# The Use of Wind Gustiness and Air Density in Wave Modelling: Impact and Implications

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The impact of wind gustiness on the evolution of wave fields is analysed by superimposing to the nominal wind speed a fluctuation whose amplitude is related to the local air-sea temperature difference. The use of fluctuations represented by a Gaussian process, characterised by coherence in time, produces realistic time series whose characteristics are compatible with those obtained from previous studies and open sea measurements. To display the impact of the quasi-realistic temporal coherence, wind gustiness was represented in the wave as a Gaussian process with and without coherence in time. While a single extended simulation can provide a general idea of the impact of gustiness on the climatology, its randomness does not allow definite conclusions when one focuses on a specific location and on a given time. This effect is more pronounced in the case of coherence. An ensemble approach is used with several tens of random realisations.

The effect of a variable air density on wave generation has been explored by repeating the hindcasts using air density values estimated from the output of a meteorological model.

Table 1 summarises some of the numerical tests we carried out in the North Atlantic and the Mediterranean to display the impact of gustiness and variable air density on wave generation. Table 2 summarises the impact of gustiness without and with coherence and air density on the predicted significant wave height. Fig. 1 shows the results of the ensemble approach at buoy 64046 (located north of the UK at around 60.5°N, 5.0°W).

The introduction of gustiness leads to an evident average increase of the resulting wave heights, larger in an open ocean (the North Atlantic) than in an enclosed basin (the Mediterranean Sea). It is worthwhile mentioning that there is significant impact of gustiness during some individual storms characterised by high unstable conditions like the Mistral. This can be clearly seen in Figure 1 and inferred from the high maximum differences in Table 2. The randomness of the wind, and hence, at a more limited extent, of the wave, fields implies the possible occurrence of wave heights much larger than expected in a *non-gusty* field. The impact is more pronounced in the case of gustiness with coherence in time. The quasi-realistic air density in the North Atlantic Ocean leads to an increase of the wave heights during the winter storms. This impact is much limited in the Mediterranean Sea. The details can be found in Abdalla and Cavaleri (2002).

## Reference:

Abdalla, S. and L. Cavaleri, 2002. Effect of wind variability and variable air density on wave modelling, *Accepted for publication in Journal of Geophysical Research.*

**Table 1:** Summary of some of the numerical tests.

| Run ID | Forcing | Period | Region |
|---|---|---|---|
| AR | Reference (standard model run) | 01 October 1999 - 31 March 2000 | North Atlantic |
| AN | Gustiness without coherence | | |
| AC | Gustiness with coherence | | |
| AD | Variable air density | | |
| AE | Ensemble of 50 members, gustiness with coherence | 15-20 December 1999 | |
| MR | Reference (standard model run) | 01 October 1993 – 31 March 1994 | Mediterranean |
| MN | Gustiness without coherence | | |
| MC | Gustiness with coherence | | |
| MD | Variable air density | | |
| ME | Ensemble of 50 members, gustiness with coherence | 21-24 October 1993 (Mistral Storm) | |

**Table 2:** Gustiness and air density impact on predicted significant wave heights. The first row provides the maximum negative difference (metre), in space and time, with respect to the reference run. The second row refers to the long term average differences on the single points of the grid. The third and fourth rows provide the corresponding positive results. The columns ***AR*** and ***MR*** show the overall mean and maximum for both reference runs.

| Run ID: | *AR* | AN | AC | AD | *MR* | MN | MC | MD |
|---|---|---|---|---|---|---|---|---|
| Max. negative diff. | ---- | -1.09 | -2.35 | -0.49 | ---- | -0.75 | -1.41 | -0.37 |
| Lowest mean | *4.13* | -0.00 | +0.00 | -0.01 | *1.44* | -0.01 | -0.00 | -0.01 |
| Highest mean | | +0.07 | +0.20 | +0.10 | | +0.00 | +0.03 | +0.01 |
| Max. positive diff. | *14.73* | +2.37 | +6.59 | 1.09 | *9.57* | +0.64 | +2.01 | +0.33 |

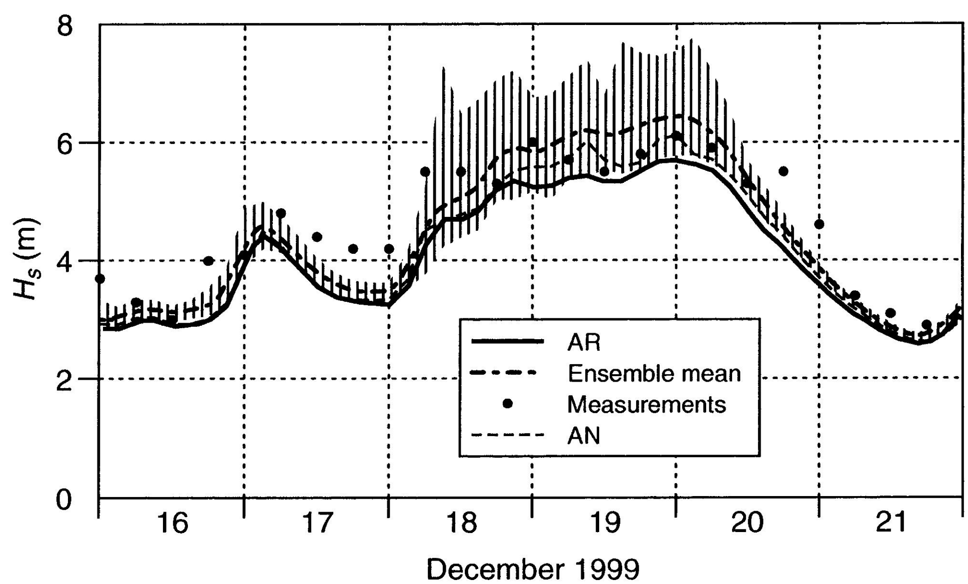


**Fig. 1:** Time history of wave height at buoy 64046 (shaded area represents envelope of AE).