

1. INTRODUCTION

- Sea breezes are studied in an area of **complex topography** in the Northern Spain.
- Previous studies have evidenced the influence of sea breezes in **pollution episodes** in industrialised areas [1] (e.g., Bilbao).
- With predominant southerly winds in summer months temperatures can reach up to **40 °C** quite close to the shoreline before the establishment of the sea breeze [2]. Should synoptic wind be strong enough, the latter does not happen.

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OBJECTIVES:

- Observational study:** obtain a sea-breeze database in summer months and main characteristics of the phenomena in this area.
- Predictability** of the sea breeze: Sea-Breeze Index [3] (SBI).
- Numerical study:** simulations from the WRF model and representation of turbulent parameters.

2. SEA-BREEZE DATABASE

- Period:** 01/07/2013 – 31/08/2013.
- Study-area:** eastern Cantabrian coast (Basque coast).
- Data:** wind and temperature data from surface meteorological stations and buoys; synoptic data from radiosondes (Fig. 1).
- Selection method:** an automated objective method for selecting sea-breeze days [4] (Fig. 2).

3. MODEL SETUP

MODEL	WRF-ARW version 3.5.1
INITIAL AND BOUNDARY CONDITIONS	NCEP FNL Global Analysis Data (every 6 h with a resolution of 1° x 1°)
HORIZONTAL RESOLUTION	4 nested domains (27 km; 9 km; 3 km; 1 km)
VERTICAL RESOLUTION	35 eta levels (default) until 50 hPa; 7 levels between surface and h = 1000 m.
TIME STEP	180 s
SPIN UP	24 h
TESTS	PBL scheme (YSU and MYJ) and including/no including grid analysis nudging

❖ SST update is considered.

❖ PBL scheme election is bound to the **Surface Layer Scheme** (YSU^[5] - MM5 and MYJ^[6] - Eta).

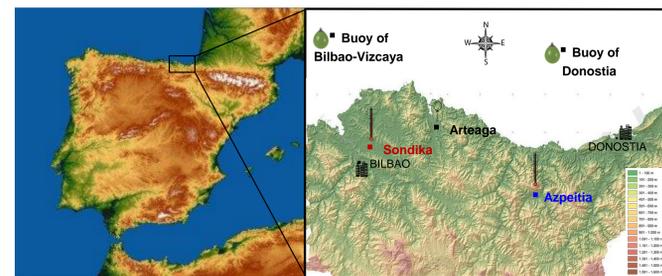


Figure 1. Study area. Surface meteorological stations are located in Azpeitia (surrounded by complex topography) and Sondika (in a valley opened to sea) and the radiosonde station is located in Arteaga. Buoys are also marked on the map. At the right side topography of the map is shown.

Figure 2. Automated selection method.

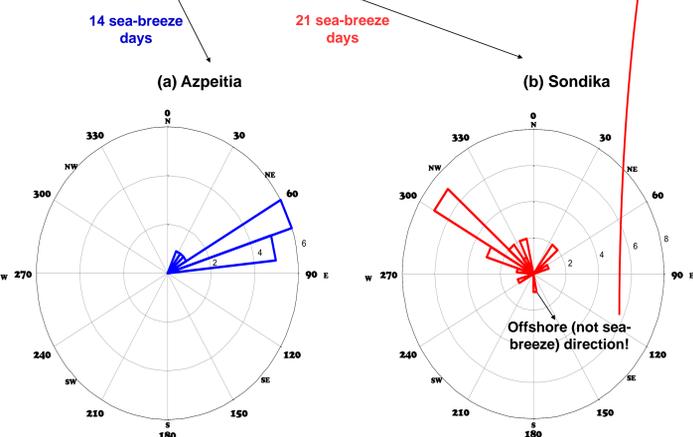
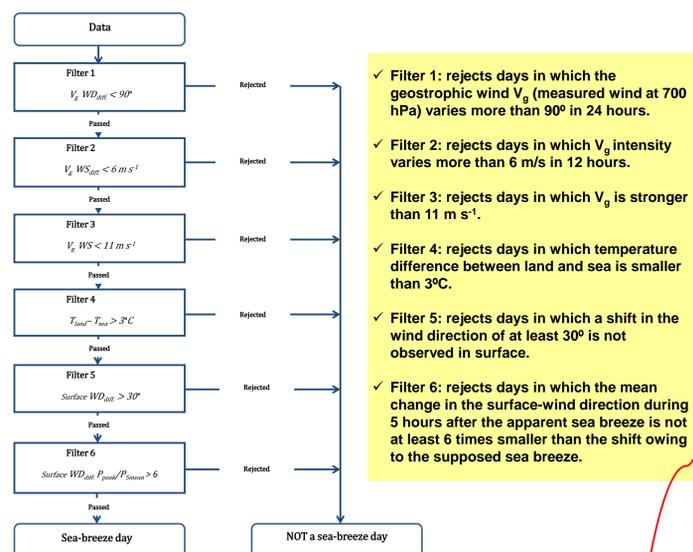


Figure 3. Wind rose. Sea-breeze direction in both locations for the selected sea-breeze days. Sea-breeze direction is computed as the mean direction measured in the 5 hours after the shift due to the onset of the sea breeze.

4. CASE STUDY

31ST OF JULY CASE STUDY IN SONDIKA:

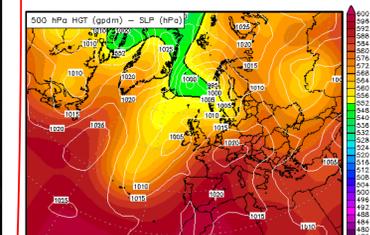


Figure 4. Sea-level pressure and geopotential height in 500 hPa for the 31/07/13 at 12 UTC from NCEP Reanalysis.

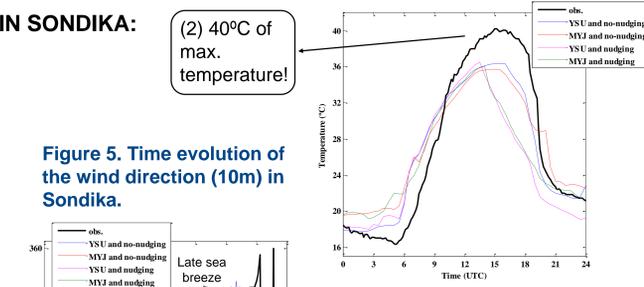


Figure 5. Time evolution of the wind direction (10m) in Sondika.

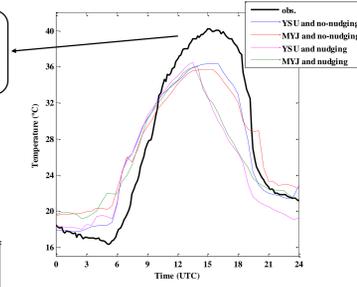


Figure 6. Time evolution of the temperature (2m) in Sondika.

(4) Azpeitia does not show an early nor late sea breeze. Sea-Breeze Index (SBI) is used to predict the sea breeze:

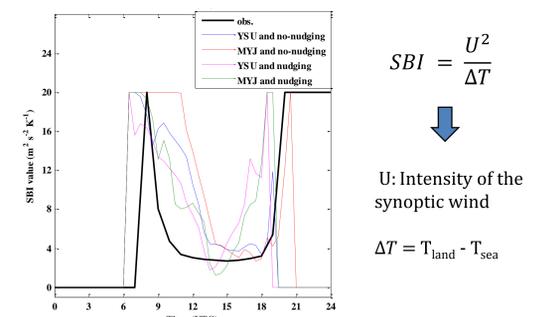


Figure 7. Time evolution of the SBI in Sondika. Negative values are limited to 0 and values greater than 20 are saturated (above that value sea breeze does not establish [3]). SBI decline is related to sea-breeze occurrence.

$$SBI = \frac{U^2}{\Delta T}$$

U: Intensity of the synoptic wind

$$\Delta T = T_{land} - T_{sea}$$

INFLUENCE OF GRID ANALYSIS NUDGING ON SIMULATIONS

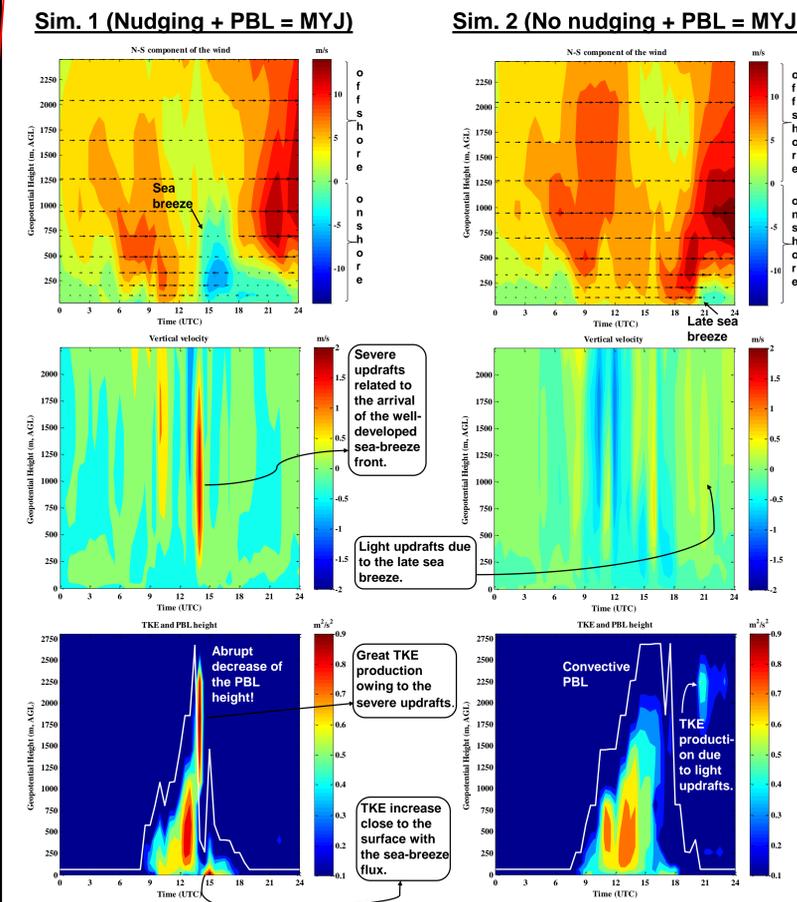


Figure 8. Time evolution of the simulated variables in the grid-point nearest to Sondika in the day of study (31st of July): (a) N-S component of the wind (N is onshore direction and S offshore) (b) Vertical velocity (c) TKE in contours and the PBL (Planetary Boundary Layer) height as the white line.

5. CONCLUSIONS

- SELECTION METHOD → more sea-breeze days in Sondika than in Azpeitia, perhaps due to the complex topography of the latter. It also fails filtering a late sea-breeze day in which 40°C are recorded.
- BEST SIMULATION ('real' sea breeze) → YSU + NO-NUDGING.
- NUDGING → greater decrease of the SBI → 'false' sea breeze.
- Arrival of the sea-breeze FRONT →
 - Severe UPDRAFTS (TKE ↑)
 - TKE ↓ at the surface.
 - PBL height ↓↓

6. REFERENCES

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