Numerical Modelling...

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Lecturer:

Content

- What is NWP Model?
- General overview
- Global models
- Limited Area Models (LAM).
- Initial Data
- NWP model Products
- Pc cluster
- Errors of the NWP

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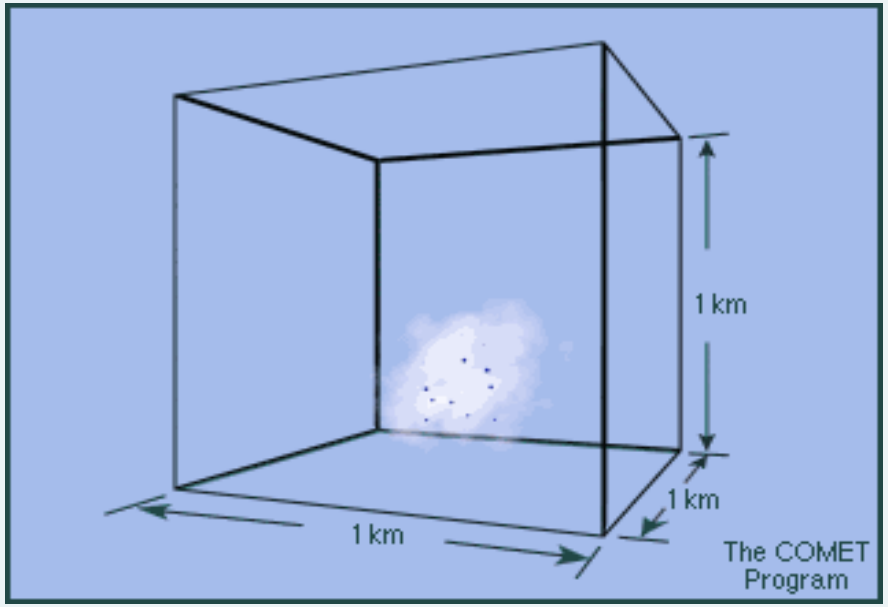
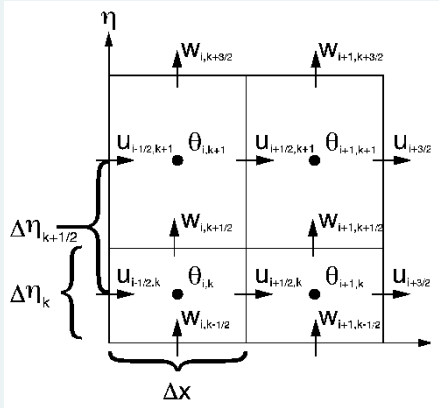
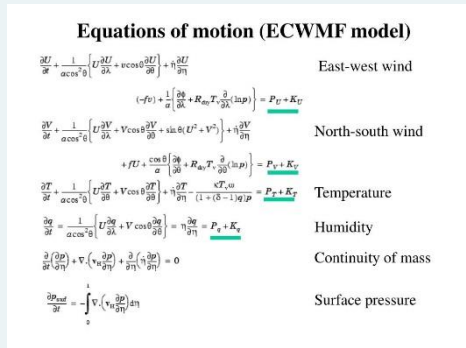
What is NWP Model?

- Take the equations that describe atmospheric processes.
- Convert them to a form where they can be programmed into a large computer.
- Let the computer to solve them
- This is called a "model" of the atmosphere







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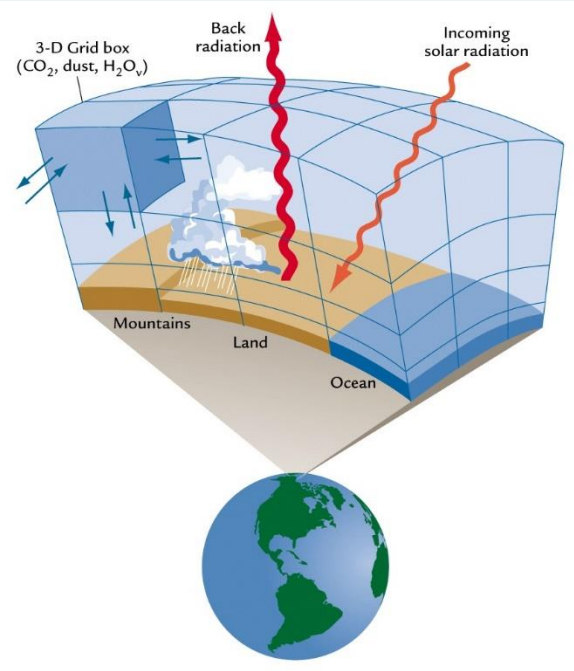
What do we mean by "solve the equations"

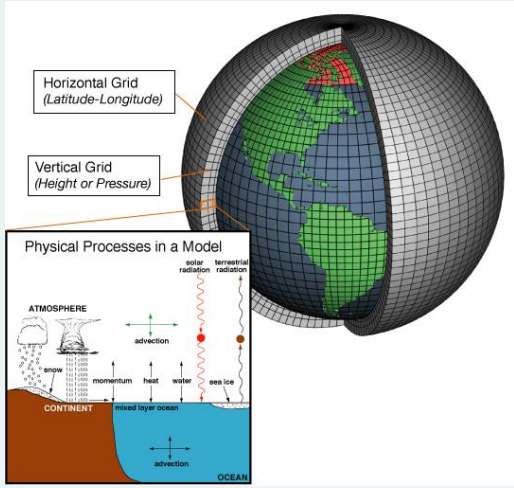
- **The equations describe how the atmosphere changes with time.**
- **For example, one equation would be**

$$\frac{T\ Change}{Time} = Solar + Condensation + Convection + Evaporation + Advection + ...$$

NWP Concept: General overview

- NWP consists in :
  - Subdividing a chosen geographic 3D area in thousands (or millions) of little cubes.





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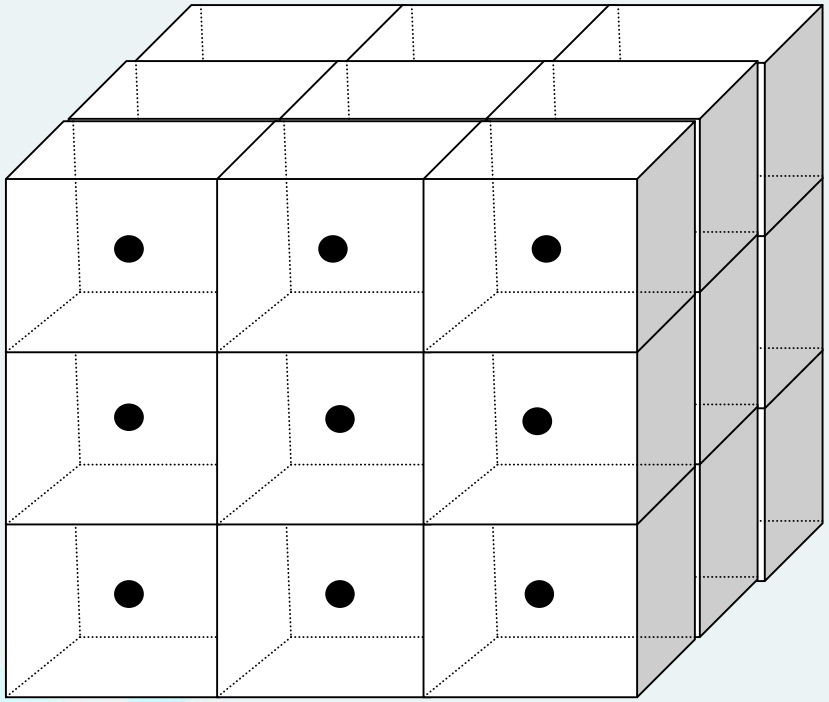
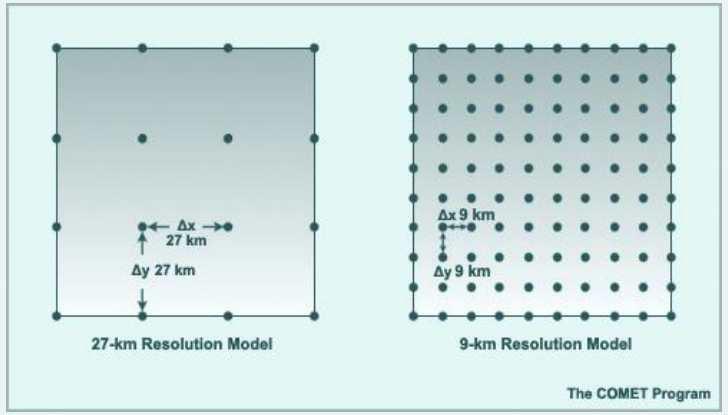
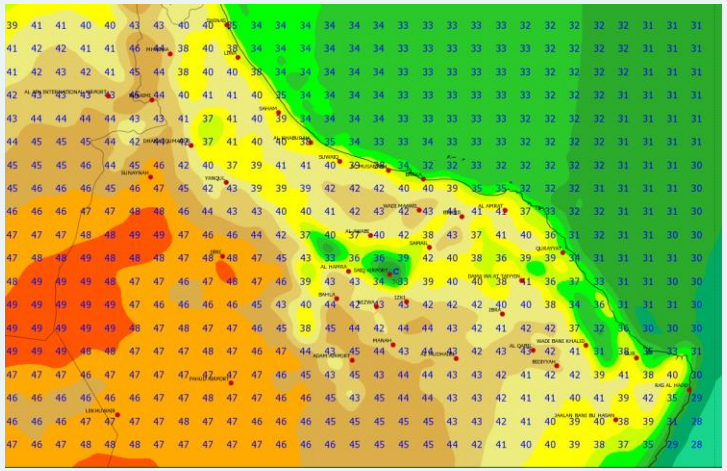
NWP Concept: General overview

3D cubes of the atmosphere used by NWP models







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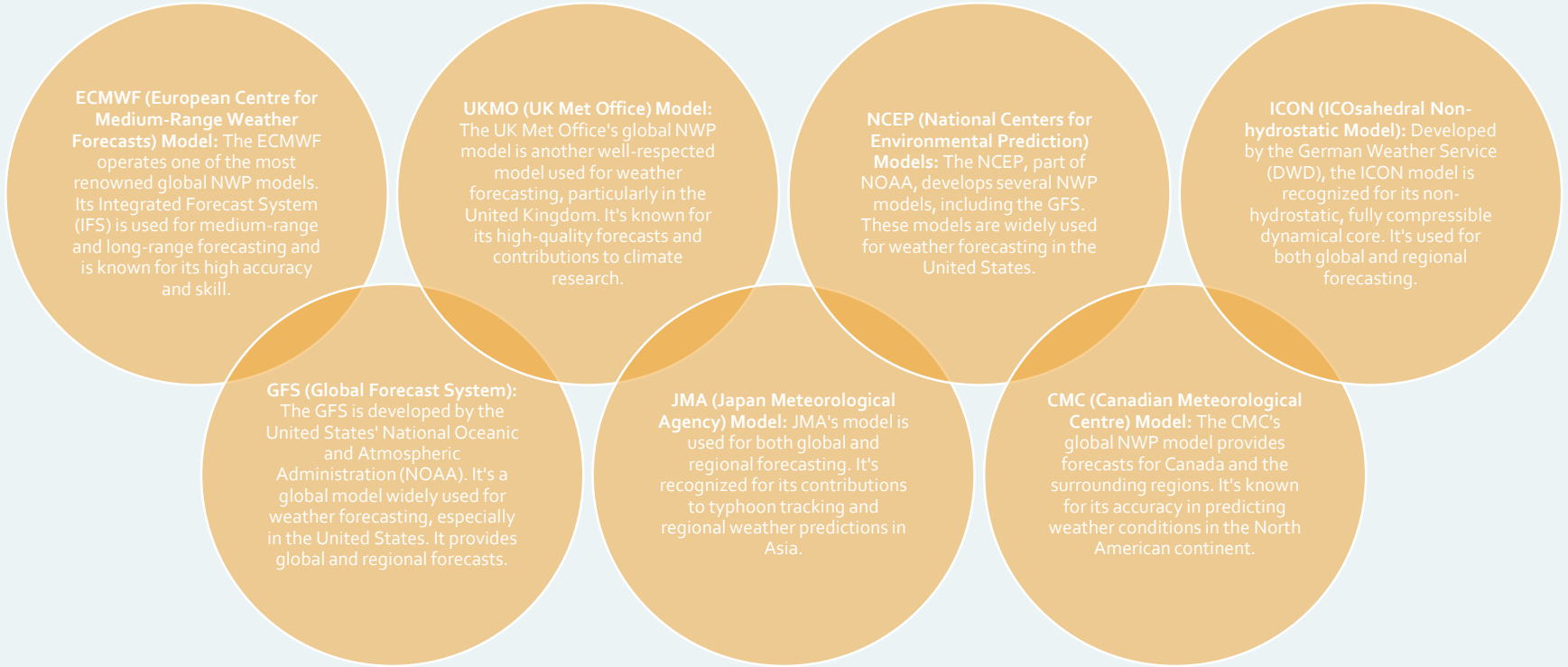
NWP concepts : Global models

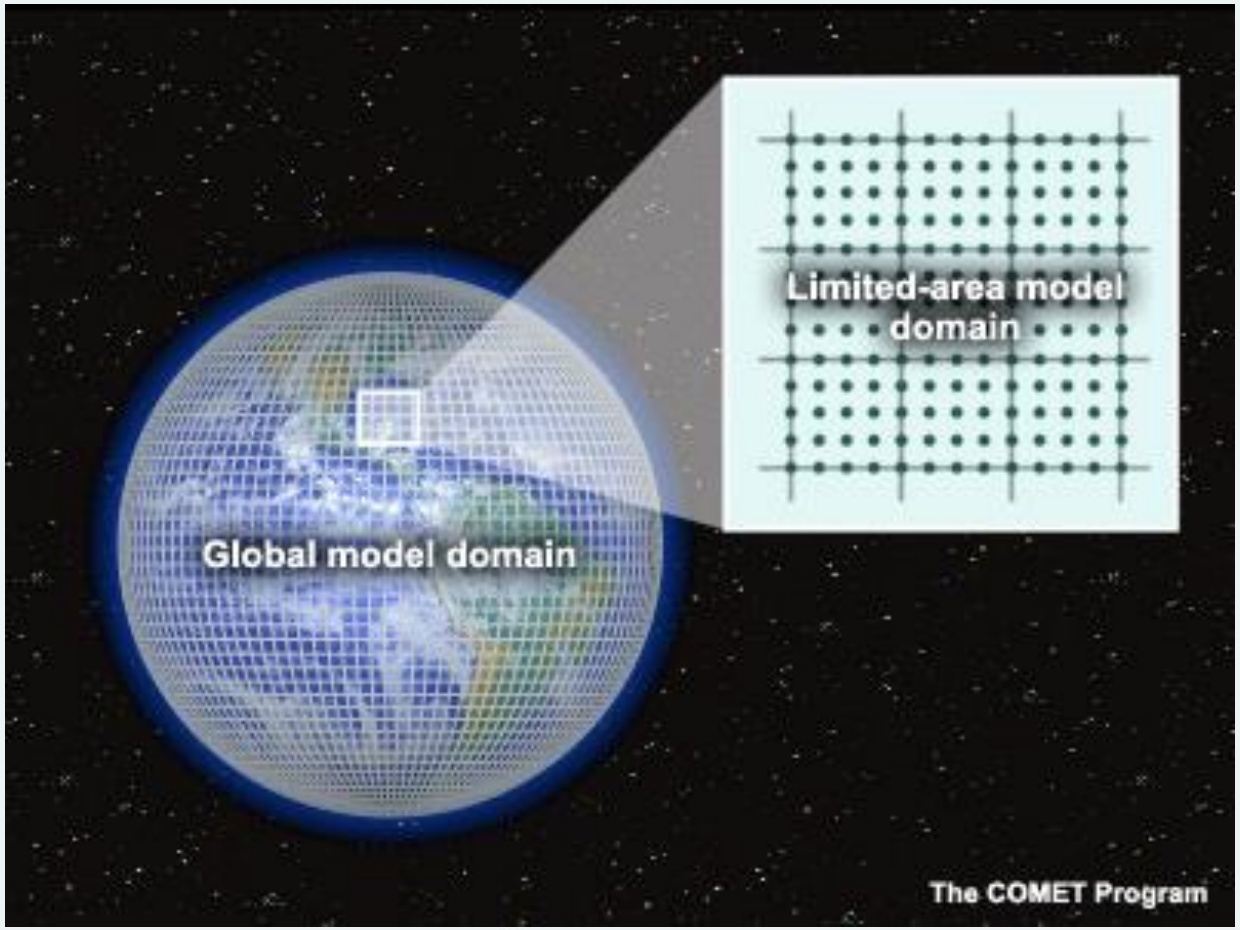
- Global models resolve atmospheric equations on the whole glob.
- They can not use very fine resolution because of computers limitations.
- Because of their weak resolution, they can not detect small scale phenomena.
- The most popular global models are :
  - ECMWF/IFS (partially public and received on MDD) : http://www.ecmwf.int.
  - NCEP/GFS (completely public) : http://www.ncep.noaa.gov.
  - Météo-France/ARPEGE (not available on the net).
  - German DWD global model.
  - METOFFICE/UKMO Unified Model.
  - Japan Meteorological Agency JMA Global Model.
- Global models are used to forecast general synoptic circulation and to provide Initial and Lateral Boundary Data for Limited Area models.

The most famous and widely used Numerical Weather Prediction (NWP) models often come from leading meteorological and research institutions. As of my last knowledge update in September 2021, some of the most prominent global NWP models included:



NWP Concepts : Limited Area Models (LAM).

- They are widely used by Weather Centers over the world.
- The most popular LAMs are:
  - ICON / LM
  - WRF
  - ECMWF/IFS
  - ALADIN

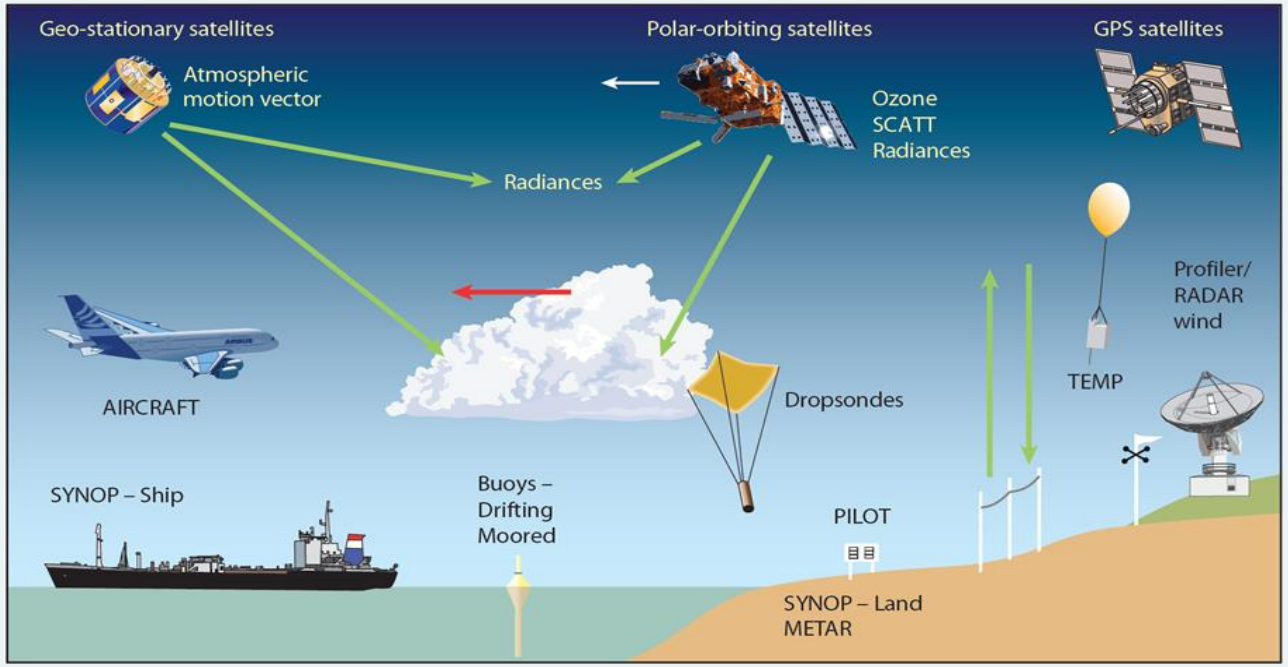


NWP Concepts : Initial Data.

- The **actual situation** used by the model to start integrate equations.

- It is created by techniques called **data assimilation**.
- The information used to create initial data are:
  - **GTS data** (Conventional observations) :

  SYNOP, SHIP, BUOY, TEMP, PILOT, AMDAR,…)
- The process of initial data creation (analysis and data assimilation) is more **complicate** than the forecast model itself, and more **consumer in term of CPU time**.



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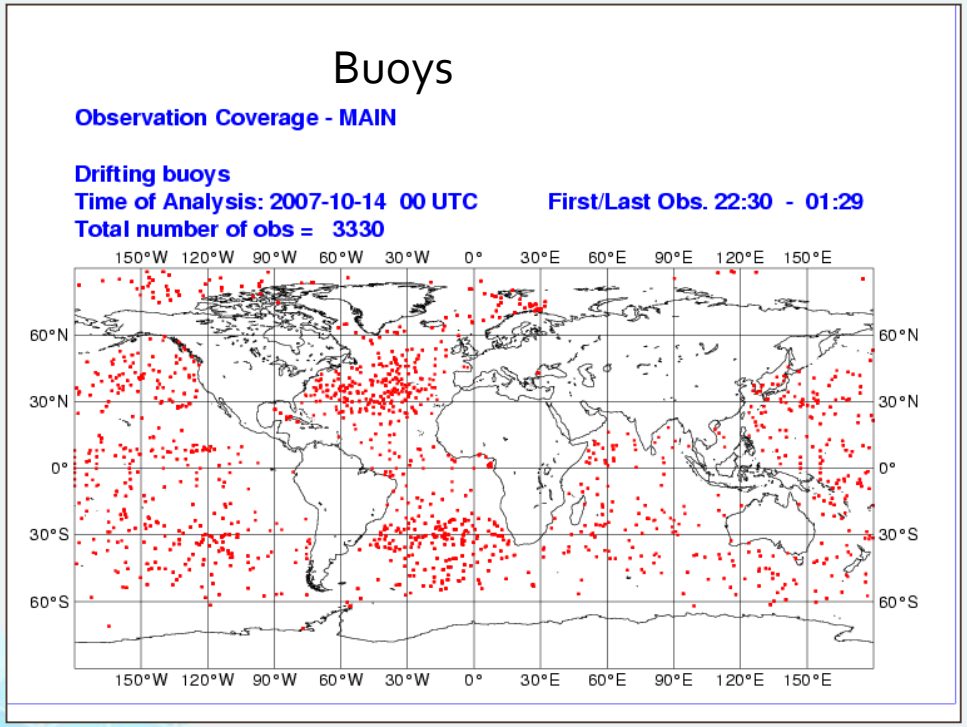
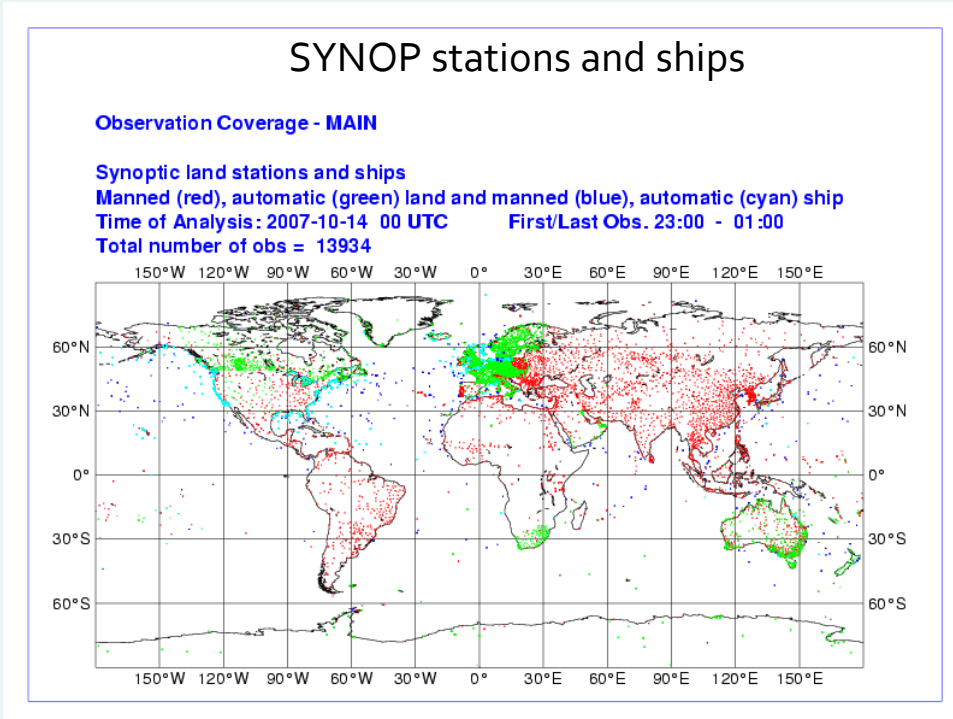
NWP Concepts : Initial Data.

Buoys



SYNOP stations and ships



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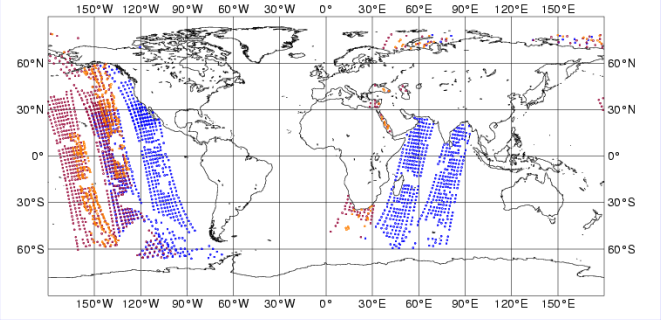
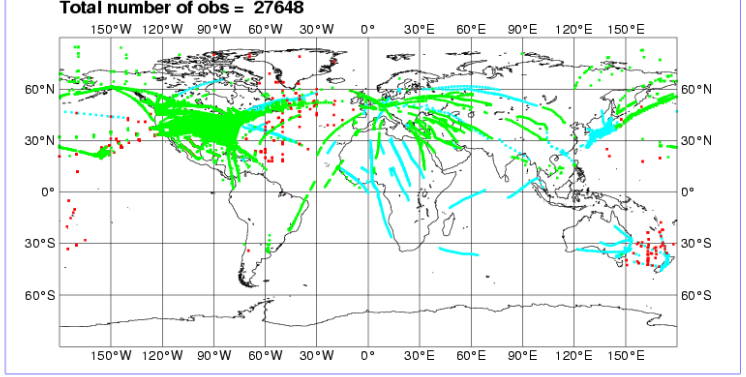
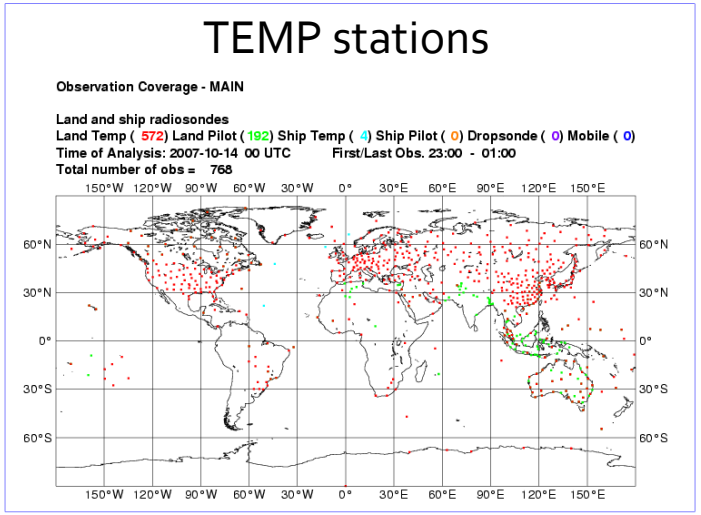
polar orbiting satellites



Aircraft measurements (AMDAR)



TEMP stations



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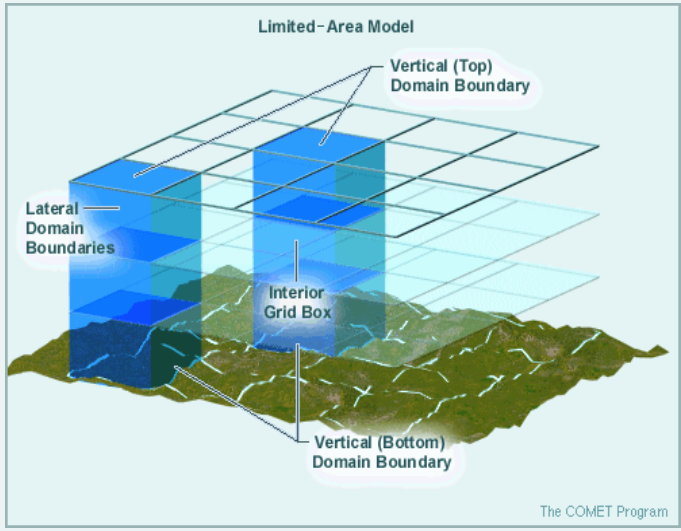
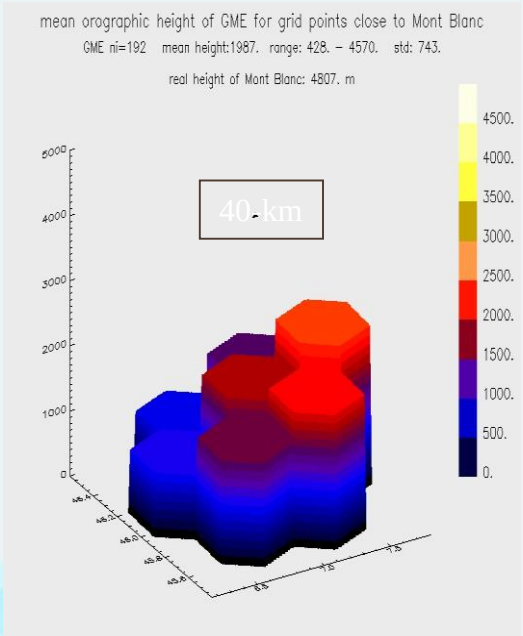
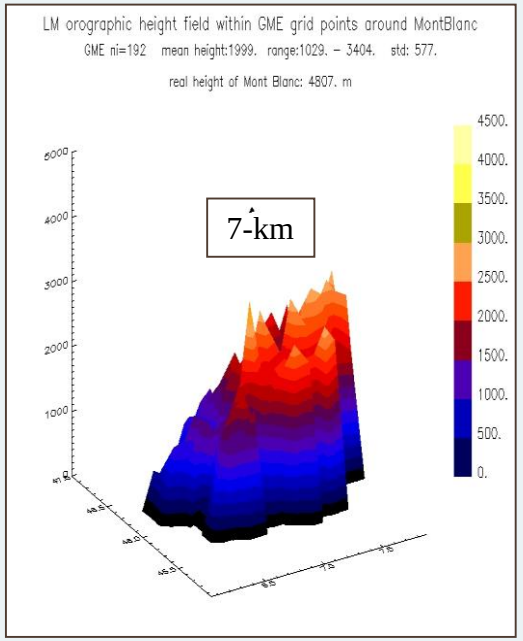
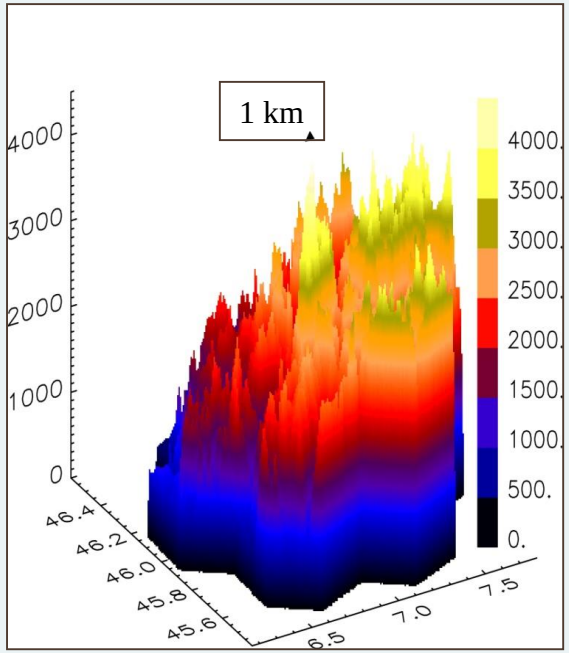
Orography


Limited-Area Model
Vertical (Top)
Domain Boundary
Lateral
Domain
Boundaries
Interior
Grid Box
Vertical (Bottom)
Domain Boundary
The COMET Program


mean orographic height of GME for grid points close to Mont Blanc
GME ni=192 mean height:1987. range: 428. – 4570. std: 743.
real height of Mont Blanc: 4807. m
40-km


LM orographic height field within GME grid points around MontBlanc
GME ni=192 mean height:1999. range:1029. – 3404. std: 577.
real height of Mont Blanc: 4807. m
7-km


1 km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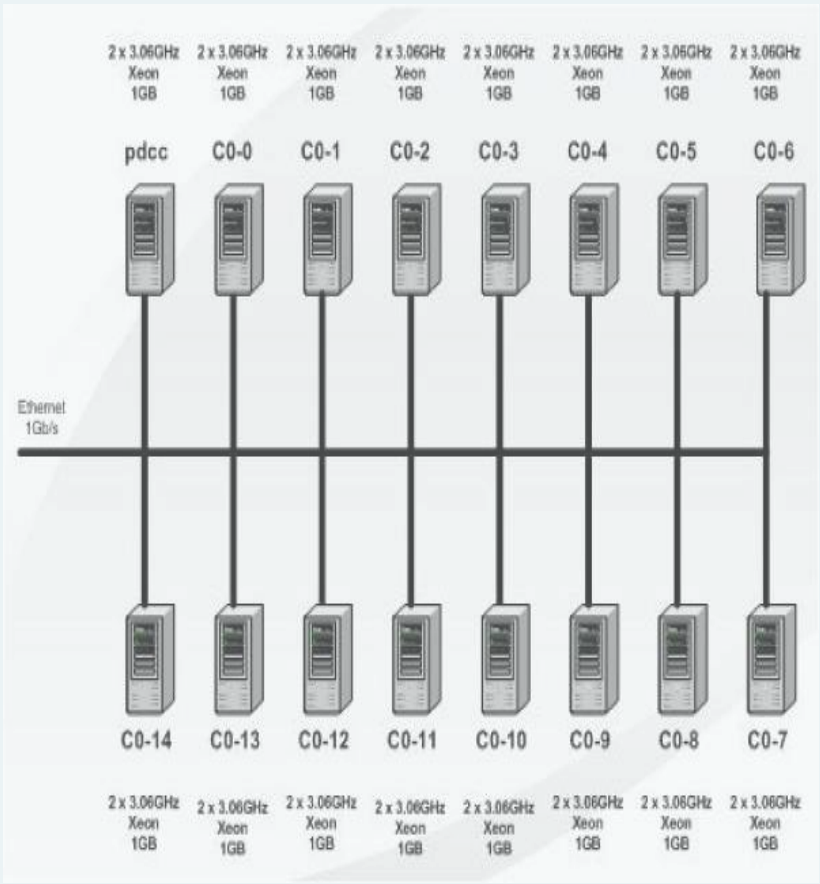
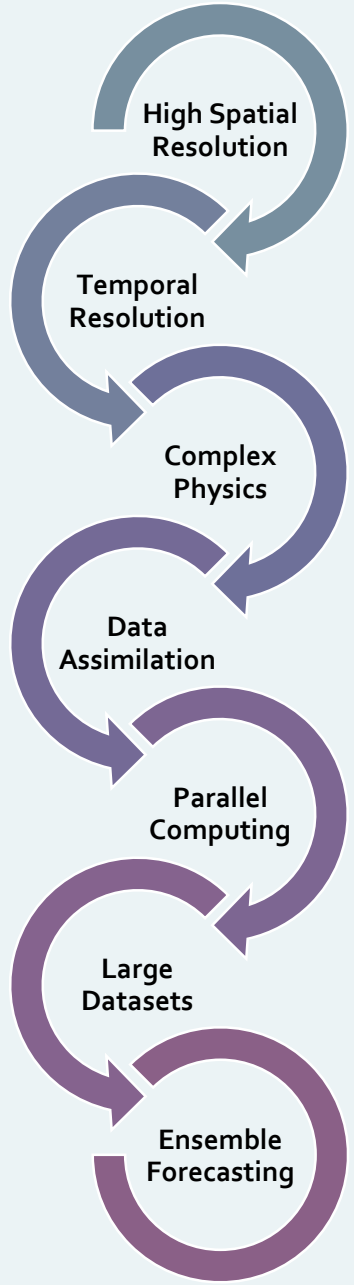
Parameterization

Pc cluster





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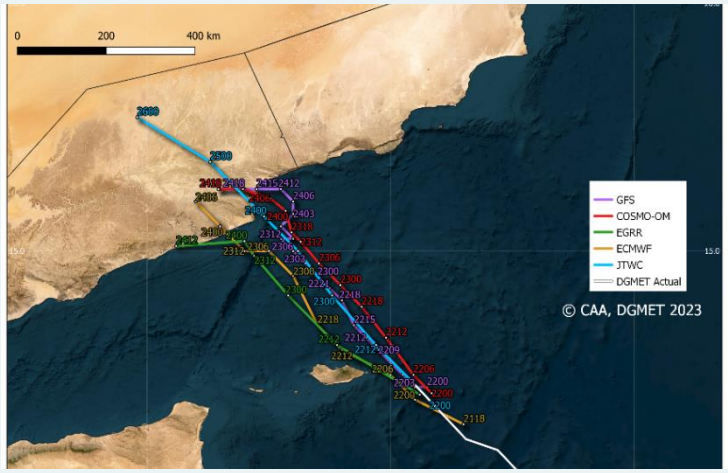
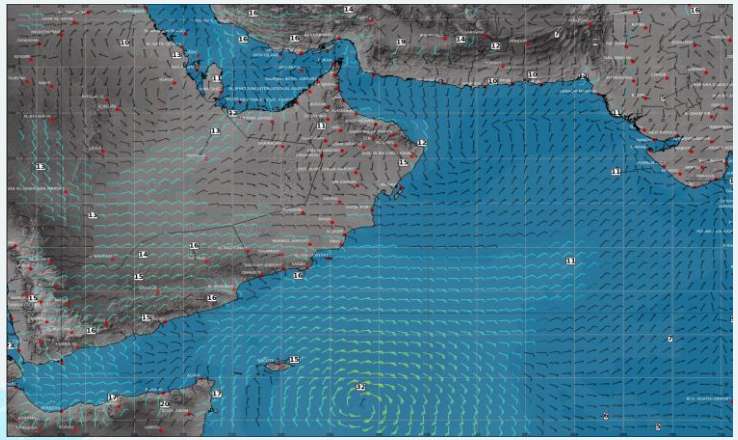
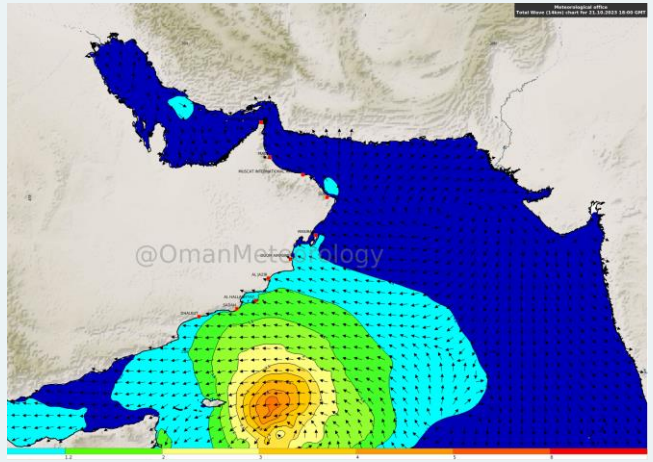
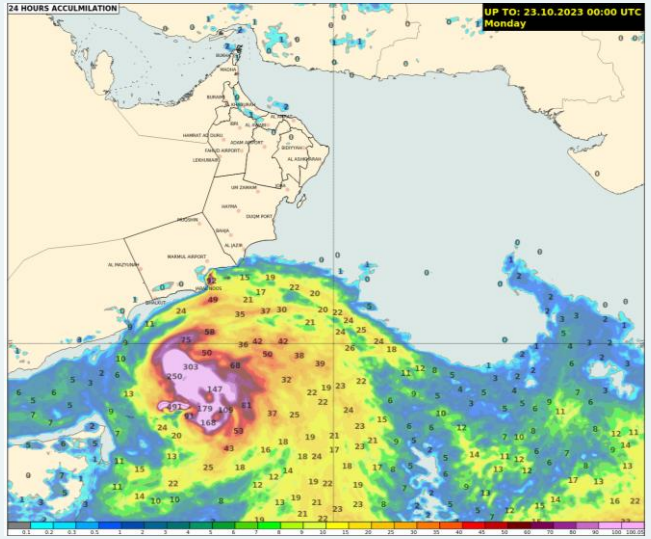
NWP model Products









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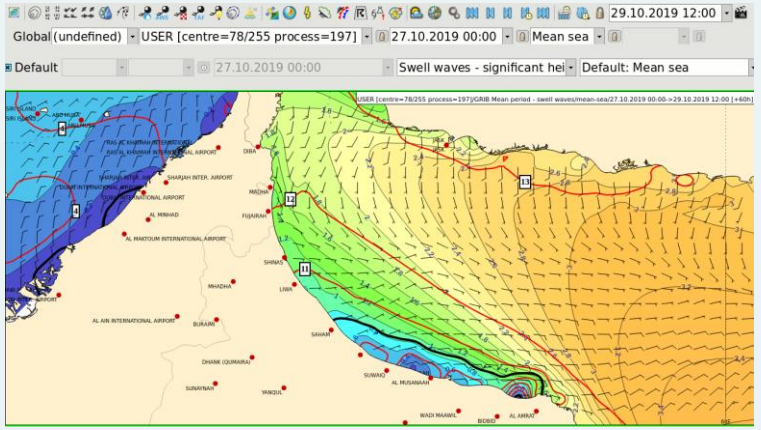
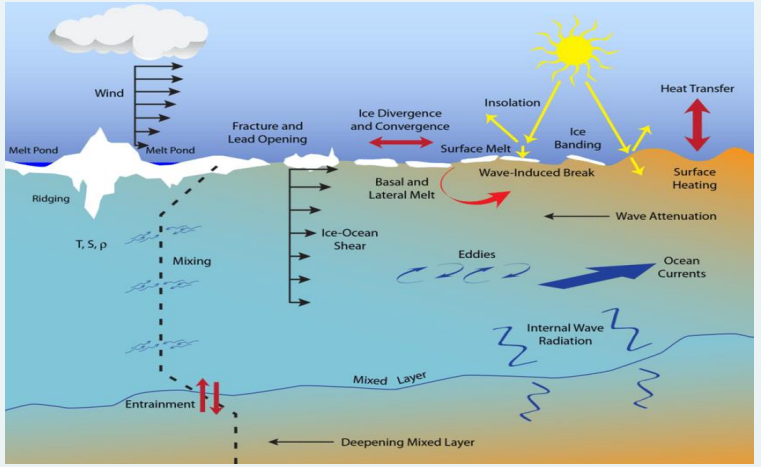
NWP Wave





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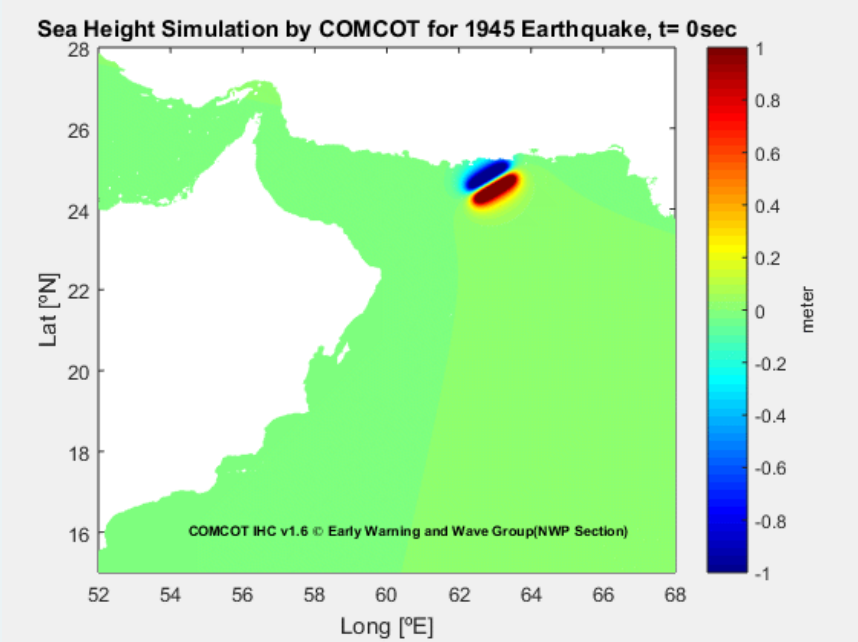
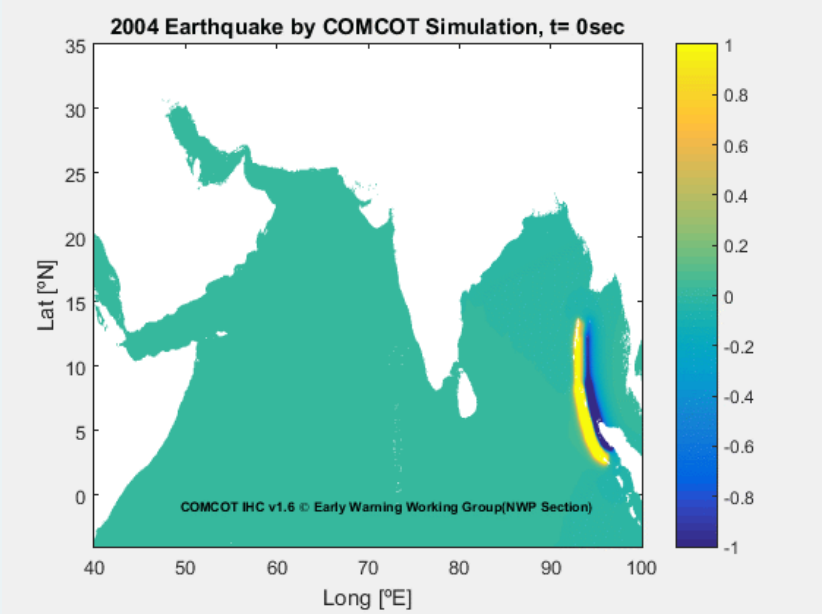
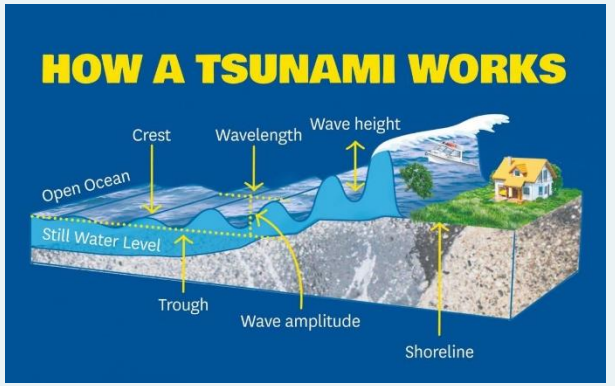
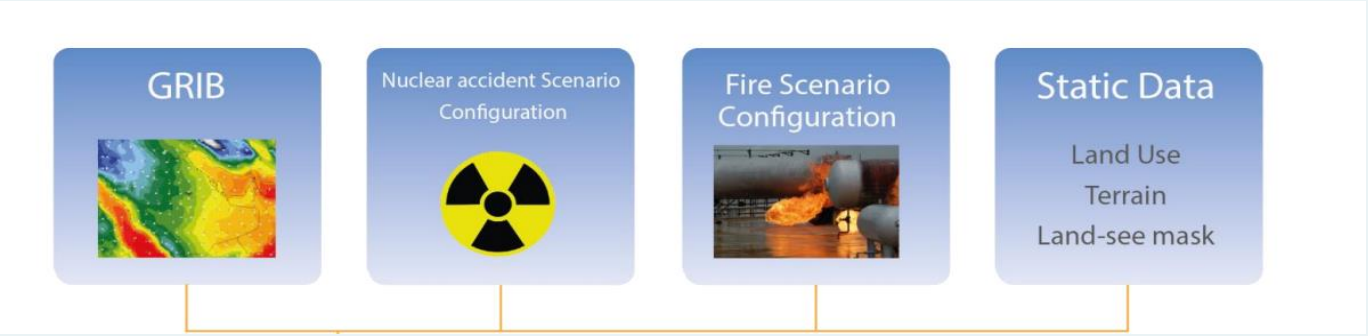
Tsunami models

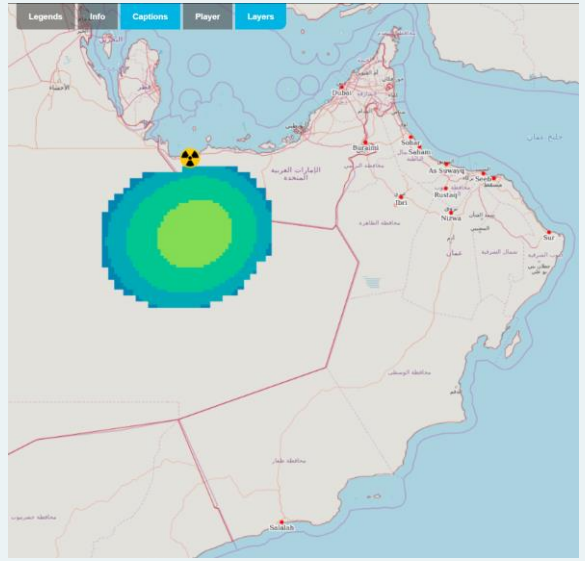






Fire and desperation model





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Guidance in Using NWP

1- Verify each of the models you are intended to use

2- Use different NWP sources, as many as you could

3- Remember the error margin when you do the forecast

Guidance in Using NWP

using Numerical Weather Prediction (NWP) models can be a powerful tool for obtaining weather forecasts and understanding atmospheric conditions. Whether you're a meteorologist, a researcher, a decision-maker in an industry impacted by weather, or simply an enthusiast, here's some guidance on how to effectively use NWP models:

Understand the Basics:

- Familiarize yourself with the fundamental concepts of NWP, including how the models work, the equations they solve, and the parameters they forecast.

Accessing NWP Data:

- NWP data is often publicly available from meteorological agencies, research institutions, and weather services. Identify reliable sources of NWP data relevant to your region and needs.

Choose the Right Model:

- Select an NWP model appropriate for your specific application. Consider factors like spatial and temporal resolution, the area of coverage (global, regional, or local), and the lead time you require.

Data Assimilation:

- Understand the data assimilation process. NWP models rely on real-world observations to initialize the forecast. Evaluate the quality and frequency of observational data used in the model.

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Guidance in Using NWP

Ensemble Forecasting:

- Consider using ensemble forecasting techniques, which involve running the model multiple times with slightly different initial conditions or model configurations. Ensembles provide a range of possible outcomes and can help quantify forecast uncertainty.

Verification and Skill Scores:

- Verify the accuracy of NWP model forecasts against observed weather conditions. Various verification and skill score methods are available to assess forecast quality.

Visualization Tools:

- Utilize visualization tools and software to display NWP model data in a user-friendly manner. Visualization can aid in understanding and communicating the forecast information.

Local Knowledge:

- Combine NWP data with local knowledge and expertise. Local factors, such as topography and microclimates, can significantly influence weather conditions and may not be captured accurately in global or regional models.

Continuous Learning:

- NWP is a rapidly evolving field. Stay updated with the latest advancements, model upgrades, and research findings to enhance your forecasting skills.

Errors of the NWP

- Due to model formulation.
- Due to uncertainty in the initial state.
- Due to errors in lateral boundary conditions.
- Due to uncertainties in soil fields (soil temperature and soil water content, …).

Decision-Making:

- If you're using NWP for decision-making in fields like agriculture, aviation, or emergency management, be aware of the limitations and uncertainties associated with model forecasts. Consult with experts if necessary.

Emergency Situations:

- In emergency situations, such as severe weather events, consult official weather advisories and warnings from local meteorological agencies, as their forecasts are typically based on a combination of NWP data and expert analysis.

Collaboration:

- Collaborate with meteorologists and experts in the field. Meteorological professionals can provide valuable insights and guidance on using NWP effectively.

Thank you

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