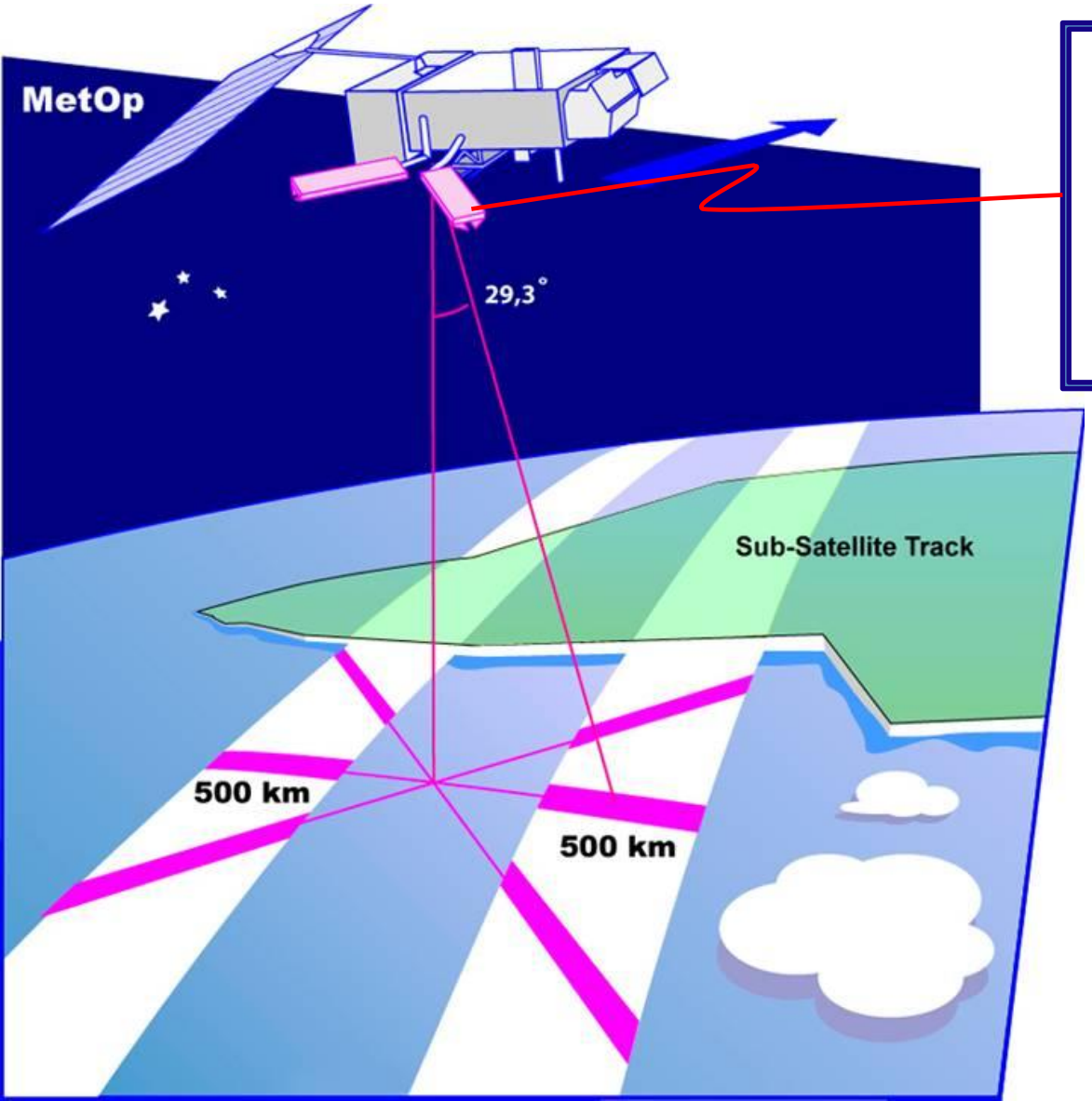
# ASCAT Geometry




C-band radar (5.25GHz)

**5.7cm** Wavelength

3 x 2.2m Antenna

Active instrument: **send and receive**

*What happens when the radiation hits water?*

# The Beaufort Scale

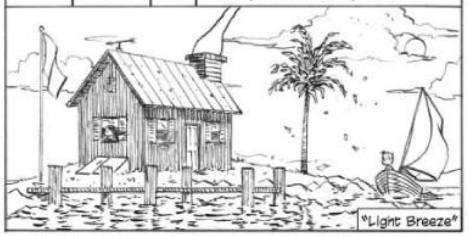
"Over thousands of years sailors have learnt to estimate the speed of the wind just by looking about. This technique matured into what we now call the Beaufort scale. The universe tells you everything you need to know about it as long as you are prepared to watch, to listen, to smell, in short to observe"

.....Howtoons 2006

| FORCE | SPEED | | |
|---|---|---|---|
| 0 | 0 Knots<br>0 mph<br>0 km/h | SEA | Sea like a mirror |
| | | LAND | Smoke rises vertically |


| FORCE | SPEED | | |
|---|---|---|---|
| 1 | 1-3 Knots<br>1-3 mph<br>1-6 km/h | SEA | Ripples with the appearance of scales are formed, but without foam crests |
| | | LAND | Direction of wind shown by smoke but not by wind vanes |


| FORCE | SPEED | | |
|---|---|---|---|
| 2 | 4-6 Knots<br>4-7 mph<br>7-11 km/h | SEA | Small wavelets. Crests have a glassy appearance and do not break |
| | | LAND | Wind felt on face; leaves rustle; ordinary vane moved by wind |

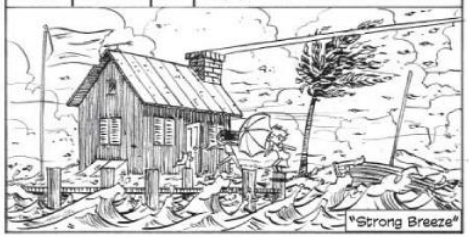



| FORCE | SPEED | | |
|---|---|---|---|
| 3 | 7-10 Knots<br>8-12 mph<br>12-19 km/h | SEA | Large wavelets. Crests begin to break. Foam of glassy appearance. |
| | | LAND | Leaves and small twigs in constant motion; wind extends light flag |


| FORCE | SPEED | | |
|---|---|---|---|
| 4 | 11-16 Knots<br>13-18 mph<br>20-29 km/h | SEA | Small waves, becoming longer, fairly frequent white horses |
| | | LAND | Raises dust and loose paper; small branches are moved |


| FORCE | SPEED | | |
|---|---|---|---|
| 5 | 17-21 Knots<br>19-24 mph<br>30-39 km/h | SEA | Moderate waves, taking a more pronounced long form; many white horses are formed. |
| | | LAND | Small trees in leaf begin to sway; wavelets form on inland waters |


| FORCE | SPEED | | |
|---|---|---|---|
| 6 | 22-27 Knots<br>25-31 mph<br>40-50 km/h | SEA | Large waves begin to form; the white foam crests are more extensive everywhere. |
| | | LAND | Large branches in motion; whistling heard in telegraph wires; umbrellas use difficult. |




| FORCE | SPEED | | |
|---|---|---|---|
| 7 | 28-33 Knots<br>32-38 mph<br>51-62 km/h | SEA | Sea heaps up and white foam from breaking waves starts to blow in streaks with wind. |
| | | LAND | Whole trees in motion; umbrellas discarded; inconvenience felt when walking |

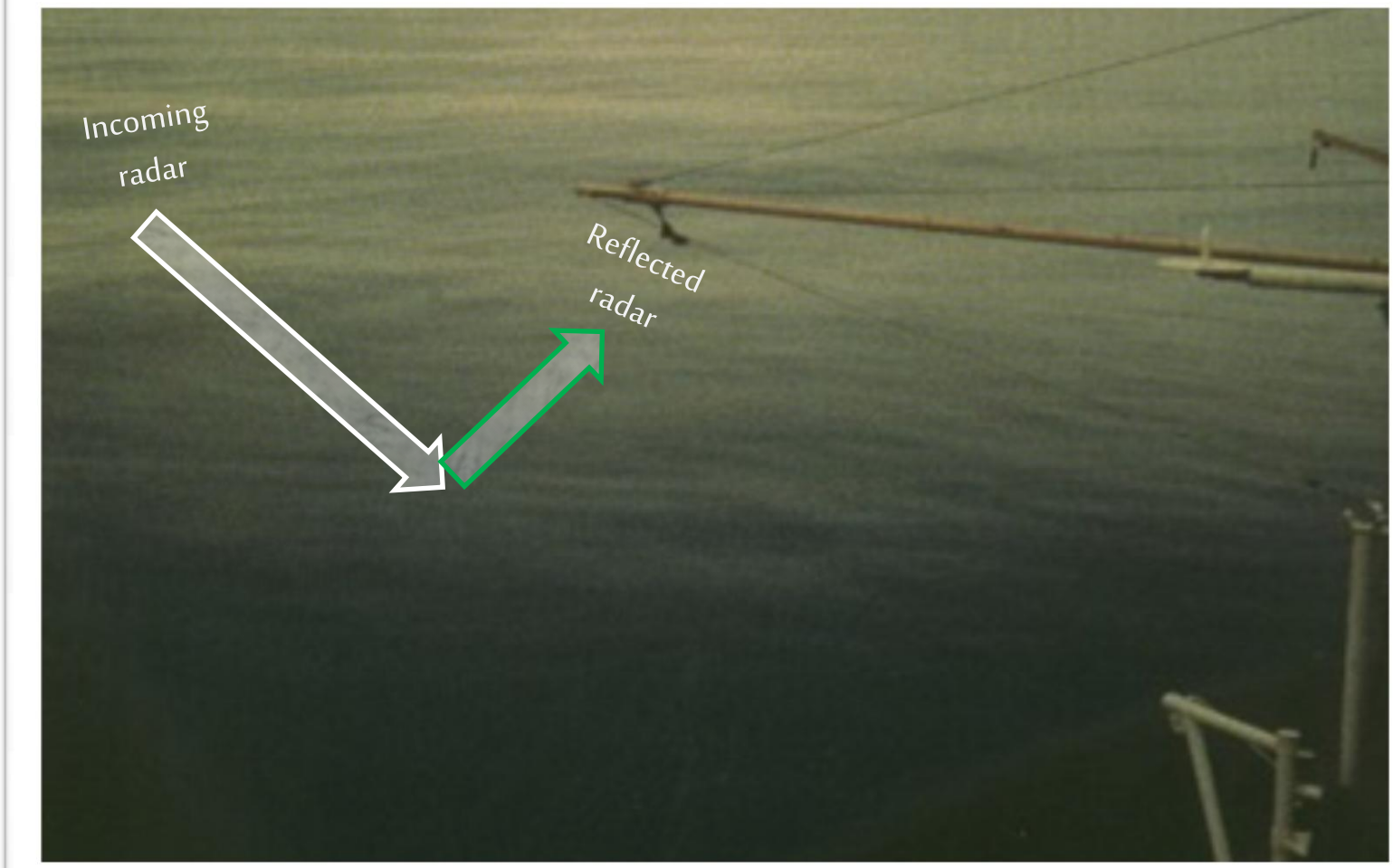

| FORCE | SPEED | | |
|---|---|---|---|
| 8 | 34-40 Knots<br>39-46 mph<br>63-75 km/h | SEA | Moderate high waves of greater length; edges of crests begin to break into spindrift. |
| | | LAND | Breaks twigs off trees; generally impedes progress |


| FORCE | SPEED | | |
|---|---|---|---|
| 9 | 41-47 Knots<br>47-54 mph<br>76-87 km/h | SEA | High waves. Crests of waves begin to tumble and roll over. Spray may affect visibility |
| | | LAND | Slight structural damage occurs; chimney pots and slates removed |

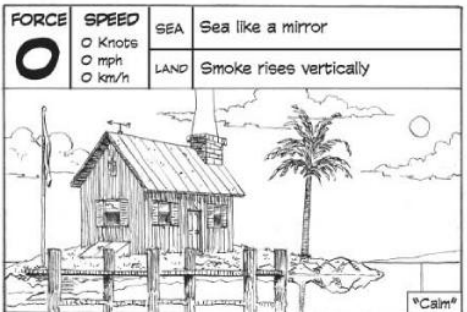

| FORCE | SPEED | | |
|---|---|---|---|
| 10 | 48-55 Knots<br>55-63 mph<br>88-102 km/h | SEA | Very high waves. Surface of the sea takes on a white appearance. Visibility affected |
| | | LAND | Seldom experienced inland; trees uprooted; considerable structural damage occurs |

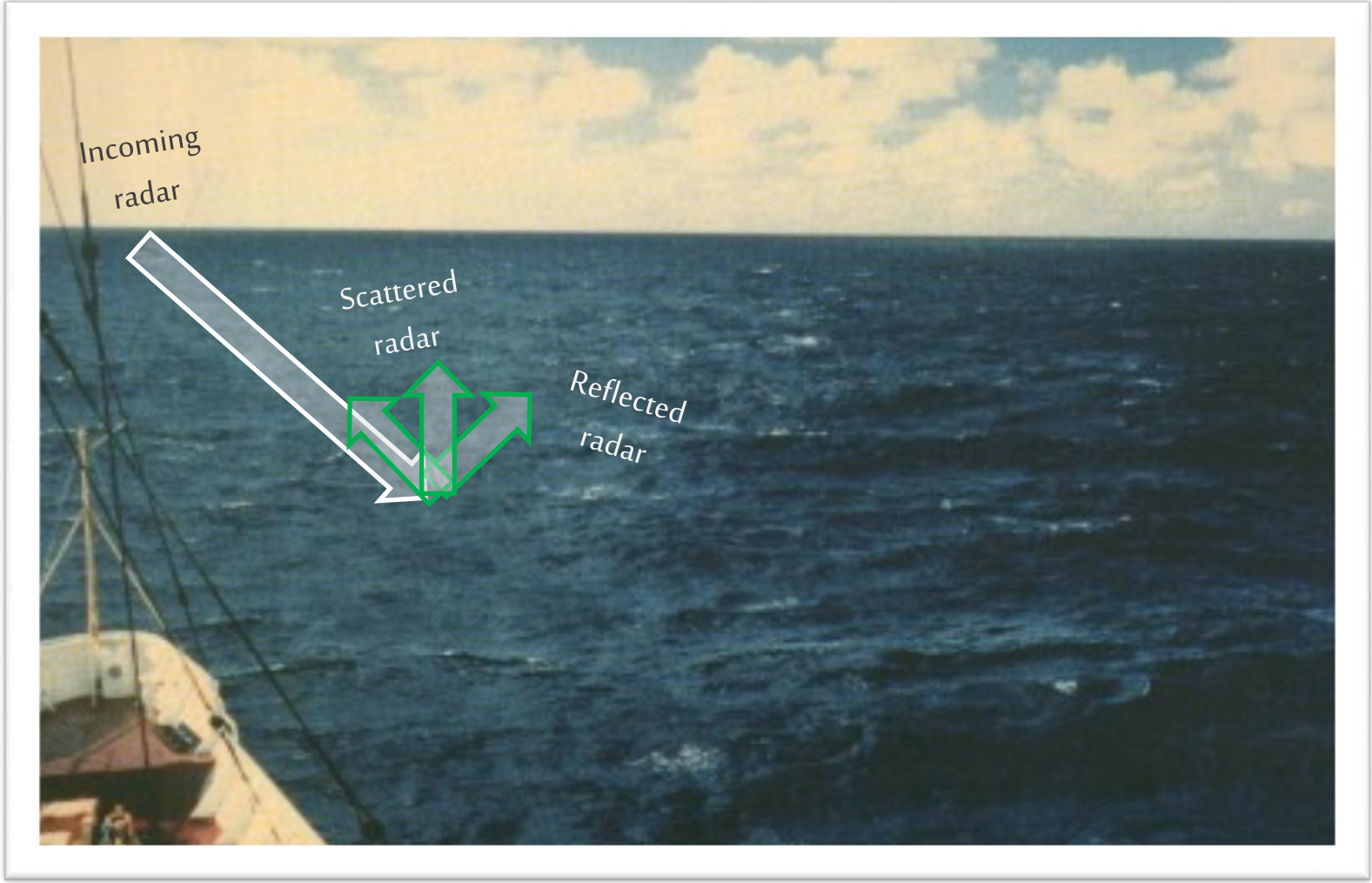

| FORCE | SPEED | | |
|---|---|---|---|
| 11 | 56-63 Knots<br>64-72 mph<br>103-117 km/h | SEA | Exceptionally high waves. The sea is covered with long white patches of foam. |
| | | LAND | Very rarely experienced on land; accompanied by widespread damage. |

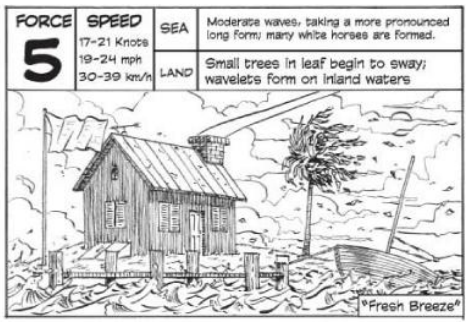

| FORCE | SPEED | | |
|---|---|---|---|
| 12 | over 63 Knots<br>over 72 mph<br>over 117 km/h | SEA | Huge waves; air is filled with foam and spray. Sea white with driving spray; visibility very seriously affected |
| | | LAND | Countryside is devastated |




No energy is scattered back to the source






Some of the energy is scattered back to the source

And it then measured as signal:

**ASCAT measures backscatter**

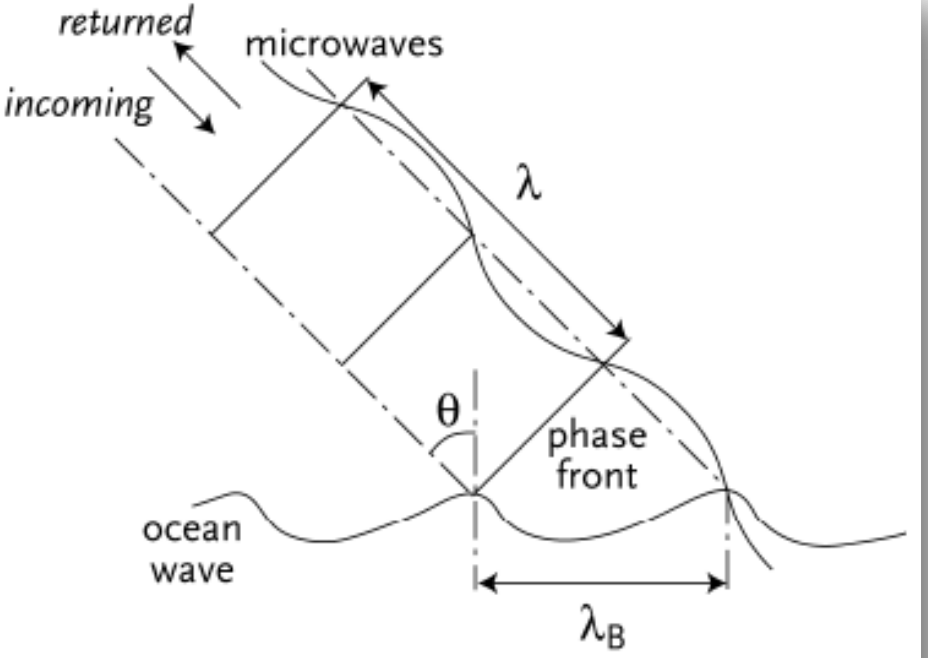



**Figure 11.** Bragg scattering: A plan-parallel radar beam with wavelength $\lambda$ hits the rough ocean surface at incidence angle $\theta$, where capillary gravity waves with Bragg wavelength $\lambda_B$ will cause microwave resonance.

*What happens when the radiation hits water?*

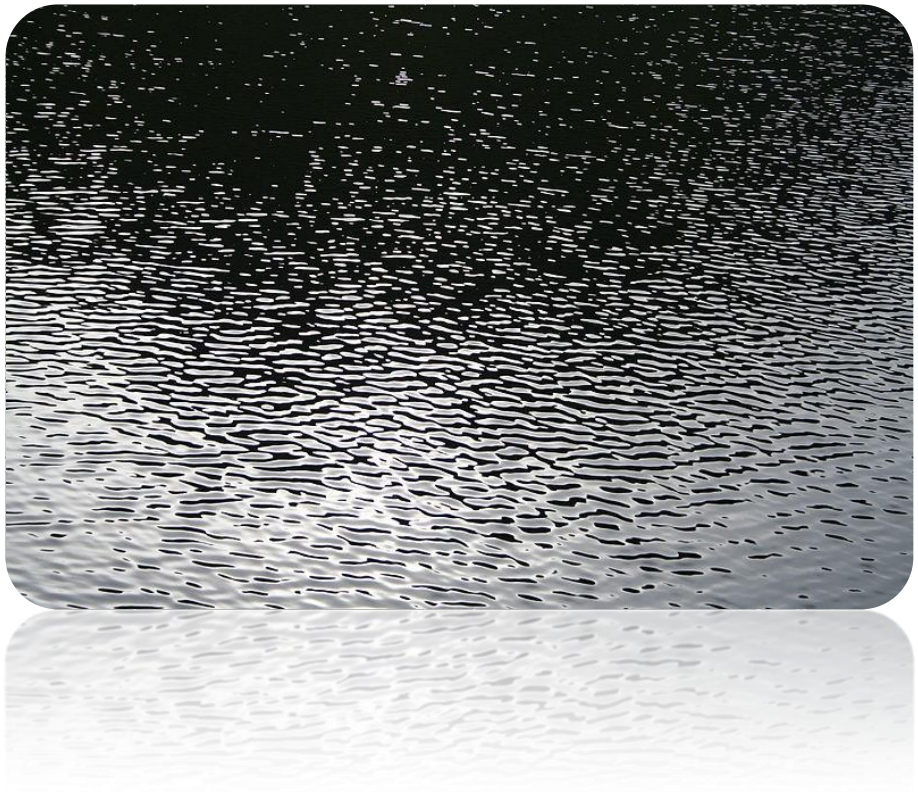
**Bragg scattering:**
Incoming microwave radiation in resonance with short waves (dominant for 30°< $\theta$ < 70 °)

$$\lambda_B = \lambda/(2\sin(\theta))$$

**Specular reflection:**
Ocean facets normal to incident radiation (non-negligible for $\theta$ < 30°)

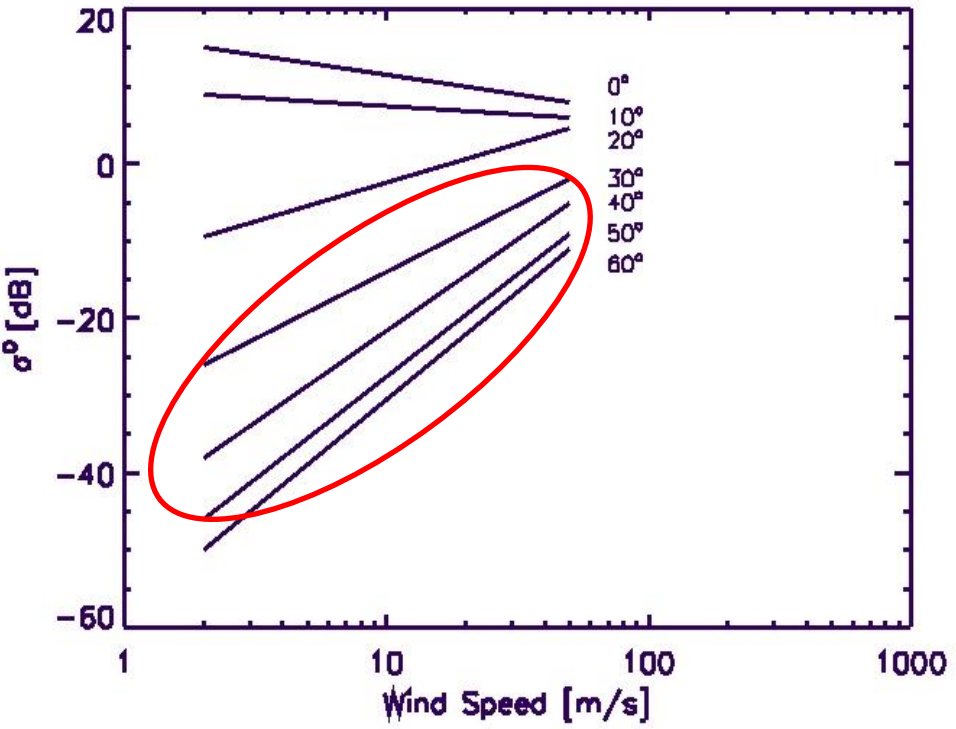
$\lambda$ ~ 2cm (Ku-band) ; $\lambda$ ~ 5cm (C-band)

More energy is backscattered where the surface wavelength is similar to the radar wavelength



***Ripples / 'gravity capillary waves' / surface roughness***

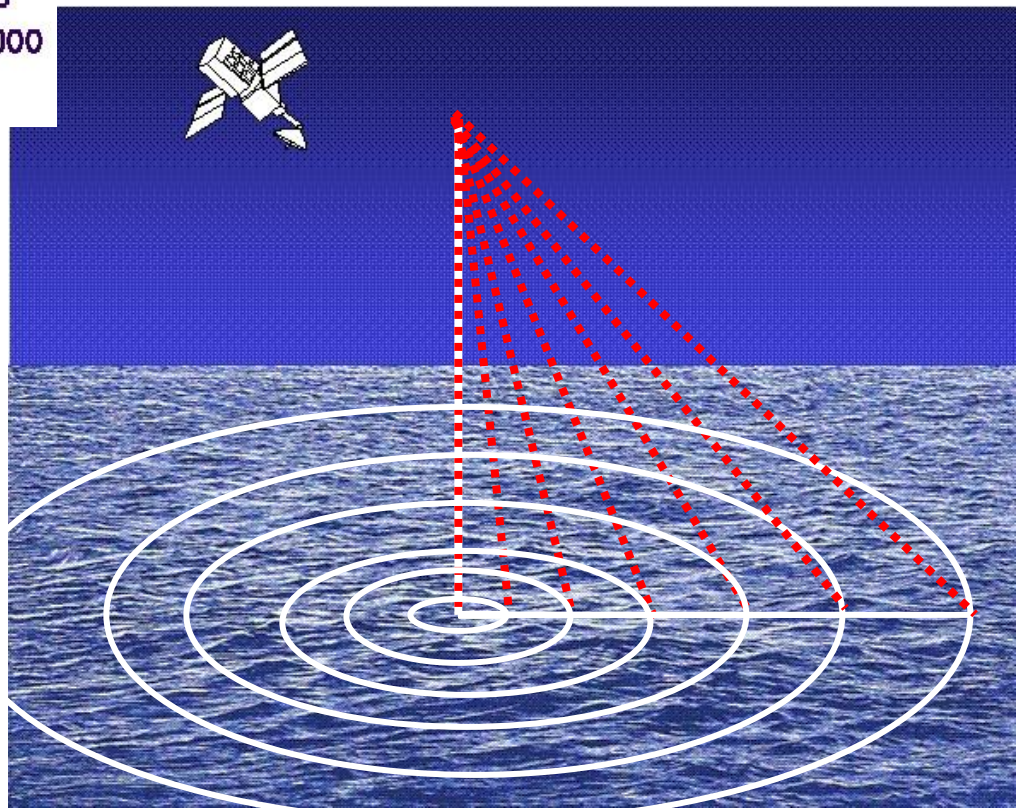
It is the **ripples** (not the big waves) that matter

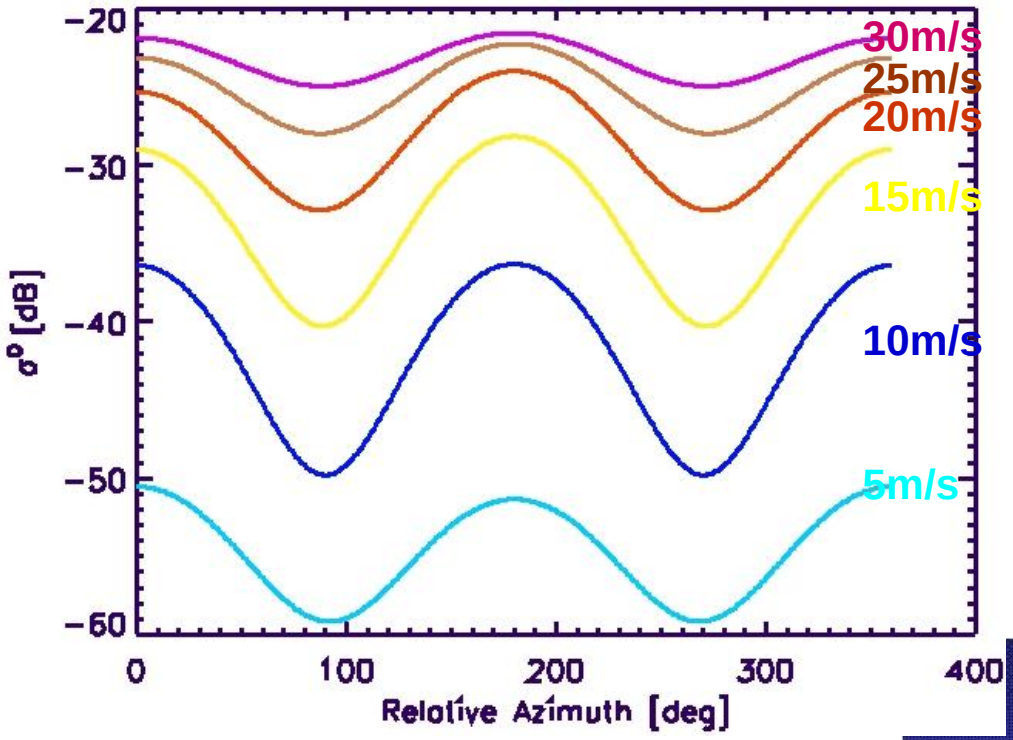



## *Variation with wind speed and incidence angle*

More VARIATION at high angles so greater sensitivity to variation in wind speed

(Angle increases across ASCAT swath)

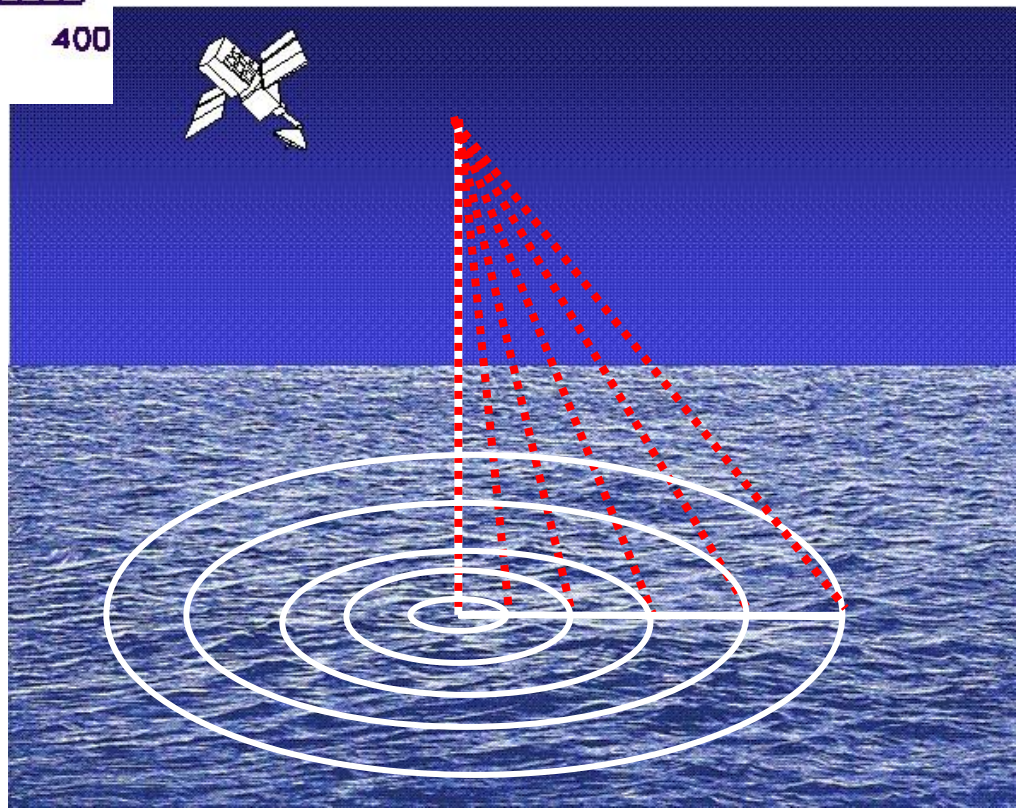




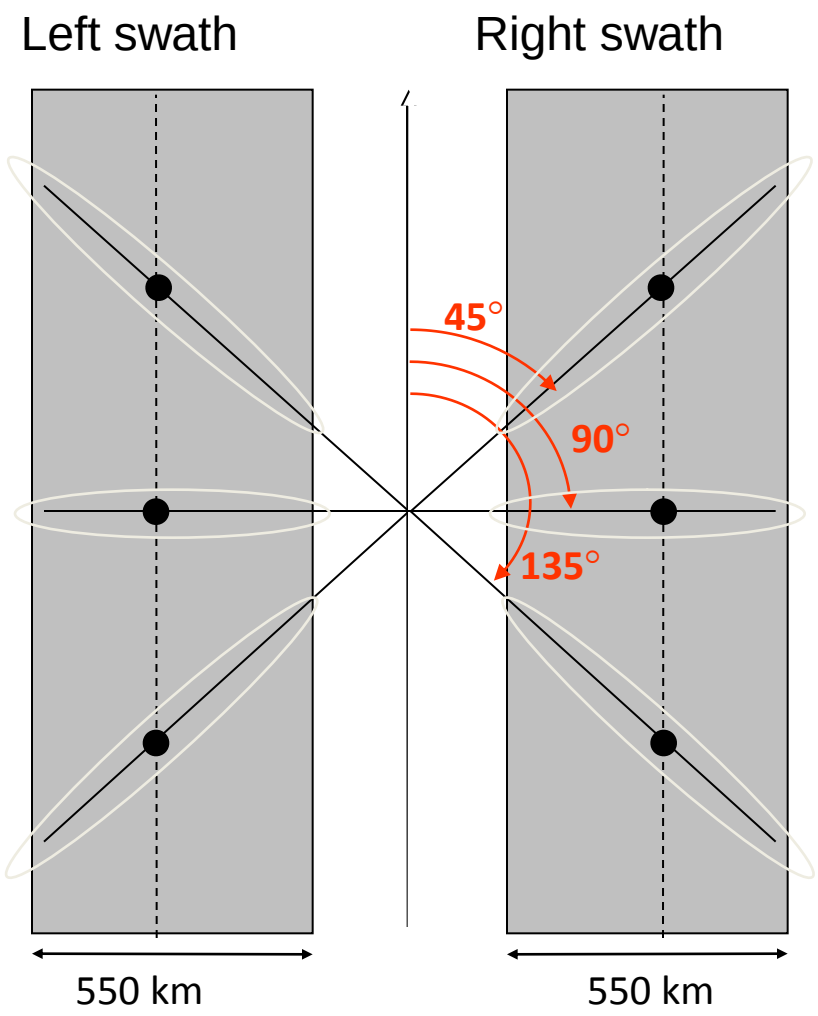

## *Variation with relative AZIMUTH*

*(Angle between Radar beam and wind direction)*

More sensitive at slower speeds
& **ambiguity** in direction



# ASCAT observation geometry




- Measuring geometry: 3 fan-beam antennas, double swath, incidence angles between **25** and **65** deg
- Measurement: normalised radar cross-section (NRCS, backscatter, σ0)
- Swath gridded into nodes (25 km and 12.5 km spacing), one triplet of averaged backscatter measurements per node

# Scatterometer Data sources:

**Direct: GTS and EUMETcast**

**ASCAT – online:**
http://www.knmi.nl/scatterometer/ascat_osi_co_prod/ascat_app.cgi
http://eumetrain.org/eport/tsms_12.php
http://manati.orbit.nesdis.noaa.gov/datasets/ASCATData.php/ASCATData.php
http://podaac.jpl.nasa.gov/dataset/ASCAT-L2-12.5km [netcdf]

**Oceansat-2 – online:**
http://www.knmi.nl/scatterometer/oscat_50_prod/oscat_app.cgi

# OSCAT observation geometry

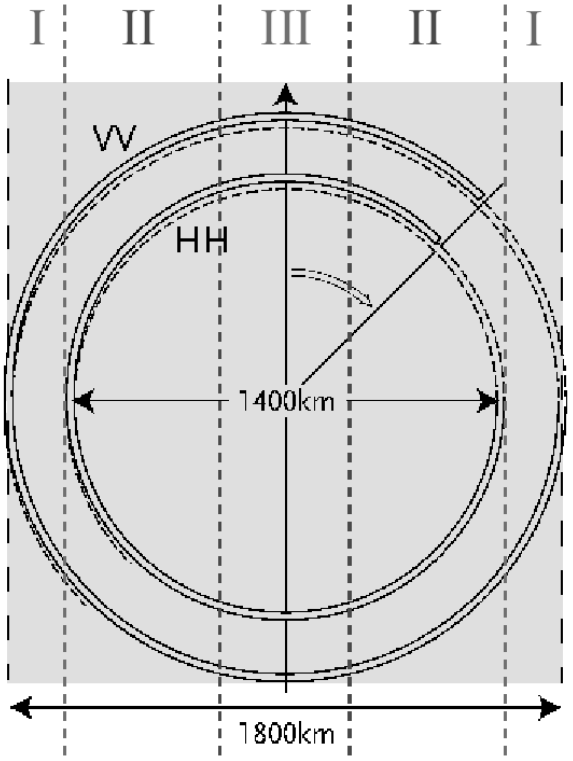
***Rotating 'pencil beam'***

- Ku-band (2 cm) [**Rain**]
- Dual polarization
- Sampling 25 km, 50 km
- Rotating -> many azimuths

Does the incidence angle vary?

What do the three bands labelled I,II & III signify?

How does rain affect measurements?



# Geophysical Model Function

An **empirical** geophysical model function (GMF) relates ocean 'surface' wind vector to the backscatter cross section measurements

$$\sigma_o^{\text{model}} = \text{GMF}(U_{10N}, \varphi, \theta, p, \lambda)$$

$U_{10N}$: equivalent neutral wind speed
$\varphi$ : wind direction w.r.t. beam pointing
$\theta$ : incidence angle
$p$ : radar beam polarization
$\lambda$: microwave wavelength

# Equivalent neutral wind $U_{10N}$

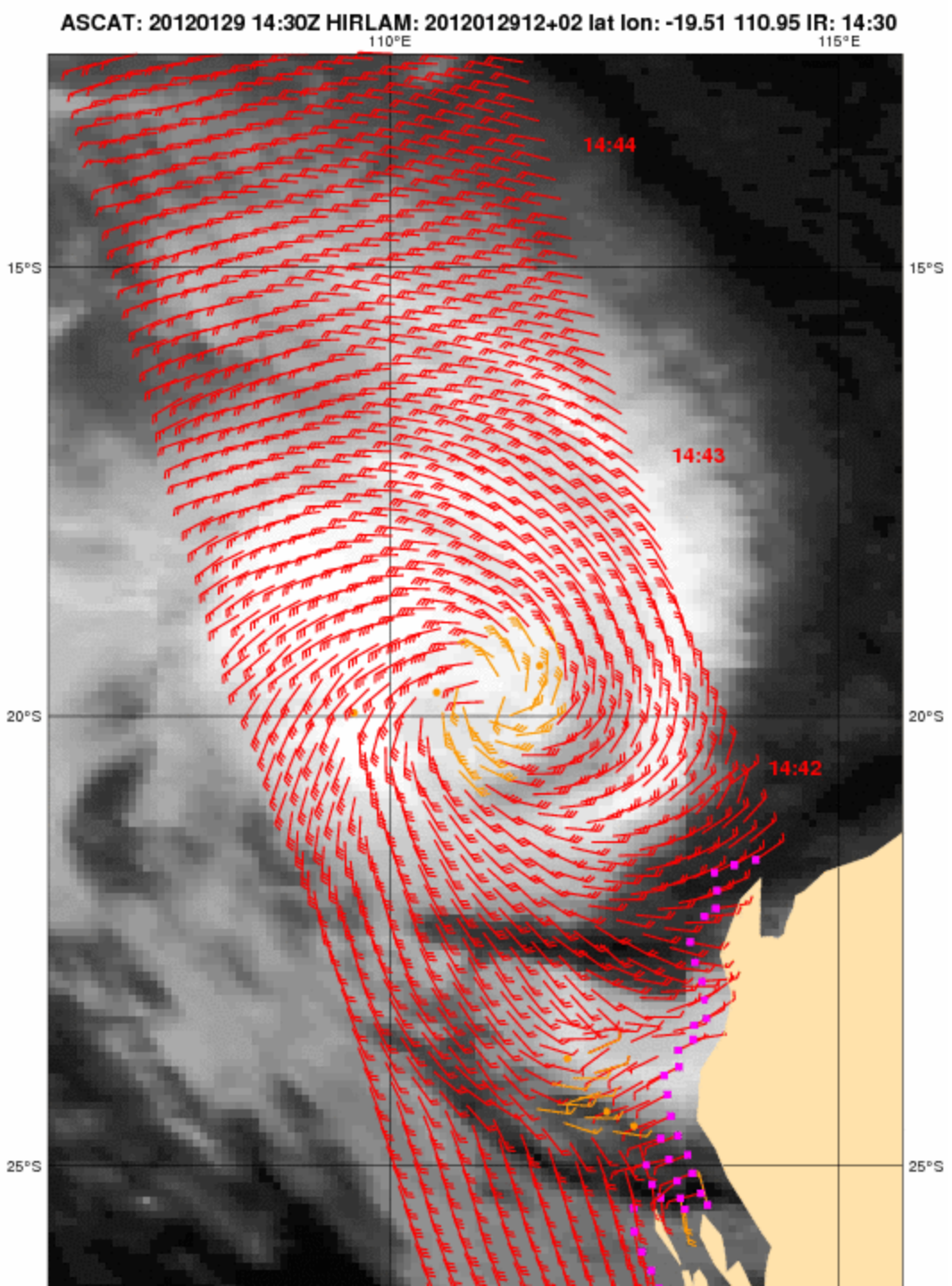
$$U_{10} = \frac{u_*\left[\ln\left(10/z_0\right) - \psi(10/L)\right]}{k(=0.4)} + U_S$$

$$z_0 = \frac{0.11 \cdot \nu}{u_*} + \frac{\alpha \cdot u_*^2}{g}$$

$$U_{10N} = \frac{u_* \ln\left(10/z_0\right)}{k}$$

- $U_{10}$ depends on air stability $y$ while $s^0$ is a sea property
- Surface roughness $z_0$ relates to $s^0$ and depends on friction velocity $u_*$
- $U_{10N}$ is computed from $u_*$ by setting $y$ = 0 and is available from NWP models and buoys
- GMF fits $s^0$ and collocated $U_{10N}$
- So, $s^0$ = GMF ( $U_{10N}$, $f$, $q$, $p$, $l$ )
- NWP models usually ignore current ($U_s$ = 0), but a scatterometer does measure relative to ocean motion [note for climate]

Portabella & Stoffelen, 2009




*So ...*

*what is this?*

*<- <- <-*

***Will a buoy measure higher or lower speeds?***

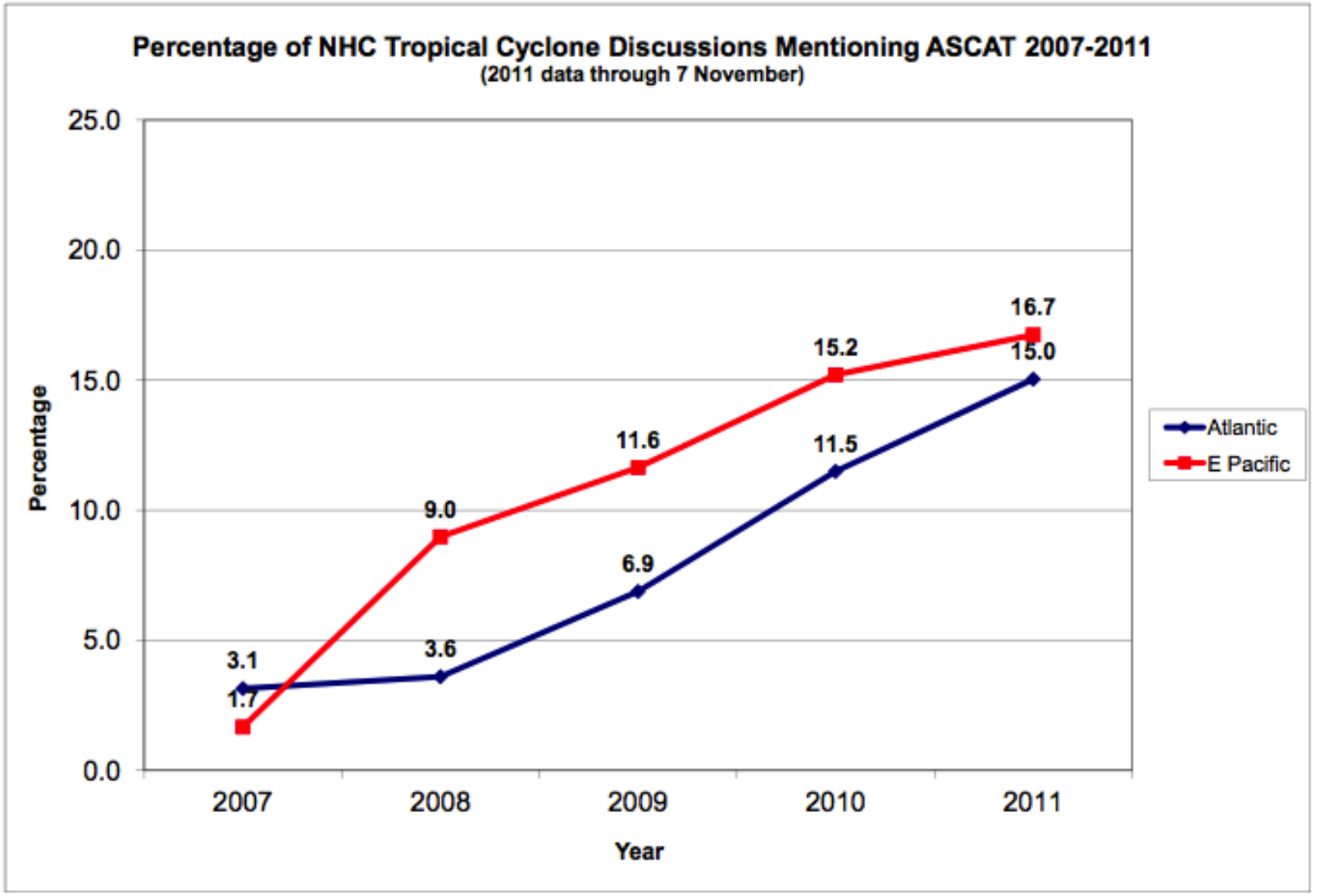
***Does incidence angle make a difference here?*** *(The sub satellite point is west of this swath)*

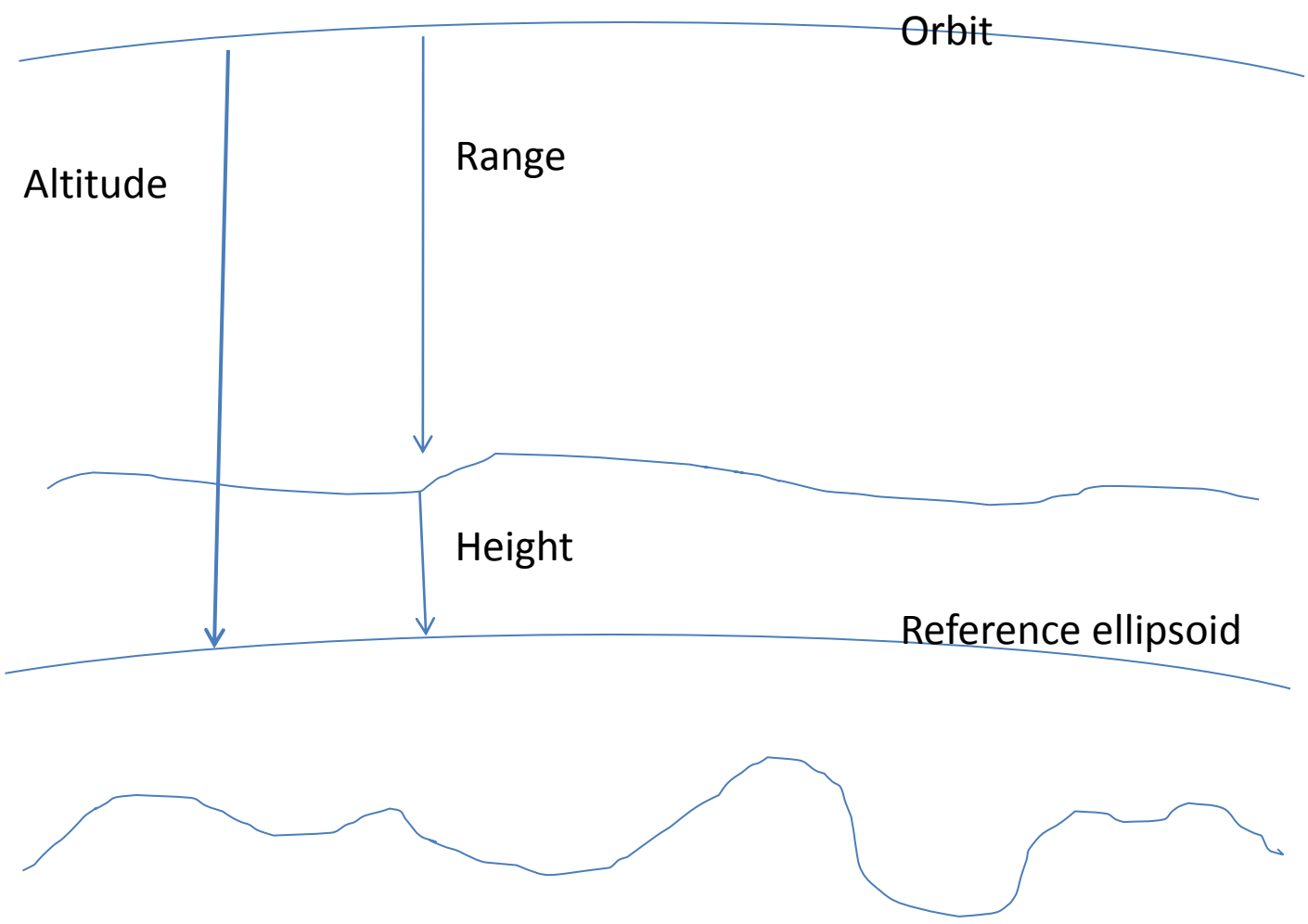
***Will sea ice make a difference?***

***Should we ignore the flagged data?***

# ASCAT Scatterometer winds

- Represent the mean "wind vector cell" wind
- Are provided as **equivalent neutral 10m winds**
- Verify very well with NWP model
- Verify very well with buoys
- Spatial plots show small-scale features in line with these three statistical findings
- Can be contaminated by land, sea ice and rain, but to a **small degree only** (0.5% QC vs ~5% for OSCAT)
- ASCAT winds > 30 m/s are difficult to measure
- ASCAT winds have a typical 180 degree ambiguity


Percentage of NHC Tropical Cyclone Discussions Mentioning ASCAT 2007-2011
(2011 data through 7 November)
25.0
20.0
15.0
10.0
5.0
0.0
Percentage
2007
2008
2009
2010
2011
Year
3.1
1.7
3.6
9.0
6.9
11.6
11.5
15.2
15.0
16.7
Atlantic
E Pacific


Orbit
Altitude
Range
Height
Reference ellipsoid