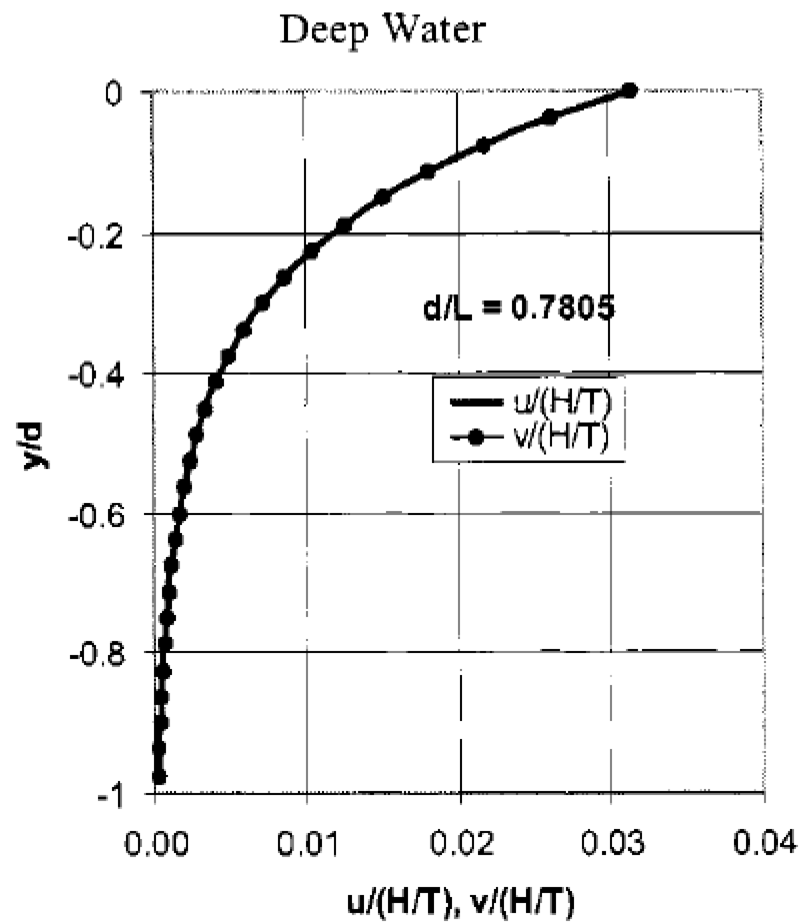


Regular waves



Particle velocity amplitudes with depth





Regular waves

- **Kinetic energy** per unit length of wave crest for a wave defined with the linear theory

$$\bar{E}_k = \int_x^{x+L} \int_{-d}^{\eta} \rho \frac{u^2 + w^2}{2} \, dz \, dx = \frac{1}{16} \rho g H^2 L$$

- **Potential energy** per unit length of wave crest for a linear wave

$$\bar{E}_p = \int_x^{x+L} \rho g \left[\frac{(\eta + d)^2}{2} - \frac{d^2}{2} \right] dx = \frac{1}{16} \rho g H^2 L$$

- Total wave energy in one wavelength per unit crest width

$$E = E_k + E_p = \frac{\rho g H^2 L}{16} + \frac{\rho g H^2 L}{16} = \frac{\rho g H^2 L}{8}$$

Linear Theory of Regular Waves Review

Wave property	SHALLOW WATER ($d/\lambda < 1/20$)	INTERMEDIATE WATER ($1/20 < d/\lambda < 1/2$)	DEEP WATER ($d/\lambda > 1/2$)
Velocity potential ($u = \nabla\phi$)	$\phi = \frac{ag}{\omega}\frac{\cosh k(z+d)}{\cosh kd}\cos(\omega t - kx)$	$\phi = \frac{ag}{\omega}\frac{\cosh k(z+d)}{\cosh kd}\cos(\omega t - kx)$	$\phi = \frac{ag}{\omega} e^{kz}\cos(\omega t - kx)$
Dispersion relation	$\omega^2 = g k^2 d$	$\omega^2 = gk \tanh kd$	$\omega^2 = gk$
Wave length - wave period relation	$\lambda = T\sqrt{gd}$	$\lambda = \frac{g}{2\pi}T^2 \tanh\frac{2\pi d}{\lambda}$	$\lambda = \frac{g}{2\pi}T^2$ ($\approx 1.56\ T^2$)
Wave profile	$\eta = a\sin(\omega t - kx)$	$\eta = a\sin(\omega t - kx)$	$\eta = a\sin(\omega t - kx)$
Dynamic pressure	$p_d = \rho g a \sin(\omega t - kx)$	$p_d = \rho g a\frac{\cosh k(z+d)}{\cosh kd}\sin(\omega t - kx)$	$p_d = \rho g a\, e^{kz}\sin(\omega t - kx)$
Horizontal particle velocity	$u = \frac{\omega a}{kd}\sin(\omega t - kx)$	$u = \omega a\frac{\cosh k(z+d)}{\sinh kd}\sin(\omega t - kx)$	$u = \omega a e^{kz}\sin(\omega t - kx)$
Vertical particle velocity	$w = \omega a\frac{z+d}{d}\cos(\omega t - kx)$	$w = \omega a\frac{\sinh k(z+d)}{\sinh kd}\cos(\omega t - kx)$	$w = \omega a e^{kz}\cos(\omega t - kx)$
Horizontal particle acceleration	$\dot{u} = \frac{\omega^2 a}{kd}\cos(\omega t - kx)$	$\dot{u} = \omega^2 a\frac{\cosh k(z+d)}{\sinh kd}\cos(\omega t - kx)$	$\dot{u} = \omega^2 a\, e^{kz}\cos(\omega t - kx)$
Vertical particle acceleration	$\dot{w} = -\omega^2 a\frac{z+d}{d}\sin(\omega t - kx)$	$\dot{w} = -\omega^2 a\frac{\sinh k(z+d)}{\sinh kd}\sin(\omega t - kx)$	$\dot{w} = -\omega^2 a\, e^{kz}\sin(\omega t - kx)$
Group velocity	$c_g = c$	$c_g = \frac{1}{2}c\left(1 + \frac{2kd}{\sinh 2kd}\right)$	$c_g = \frac{1}{2}c$

Regular waves

Nonlinear wave theories

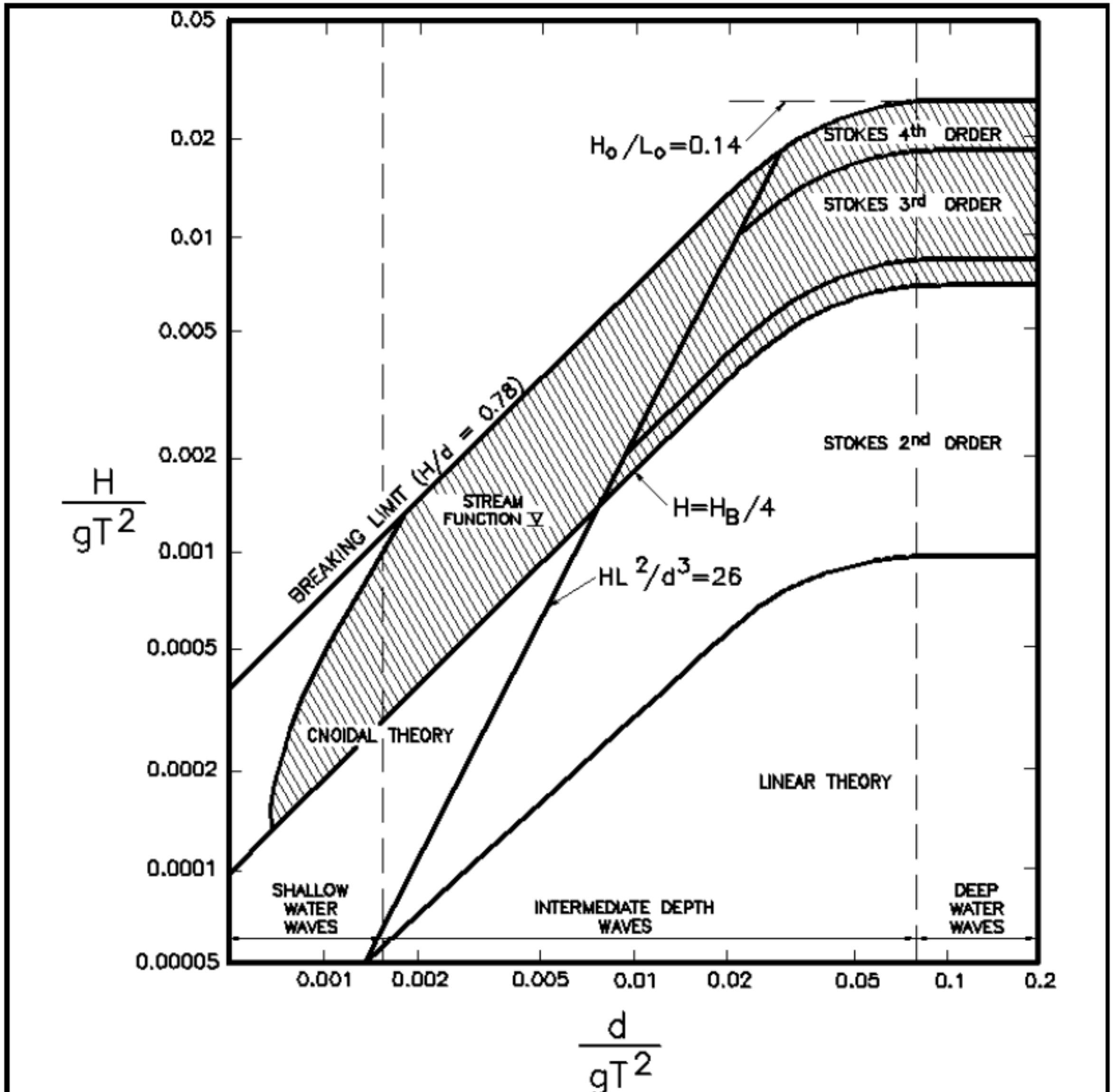
- **Wave steepness (H/L)** is a measure of how large a wave is relative to its height and whether the linear wave assumption is valid.
- **Relative depth (d/L)** determines whether waves are dispersive or nondispersive and whether the celerity, length, and height are influenced by water depth
- Large values of the **relative wave height** indicate that the small-amplitude assumption may not be valid.

$$\frac{H/L}{d/L} = \frac{H}{d}$$

- Maximum wave steepness (Michell, 1893)

$$\left(\frac{H_0}{L_0}\right)_{max} = 0.142 \approx \frac{1}{7}$$

Region of application of wave theories

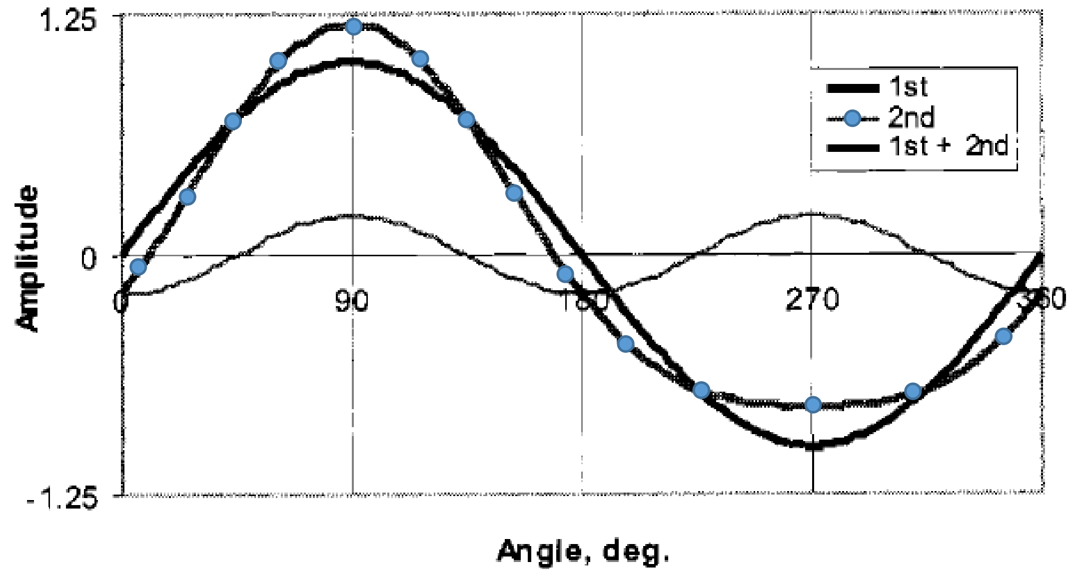


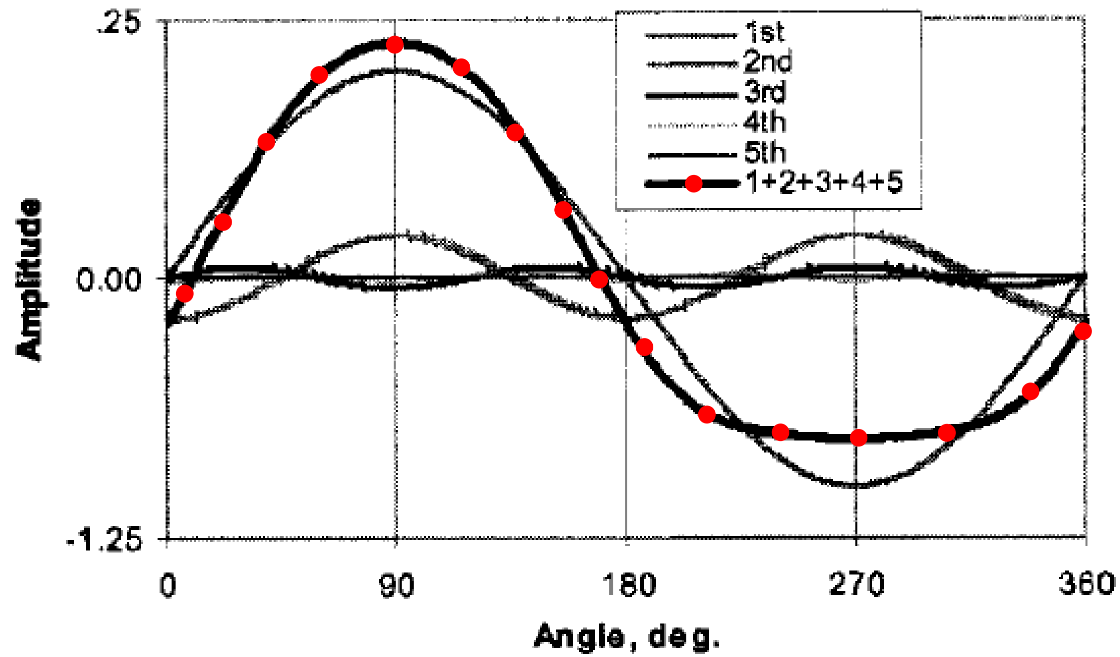
부산대학교
조선 · 해양공학

Formulas for Stokes' second-order wave theory

Quantity	First-Order Component	Second-Order Component
Dispersion relationship	$c^2 = \frac{g}{k}\tanh kd$	$c^2 = \frac{g}{k}\tanh kd$
Wave profile	$\eta = \frac{H}{2}\cos(kx - \omega t)$	$\eta = \frac{\pi H^2}{8L}\frac{\cosh kd}{\sinh^3 kd}[2 + \cosh 2kd]\cos 2(kx - \omega t)$
Horizontal velocity	$u = \frac{\pi H}{T}\frac{\cosh ks}{\sinh kd}\cos(kx - \omega t)$	$u = \frac{3}{4c}\left(\frac{\pi H}{T}\right)^2\frac{\cosh 2ks}{\sinh^4 kd}\cos 2(kx - \omega t)$
Vertical velocity	$v = \frac{\pi H}{T}\frac{\sinh ks}{\sinh kd}\sin(kx - \omega t)$	$v = \frac{3}{4c}\left(\frac{\pi H}{T}\right)^2\frac{\sinh 2ks}{\sinh^4 kd}\sin 2(kx - \omega t)$
Horizontal acceleration	$\dot{u} = \frac{2\pi^2 H}{T^2}\frac{\cosh ks}{\sinh kd}\sin(kx - \omega t)$	$\dot{u} = \frac{3\pi}{2L}\left(\frac{\pi H}{T}\right)^2\frac{\cosh 2ks}{\sinh^4 kd}\sin 2(kx - \omega t)$
Vertical acceleration	$\dot{v} = -\frac{2\pi^2 H}{T^2}\frac{\sinh ks}{\sinh kd}\cos(kx - \omega t)$	$\dot{v} = -\frac{3\pi}{4L}\left(\frac{\pi H}{T}\right)^2\frac{\sinh 2ks}{\sinh^4 kd}\cos 2(kx - \omega t)$
Dynamic pressure	$p = \rho g\frac{H\cosh ky}{2\cosh kd}\cos[k(x - ct)]$	$p = \frac{3}{4}\rho g\frac{\pi H^2}{L}\frac{1}{\sinh 2kd}\left[\frac{\cosh 2ks}{\sinh^2 kd} - \frac{1}{3}\right]\cos 2(kx - \omega t)$ $- \frac{1}{4}\rho g\frac{\pi H^2}{L}\frac{1}{\sinh kd}[\cosh 2ks - 1]$

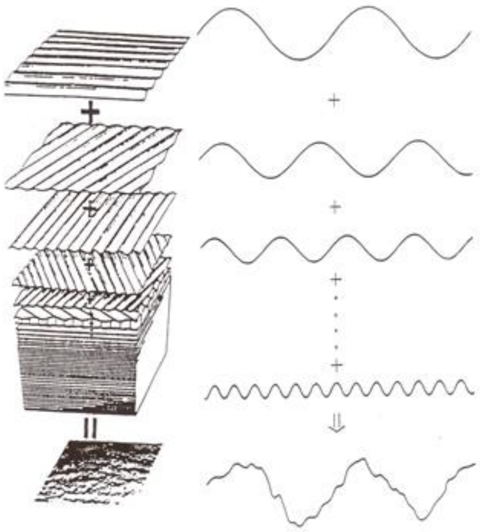
$$u = \sum_{n=1}^{5} u_n \cosh nks \cos n(kx - \omega t)$$





Irregular Waves

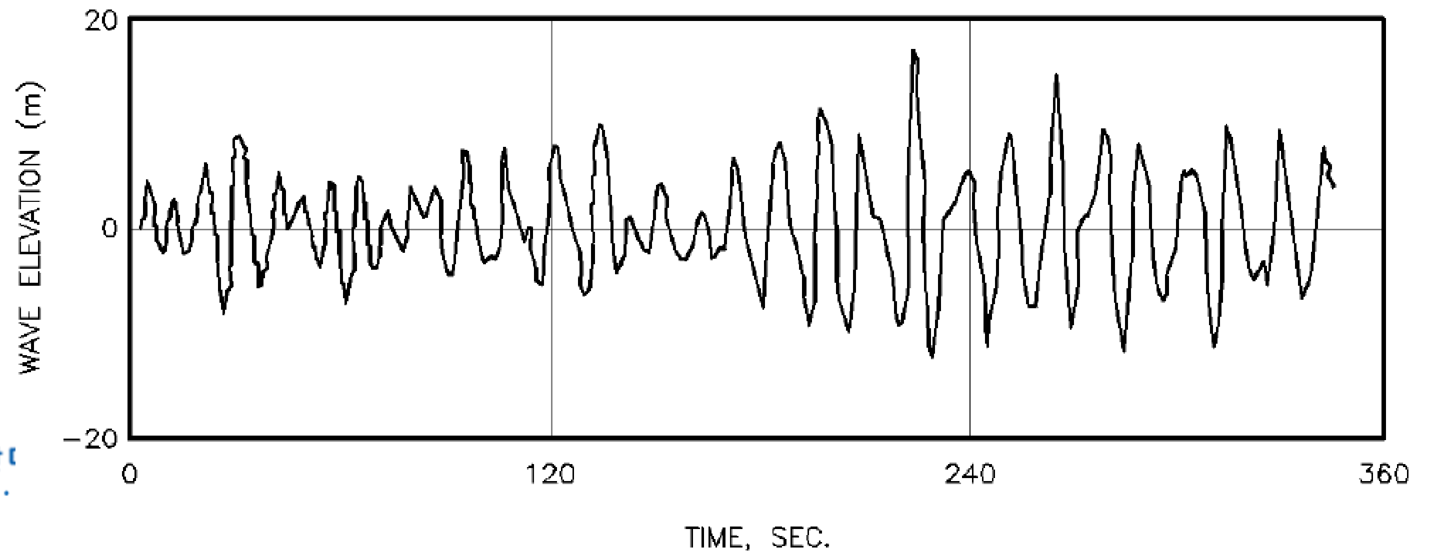
- Ocean waves are, generally, random in nature.



- Larger waves in a random wave series may be given the form of a regular wave that may be described by a deterministic theory.

Irregular Waves

- These individual components were generated by the wind in different regions of the ocean and have propagated to the point of observation.
- If a recorder were to measure waves at a fixed location on the ocean, a non-repeating wave profile would be seen and the wave surface record would be rather irregular and random.
- Definitions of wave height, period, and duration must be statistical and simply indicate the severity of wave conditions.



Irregular Waves

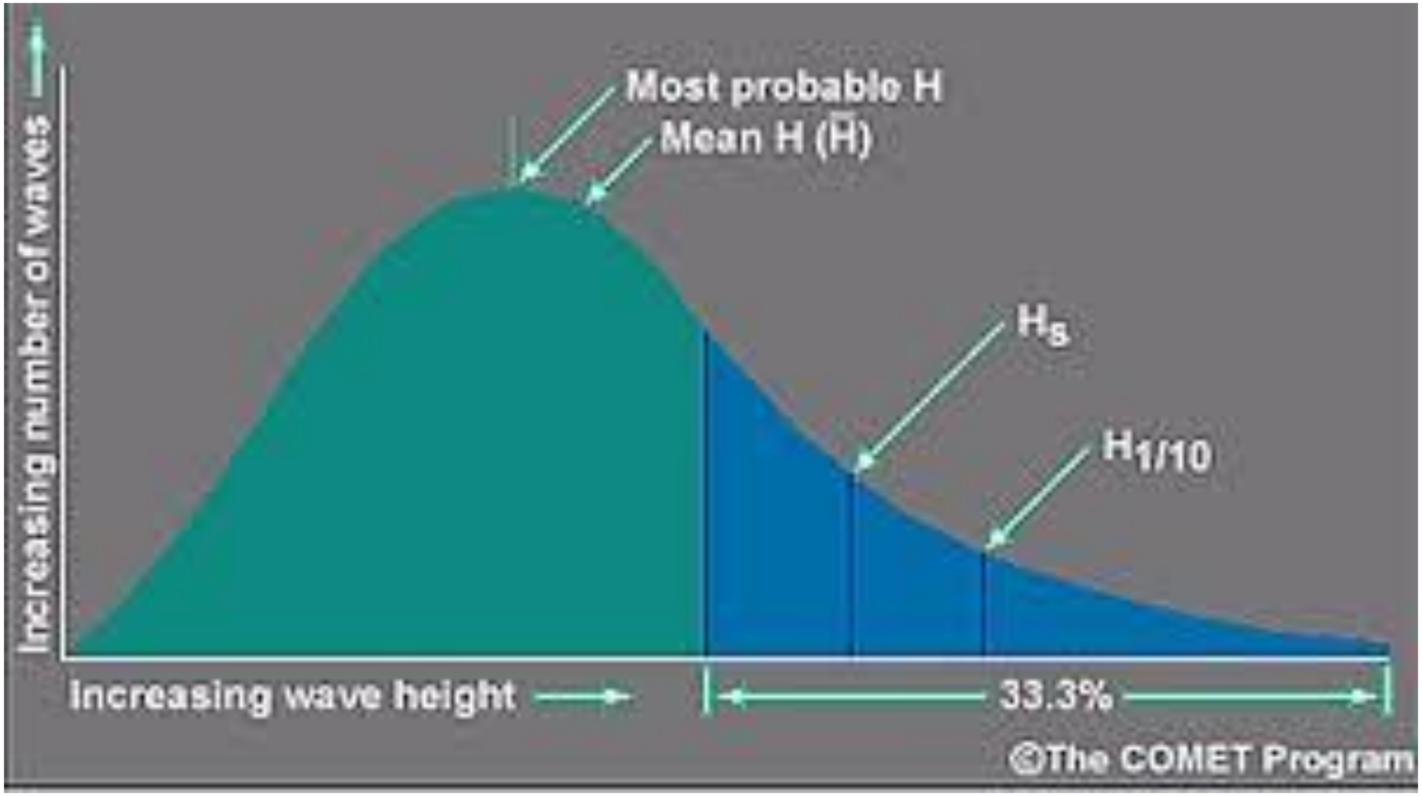
Rayleigh distribution

- Longuet-Higgins (1952) found from statistical theory that both wave amplitudes and heights follow the Rayleigh distribution.

$$p(x) = \left\{ \frac{\pi x}{2\mu_x^2} \, e^{\frac{\pi}{4}\left(\frac{x}{\mu_x}\right)^2} \quad for \; x \geq 0 \right\}$$

$$P(x) = \left\{ 1 - e^{-\frac{\pi}{4}\left(\frac{x}{\mu_x}\right)^2} \quad for \; x \geq 0 \right\}$$

Significant Wave Height



Global wave climate

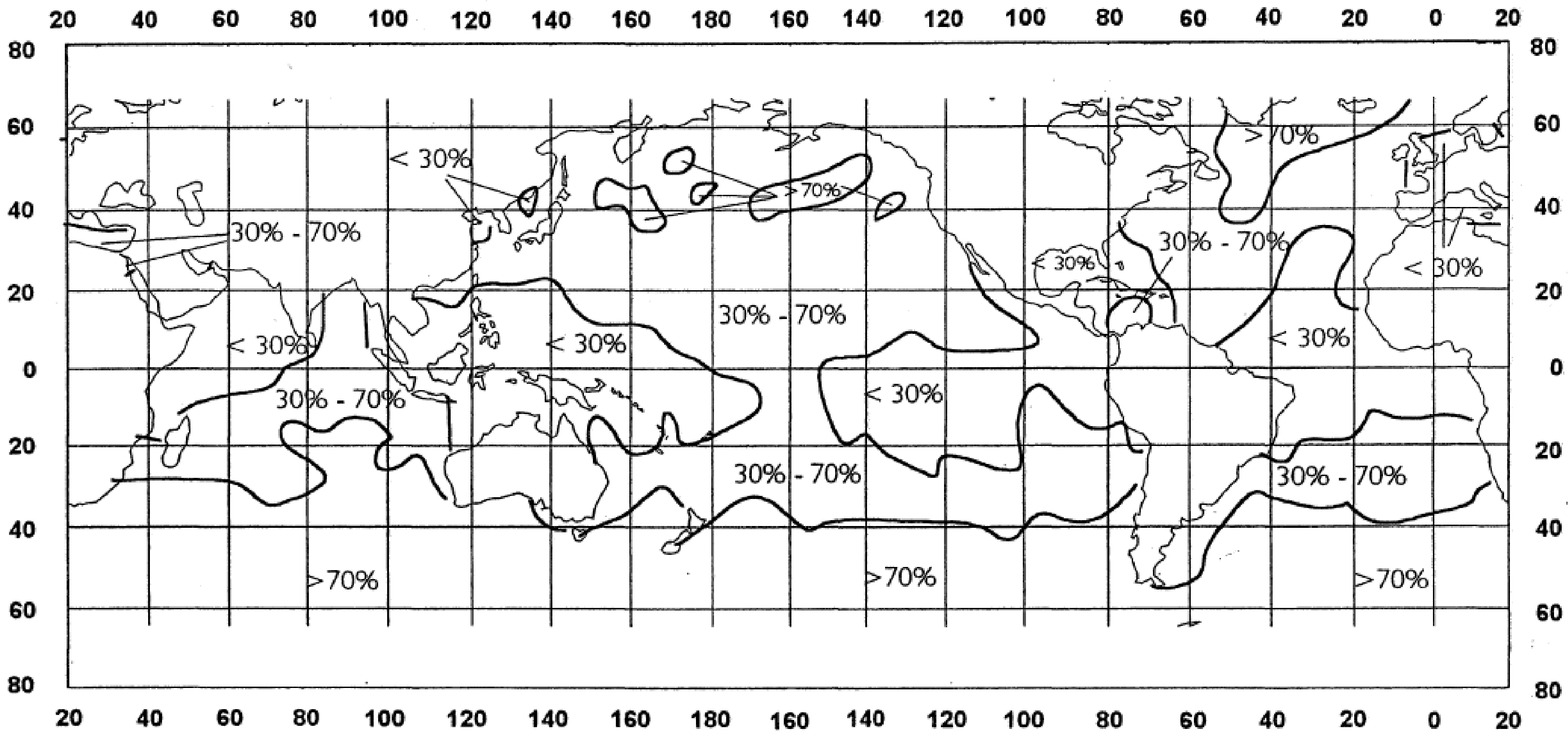


Figure 2.5 Global mapping of significant wave height from GEOS 3 (after McMillan, 1981),% of time that Hs > 2.5m

부산대학교
조선 · 해양공학과

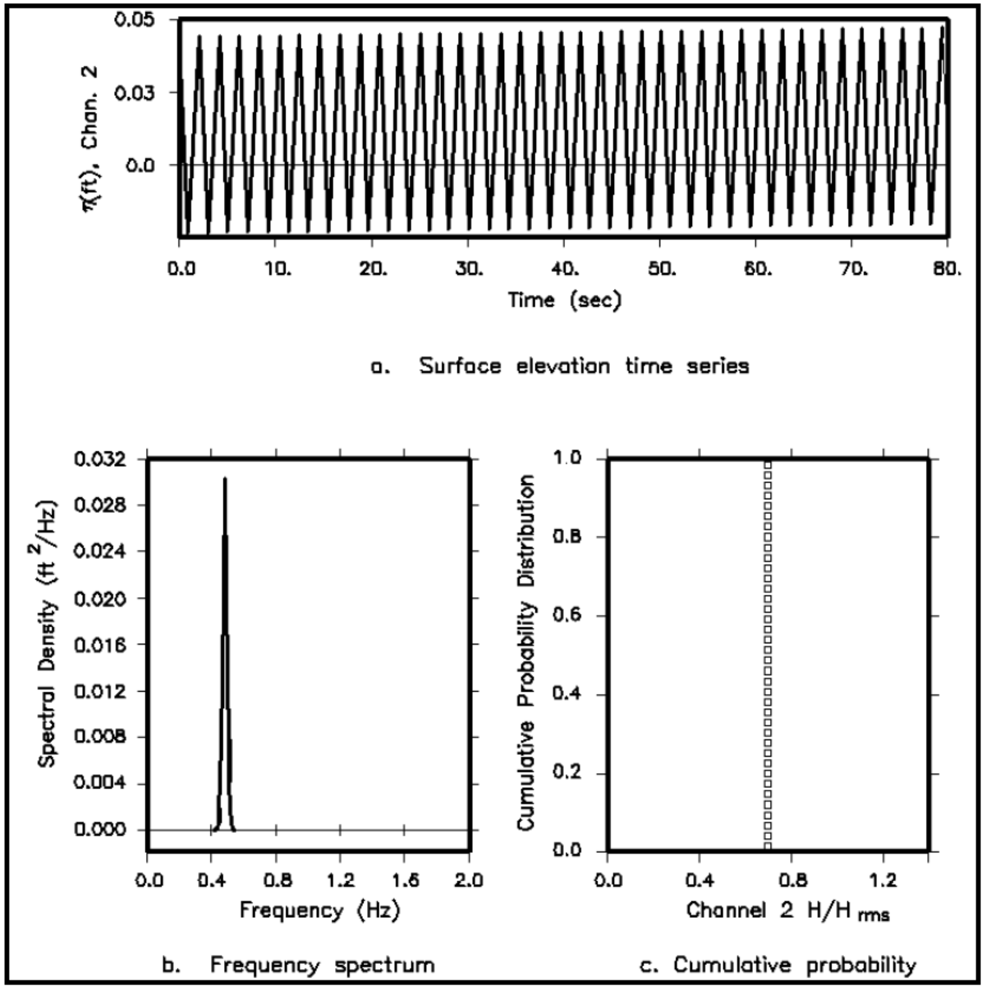
Spectral analysis

- Rice's (1944-1945) work on signal processing was extended to ocean waves (Kinsman 1965; Phillips 1977).

- E(f) or S(f) is actually a measurement of variance, it is often called frequency energy spectrum because (assuming linear wave theory) the energy of the wave field may be estimated by multiplying E(f) by ρg.

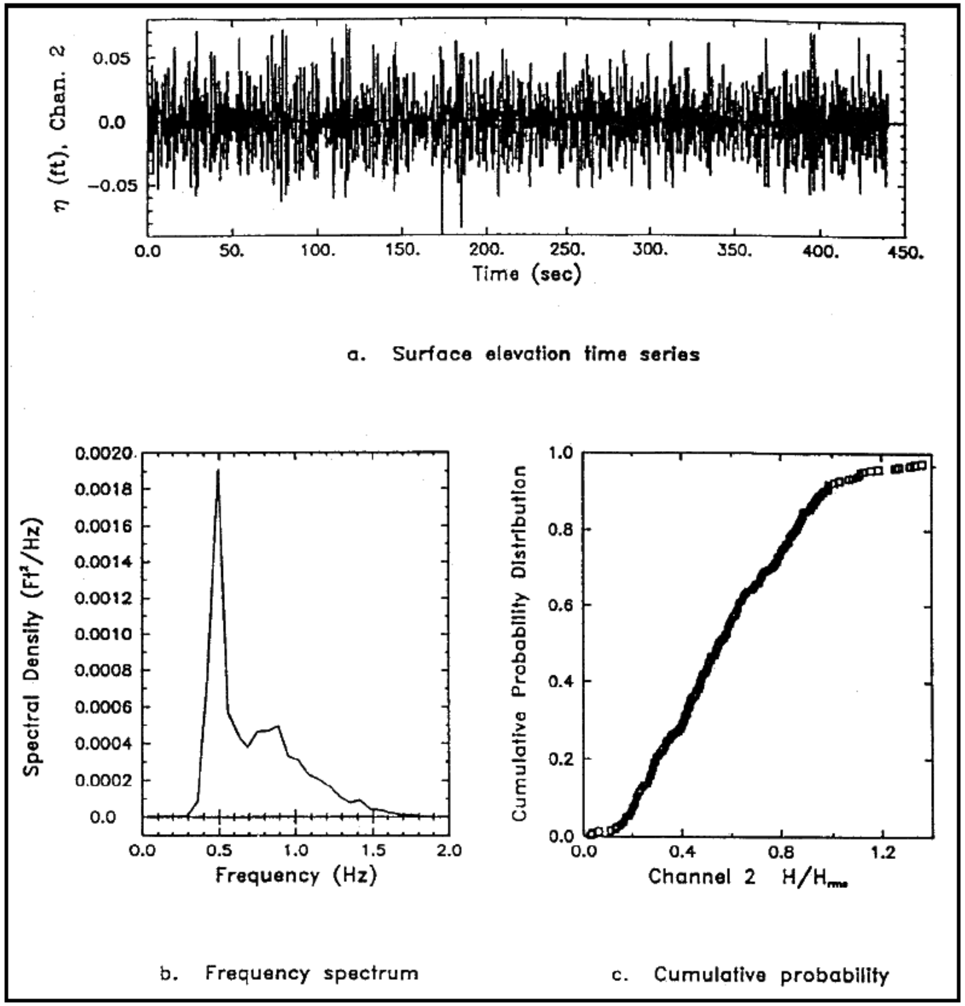
- The **wave energy spectral density**, E(f) or S(f), simply the wave spectrum may be obtained directly from a continuous time series of the surface (t) with the aid of the Fourier analysis.

Spectral analysis



부산대학교
조선 · 해양공학과

Spectral analysis



Spectral analysis

$$\eta(t) = \sum_{n=0}^{\infty} A_n \cos(\omega_n t - \varepsilon_n)$$

$$= \sum_{n=0}^{\infty} a_n \cos n\omega t + b_n \sin n\omega t$$

$$\overline{\eta}^2(t) = \sum_{0}^{\infty} A_n^2 \, \Delta f$$

$$A_n^2 = \frac{1}{2}\sqrt{a_n^2 + b_n^2}$$

$$\varepsilon_n = \tan^{-1} \frac{b_n}{a_n}$$

Spectral analysis

- Zero-th moment of the spectrum (m_0)

$$\sigma_\eta^2 = \sum_{n=1}^{\infty} \frac{a_n^2}{2} = \int_0^{\infty} E(f)\ df = m_0$$

- Moments of a spectrum $$m_i = \int_0^{\infty} f^i\ E(t)\ df \qquad \mathrm{i} = 0,1,2,\ldots$$

- Approximate relations for most common wave parameters by the statistical analysis

$$H_S = 4.0\ \sqrt{m_0} \quad ; \quad H_{1/10} = 5.1\ \sqrt{m_0}$$

$$T_z = \sqrt{\frac{m_0}{m_2}} \quad ; \quad T_c = \sqrt{\frac{m_2}{m_4}}$$

Wave height distribution

- If wave energy is concentrated in a very narrow range of wave period, the maxima of the wave profile will coincide with the wave crests and the minima with the troughs.
- This is termed a **narrow-band condition**.
- Under the narrow-band condition, wave heights are represented by the following **Rayleigh distribution.**

$$H_{1/3} \approx 4.00\sqrt{m_0} = 1.416\ H_{rms}$$

$$H_{1/10} = 1.27\ H_{1/3} = 1.80\ H_{rms} = 5.091\sqrt{m_0}$$

$$H_{1/100} = 1.67\ H_{1/3} = 2.36\ H_{rms} = 6.672\sqrt{m_0}$$

$$H_{\max} = 1.86\ H_{1/3} \quad (for\ 1000\ wave\ cycles\ in\ the\ record)$$

Definition of Sea State

Sea state code	Significant wave height(m)		Wind speed (knots)		Wave period(s)	
	Range	Median	Range	Median	Range	Most probability
0−1	0 − 0.1	0.05	0 − 6	3.0	−	−
2	0.1 − 0.5	0.30	7 − 10	8.5	5.1−14.9	6.3
3	0.5 − 1.25	0.88	11 − 16	13.5	5.3−16.1	7.5
4	1.25 − 2.5	1.88	17 − 21	19.0	6.1−17.2	8.8
5	2.5 – 4.0	3.25	22 − 27	24.5	7.7−17.8	9.7
6	4.0 – 6.0	5.00	28 − 47	37.5	10.0−18.7	12.4
7	6.0 − 9.0	7.50	48 − 55	51.5	11.7−19.8	15.0
8	9.0 − 14.0	11.50	56 − 63	59.5	14.5−21.5	16.4
>9	>14.0	>14.0	>63.0	>63.0	16.4−22.5	20.0

Bretschneider Spectrum

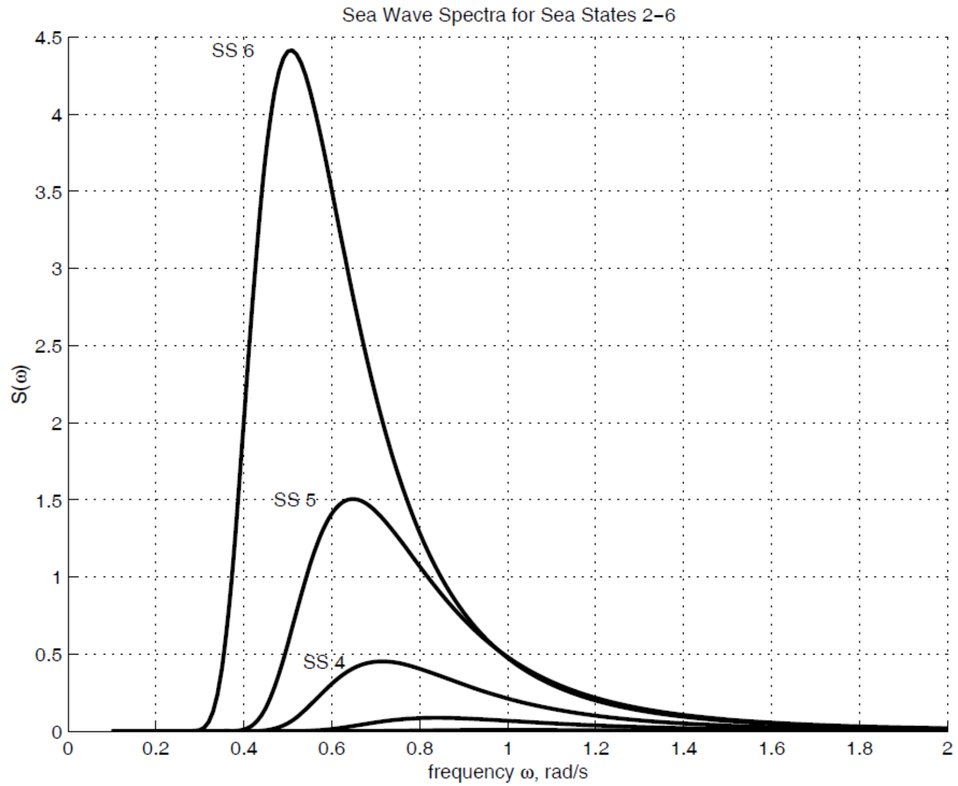
$$S_\eta(f) = \frac{5H_s^2}{16 f_0 (f/f_0)^5} e^{\left\{-\frac{5}{4}\left(\frac{f}{f_0}\right)^{-4}\right\}}$$

or,

$$S_\eta(f) = \frac{\alpha'}{f^5} e^{\left[-\frac{\beta''}{f^4}\right]}$$

where

$$\alpha' = \frac{5H_s^2 f_0^4}{16} \quad \text{and} \quad \beta'' = \frac{5 f_0^4}{4}$$



부산대학교
조선 · 해양공학과

Pierson-Muskowitz Spectrum

$S_\eta(\omega) = \phi(U, g, f)$ where

U = Wind speed

f = Wave frequency,

$\omega = 2\pi f$

$$S_\eta(\overline{\omega}) = \frac{a g^2}{\overline{\omega}^5} e^{\left[-\beta\left(\frac{\overline{\omega}_0}{\overline{\omega}}\right)^4\right]}$$

where

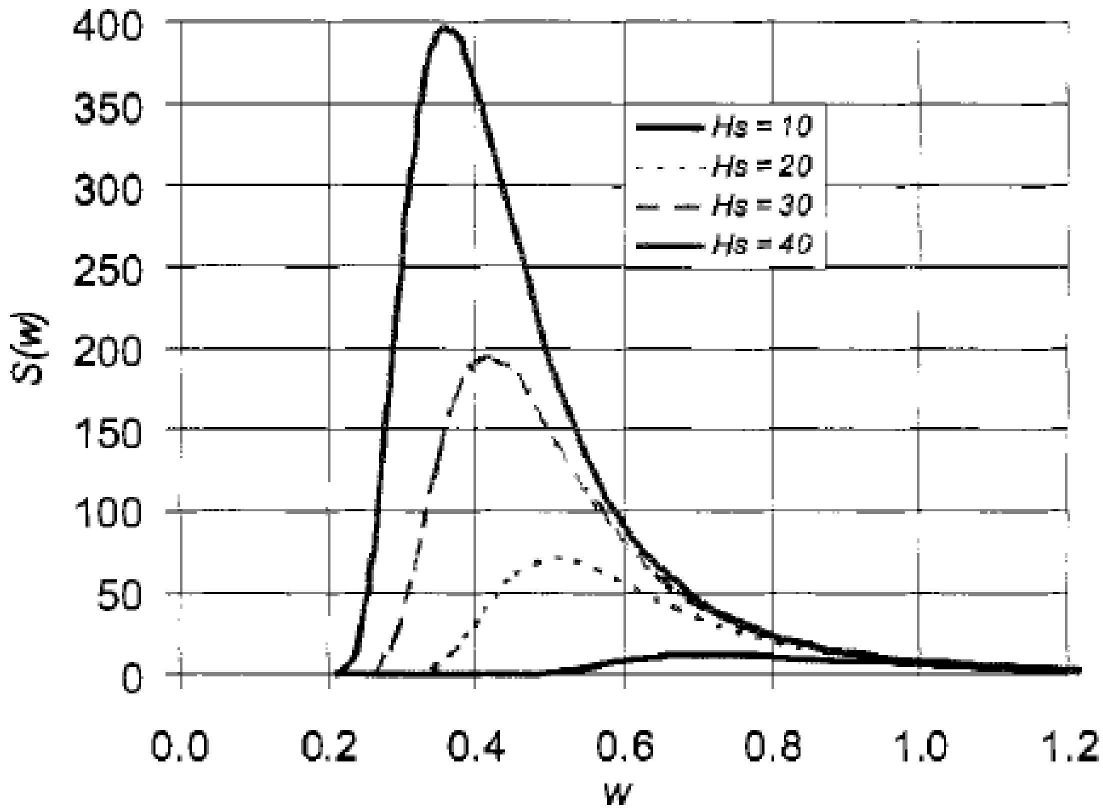
α = Philip constant = 0.0081 (This is independent of U and wind fetch F)

β = 0.74

$\overline{\omega}_0$ = Frequency corresponding to the peak value of the energy spectrum

$= 2\pi f_0$ = g/U_w

Pierson-Muskowitz Spectrum



JONSWAP Spectrum

Joint North Sea Wave Project

$$S(\omega) = 173\frac{H_S^2 T_S (T_S\omega)^{-5}}{F_1 F_2^4} exp(-692(F_2 T_S \omega)^{-4})\gamma^{\exp[-(0.206F_2 T_S\omega - 1)^2/2\sigma^2]}$$

H_S : Significant wave height (m)

ω : Angular wave frequency (rad/s)

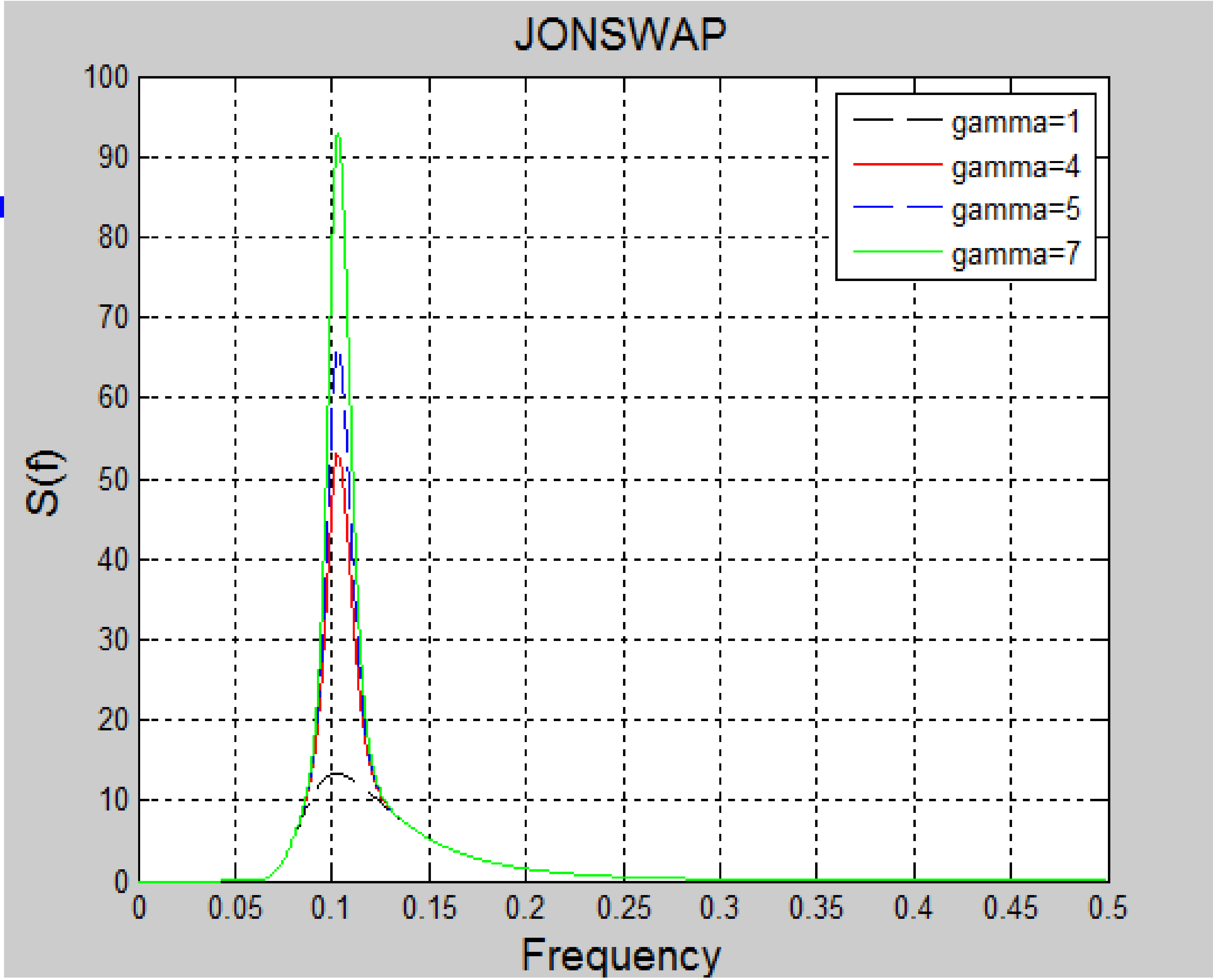
T_S : Mean wave period (s)

γ : JONSWAP peakedness parameter

$$\sigma = \begin{cases} 0.07 \text{ for } \omega \le (0.206F_2 T_S)^{-1} \\ 0.09 \text{ for } \omega > (0.206F_2 T_S)^{-1} \end{cases}$$

JONSWAP Spectrum

γ	F_1	F_2
1	1.00	1.0
2	1.24	0.95
3	1.46	0.93
3.3 (1)	1.52	0.82
4	1.66	0.91
5	1.89	0.90
6	2.04	0.89
(1) Mean JONSWAP spectrum		


JONSWAP
S(f)
Frequency
gamma=1
gamma=4
gamma=5
gamma=7
0
10
20
30
40
50
60
70
80
90
100
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

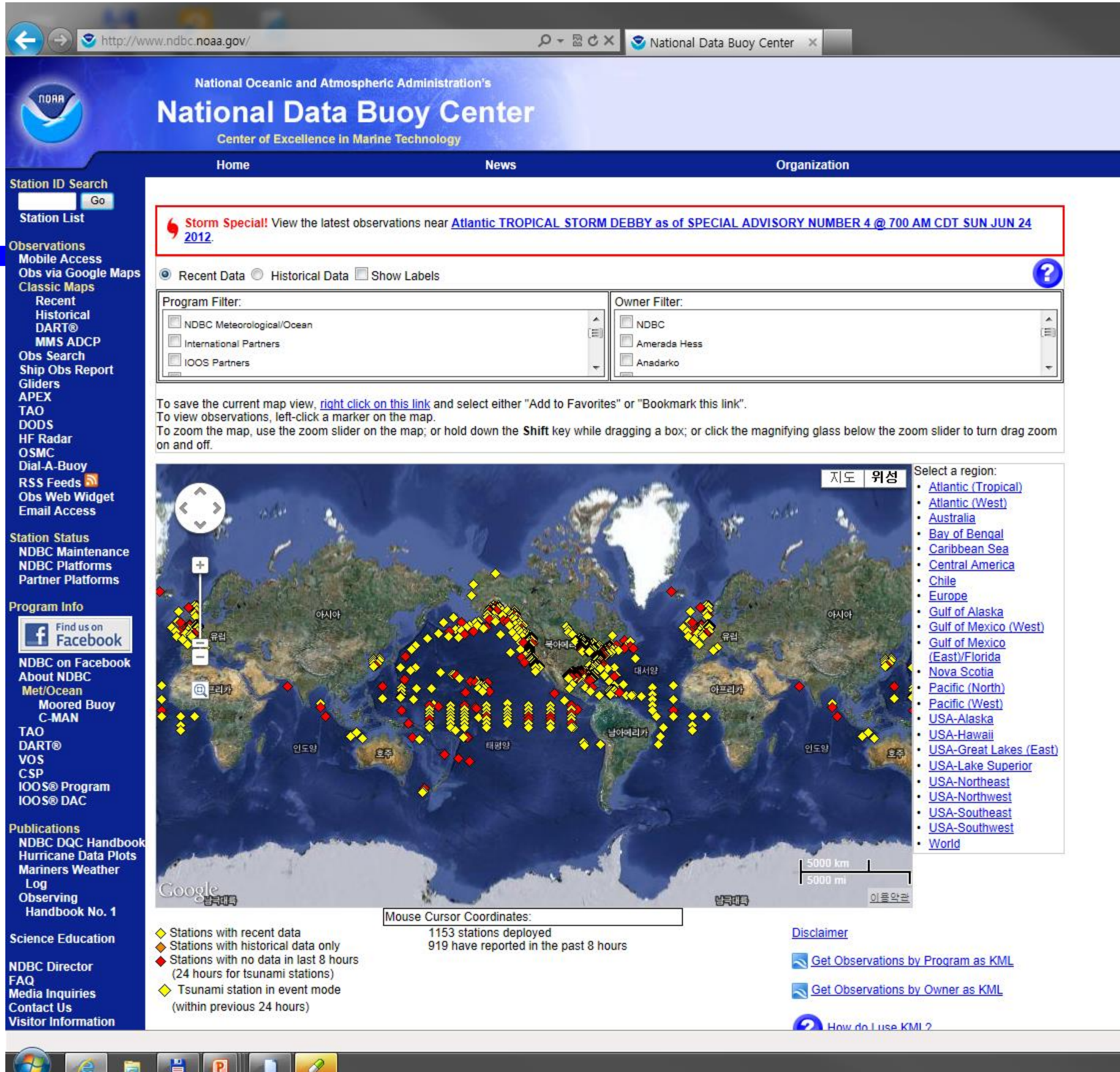
Common spectral models for oceans

Location	Operational	Survival
Gulf of Mexico	P–M	P–M or JONSWAP
North Sea	JONSWAP	JONSWAP
Northern North Sea	JONSWAP	JONSWAP
Offshore Brazil	P–M	P–M or JONSWAP
Western Australia	P–M	P–M
Offshore Newfoundland	P–M	P–M or JONSWAP
West Africa	P–M	P–M

Typical JONSWAP γ-values for various offshore locations

Location	γ
North Sea or North Atlantic	3.3
Northern North Sea	Up to 7
Offshore West Africa	1.5 ± 0.5
Gulf of Mexico	1 for $H_s <= 6.5$ m
	2 for $H_s > 6.5$ m
Offshore Brazil	1–2

부산대학교
조선 · 해양공학과


http://www.ndbc.noaa.gov/
National Data Buoy Center
National Oceanic and Atmospheric Administration's
National Data Buoy Center
Center of Excellence in Marine Technology
Home
News
Organization
Station ID Search
Go
Station List
Observations
Mobile Access
Obs via Google Maps
Classic Maps
Recent
Historical
DART®
MMS ADCP
Obs Search
Ship Obs Report
Gliders
APEX
TAO
DODS
HF Radar
OSMC
Dial-A-Buoy
RSS Feeds
Obs Web Widget
Email Access
Station Status
NDBC Maintenance
NDBC Platforms
Partner Platforms
Program Info
Find us on Facebook
NDBC on Facebook
About NDBC
Met/Ocean
Moored Buoy
C-MAN
TAO
DART®
VOS
CSP
IOOS® Program
IOOS® DAC
Publications
NDBC DQC Handbook
Hurricane Data Plots
Mariners Weather Log
Observing Handbook No. 1
Science Education
NDBC Director
FAQ
Media Inquiries
Contact Us
Visitor Information
Storm Special! View the latest observations near Atlantic TROPICAL STORM DEBBY as of SPECIAL ADVISORY NUMBER 4 @ 700 AM CDT SUN JUN 24 2012.
Recent Data
Historical Data
Show Labels
Program Filter:
NDBC Meteorological/Ocean
International Partners
IOOS Partners
Owner Filter:
NDBC
Amerada Hess
Anadarko
To save the current map view, right click on this link and select either "Add to Favorites" or "Bookmark this link".
To view observations, left-click a marker on the map.
To zoom the map, use the zoom slider on the map; or hold down the Shift key while dragging a box; or click the magnifying glass below the zoom slider to turn drag zoom on and off.
지도
위성
아시아
유럽
북아메리카
대서양
아프리카
인도양
태평양
남아메리카
호주
5000 km
5000 mi
이용약관
Select a region:
Atlantic (Tropical)
Atlantic (West)
Australia
Bay of Bengal
Caribbean Sea
Central America
Chile
Europe
Gulf of Alaska
Gulf of Mexico (West)
Gulf of Mexico (East)/Florida
Nova Scotia
Pacific (North)
Pacific (West)
USA-Alaska
USA-Hawaii
USA-Great Lakes (East)
USA-Lake Superior
USA-Northeast
USA-Northwest
USA-Southeast
USA-Southwest
World
Mouse Cursor Coordinates:
Stations with recent data
Stations with historical data only
Stations with no data in last 8 hours (24 hours for tsunami stations)
Tsunami station in event mode (within previous 24 hours)
1153 stations deployed
919 have reported in the past 8 hours
Disclaimer
Get Observations by Program as KML
Get Observations by Owner as KML
How do I use KML?

http://www.ndbc.noaa.gov/station_page.php?station=42002 | noaa - Google 검색 | I Bleed Cri

National Oceanic and Atmospheric Administration's

National Data Buoy Center

Center of Excellence in Marine Technology

Home | News | Organization

Station ID Search Go
Station List

Observations
Mobile Access
Obs via Google Maps
Classic Maps
Recent
Historical
DART®
MMS ADCP
Obs Search
Ship Obs Report
Gliders
APEX
TAO
DODS
HF Radar
OSMC
Dial-A-Buoy
RSS Feeds
Obs Web Widget
Email Access

Station Status
NDBC Maintenance
NDBC Platforms
Partner Platforms

Program Info
Find us on Facebook
NDBC on Facebook
About NDBC
Met/Ocean
Moored Buoy
C-MAN
TAO
DART®
VOS
CSP
IOOS® Program
IOOS® DAC

Publications
NDBC DQC Handbook
Hurricane Data Plots
Mariners Weather Log
Observing Handbook No. 1

Science Education

NDBC Director
FAQ
Media Inquiries
Contact Us
Visitor Information

Storm Special! View the latest observations near Atlantic TROPICAL STORM DEBBY as of SPECIAL ADVISORY NUMBER 4 @ 700 AM CDT SUN JUN 24 2012.

Station 42002 (LLNR 1405) - W GULF 207 NM East of Brownsville, TX

Owned and maintained by National Data Buoy Center
10-meter discus buoy
ARES payload
25.790 N 93.666 W (25°47'24" N 93°39'58" W)

Site elevation: sea level
Air temp height: 10 m above site elevation
Anemometer height: 10 m above site elevation
Barometer elevation: sea level
Sea temp depth: 1 m below site elevation
Water depth: 3566.16 m
Watch circle radius: 3523 yards

Station 42002 is transmitting intermittently since 04/18/2012. This buoy will be restored to service when it can be worked into the schedule. When the service date is known, it will be posted in the maintenance report.

42002 was re-established at the above location on 2/8/2008.

Previously the station was positioned at 25* 10' 00" N 094* 25' 00" W.

Latest NWS Marine Forecast

Important Notice to Mariners

Search And Rescue (SAR) Data

Meteorological Observations from Nearby Stations and Ships

Large icon indicates selected station. Disclaimer
◇ Stations with recent data
◆ Stations with no data in last 8 hours (24 hours for tsunami stations)

Conditions at 42002 as of (6:50 am CDT) 1150 GMT on 06/24/2012:

Unit of Measure: English Time Zone: Station Local Time Select

Click on the graph icon in the table below to see a time series plot of the last five days of that observation.

Wind Direction (WDIR):	NNE (20 deg true)
Wind Speed (WSPD):	9.7 kts
Wind Gust (GST):	11.7 kts
Wave Height (WVHT):	4.6 ft
Dominant Wave Period (DPD):	8 sec
Average Period (APD):	5.8 sec
Mean Wave Direction (MWD):	ENE (68 deg true)
Atmospheric Pressure (PRES):	29.86 in

www.ndbc.noaa.gov/station_page.php?station=42002 | noaa - Google 검색 | I Bl

06	23	11:50 am	NNE	13.6	15.5	4.6	8	5.5	ENE	29.80	+0.02	83.5	83.3	79.0	-	-	-
06	23	9:50 am	NNE	11.7	15.5	4.9	8	5.8	ENE	29.79	+0.04	83.1	82.9	79.2	-	-	-
06	23	8:50 am	NNE	11.7	15.5	4.9	7	5.5	ENE	29.78	+0.04	82.9	82.9	78.1	-	-	-
06	23	7:50 am	NNE	13.6	17.5	5.6	7	5.7	ENE	29.76	+0.03	83.1	82.9	78.4	-	-	-
06	23	6:50 am	NE	13.6	17.5	5.2	8	5.4	ENE	29.75	+0.02	82.4	82.9	78.8	-	-	-

Detailed Wave Summary for 42002 as of (7:00 am CDT) 1200 GMT on 06/24/2012:

These wave data are displayed in rounded times.

Unit of Measure: English Time Zone: Station Local Time Select

Click on the graph icon in the table below to see a time series plot of the last five days of that observation.

Significant Wave Height (WVHT):	4.6 ft
Swell Height (SwH):	4.3 ft
Swell Period (SwP):	7.7 sec
Swell Direction (SwD):	ENE
Wind Wave Height (WWH):	1.6 ft
Wind Wave Period (WWP):	4.3 sec
Wave Steepness (STEEPNESS):	AVERAGE
Average Wave Period (APD):	5.8 sec

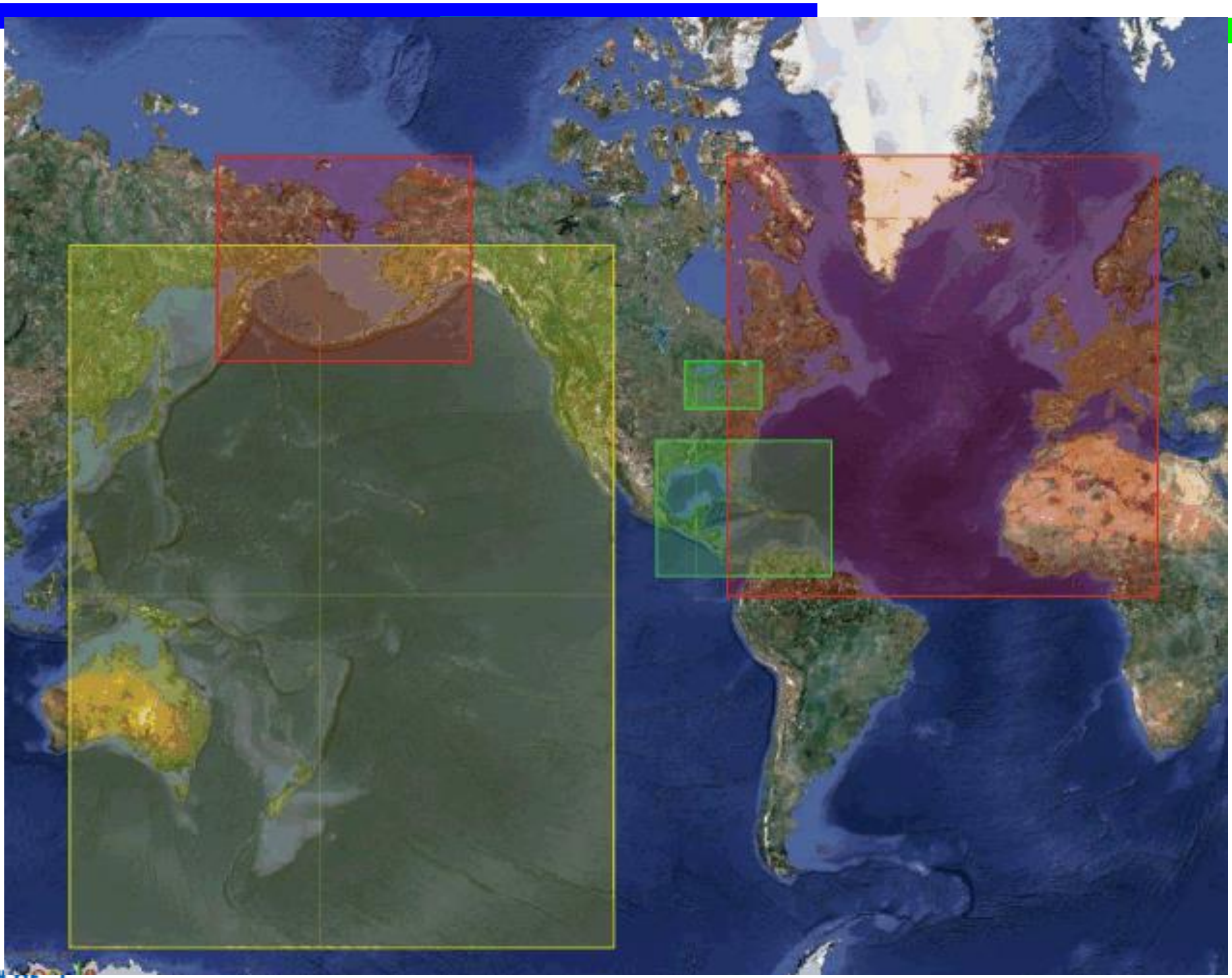
Previous observations

MM	DD	TIME (CDT)	WVHT ft	SwH ft	SwP sec	SwD	WWH ft	WWP sec	WWD	STEEPNESS	APD sec
06	24	6:00 am	3.6	3.6	7.1	ENE	1.3	3.6	-	AVERAGE	5.5
06	24	5:00 am	3.9	3.6	5.9	ENE	1.3	3.7	-	STEEP	5.3
06	24	4:00 am	3.9	3.6	7.1	ENE	1.6	4.3	-	AVERAGE	5.1
06	24	3:00 am	4.3	3.9	6.7	ENE	1.6	3.6	-	STEEP	5.2
06	24	2:00 am	4.3	3.9	6.7	ENE	1.6	4.2	-	STEEP	5.2
06	24	1:00 am	4.3	3.9	6.7	NE	2.0	4.3	-	STEEP	5.0
06	24	12:00 am	4.3	3.3	6.7	ENE	2.6	5.0	NE	STEEP	5.1
06	23	11:00 pm	4.9	3.9	7.1	ENE	2.6	5.0	NE	STEEP	5.2
06	23	10:00 pm	4.6	3.6	6.7	ENE	3.3	4.3	-	STEEP	5.0
06	23	9:00 pm	4.9	0.0	-	-	4.9	6.2	ENE	STEEP	5.2
06	23	8:00 pm	4.6	1.0	8.3	E	4.6	6.7	ENE	STEEP	5.0
06	23	7:00 pm	4.9	3.6	7.1	ENE	3.3	5.9	NE	STEEP	5.3
06	23	6:00 pm	4.6	3.3	6.7	ENE	3.3	5.6	ENE	STEEP	5.2
06	23	5:00 pm	4.6	0.0	-	-	4.6	6.7	ENE	STEEP	5.1
06	23	4:00 pm	4.3	2.6	7.1	ENE	3.6	6.2	ENE	STEEP	5.2
06	23	3:00 pm	4.3	2.6	7.1	ENE	3.3	6.2	ENE	STEEP	5.3
06	23	12:00 pm	4.6	3.6	7.7	ENE	3.0	5.6	NE	AVERAGE	5.5
06	23	10:00 am	4.9	4.3	7.7	ENE	2.6	5.3	NE	AVERAGE	5.8
06	23	9:00 am	4.9	3.9	7.1	ENE	3.0	5.3	NE	STEEP	5.5
06	23	8:00 am	5.6	4.3	7.1	ENE	3.6	5.6	NE	STEEP	5.7
06	23	7:00 am	5.2	3.6	8.3	ENE	3.6	5.6	NE	AVERAGE	5.4

Plot of wave energy versus frequency (and period)

Description of Measurements

Wave Hindcast Model Domains for U.S. Coasts



US Army Corps of Engineers

Wave Information Studies
Project Documentation

December 2010

Coastal and Hydraulics Laboratory
Engineer Research and Development Center

Project Manger: Dr. Robert Jensen

Robert.E.Jensen@usace.army.mil
http://wis.usace.army.mil

Table of Contents

Supporting Material
- Product Guide
- WIS Publication List
- User Survey
- WIS Fact Sheet
