

ICON Waves Regionalization

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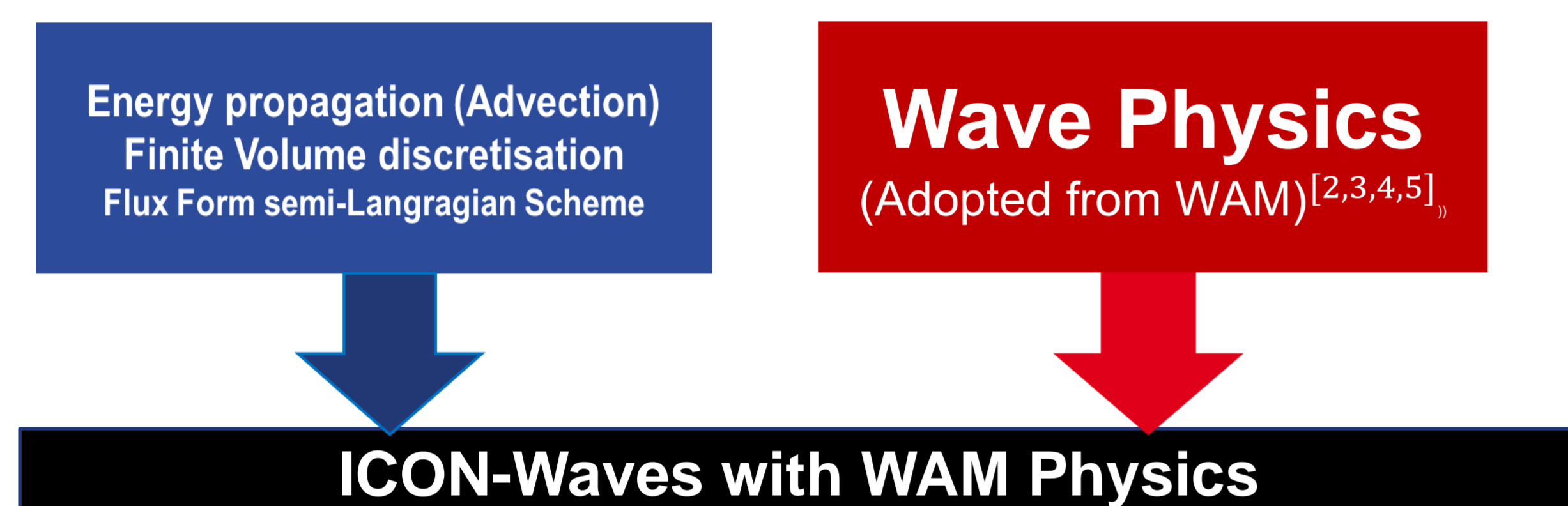
The project's goal is to develop a limited area mode (LAM) for the ICON-WAVES model. The ICON-WAVES development is an integral part of project "Earth System Model on the Weather Scale" (ESM-W) in cooperation with the GeoInfoDienst BW. The Limited Area Mode (LAM) of a numerical weather prediction model provides a high-resolution weather resolution weather forecast for a specific region of the earth. While the global weather forecast model simulates the entire earth's atmosphere. LAM concentrates on a limited region of the globe with a much finer spatial resolution. The main aim of ICON-WAVES regionalization is to expand the scope of the wave modelling system for high-resolution predictions

I. ICON-WAVES

The ICON (ICOsahedral Nonhydrostatic) modeling framework [1] is a collaborative effort involving the Deutscher Wetterdienst (DWD), the Max-Planck-Institute for Meteorology (MPI-M), the Deutsches Klimarechenzentrum (DKRZ), and the Karlsruhe Institute of Technology (KIT). This collaboration aims to create an integrated next-generation global numerical weather prediction (NWP) and climate modeling system.

ICON-waves is an integral part of the ICON framework e.g. ICON-A and ICON-O

$$\frac{\partial E}{\partial t} + \nabla \cdot (c_g E) = S_{in} + S_{nl} + S_{dis} + \dots$$



Where E represents the wave spectrum and describes the energy distribution over different wave frequencies and directions. The source function for the transport equation consists of the superposition of wind input, nonlinear transfer, and white capping dissipation. Supplementary terms such as bottom friction and refraction are included in the shallow water model case.

II. ICON-WAVES-LAM

Limited Area Mode (LAM) is a configuration of a numerical weather prediction model that gives high-resolution weather forecasting for specific regions of the globe, in contrast to global weather prediction models that simulate the entire Earth's atmosphere.

In this project, LAM combined with the waves model, called ICON-WAVES-LAM. Limited Area Models work by subdividing a specific geographical area into a grid, applying mathematical equations, numerical techniques, and physics parameterizations to simulate the atmosphere's behavior within that region. They rely on initial conditions, boundary conditions from global models, and ongoing validation to provide high-resolution weather forecasts tailored to the region of interest.

III. ICON-WAVES-LAM IMPLEMENTATION

- Grid Generation using ICON grid generator
- Generation of external parameter using ETOPO1 files
- Global run for initialization of LAM and generation boundary data
- Interpolation of data on LAM grid
- Define name list for limited area mode
- Temporal interpolation for LAM boundary coded
- Running LAM simulation
- Differences between local and global runs tested and visualized after LAM simulation

The LAM workflow is shown in Fig. 1

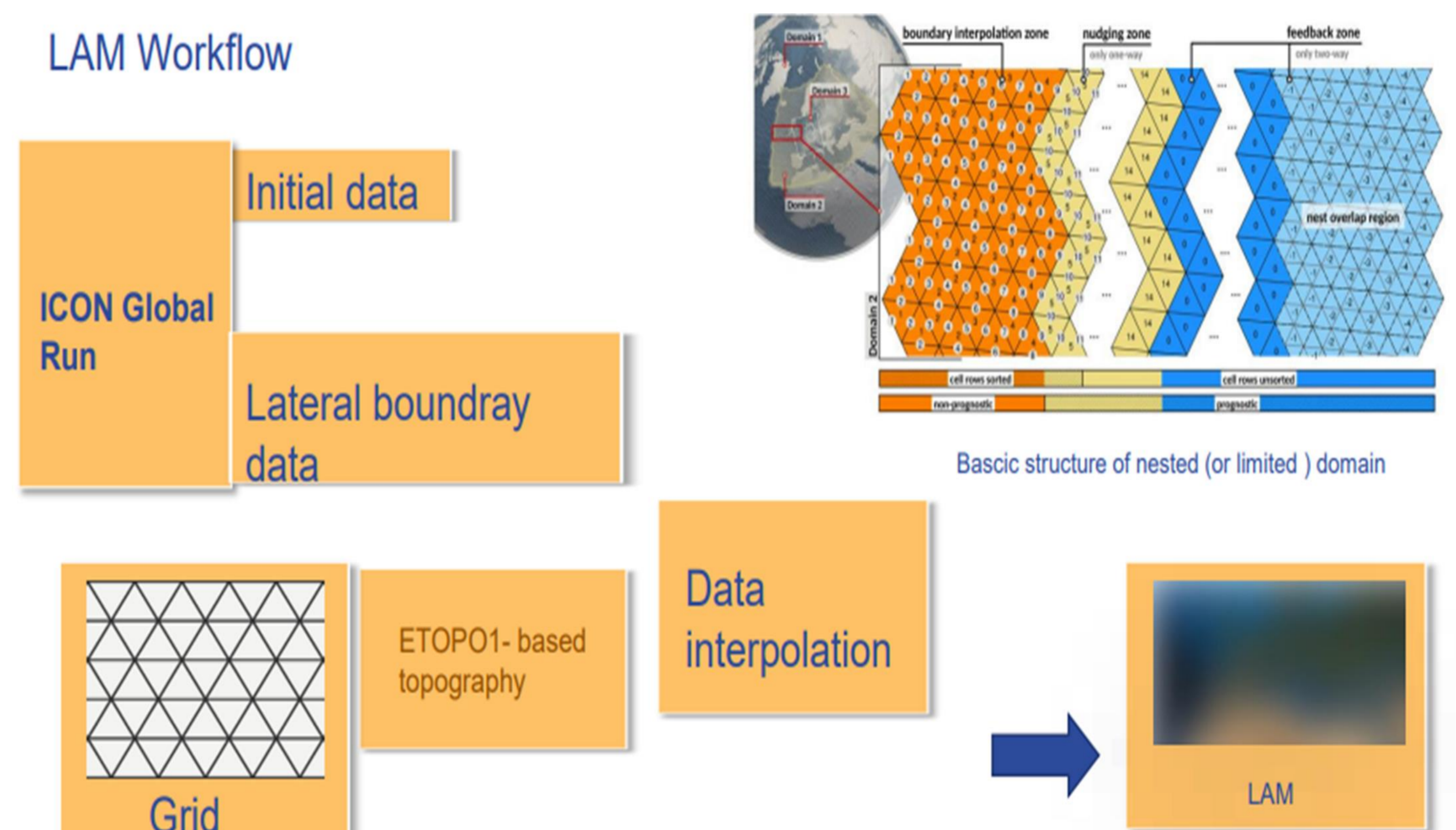
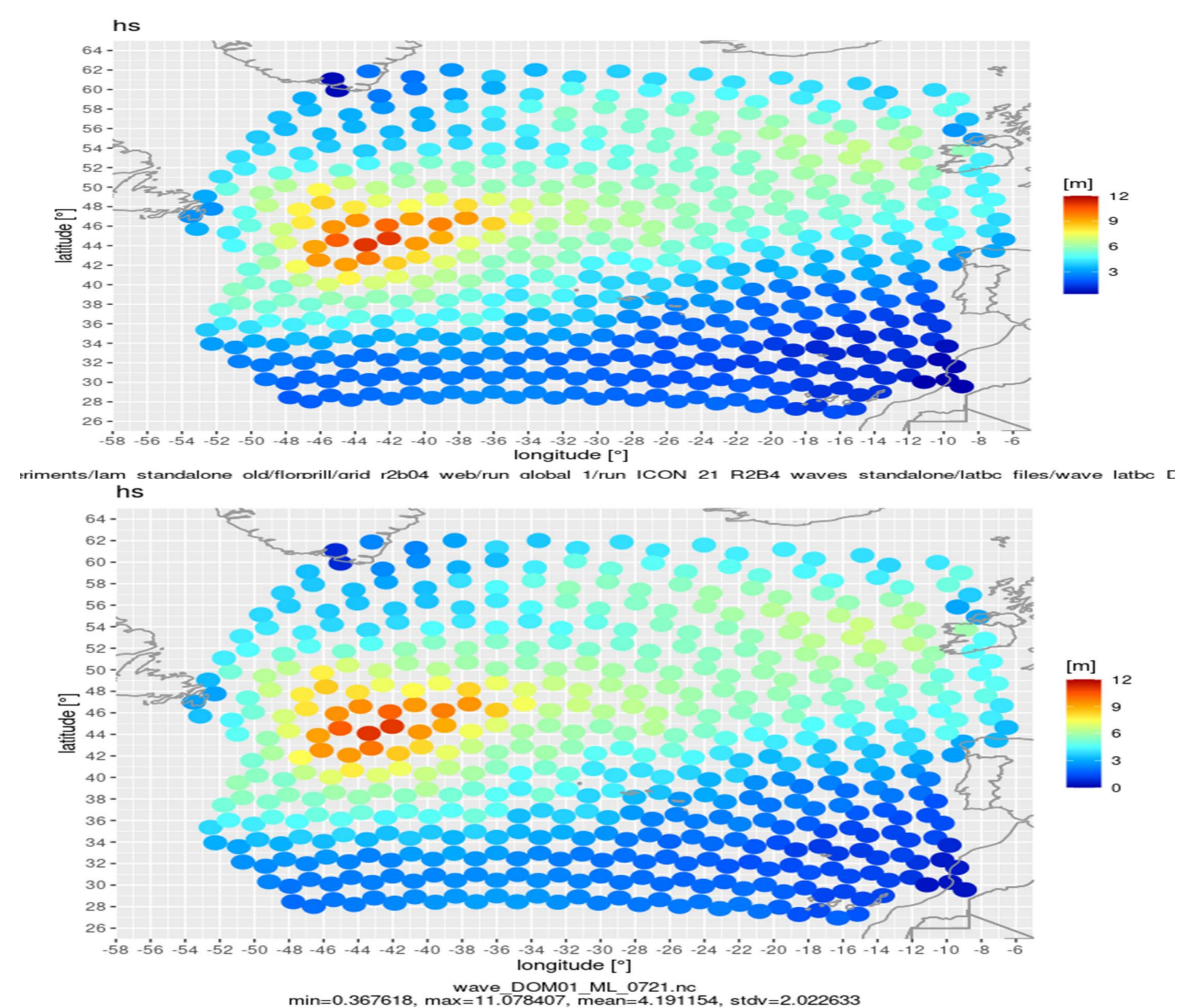


Figure 1. LAM Workflow

IV. Results of Experiment

A comparison between Local Area Model (LAM) and global simulations was conducted over a 20-day period to identify potential inconsistencies in their implementation. To mitigate potential interference from interpolation errors, both cases were set to employ the same grid resolution. Additionally, the time step was reduced to assess the validity of temporal interpolation. Detailed simulation parameters are provided for both cases. The significant height (hs) for both cases is presented in figure.



Experiment Setup:

Grid resolution R2B4 (~157.8 km)
Water only grid
Time step 600 sec

Limited Area Mode:

Region: Northern Atlantic
Boundary zone width: 4 rows
Nudging zone width: 4 rows

Conclusion:

ICON-Waves-LAM implementation
Initial result show good agreement with the reference result

Next Steps

Test the setup with different global and Lam resolution
Coupled atmosphere-waves-LAM setup

1. Zängl, Günther and Reinert, Daniel and Ripodas, Pilar and Baldauf, Michael, The ICON (ICOsahedral Non-hydrostatic) modelling framework of DWD and MPI-M: Description of the non-hydrostatic dynamical core, Quarterly Journal of the Royal Meteorological Society, 141.687;563-579.
2. Hasselmann, K., et al., (1988) The WAM model - A third generation ocean wave prediction model, Journal of Physical Oceanography 18.12, 1775-1880.
3. Hasselmann K., et al., (1984) On the Existence of a Fully Developed Wind-Sea Spectrum, American Meteorological Society, 14.8;1271-1285.
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5. Komen GJ, Cavaleri L, Donelan M, Hasselmann K, Hasselmann S, Janssen PAEM. Dynamics and Modelling of Ocean Waves. Cambridge University Press; 1994.

