



LAGRANGIAN REVIEW OF THE ORIGIN OF THE HUMIDITY FOR THE CASE OF TWO EXTREM PRECIPITATION EVENTS IN THE MEDITERRANEAN REGION

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What is a Heavy Precipitation Event (HPE)?

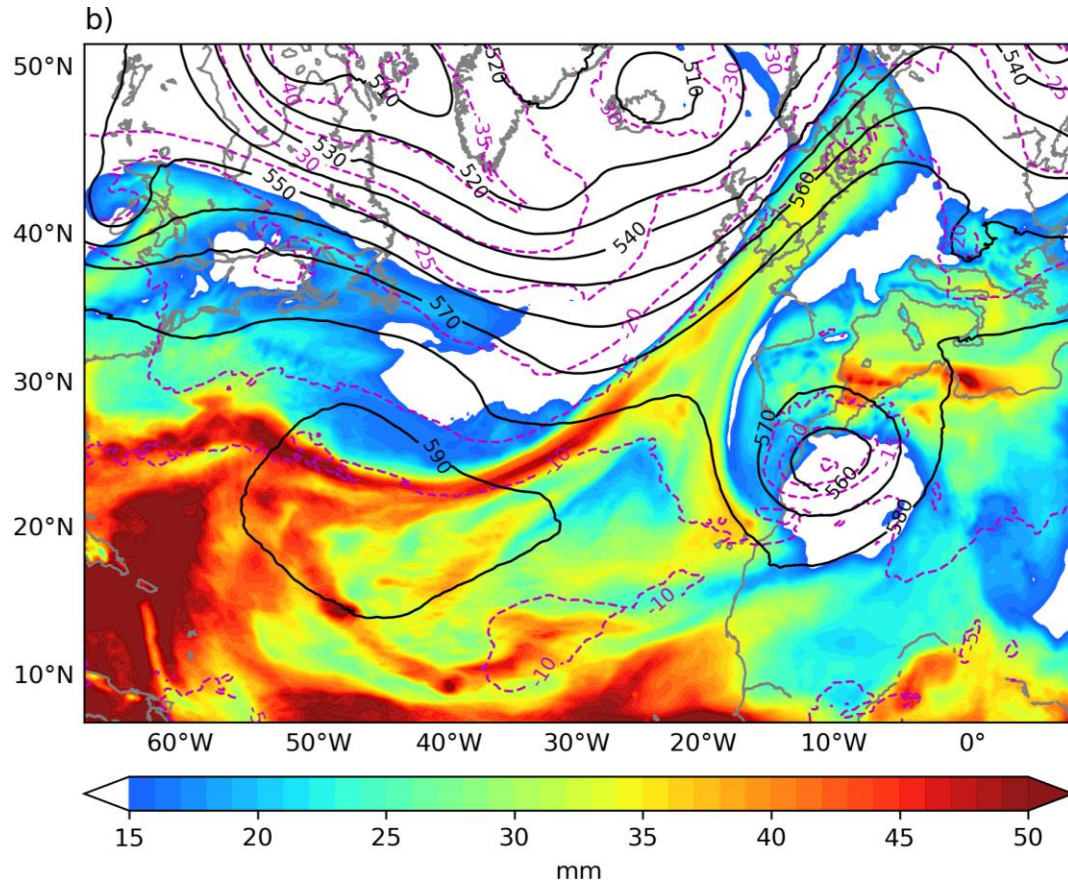
These occasional episodes can result in **more than 200 mm** of rainfall in **less than 24 h**. This phenomena led to **flash floods** which are a major environmental problem causing **social and economic losses**.

The **main cause** in the generation of HPEs is the **contrast between the warm and moist air with a low-pressure system**. Moreover, **orography** also plays a very important role.

For the Mediterranean region, most cases occur in **autumn**, due to the **combination** of a southward displacement of **the jet stream** with the **warm sea surface temperature**. Jet stream displacement can result in complex structures such as **Atlantic lows** or **cut-o-lows**.

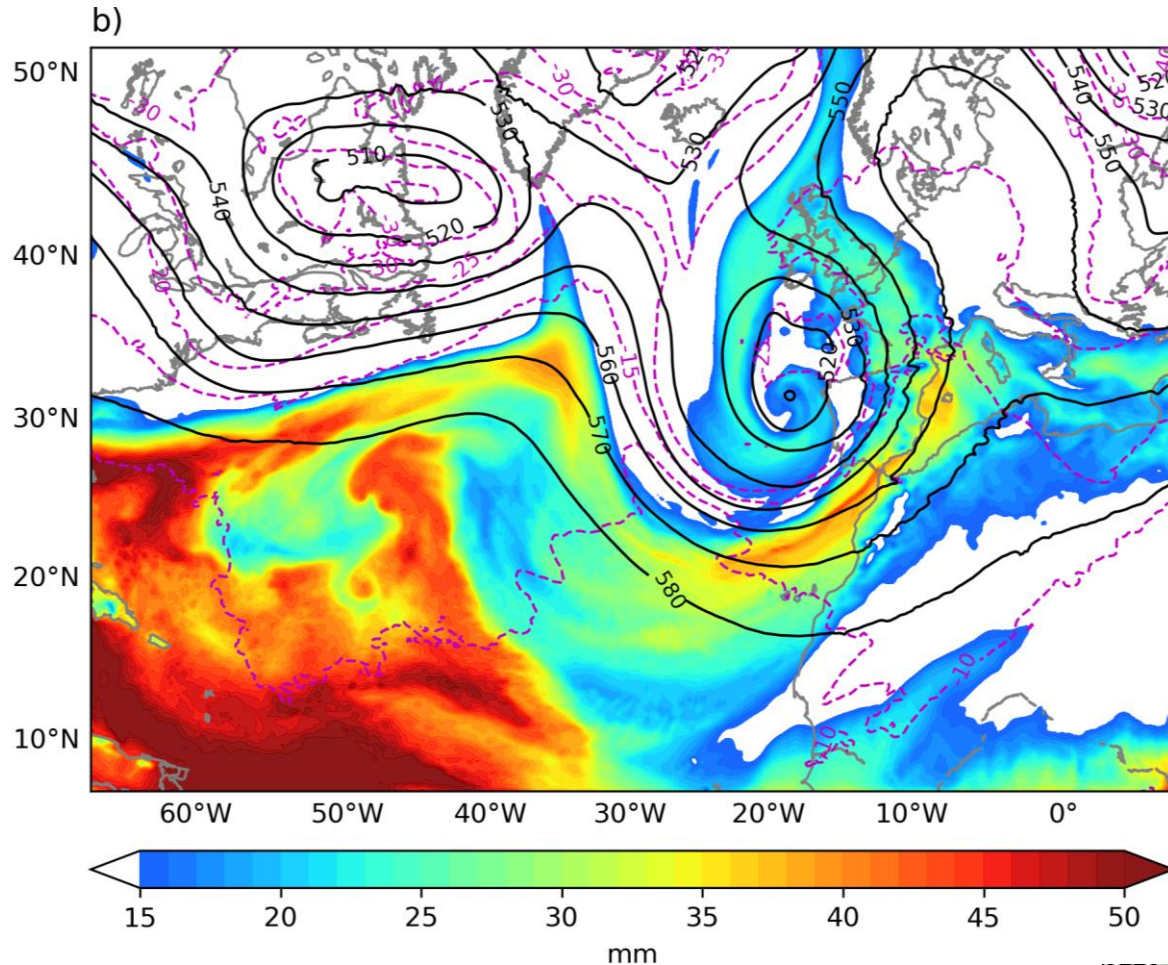


Study Case: October 1982



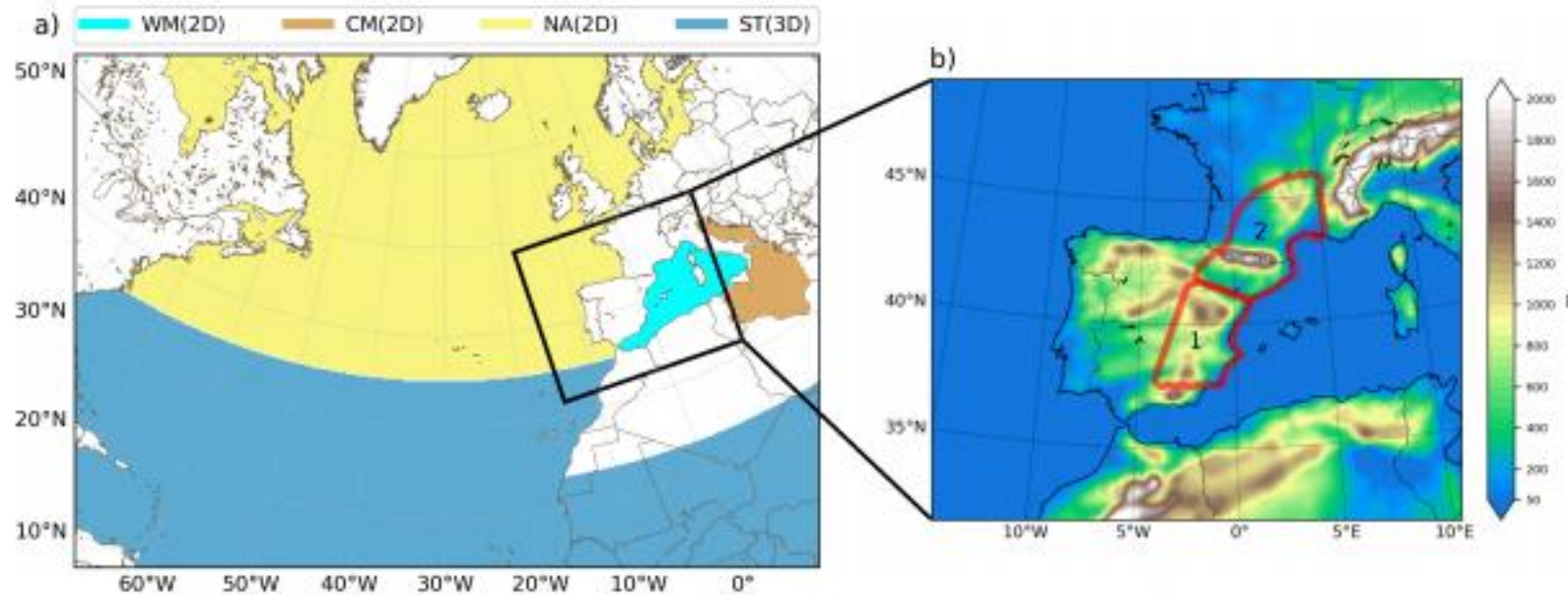
On the 20 October 1982 a **cold-core cut-of-low** originated from an Atlantic trough, was centred aloft over Morocco. The cyclone consisted of **an extensive low-pressure system** with centre over Algeria, which organized a relatively **warm and very humid easterly flow**, producing **extreme precipitations** over SE Spanish and especially over the region of Valencia, with maximum precipitation rates around 250 mm.

Study Case: November 1982



In this case, a strong **omega block pattern** was the cause of the HPE. In this case, **orography** played a very **important role**, what is specially noted over the Pyrenees and in the southern section of the French Massif Central.

Tagged areas



(a) Simulation domain and moisture sources considered: Western Mediterranean (light blue), Central Mediterranean (brown) and North Atlantic (yellow) two-dimensional sources and tropical and subtropical three-dimensional source (dark blue). (b) Domain for precipitation analysis. The areas highlighted in red are the most affected by the October (1) and the November (2) events.

Objetive

Our goal is to **determine the source of humidity masses** contributing to these extreme precipitation event through a recent Lagrangian analysis and also, to **compare** the reliability of this method with: (1) a new Eulerian tracer method [1]; and (2) an consolidated Lagrangian tracer method [2]. (These last methodologies has already been published [4], yet under review.)

This innovative ***Lagrangian tool*** (*Utrack atmospheric moisture model* [3]) can **tag and follow a moisture** from an initial evaporative state until it is allocated as precipitation. At this first stage, we have developed a sensitive study to determine the relation between some different variables.



Lagrangian Approach

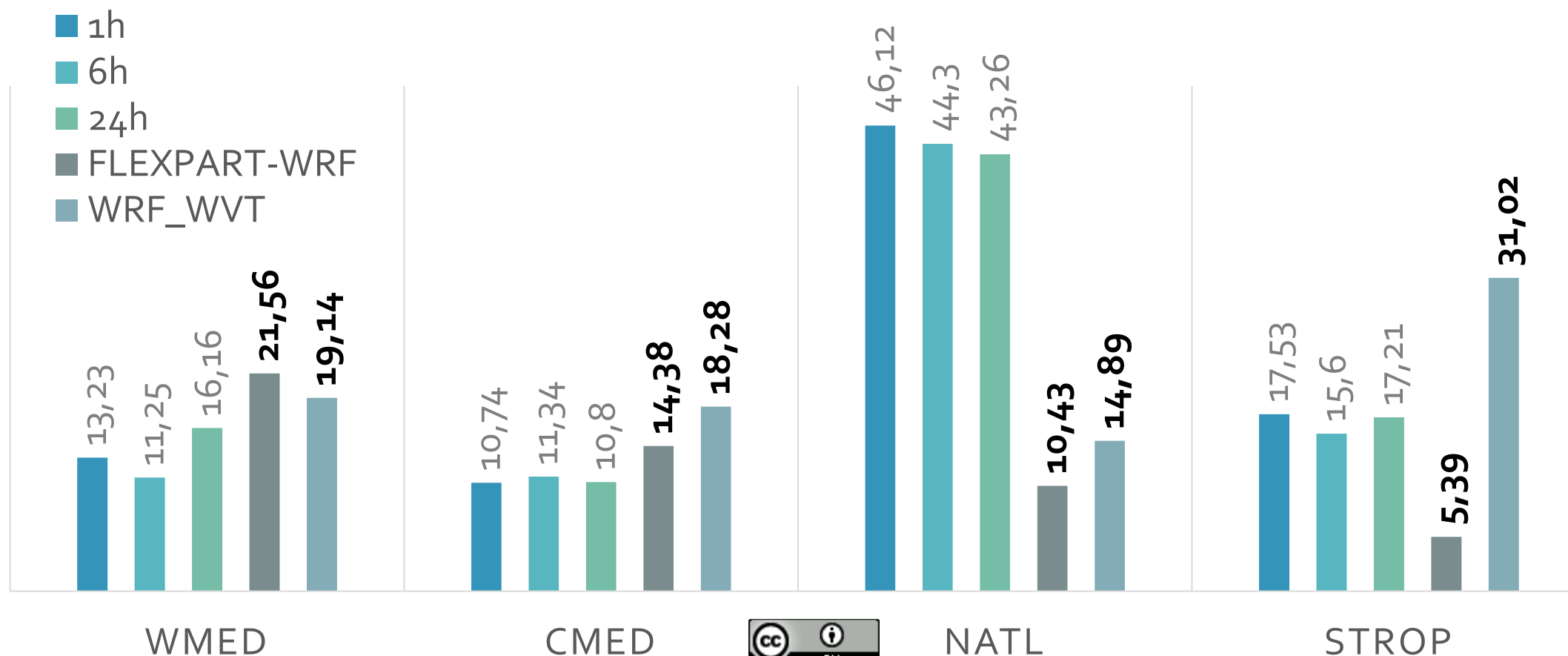
To **quantify** moisture sources for these heavy precipitation events, **Utrack atmospheric model** was used. By using ERA5 data, we run forward simulations where the humidity can be **tagged and followed** from an initial evaporative state until it is allocated as precipitation. To **determine the contributing fraction**:

$$\% \text{ Relative contribution} \Big|_{i\text{-source}} = \frac{\text{allocated moisture} \Big|_{i\text{-source}}}{\text{total precipitated water} \Big|_{\text{rain domain}}}$$



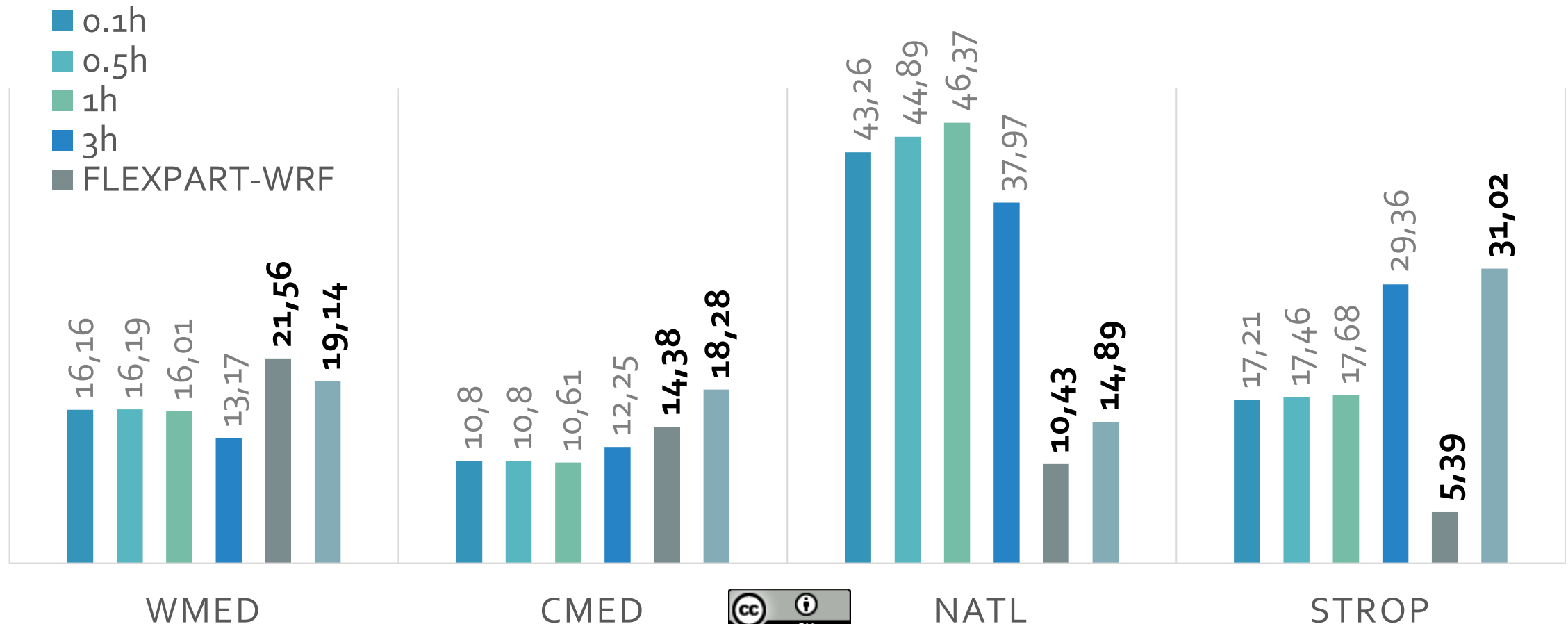
Comparison Lagrangian vs. Eulerian

VERTICAL MIXING VARIATION – OCTOBER



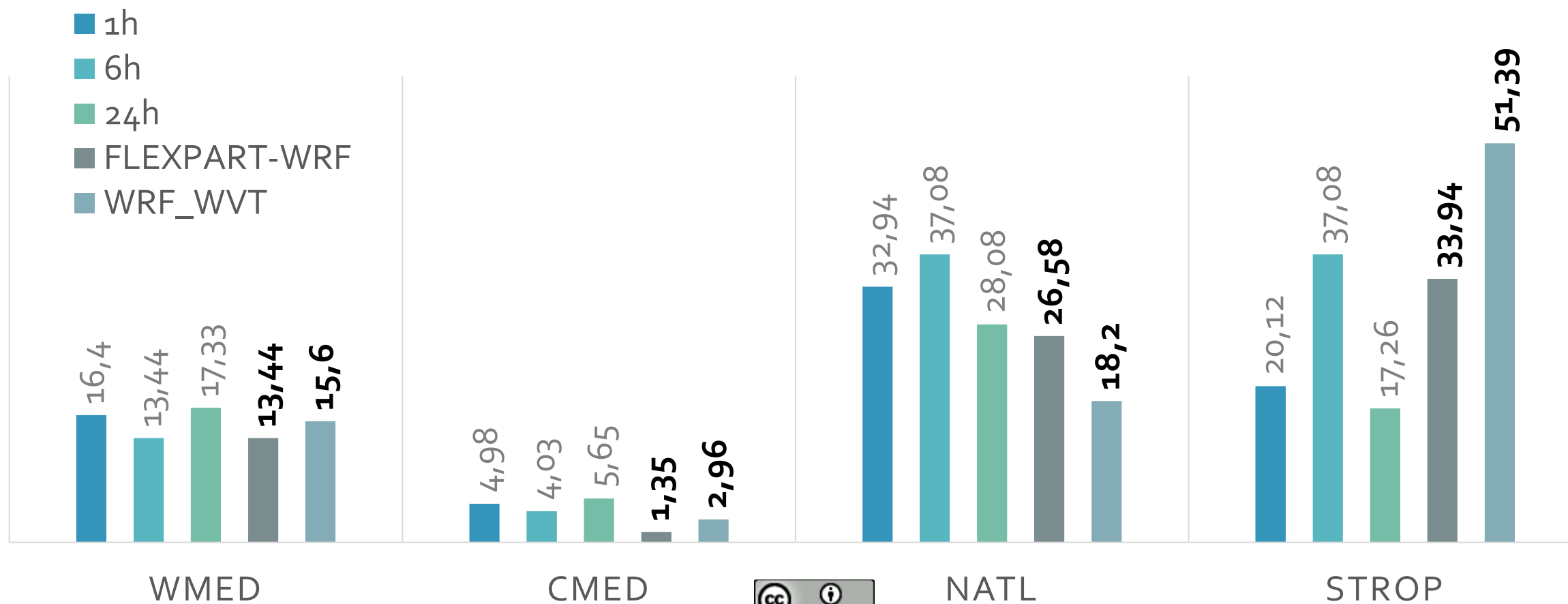
Comparison Lagrangian vs. Eulerian

TIME STEP VARIATION - OCTOBER



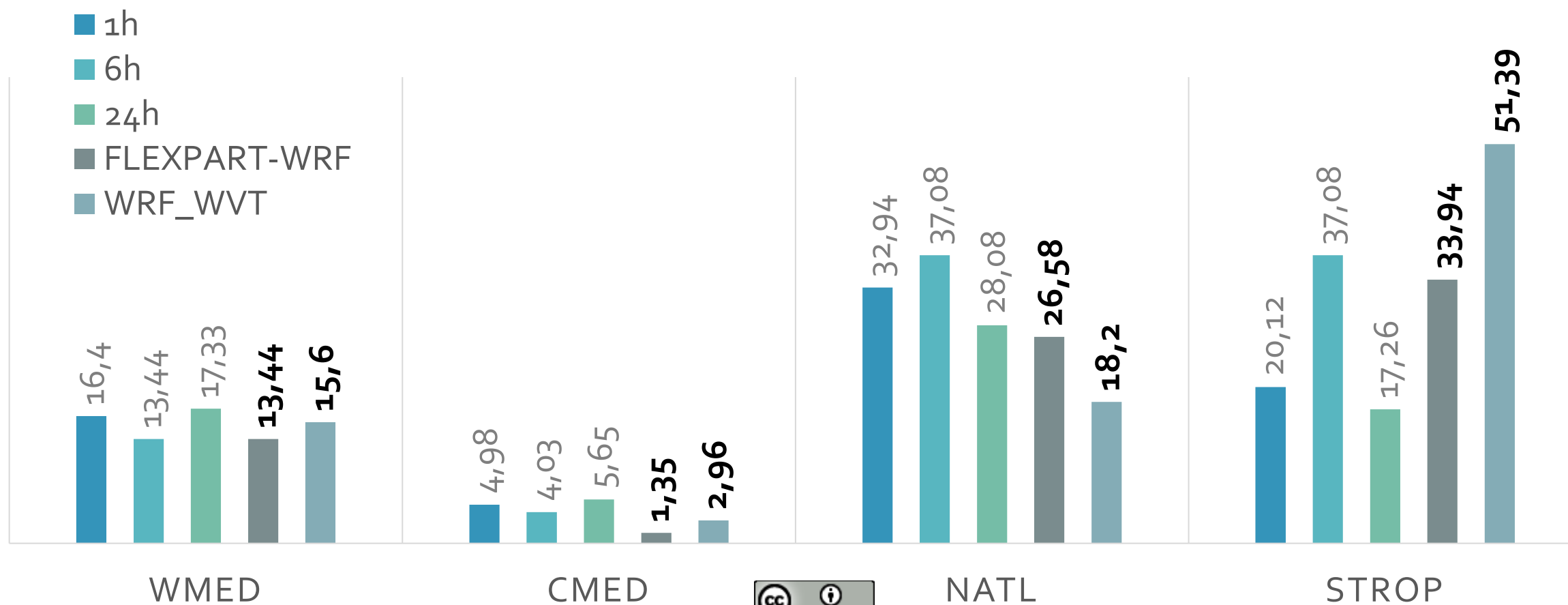
Comparison Lagrangian vs. Eulerian

VERTICAL MIXING VARIATION - NOVEMBER



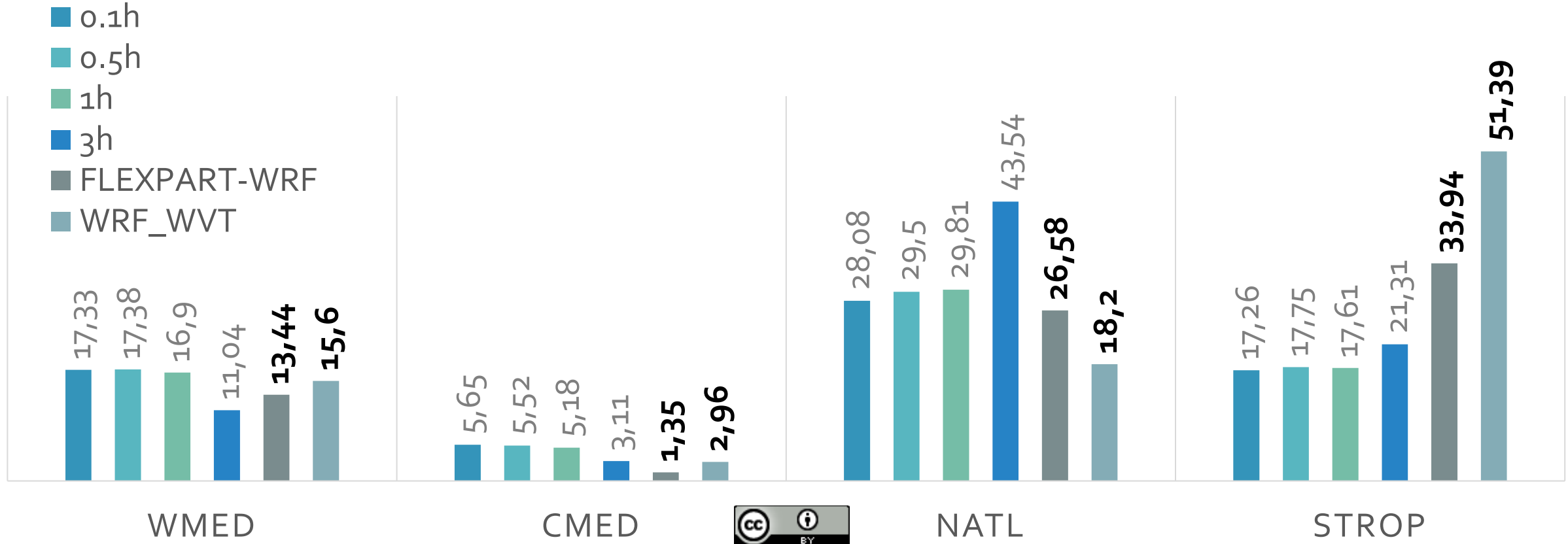
Comparison Lagrangian vs. Eulerian

VERTICAL MIXING VARIATION - NOVEMBER



Comparison Lagrangian vs. Eulerian

TIME STEP VARIATION - NOVEMBER



Conclusions

Utrack model (Lagrangian) can estimate the **similar percentages** calculated previously by both FLEXPART-WRF (Lagrangian) and WRF-WVT (Eulerian) approaches **for most of humidity sources**.

However, because november event is better estimated, future studies will be focused on a more complete understanding



Bibliography

- [1] Insua-Costa, D., & Miguez-Macho, G. (2018). A new moisture tagging capability in the Weather Research and Forecasting model: formulation, validation and application to the 2014 Great Lake-effect snowstorm. *Earth System Dynamics*, 9(1), 167-185.
- [2] Sodemann, H., Schwierz, C., & Wernli, H. (2008). Interannual variability of Greenland winter precipitation sources: Lagrangian moisture diagnostic and North Atlantic Oscillation influence. *Journal of Geophysical Research: Atmospheres*, 113(D3).
- [3] Tuinenburg, O. A., & Staal, A. (2020). Tracking the global flows of atmospheric moisture and associated uncertainties. *Hydrology and Earth System Sciences*, 24(5), 2419-2435.
- [4] Cloux, S., Garaboa-Paz, D., Insua-Costa, D., Miguez-Macho, G., & Pérez-Muñuzuri, V. (2021). Extreme precipitation events in the Mediterranean area: contrasting Lagrangian and Eulerian models for moisture sources identification. *Hydrology and Earth System Sciences Discussions*, 1-20.



THANKS FOR YOUR ATTENTION

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