Atmosphere response to a submesoscale SST front

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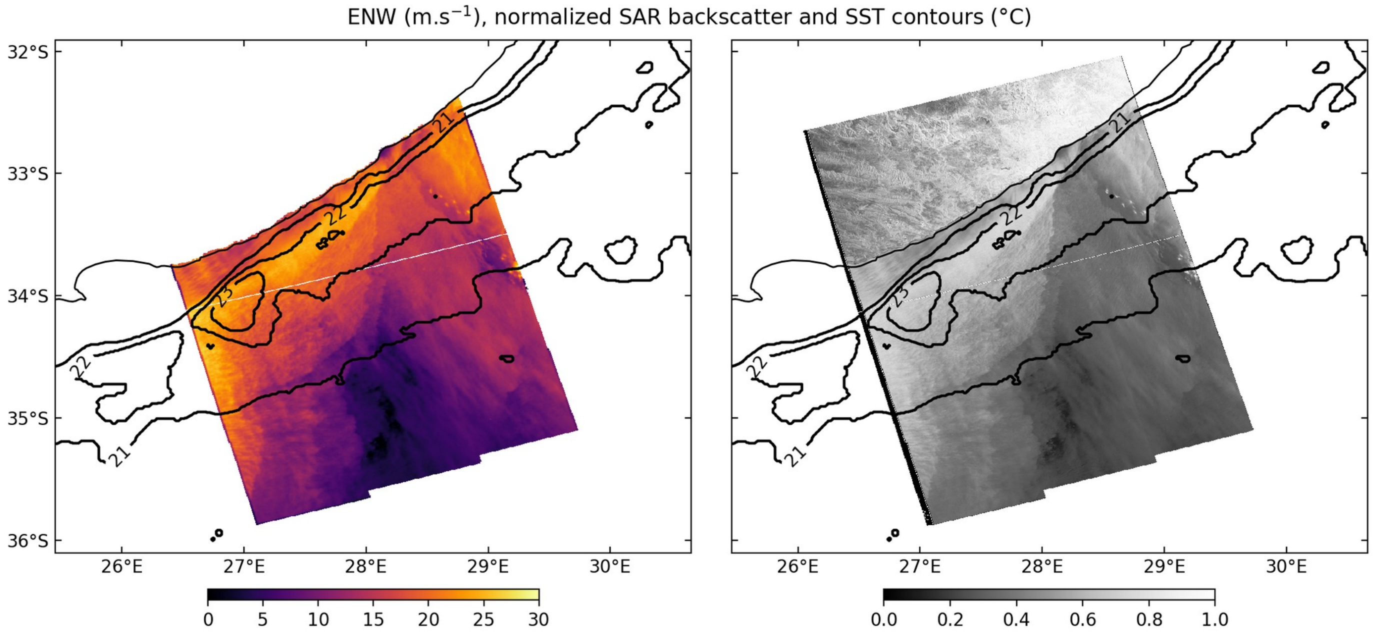
GDR Défis théoriques pour les sciences du climat, Interfaces dans le système climatique

Agulhas current

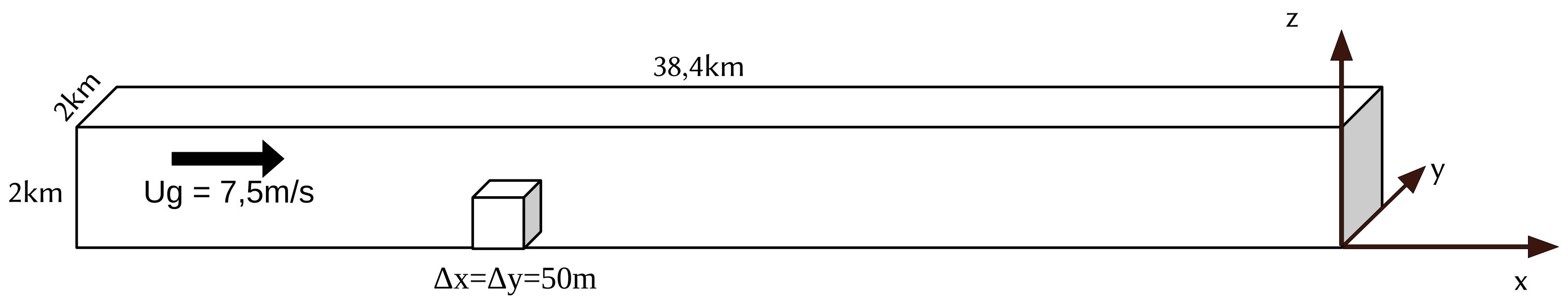
- SST fronts are multi scale
- Stronger winds on warm SST
- Roughness change with SST change



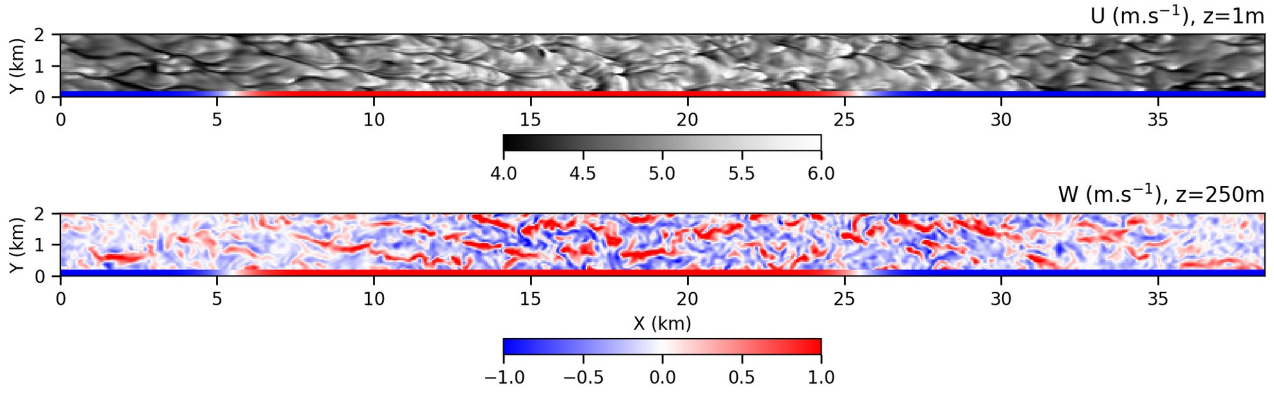
SST = Sea Surface Temperature

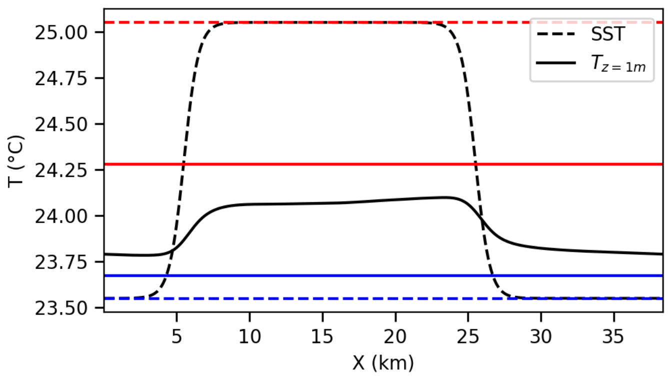
12/12/2015, SAR Sentinel-1 (ESA), SST Odyssea Regional L4 (Ifremer)

Idealized setup



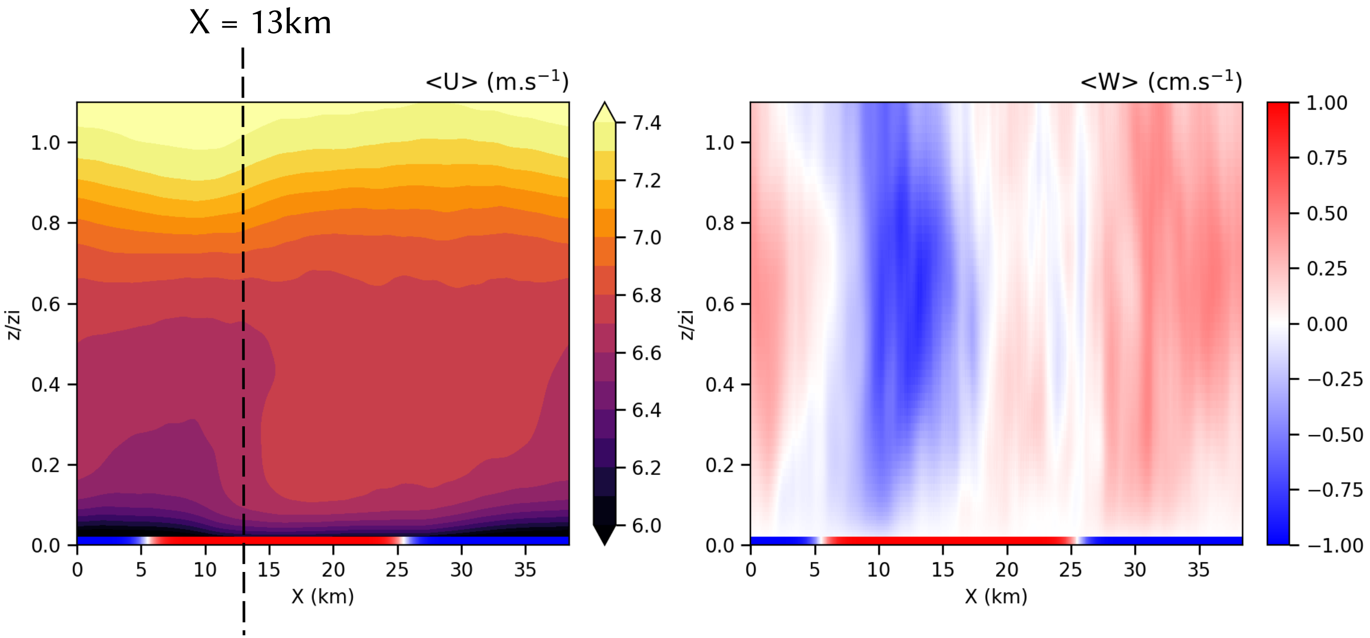
MesoNH 5.6.1
LES, 3D closure



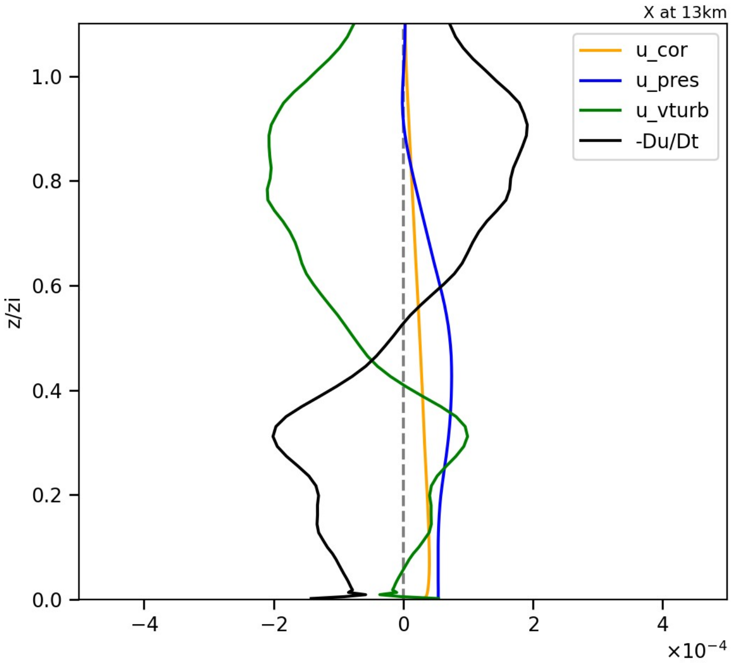


Mean wind

$< . >$ = time and Y average



- Warm SST increases winds in the lower layers of the ABL
- What is the origin of the subsidence ?



<U> budget (m.s-2)

$$\frac{D<U>}{Dt} = -f<V> - \frac{1}{\rho_0}\frac{\partial <P>}{\partial x} - \frac{\partial <uw>}{\partial z} + \dots$$

- Lagrangian derivative
- Coriolis
- Pressure gradient
- Turbulent stress

Mean <uw> profile

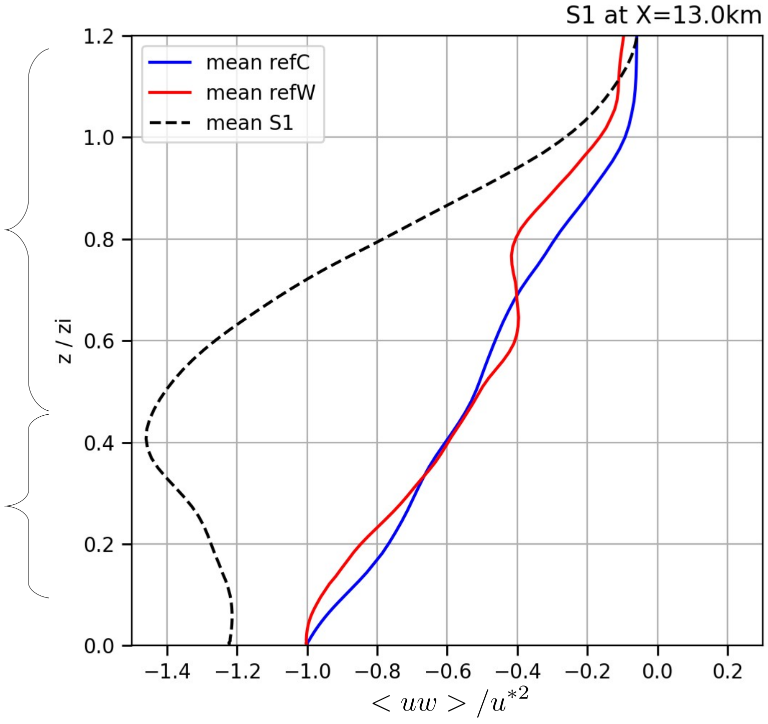
Above surface layer :

- Linear profiles for reference simulations
- S1 $\neq$ references after the SST jump

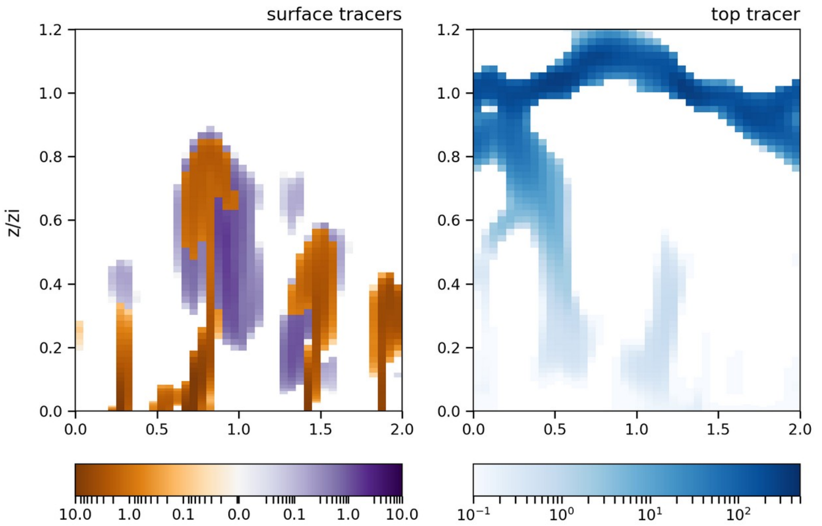
$\longrightarrow$ How to explain the shape of the flux profile ?

DU/Dt < 0

DU/Dt > 0

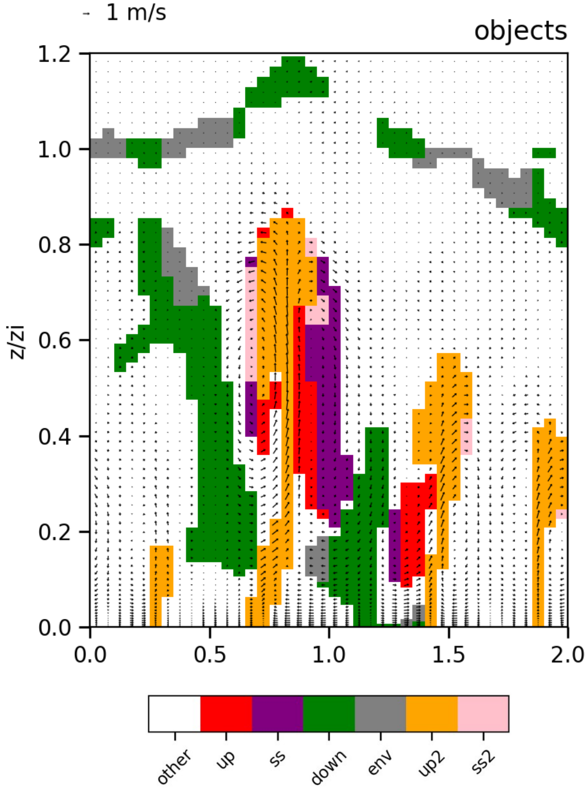


Passive tracer emission

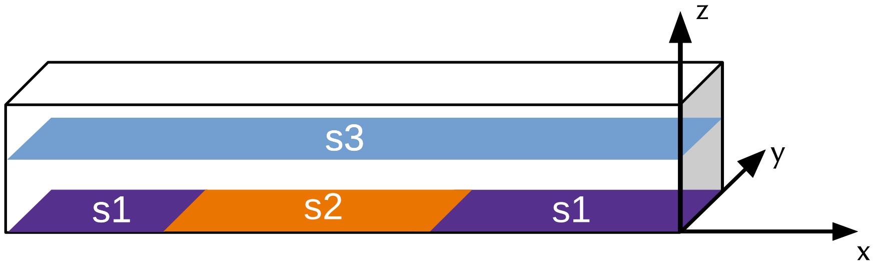


Conditional sampling

$\Rightarrow$



s_i concentration fluctuation of tracer i



Coherent structures = transport of tracer by turbulent motion

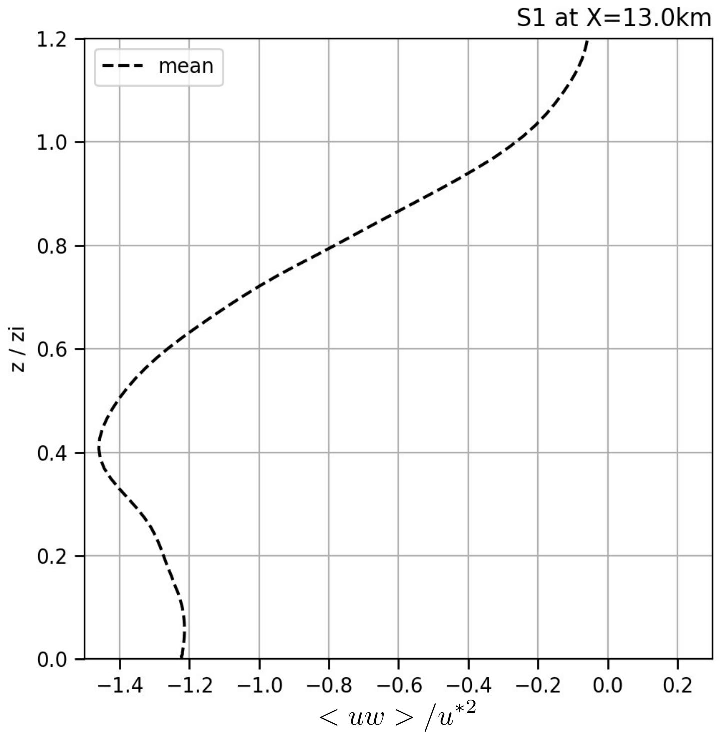
Conditional sampling

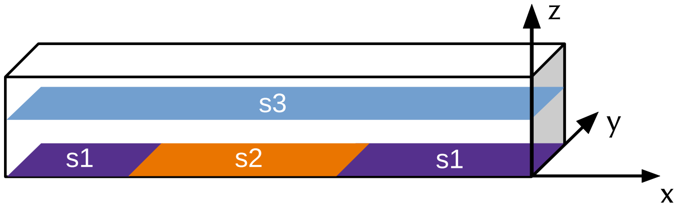
- Condition 1 $\{(x,y,z), s(x,y,z) > \sqrt{< s^2 >}(z)\ \}$

- Condition 2

	$s_1 > 0$	$s_2 > 0$	$s_3 > 0$
$w > 0$	updraft 1	updraft 2	-
$w < 0$	sub. shell 1	sub. shell 2	downdrafts

(*Couvreux et al. 2010*)





Note: coherent structures in resolved flow only

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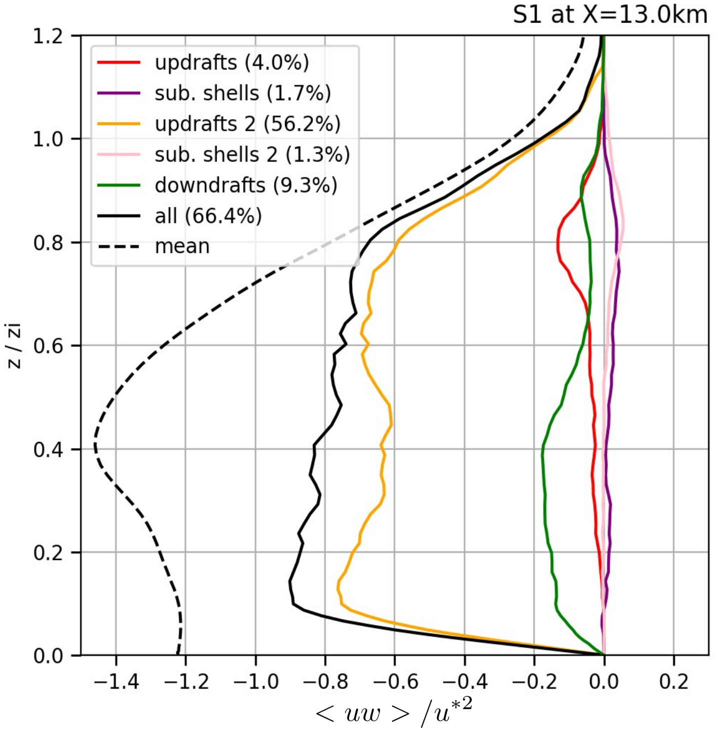
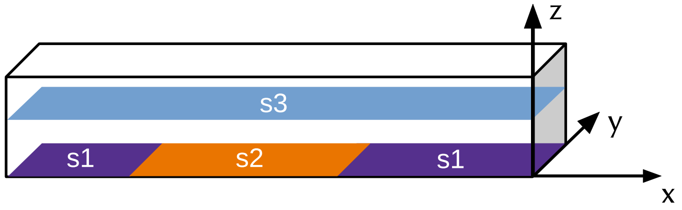




Note: coherent structures in resolved flow only

$$\rightarrow -\frac{\partial < uw >}{\partial z} > 0$$ not captured

Conditional sampling
+
Top-hat decomposition with
3 disjoint ensembles E_i : ‘updrafts’, ‘downdrafts’ and ‘other’

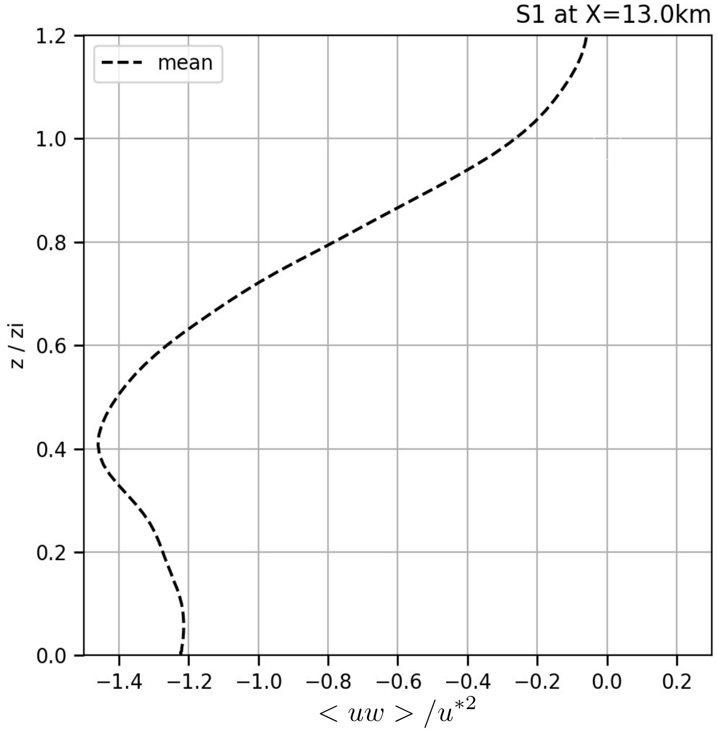
$$< uw >= \underbrace{\sum_{i=1}^{3} \alpha_i (U_i - < U >)(W_i - < W >)}_{\text{Top-hat contribution (mass-flux)}} + \underbrace{\sum_{i=1}^{3} \alpha_i < (U - U_i)(W - W_i) >_i}_{\text{Intra-variability contribution (diffusion)}}$$

(Wang and Stevens 2000)

With: α_i cover of E_i

$A =< A > + a$

$A_i =< A >_i = \frac{1}{N_i} \sum_{(x,y) \in E_i} A(x,y,z)$



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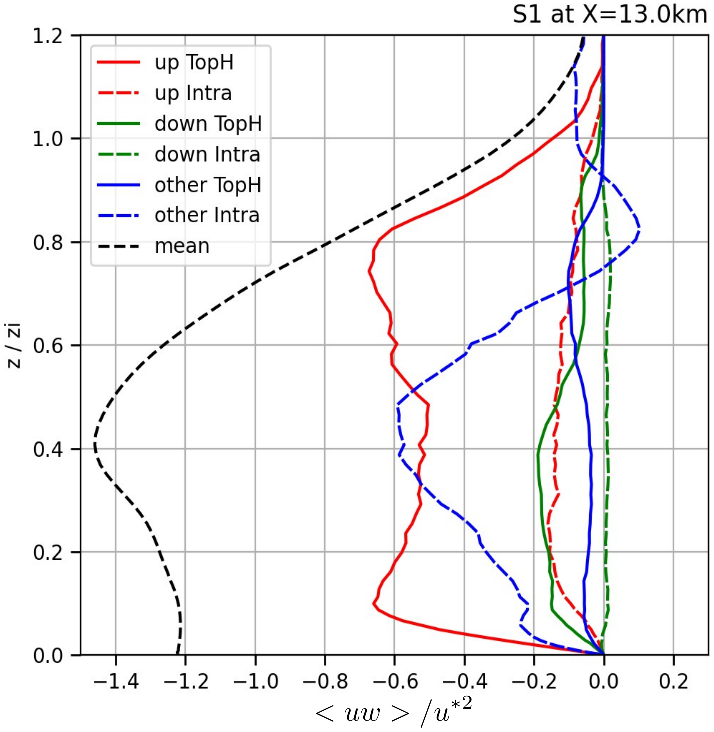


→ Lower layers wind increases by non-turbulent air contribution

The ABL response to submesoscale SST fronts has been studied with a LES channel simulation

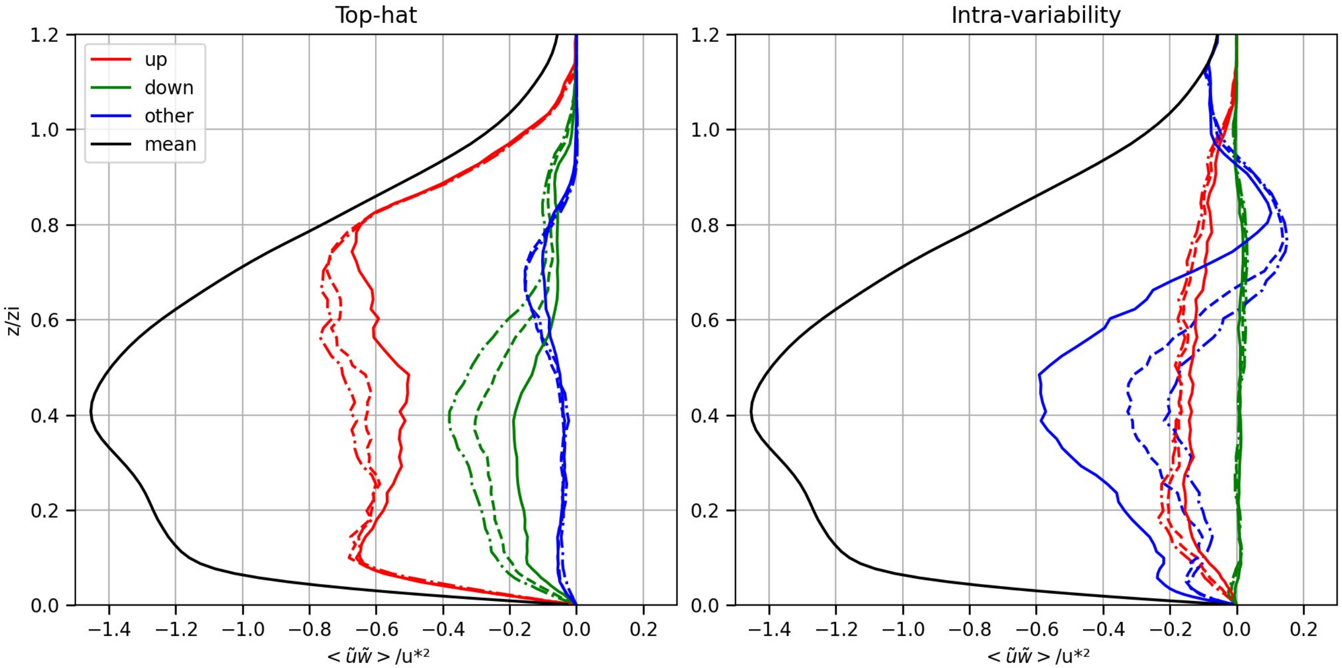
- For submesoscale SST front, advection and turbulence play key roles in the ABL response
- Mechanisms identified at the oceanic mesoscale are present here (Pressure Adjustment and Downward Momentum Mixing)
- A coherent structure analysis can be used to identify the contribution of each structures to the turbulent fluxes
  but
  It cannot detect the lower layers wind increase by a non-turbulent compensating subsidence

→ Paper to be submitted

Changing condition 1 of C10 conditional sampling :

$$\{(x, y, z),\ s(x, y, z) > m. < s^2 > (z)\}$$

C10 m sensitivity:

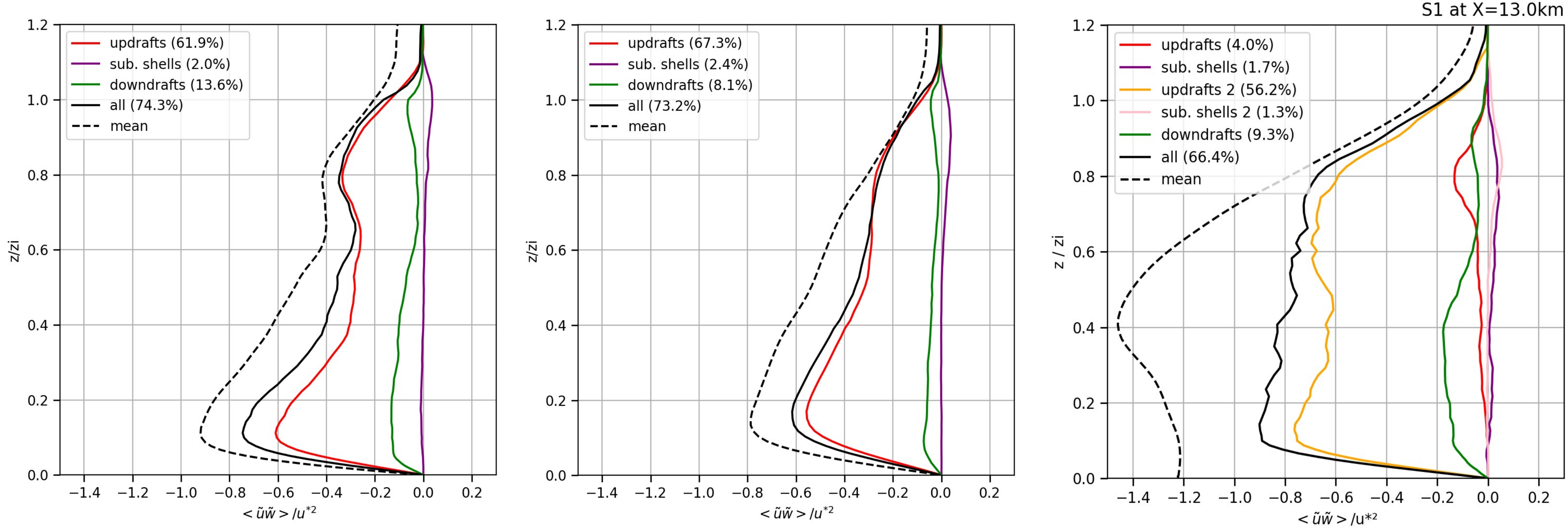


m sensitivity at X=13km : full ligne m=1, dashed m=1/2, dashed-dot m=1/4

→ Non turbulent, descending air is increasing U at the lower levels : compensating subsidence is more intense

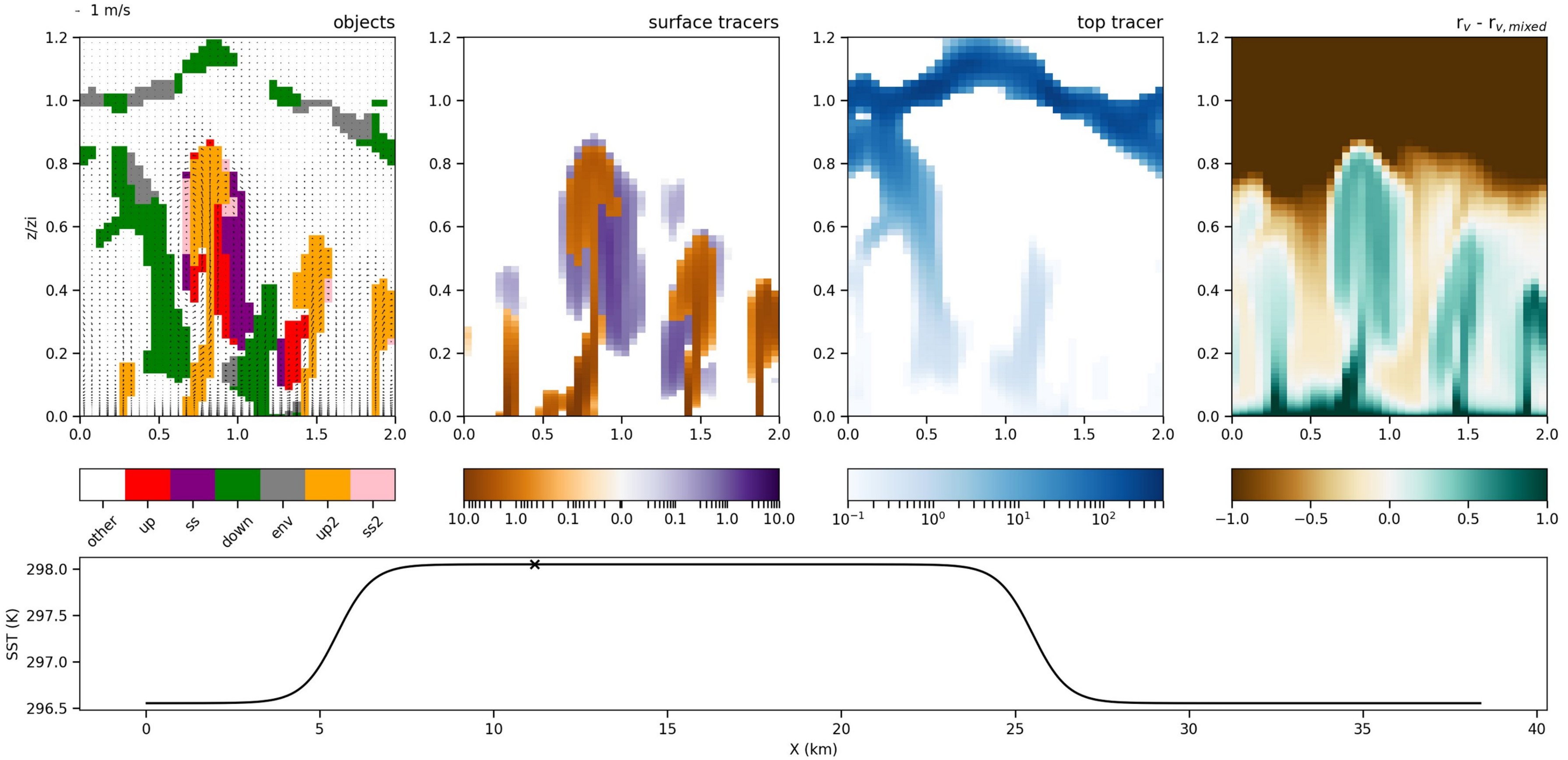
Reference simulations

refW refC



→ 74% of the flux is captured by the coherent structures when SST is homogeneous vs 66% for S1 at X=13km

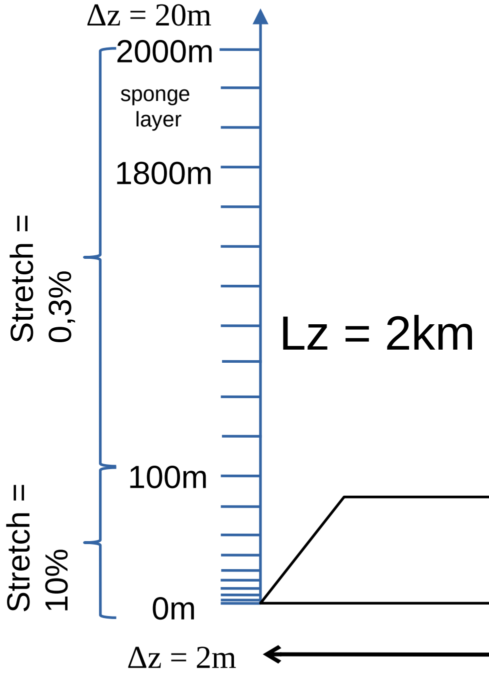
T = 2h30min30s
X = 11,1 km

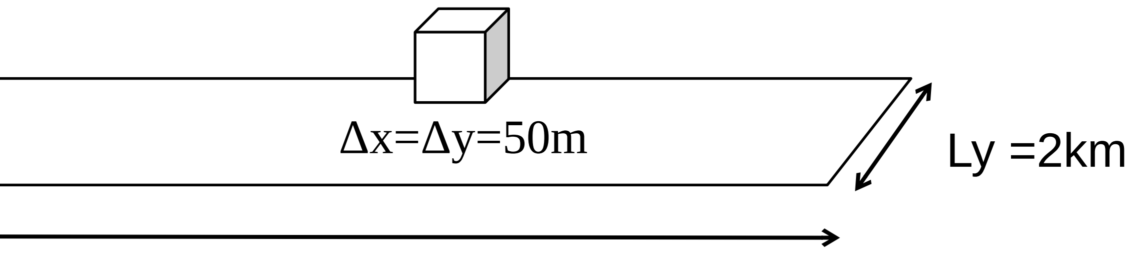


Annexes

Numerical setup:

- MesoNH 5.6.1 in LES configuration
- 1.5 order closure from Cuxart et al. (2000)
- Pseudo-incompressible from Durran (1989)
- Mixing length = DEAR = max(ΔxΔyΔz, $l = l_s = 0.76\bar{E}^{1/2}\left(\frac{g}{\theta_0}\frac{\partial\bar{\theta}_l}{\partial z}\right)^{-1/2}$)





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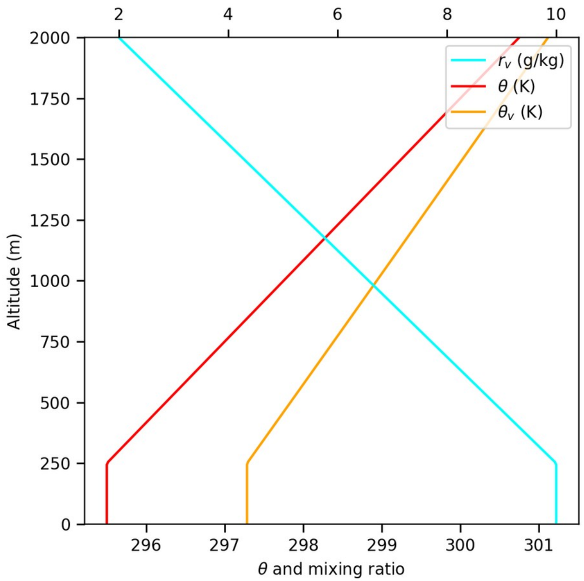
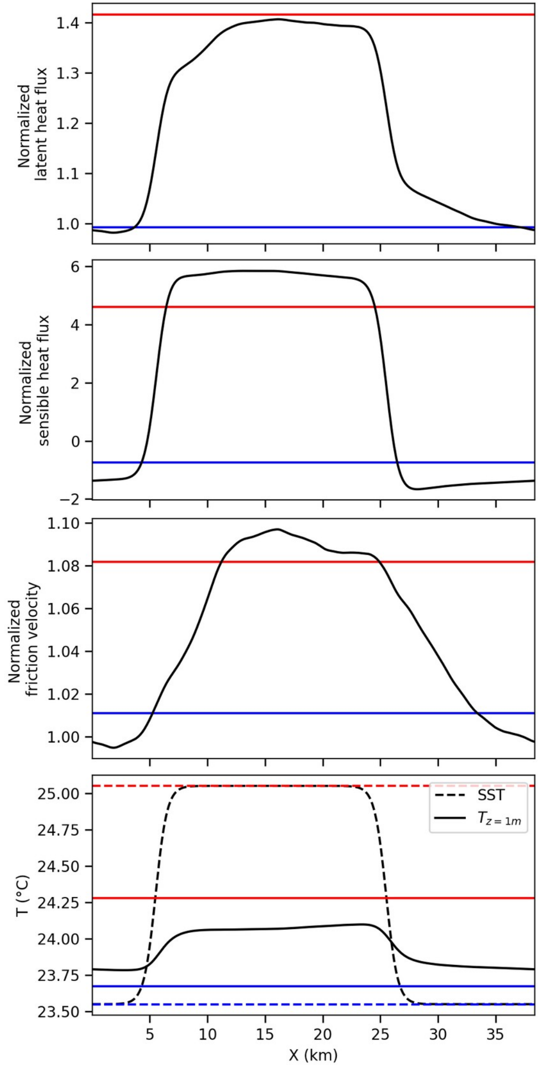
Initial conditions:



- U = Ug = (7.5, 0) m/s
- SST(x) from t=0s
- Clouds can form : ICE3
- Surface scheme : COARE3
- No radiation

Surface values:



Annexes

Realistic simulation: Agulha's current