On the benefit of downscaling a mesocale model over the coastal area of Denmark

RISØ

Introduction

Coastal Thermodynamic

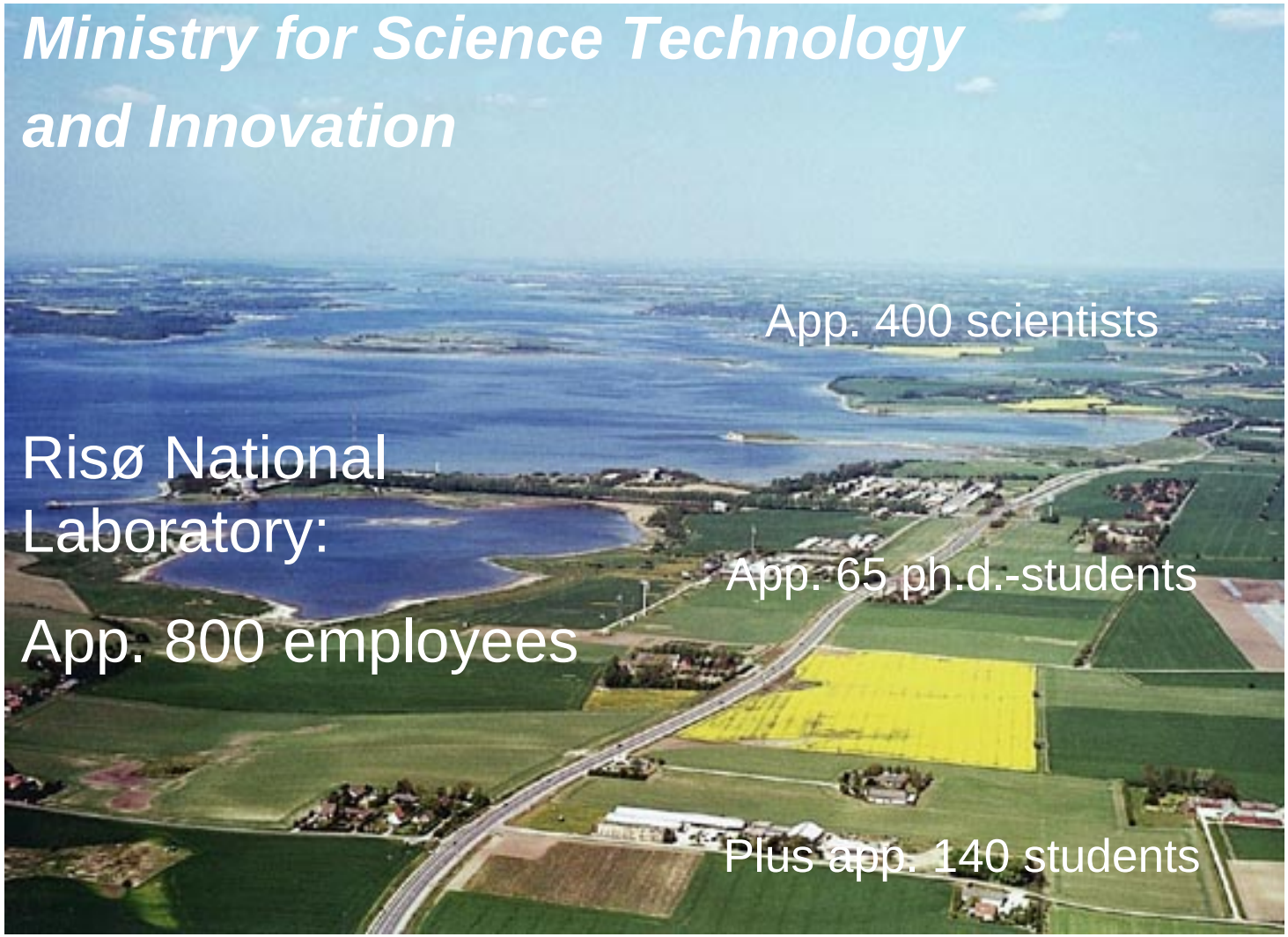
- Statement of the importance for high resolution Modelling in pollutant transport
  - Oxygen depletion in Kattegat
  - Mesoscale high resolution case study of the sea breeze circulation

Coastal mechanical forcing

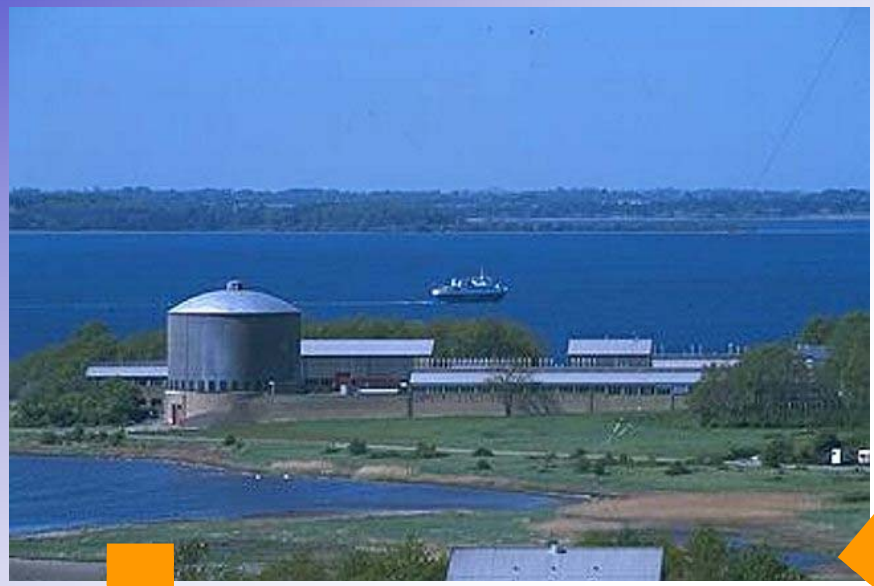
- Important meteorology
  - Low level jets (inertial oscillations)
  - Coastal coriolis speed up
  - Coastal curvature and associated vertical movements
  - Internal gravity waves

- ***Observational examples and method for Ph.D study***
- Spectral analysis to capture coherent structures and waves in the stable coastal boundary layer

Risø National Laboratory



Wind Energy Department



- **1956** Risø is established.
- **1976** new objective: atomic energy and other energy sources
- **1986** new name: Risø National Laboratory. New objective: energy
- **1990** new objective: technology research and development with energy as the main focus area
- **1994** Risø becomes a government undertaking
- **2000** The DR3 research reactor is closed down
- **2001** New strategy:
  Energy – Industrial Technology – Bioproduction – Radiation Protection

Objectives & working program for Ph.d.

RISØ

OBEJTIVES:

- Gain insight in the meteorology special for the coastal zone with focus on small space and time scales

Motivation

- **Wind-energy resources and siteing**

Environmental issues

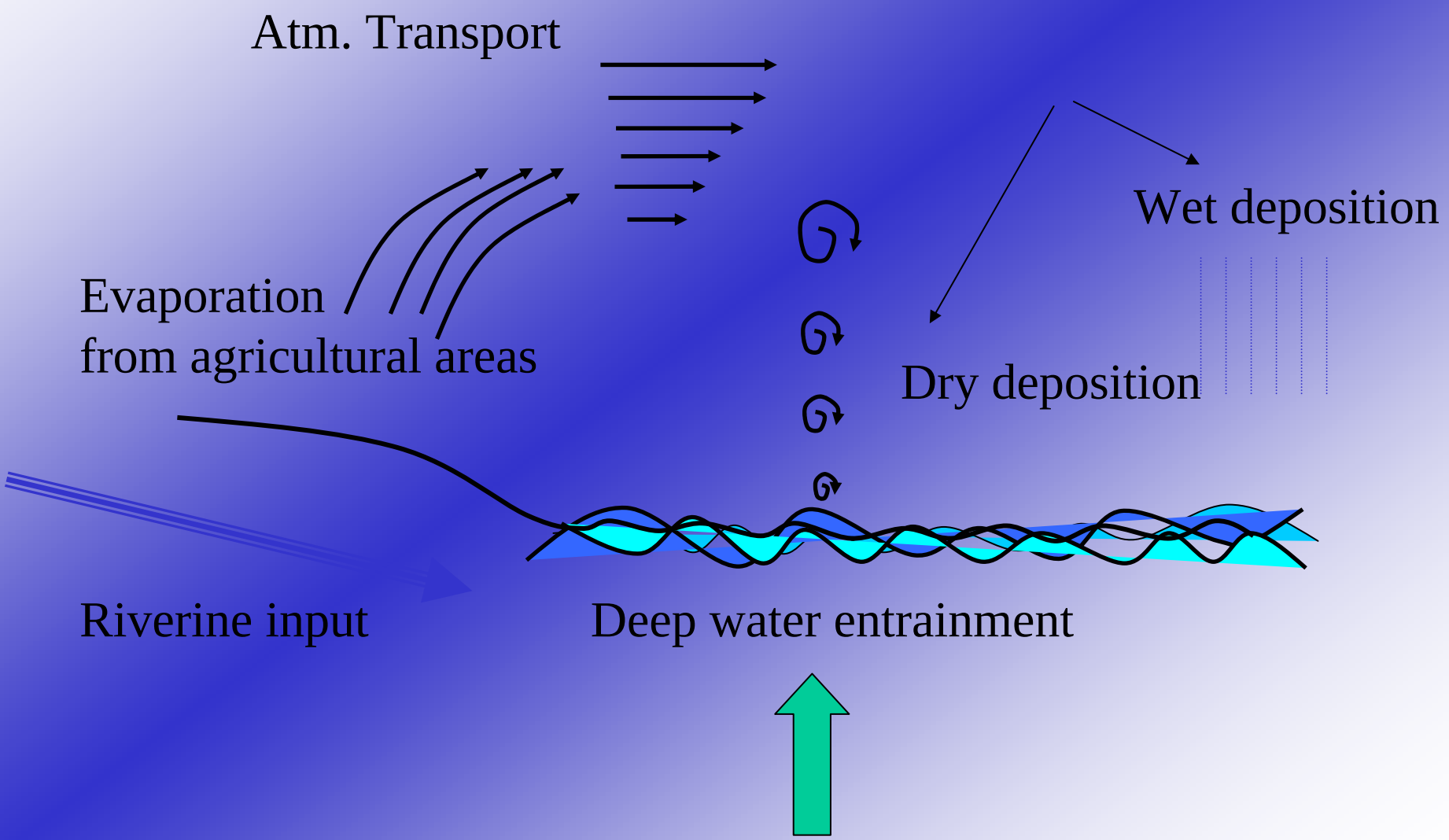
- Nutrient transport from land to sea
- Oxygen depletion in Kattegat

Method

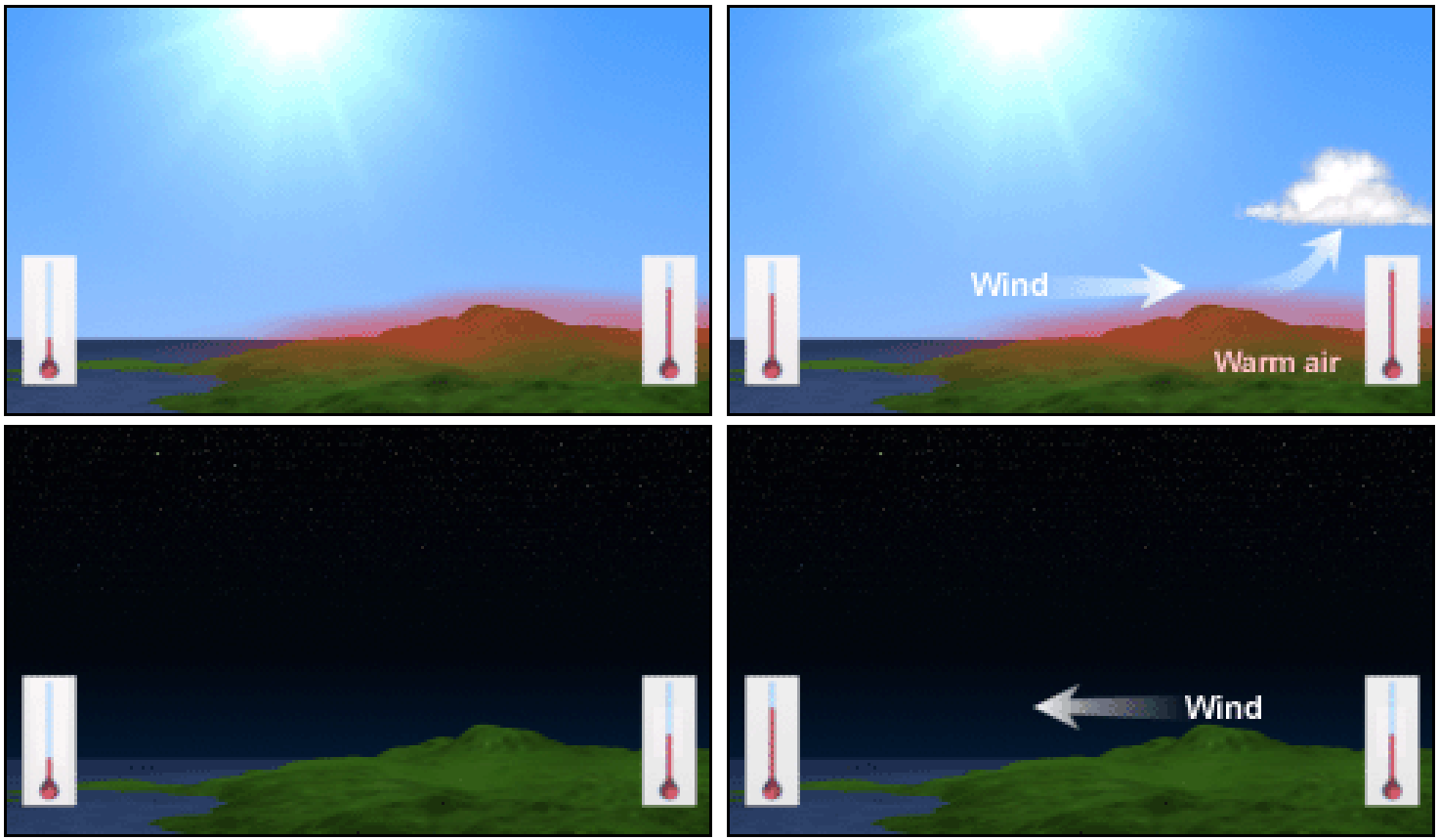
Observational analysis of important scales in the coastal zone combined with

Numeric simulation in an appropriate resolution to capture the identified structures

Algae blooms and oxygen depletion in Kattegat



Thermally forced c irculations over the coastal region



COAMPS simulation example

Dynamics, Numerics COAMPS:

Nonhydrostatic, Compressible Equations

(Klemp and Wilhelmson 1978)

Scheme C grid (Arakawa and Lamb, 1974)

Sigma-z Vertical Coordinate (Gal-Chen and Somerville,1975)

Multiple Nested Grid Option

Centered leap-frog time integration

Distributed/shared memory architecture (NRL/LLNL,2000)

Physics:

Level 2.5 TKE Closure (Mellor and Yamada 198…)

Surface Layer (Louis 1979)

Convective Parameterization (Kain and Fritsch 1990)

Radiation (Harshvardhan et al. 1987)

3D Aerosol and Tracer Module (Liu 2002)

Computer

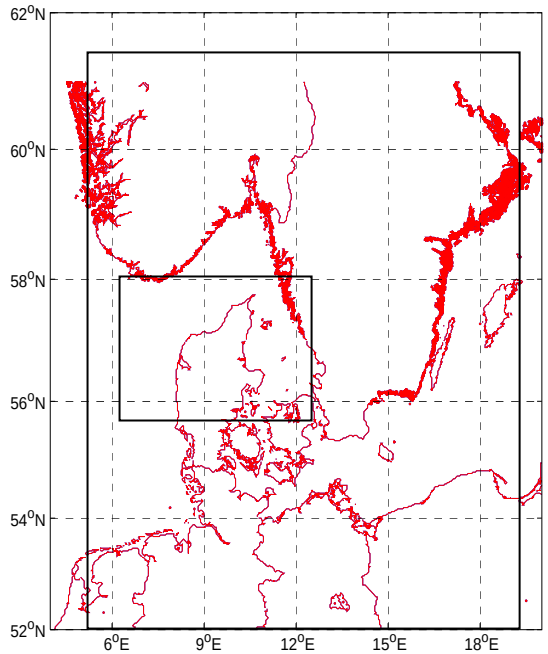
COAMPS is a parallel code running on Linux cluster at Risoe

Setup:

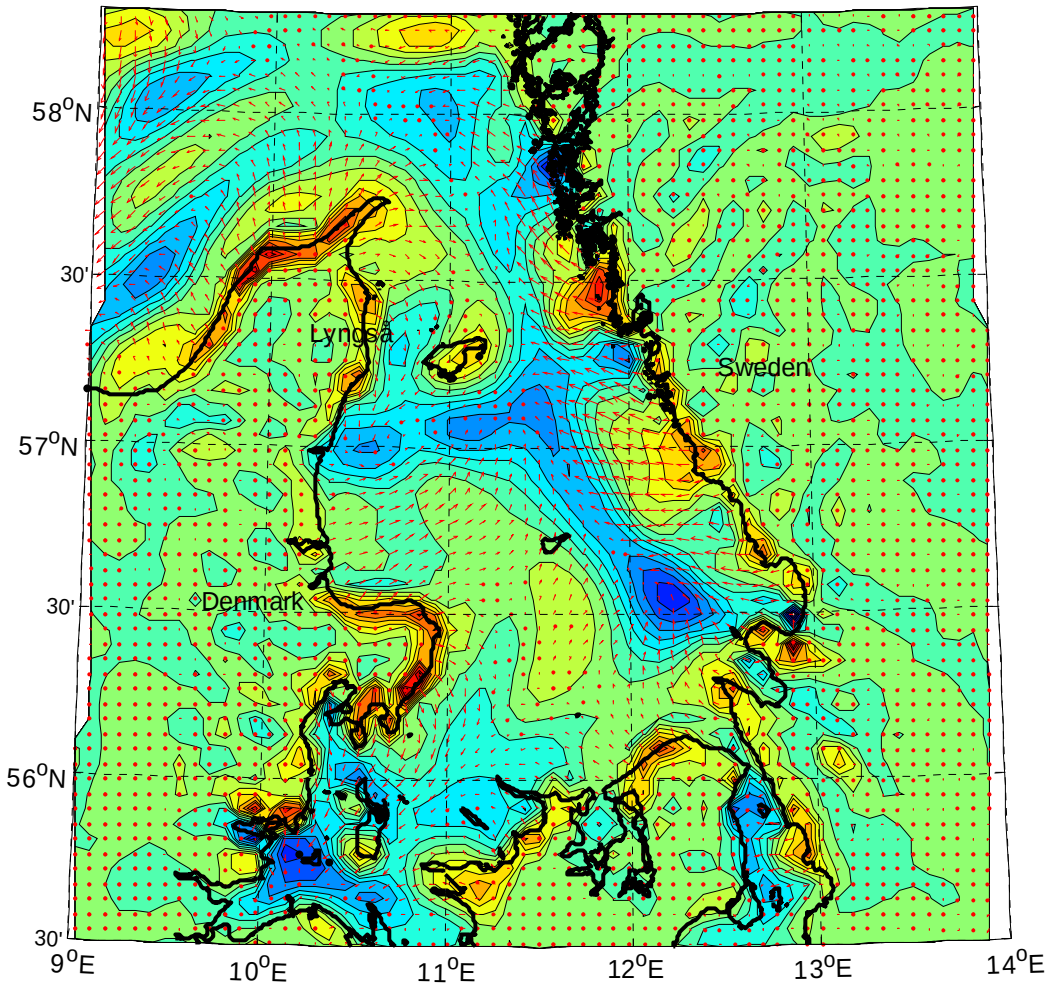
5 and 15 km horizontal resolution

40 vertical lSigma layers

Fixed outer boundary conditions



Coamps simulation of flow during land breeze

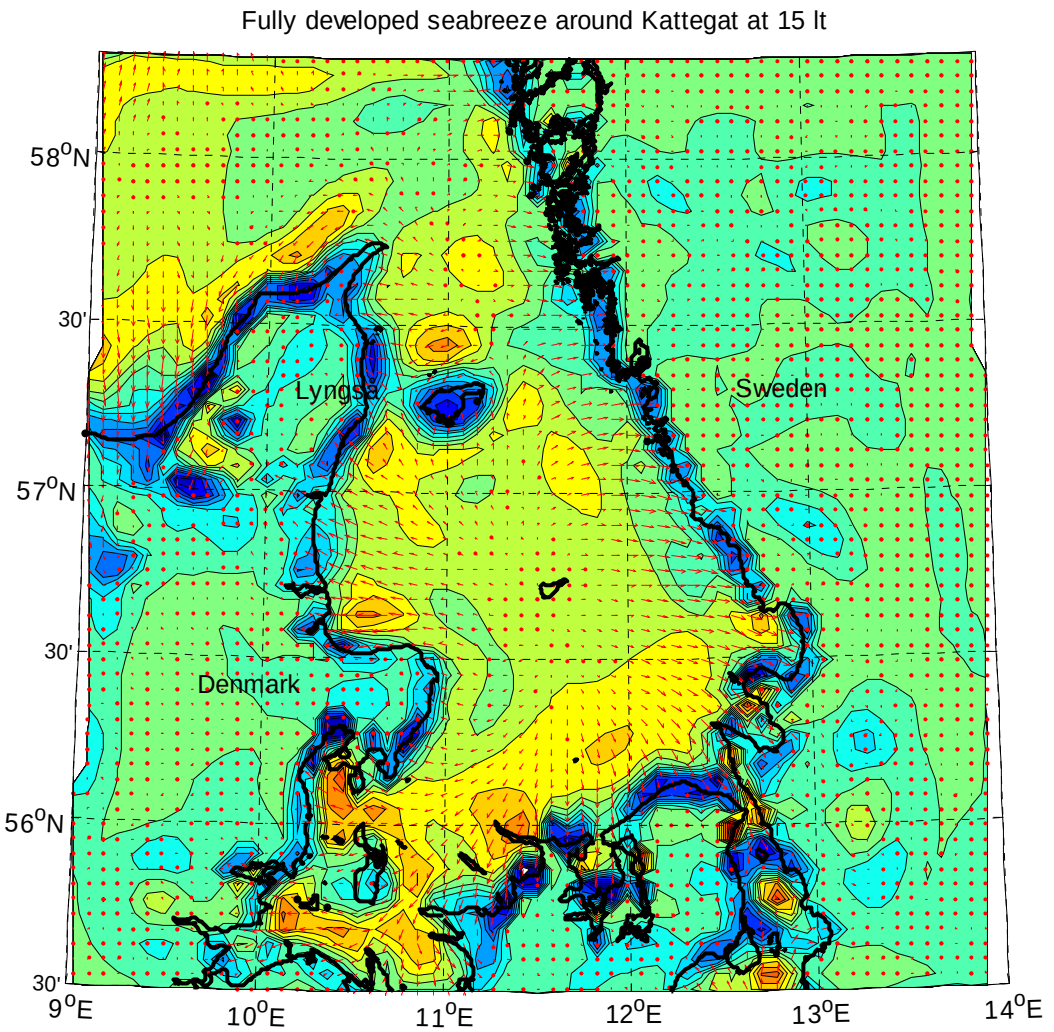


Contour lines for vertical velocity

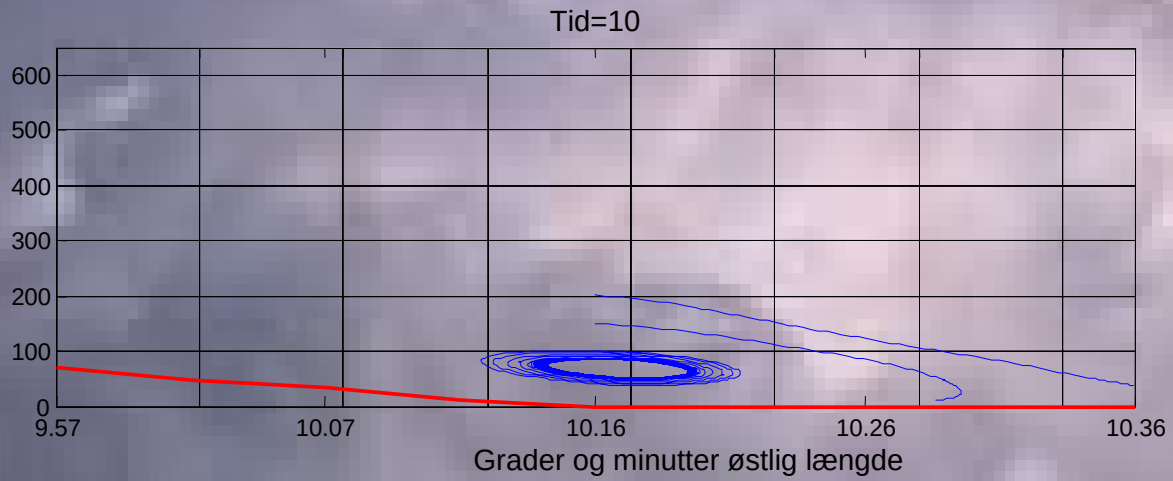
(omega)

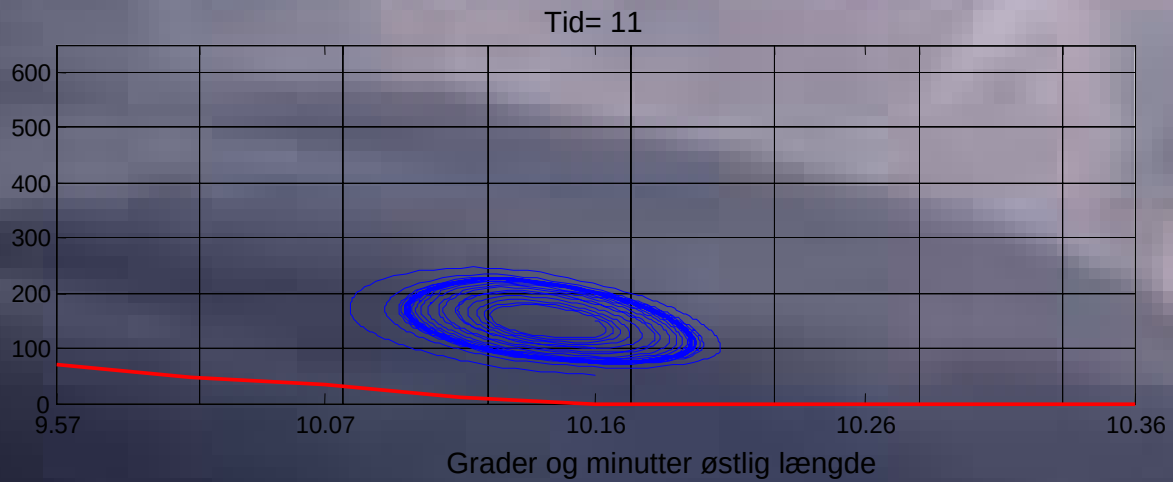
Red arrows indicates horizontal wind

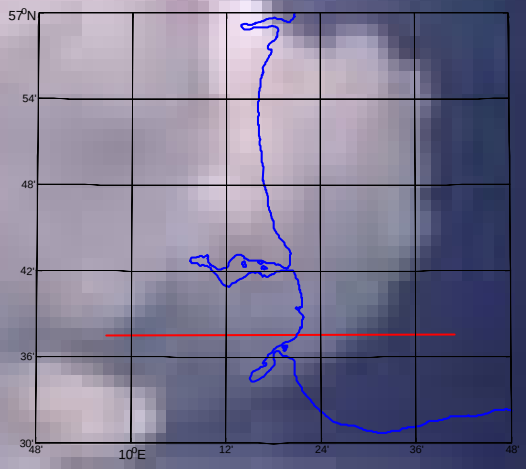
Coamps simulation of flow during sea breeze

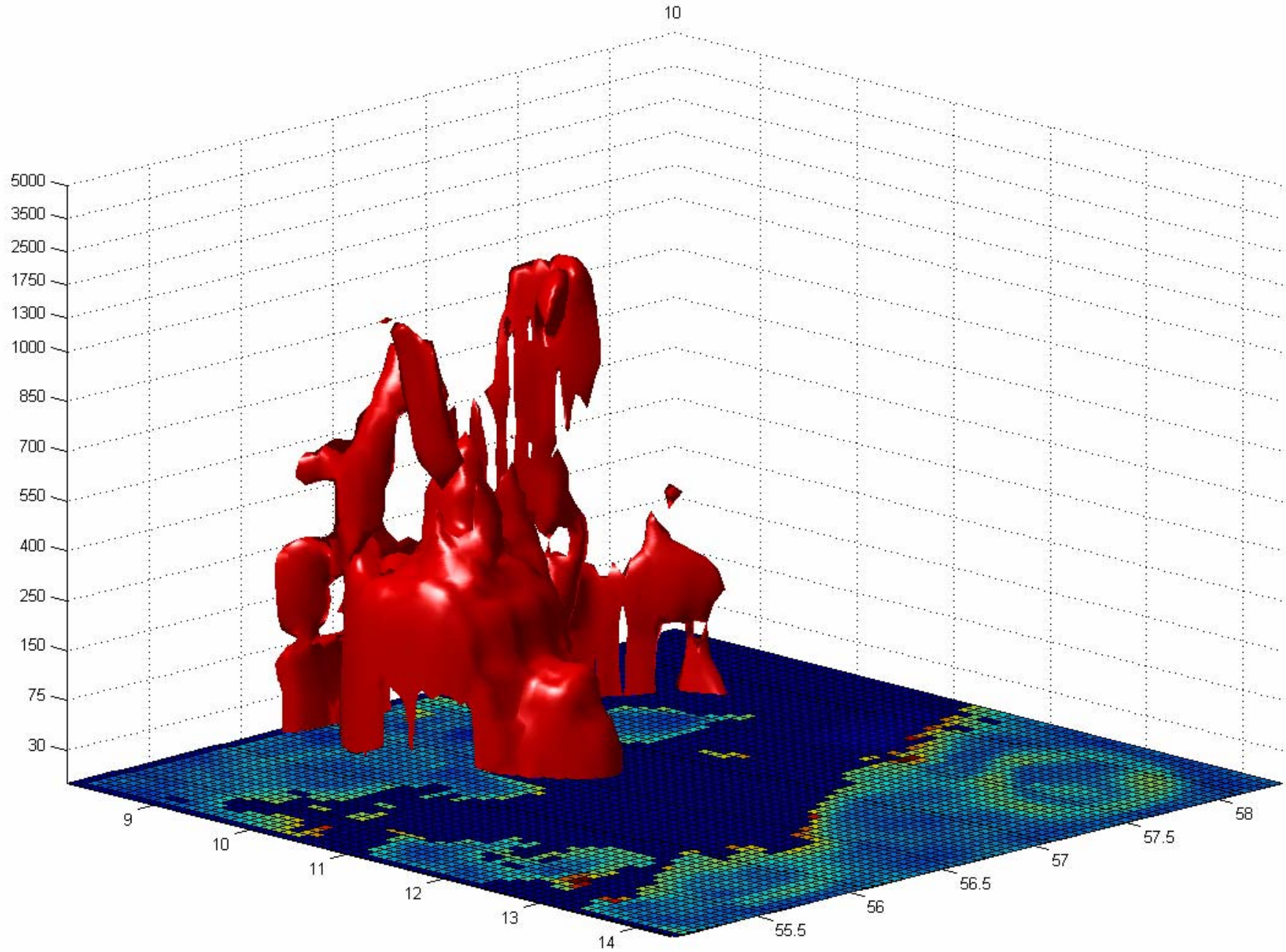


Cross section of sea breeze circulation





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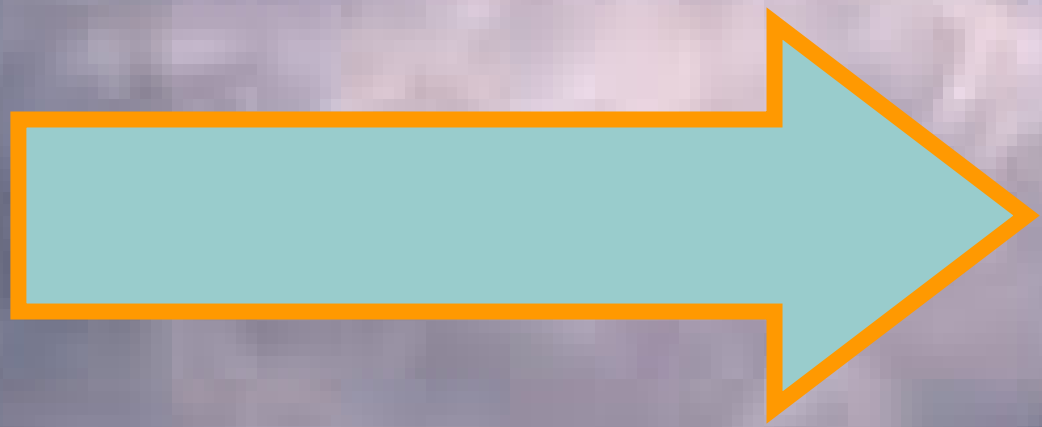
Coastal mecanical forcing



Low level jets

Impact:

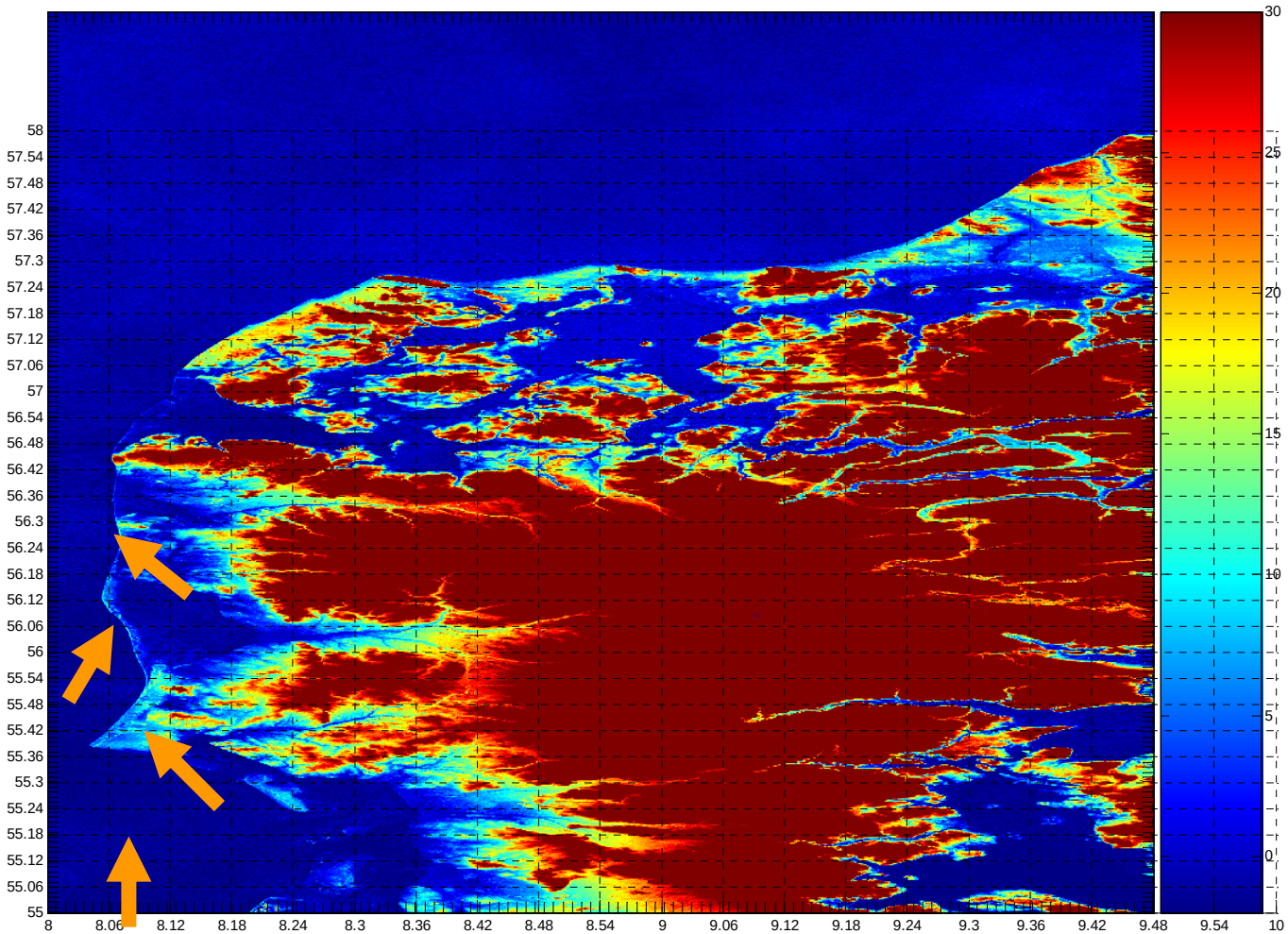
Large shear stress

on wind turbines

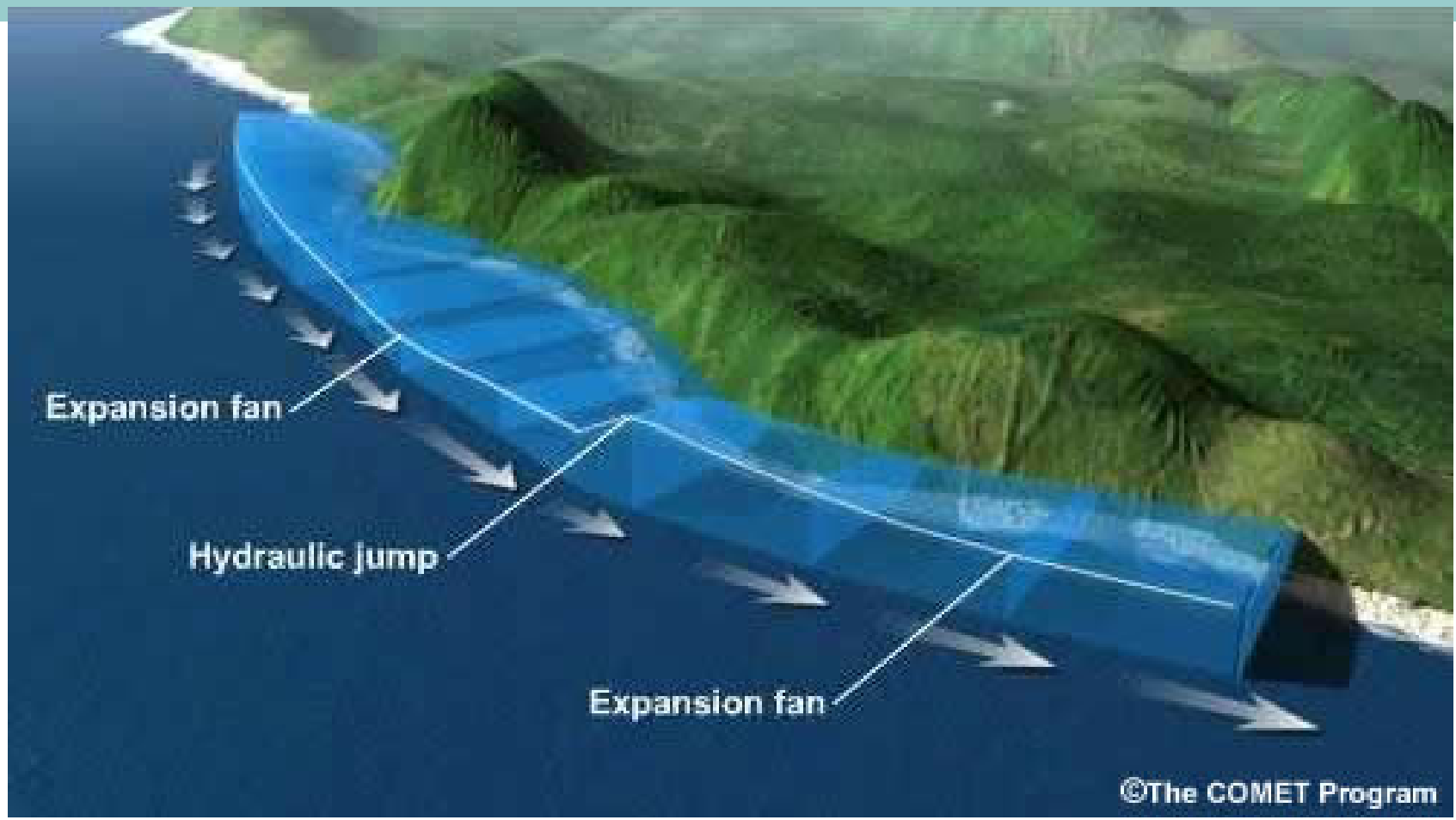
Large shear term ove
sea surface

Enhanced TKE and
deposition velocities

Coastal curvature



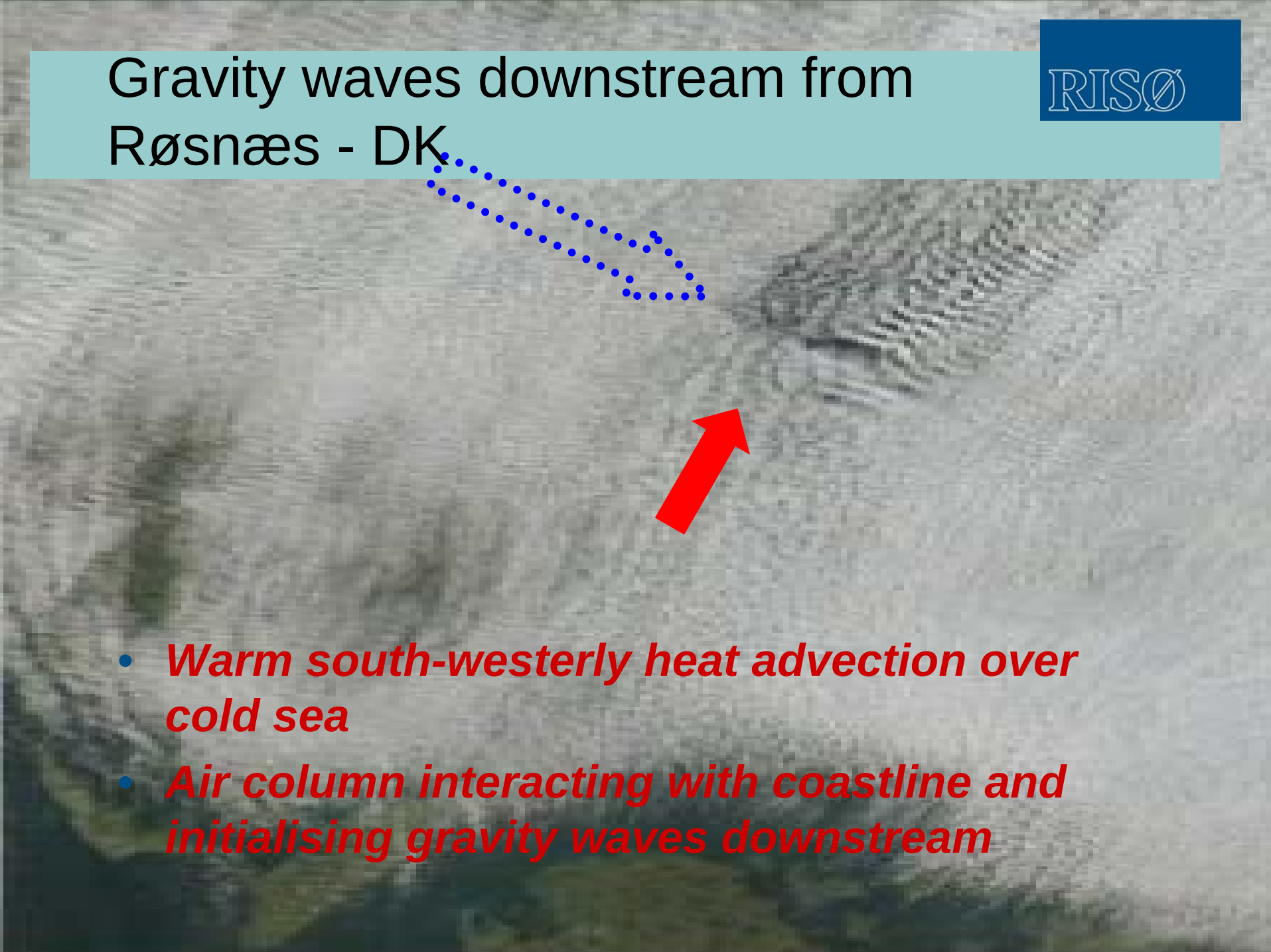
Gravity waves in the stable MBL and its influence to the coastal flow – U.S west coast



What is the resolution needed to simulate this pattern ???

Do we have similar dynamics in Denmark and can it explain some of the variability seen -- How is the transport influenced

Gravity waves downstream from Røsnæs - DK



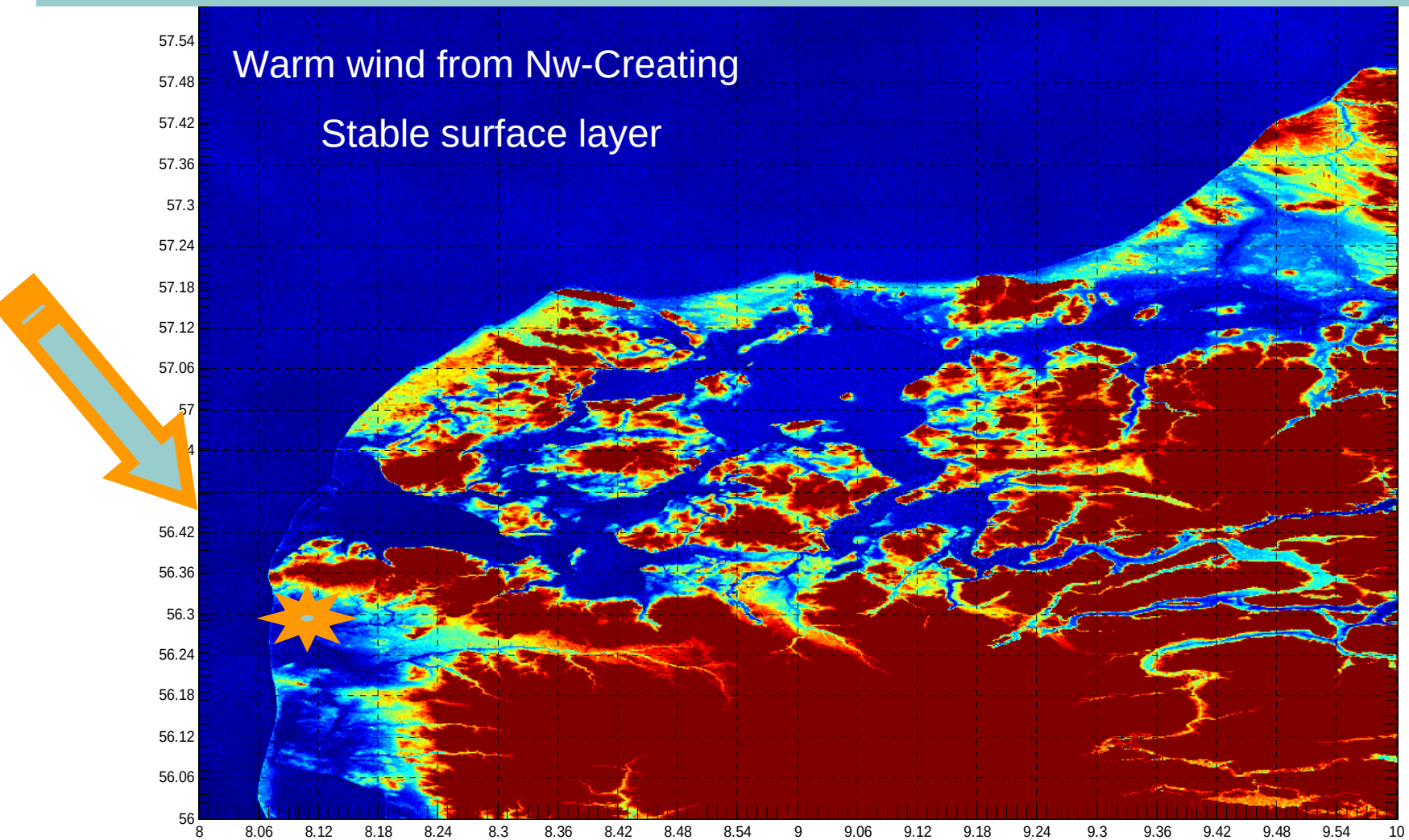
- ***Warm south-westerly heat advection over cold sea***
- ***Air column interacting with coastline and initialising gravity waves downstream***

Observational example on internal gravity waves

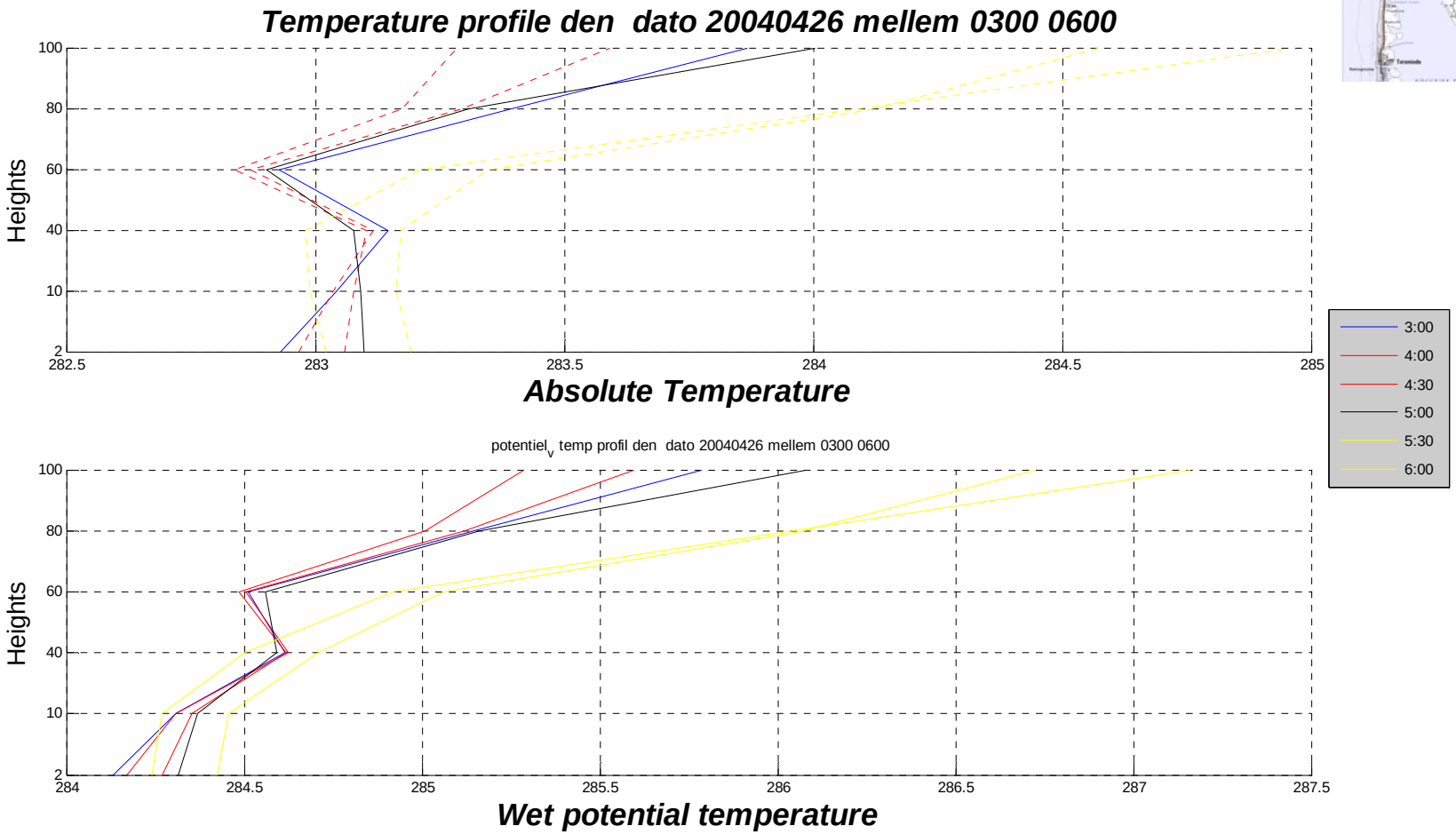
- Motivation
  - Transport
    - Internal gravity waves supplies and redistributes TKE
    - Heterogeneous deposition
    - Large horizontal wind speeds
- Meteorology
  - Capping inversions
  - Frode numbers close to critical

Observations

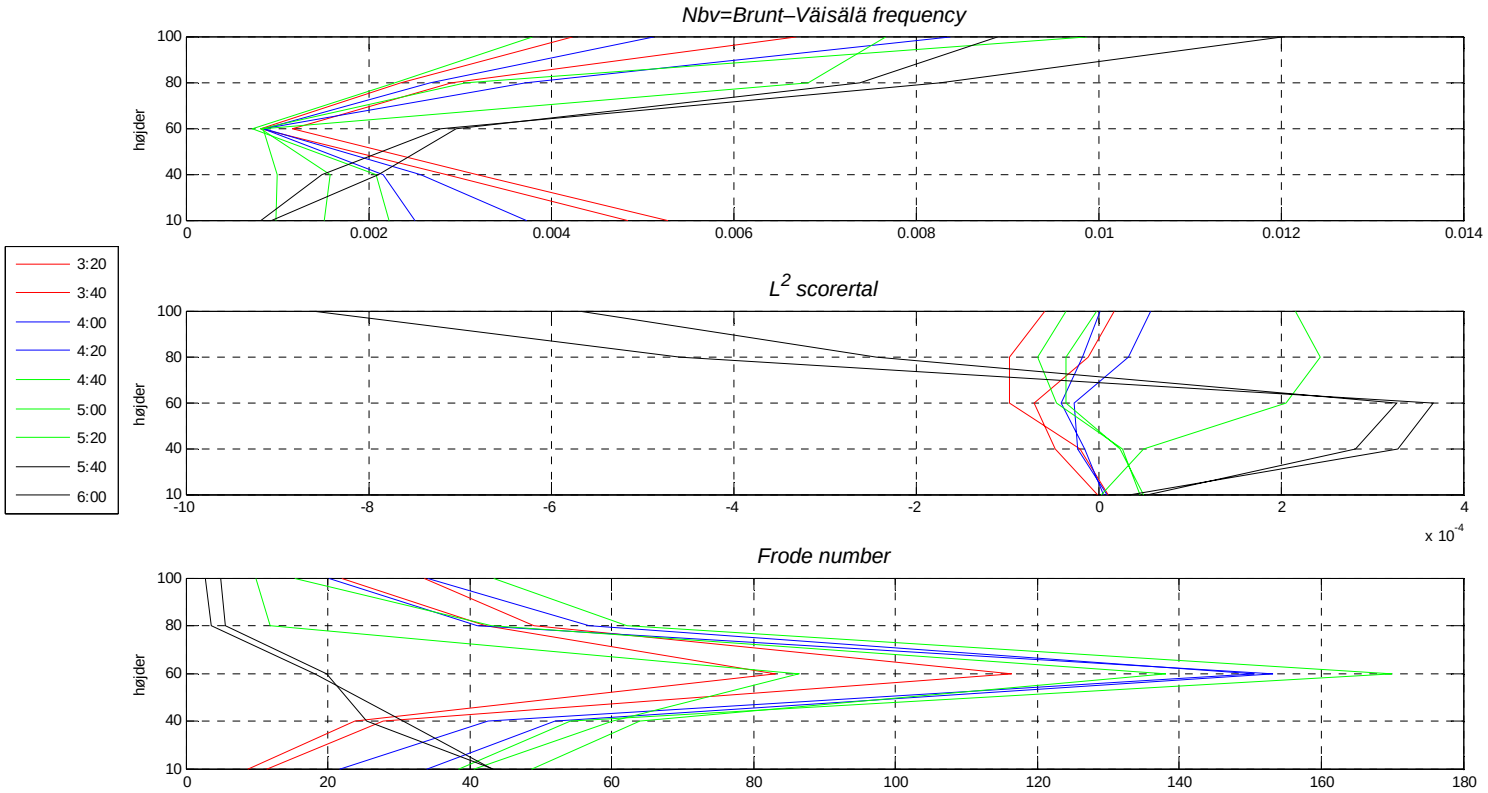
Early Spectral analisys on Høvsøre data



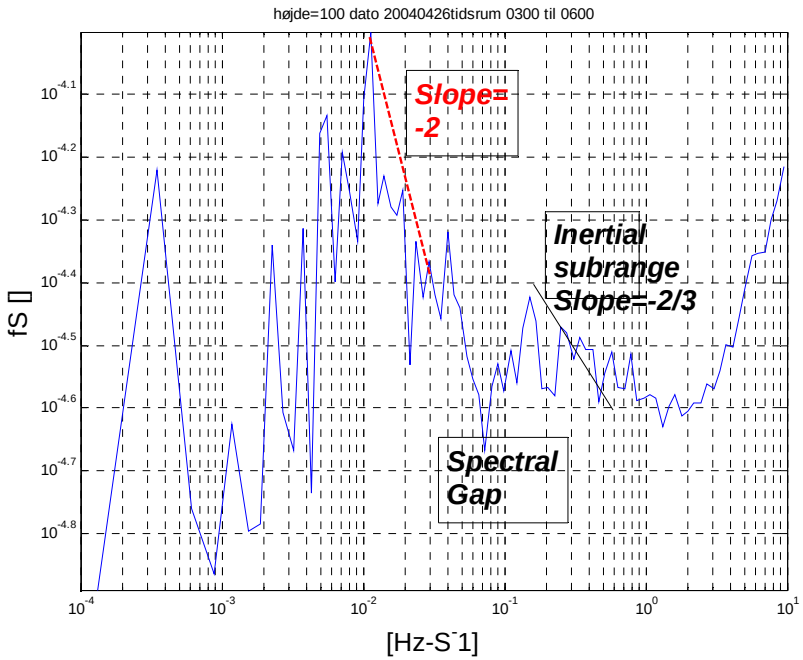
Stratification of surface layer



Flow numbers 26/04



Powerspectre of W (20 hertz data)



Summery

- ***FFT*** is used to estimate time scales
  In the flow field
- ***Taylor frozen turbulence*** provides estimation of spatial scales
- ***Numeric modelling*** hopefully provides further insight and answers the following posed questions
  - Where: (what coastal topografhy-landuse) causes
  - significant forcing to the flow And
  - When: Under which meteorological conditions is
    high resolution(100-500m) needed and beneficial And
  - If: further downscaling provides additional information

- Thanks for the attention

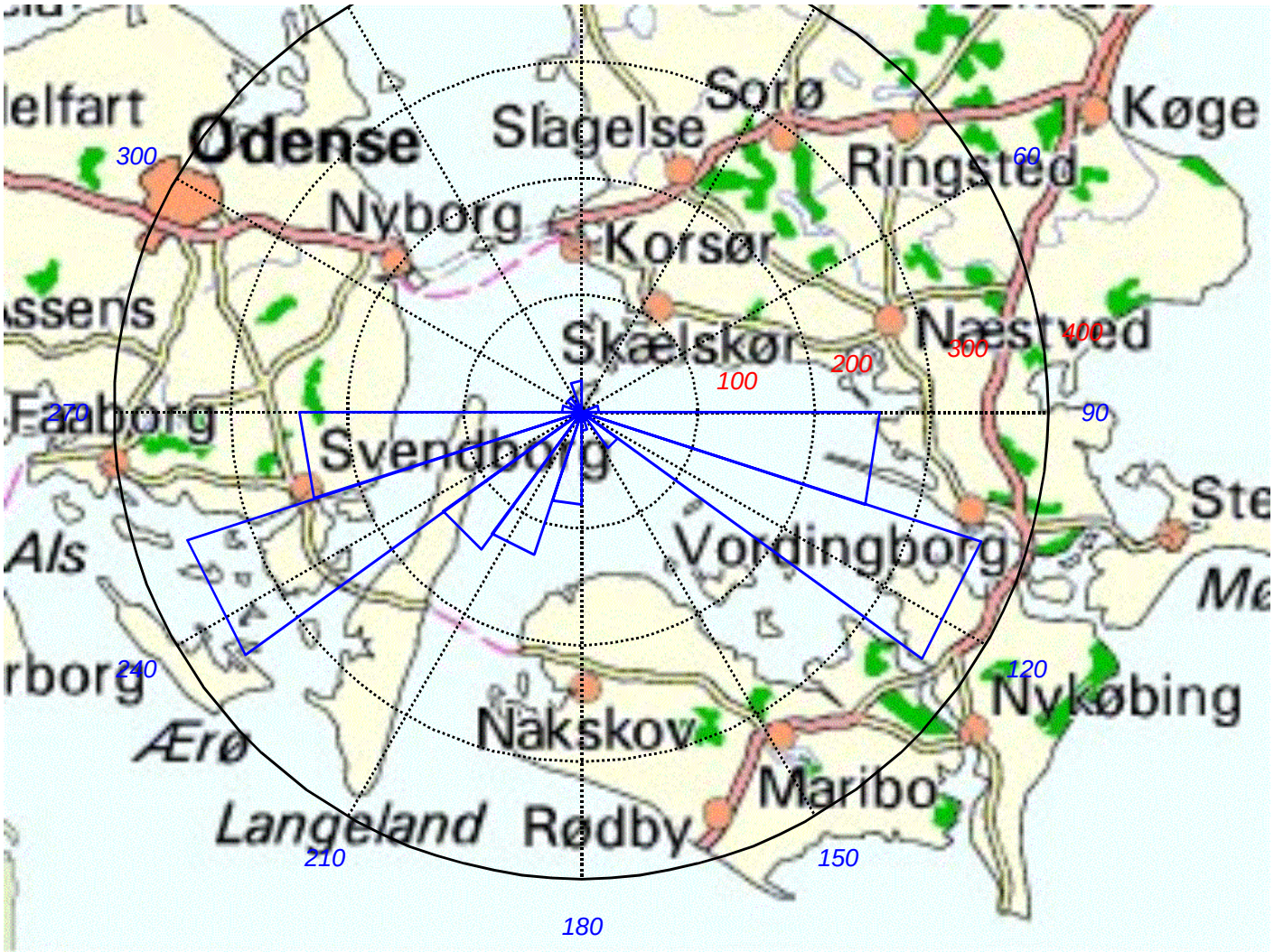
My way to Risø

- Weather forecasting at DMI Copenhagen

- Master at University of Copenhagen

- Ph.D student at Risø- August 2004

Coastal interaction with the stable MBL



Wind Directions

With with large windshear:

Between

4 and 8 m/s

per 40 m

What happens When the highly shear aircolum Interact with the Coastline ???