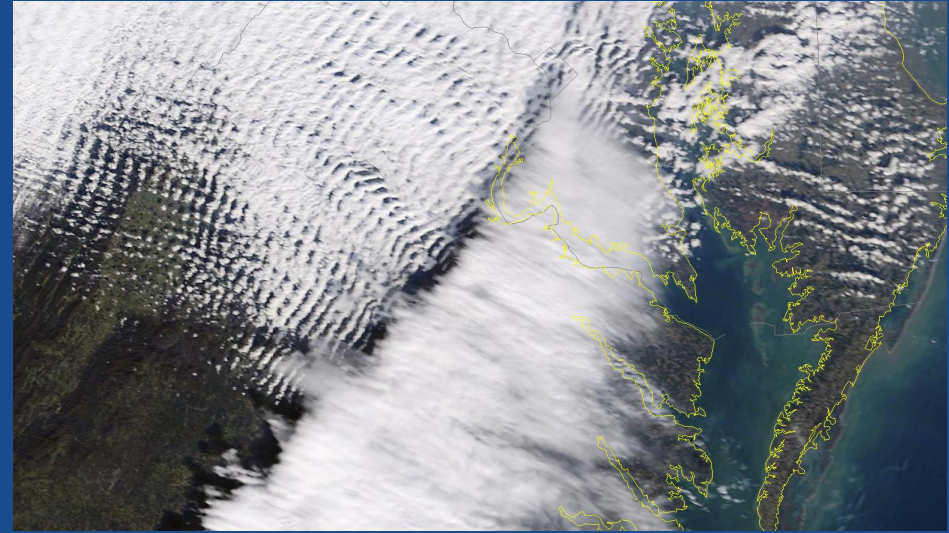


Trapped lee waves

Miguel Teixeira

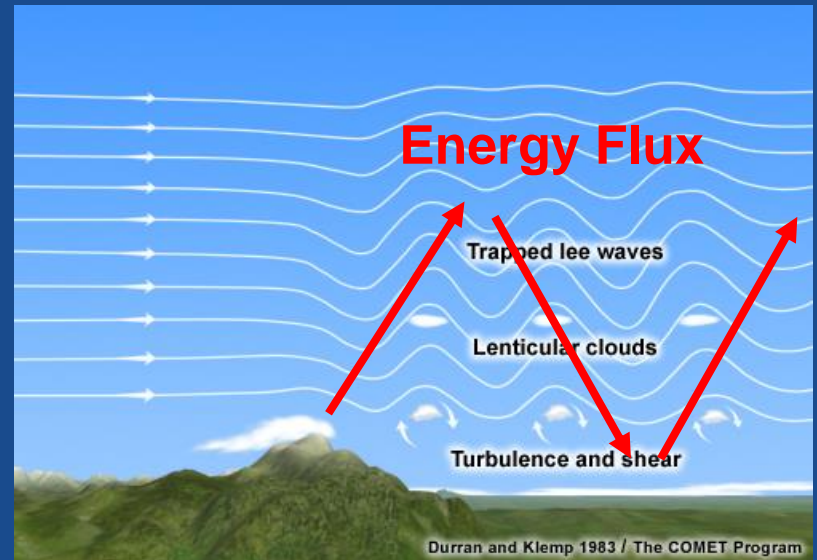
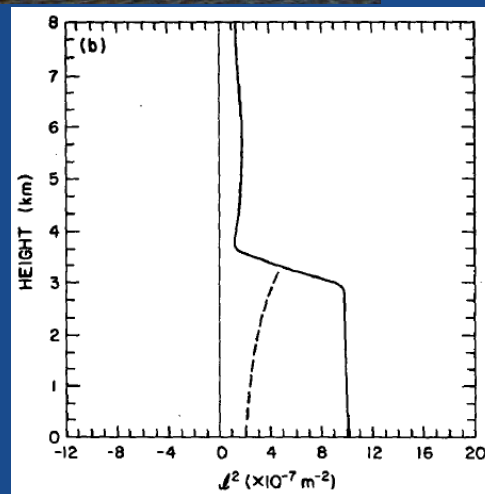
Examples



$$N^2(z) = \frac{g}{\theta_0} \frac{d\bar{\theta}}{dz}$$

Scorer parameter

$$l(z) = \left(\frac{N^2}{U^2} - \frac{1}{U} \frac{d^2U}{dz^2} \right)^{1/2}$$



Linear theory

- 2D flow
- Earth's rotation unimportant
- Stationary flow
- Linearization

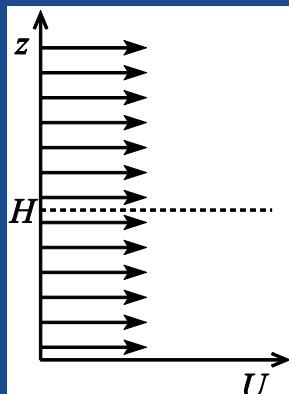
$$\frac{d^2 w}{dz^2} + (l^2 - k^2)w = 0$$

Solutions:

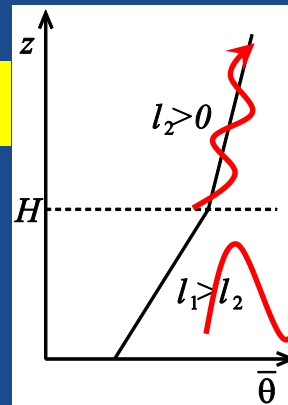
$k^2 < l^2$	$w(x, z) = a \cos(kx + mz)$	waves propagate vertically
$k^2 > l^2$	$w(x, z) = ae^{-nz} \cos(kx)$	waves are evanescent

If l decreases with height, waves with wavenumber k may propagate at low levels but not at high levels \Rightarrow **Trapped lee waves**

Examples: 2-layer atmospheres Scorer (1949)

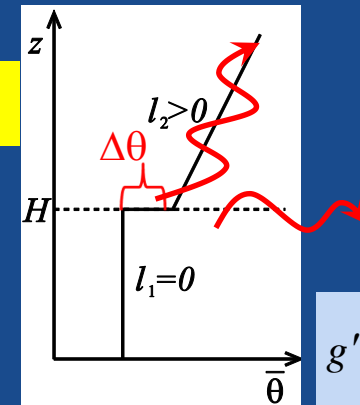


Case 1



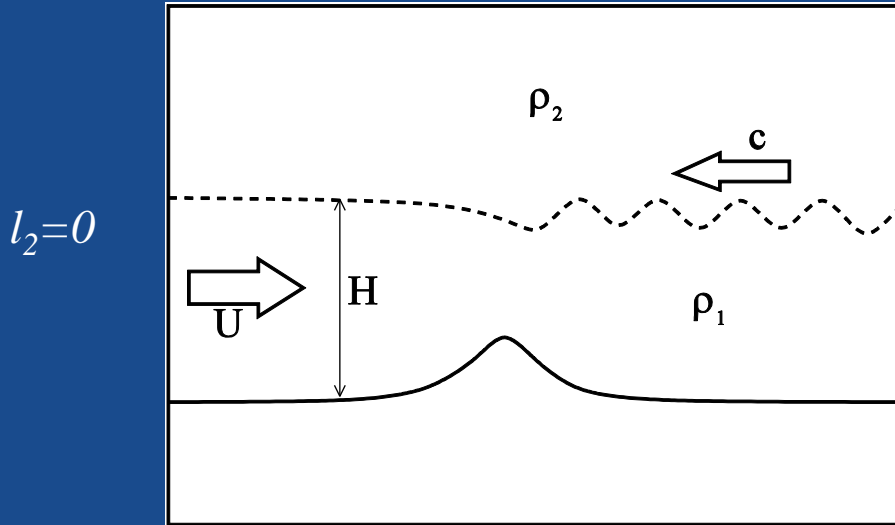
Case 2

Vosper (2004)



$$g' = g \frac{\Delta\theta}{\theta_0}$$

Simplest case



Surface waves at density interface

Phase speed: $c = \sqrt{\frac{g' \tanh(kH)}{k[1 + \tanh(kH)]}}$

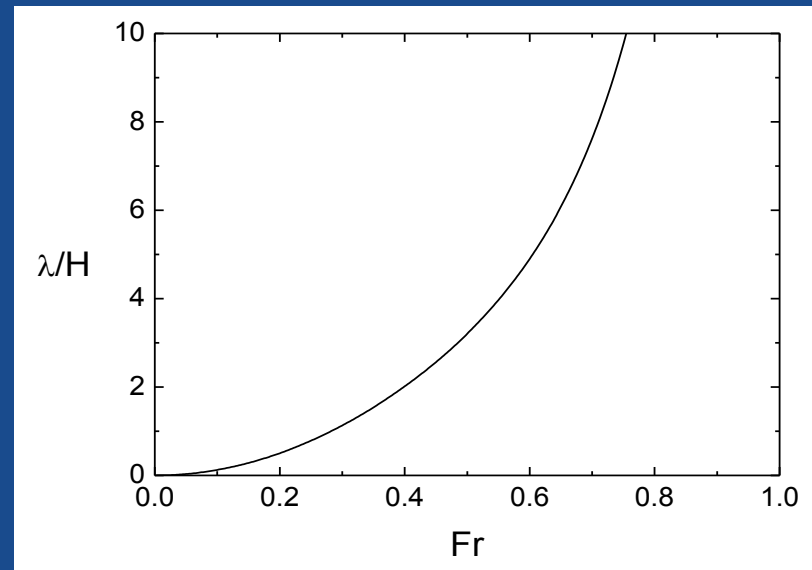
Resonance condition: $c=U$

$$\tanh(k_L H) = \frac{k_L H}{Fr^{-2} - k_L H}$$

$$Fr = \frac{U}{\sqrt{g'H}}$$

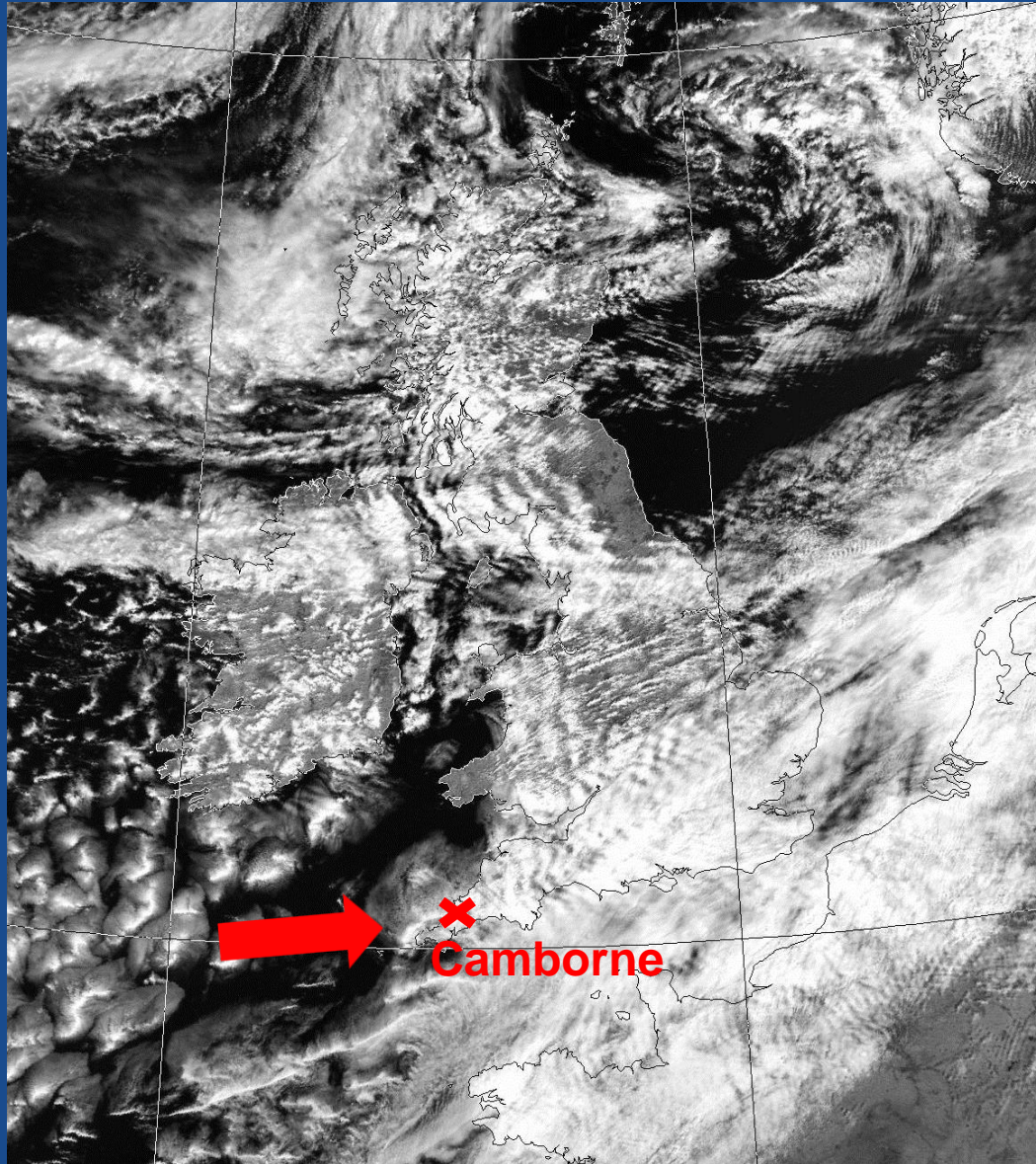
$k_L H$ is only a function of Fr

Wavelength of trapped lee waves: $\lambda_L = \frac{2\pi}{k_L}$

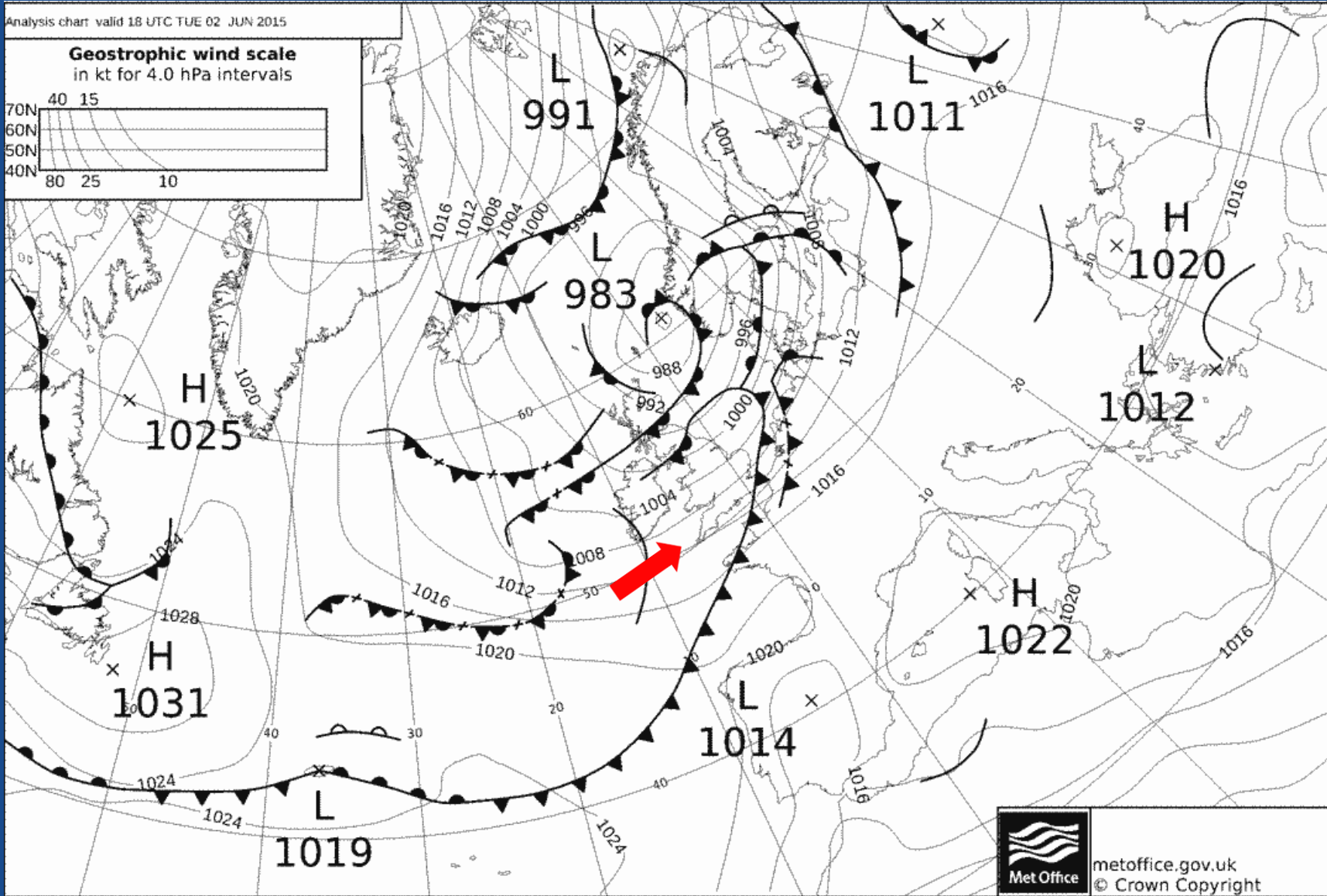


Last Tuesday

Visible, 2/6/2015, 10.35 UTC

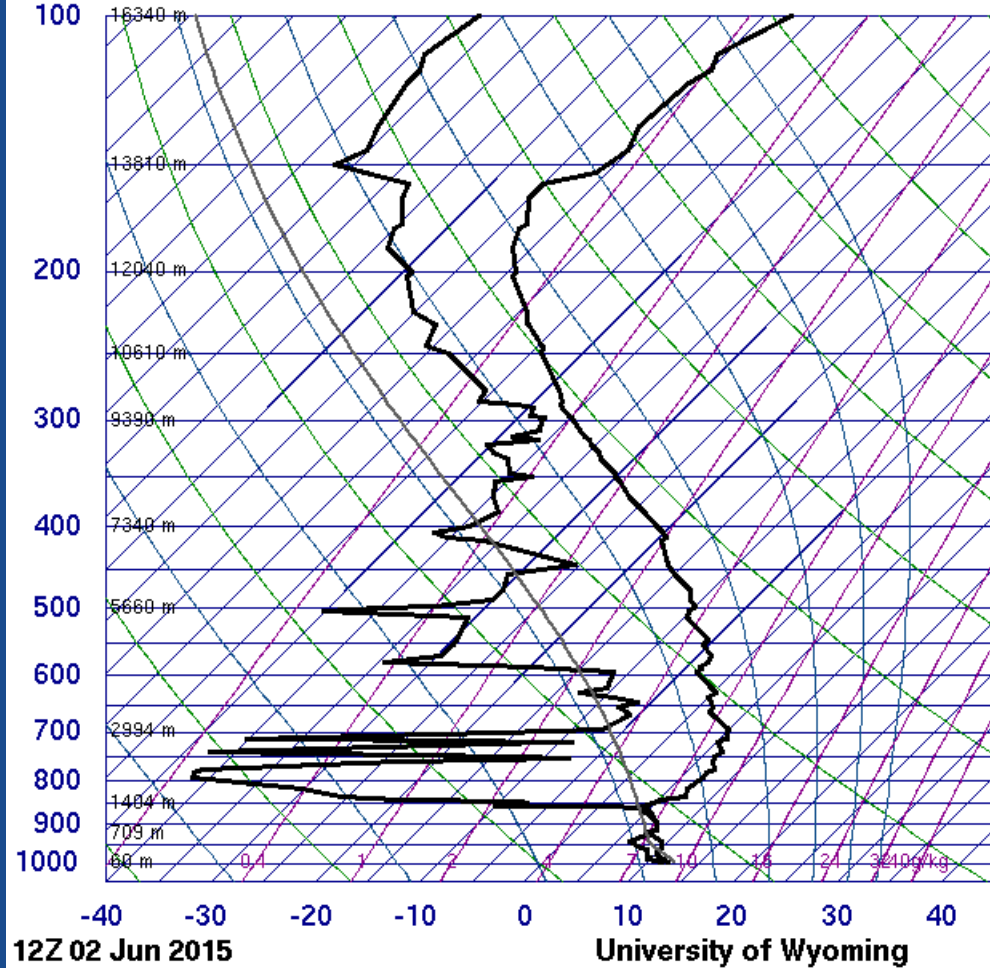


2/6/2015, 18 UTC



2/6/2015, 12 UTC

03808 Camborne

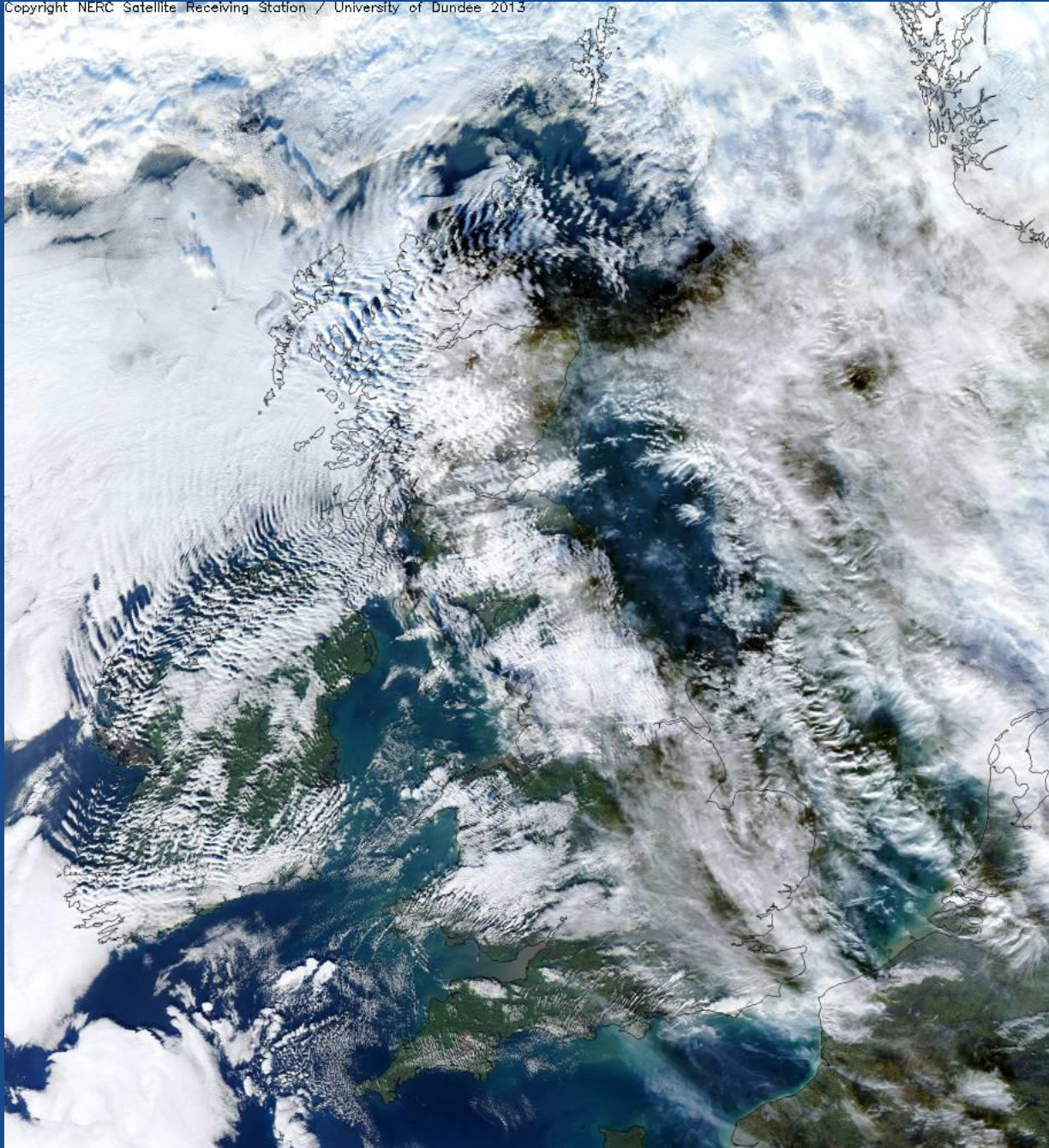


SLAT	50.22
SLON	-5.32
SELV	88.00
SHOW	19.68
LIFT	14.69
LFTV	14.57
SWET	202.8
KINX	-14.5
CTOT	2.70
VTOT	14.70
TOTL	17.40
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	-26.6
EQLV	-9999
EQTV	854.0
LFCT	-9999
LFCV	856.5
BRCH	0.00
BRCV	0.00
LCLT	281.3
LCLP	944.2
MLTH	286.0
MLMR	7.29
THCK	5600.
PWAT	16.32

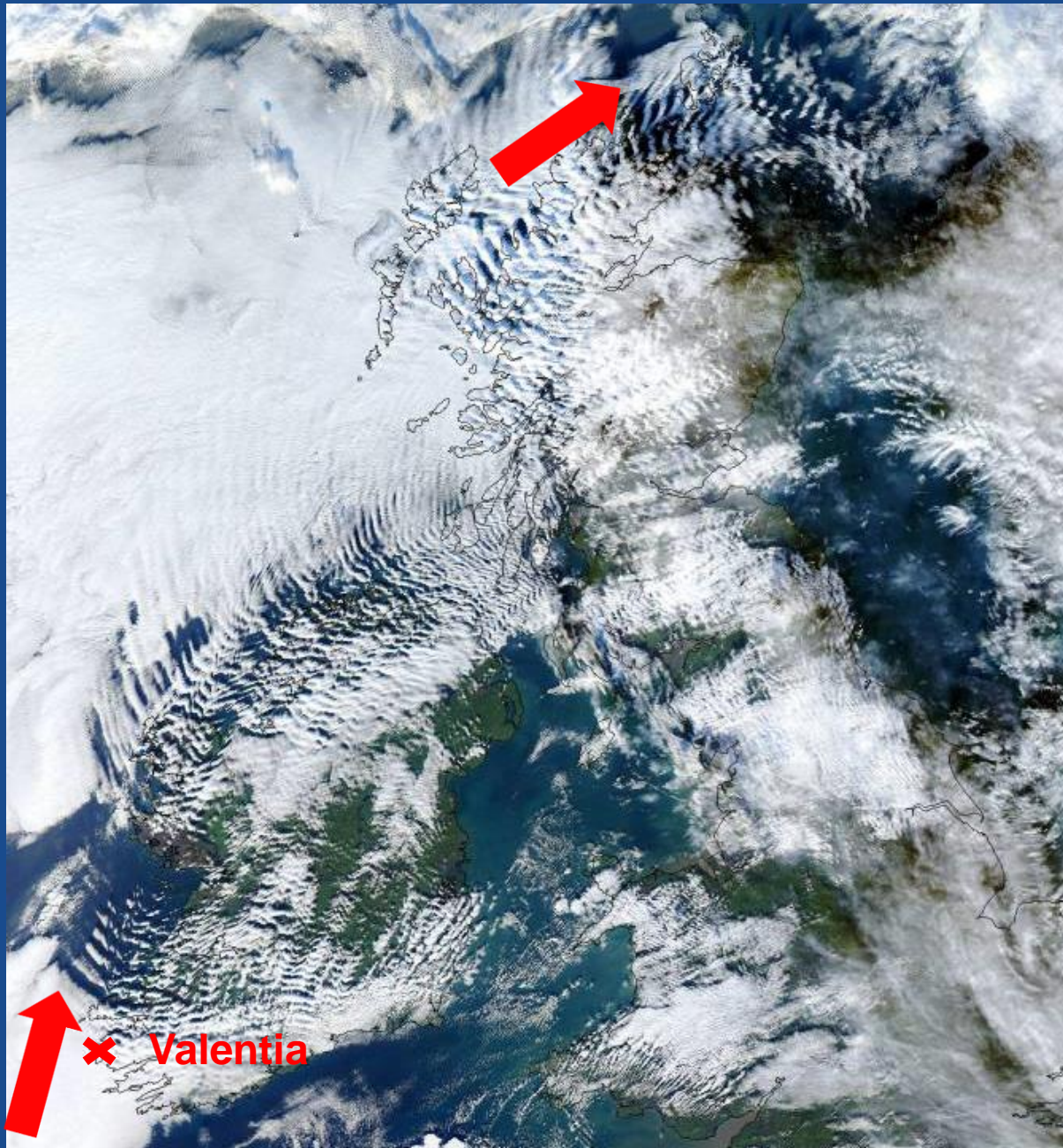
9/12/2013, ~12 UTC

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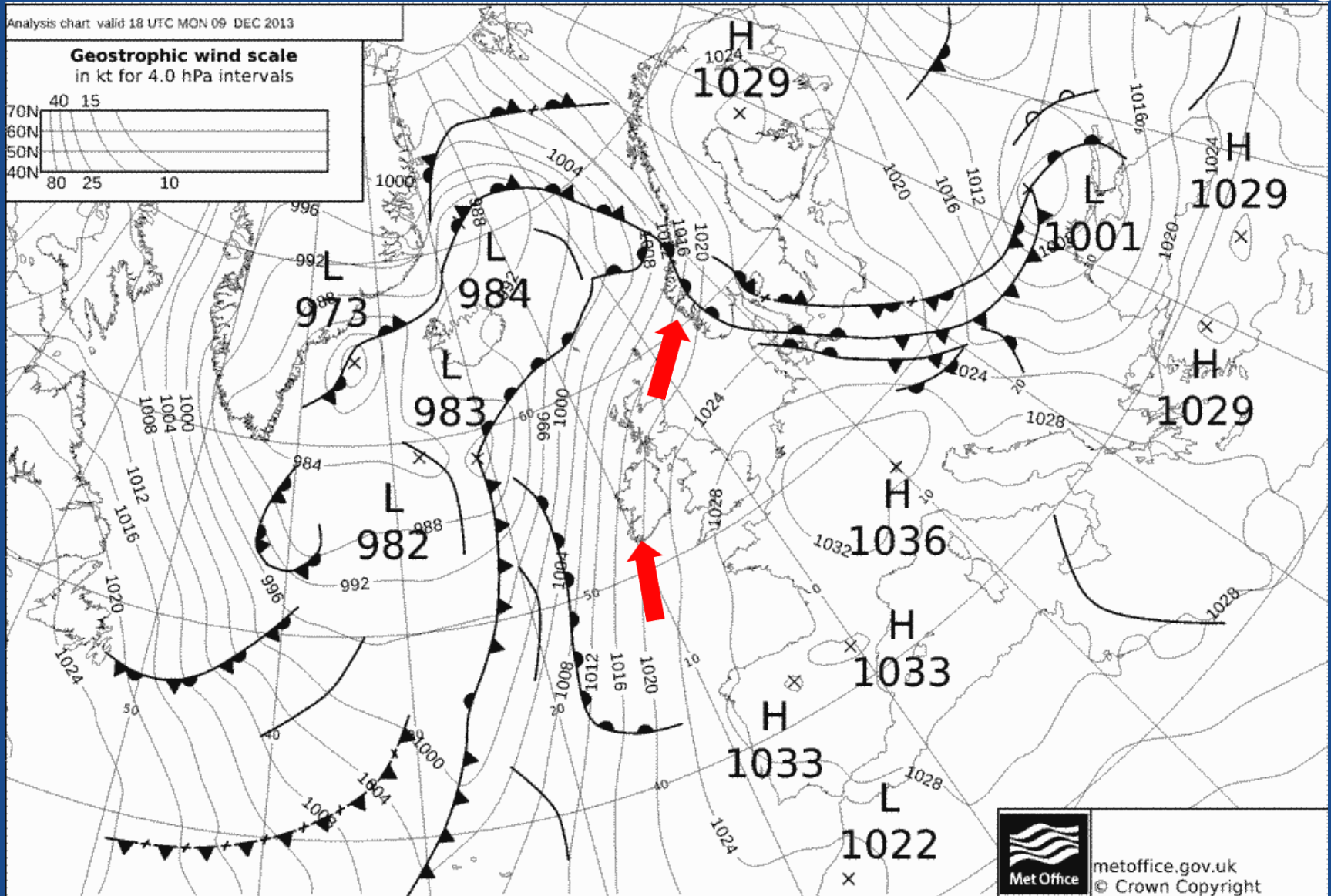
A good
example



9/12/2013, ~12 UTC

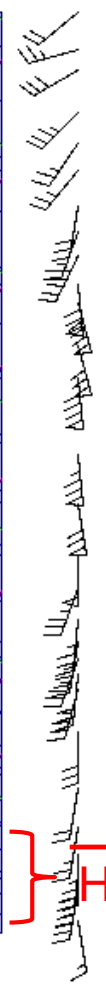
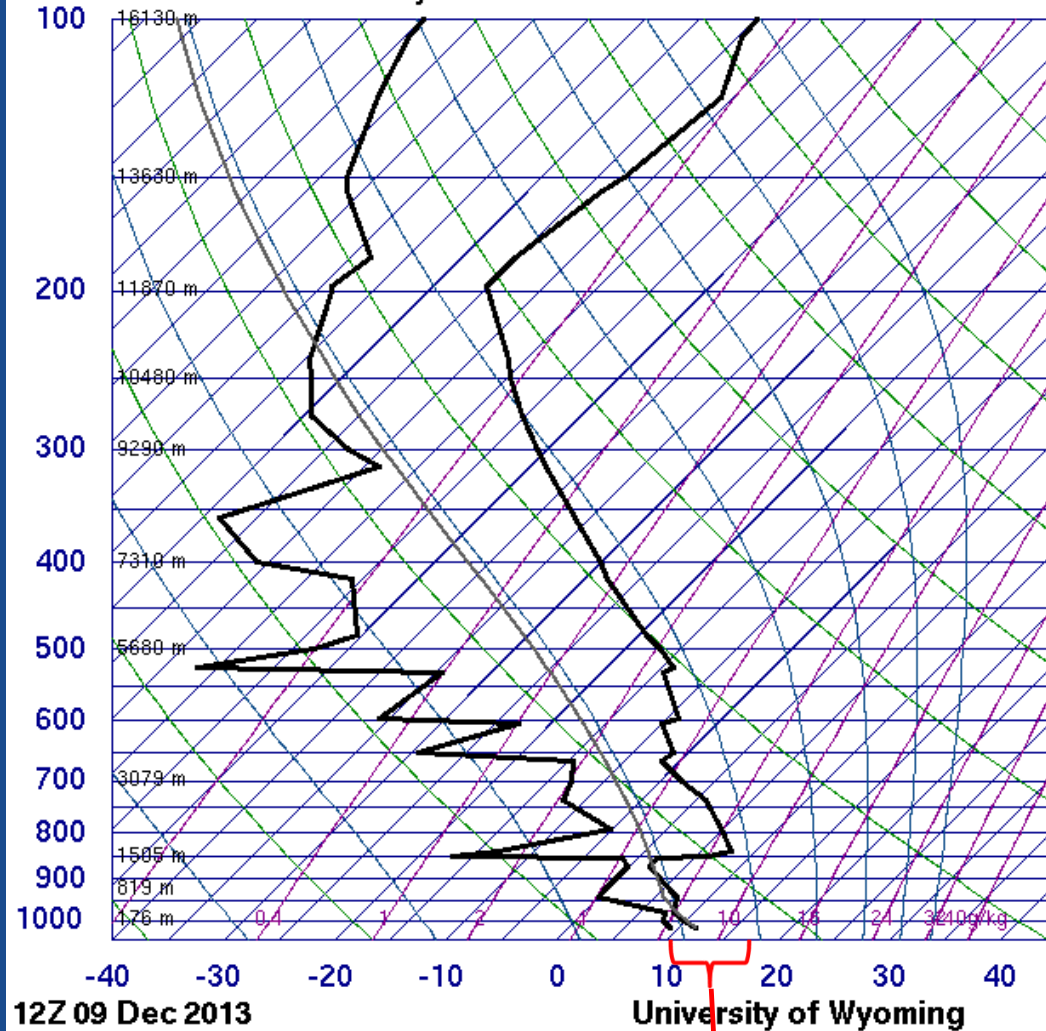


9/12/2013, ~18 UTC



9/12/2013, 12 UTC

03953 Valentia Observatory



SLAT	51.93
SLON	-10.25
SELV	30.00
SHOW	14.55
LIFT	11.32
LFTV	11.23
SWET	102.9
KINX	-3.70
CTOT	0.10
VTOT	23.10
TOTL	23.20
CAPE	0.84
CAPV	2.16
CINS	-15.2
CINV	-9.44
EQLV	865.2
EQTV	862.7
LFCT	885.8
LFCV	895.8
BRCH	0.22
BRCV	0.56
LCLT	279.7
LCLP	957.8
MLTH	283.1
MLMR	6.44
THCK	5504.
PWAT	13.89

At inversion height



U ~ 13 m/s

H ~ 1500m

$\Delta\theta \sim 7 \text{ K}$

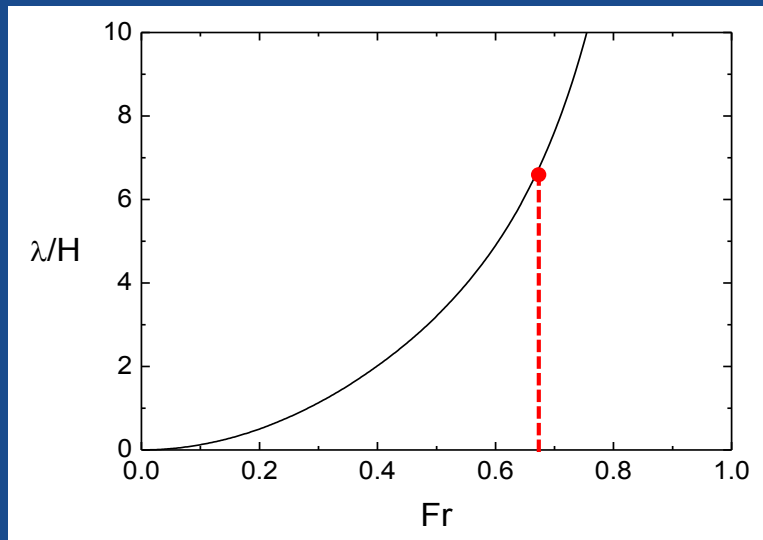
Evaluate Froude number

$$\theta \sim 290 \text{ K} \Rightarrow g' = g \Delta\theta / \theta \sim 0.24 \text{ m/s}^2$$

$$H \sim 1.5 \text{ km}$$

$$U \sim 13 \text{ m/s}$$

$$\Rightarrow \text{Fr} = U / (g' H)^{1/2} \sim 0.68$$



$$\lambda_R / H \sim 6.5 \Rightarrow \lambda_R \sim 10 \text{ km}$$

Correct?



At least right order of magnitude!

Summary

- It is easy to estimate the wavelength of trapped lee waves
- Simplest case is when these waves propagate at temperature inversion
- Then wavelength over inversion height only function of Fr

Estimates may fail for many reasons:

- Non-stationary flow
- Inversion not sharp enough
- Effects of stratification above or below inversion
- Variation of wind speed with height