Applications of the Meteorology VO in the frame of SEE-GRID-SCI project

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Meteorology VO - Applications

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- **Regional scale Multi-model, Multi-analysis ensemble forecasting system - REFS**
  - Greece: National Observatory of Athens (NOA).
  - Serbia: South Environment and Weather Agency of Serbia
  - Montenegro: Hydrometeorological Institute of Montenegro

- **Interaction of airflow with complex terrain WRF-ARW**
  - Croatia: Ruđer Bošković' Institute of Zagreb, Department of Geophysics - 'Andrija Mohorovičić' Geophysical Institute of the University of Zagreb, Faculty of Graphical Art of the University of Zagreb
  - Bosnia and Herzegovina: Federal Hydro-Meteorological Institute
  - Bosnia and Herzegovina: Republic Hydrometeorological Institute
  - Georgia: GRENA

Meteorology VO Applications - Why using the GRID

- Advances in numerical weather prediction (NWP) and related applications have been always very closely related with advances in computing sciences as NWP requires numerical calculations that are also parallelizable.
- The computer resources needed for NWP applications are important both in terms of CPU usage and disk storage.
- Although many institutions are working/ have experience on NWP, they may not have access to the necessary computer resources
- The porting of any NWP application to the grid is a natural choice.

Regional scale ensemble forecasting system - Introduction

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Application problem description

- Lorenz in 1963 discovered that the atmosphere, like any dynamical system with instabilities has :

  "a finite limit of predictability even if the model is perfect and even if the initial conditions are known almost perfectly".

- In addition it is known that neither the models nor the initial conditions are perfect
- Problem: deterministic forecasts have limited predictability that relates to the chaotic behaviour of the atmosphere
- Solution: base the final forecast not only on the predictions of one model (deterministic forecast) but on an **ensemble** of weather model outputs

Regional scale ensemble forecasting system - Introduction

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MULTI-ANALYSIS ENSEMBLE:

based on perturbing the initial conditions provided to individual models, in order to generate inter-forecast variability depending on a realistic spectrum of initial errors

1 forecast model "driven" by various initial conditions

MULTI-MODEL ENSEMBLE:

based on the use of multiple models that run with the same initial conditions, sampling thus the uncertainty in the models

Many forecast models "driven" by the same initial conditions

Regional scale ensemble forecasting system - Description

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In the frame of SEEGRID project the regional infrastructure in the area of South Eastern Europe will provide the environment for the development and deployment of a *Regional scale Multi-model, Multi-analysis ensemble forecasting system*.

This system will comprise the use of four different weather prediction models (multi-model system).

- BOLAM, MM5, NCEP/Eta, and NCEP/WRF-NMM

- The models will run for the same region many times, each initialized with various initial conditions (multi-analysis) ➡ Production of a multitude of forecasts

Regional scale ensemble forecasting system - Description

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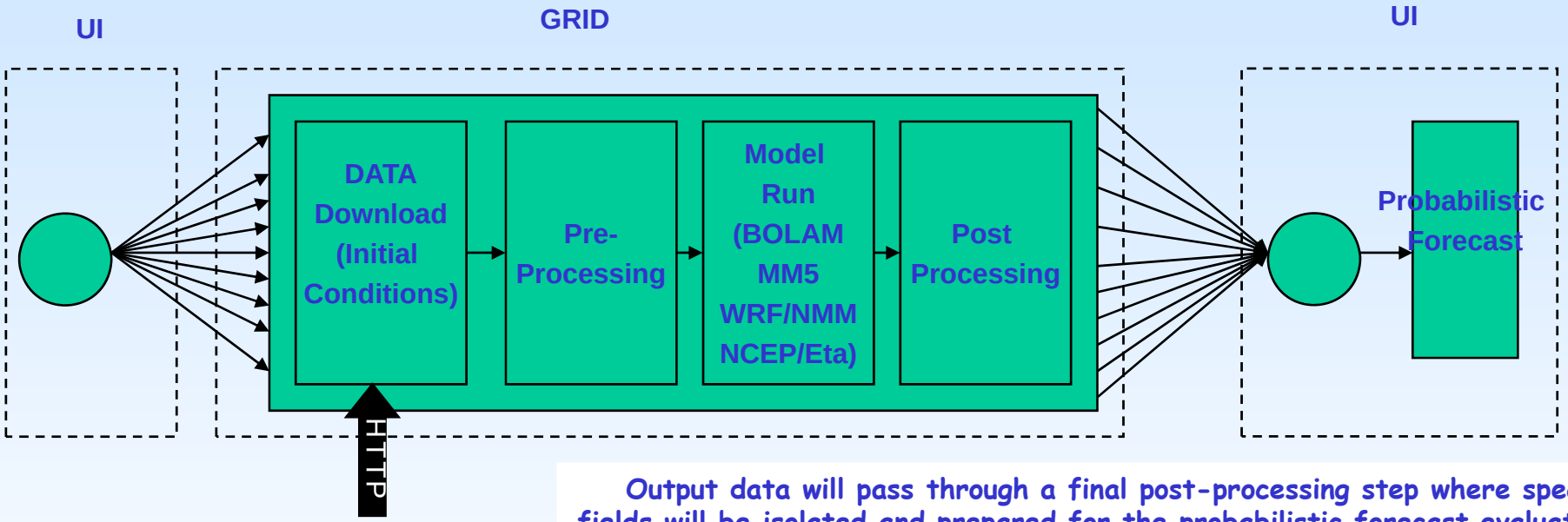
- BOLAM serial code:
  - 10 ensemble members over Europe with 10 different initial conditions (multi-analysis)
  - need of 10 available CPUs around noon local time for about 1 hour (clock-time) depending on the Worker Nodes performance.
- MM5, WRF/NMM, NCEP/Eta paralellized codes using MPI:
  - 10 ensemble members over Europe for each model
  - need to run 10 MPI jobs for 2-3 hours with at least 10 CPUs per job every day about noon time

Regional scale ensemble forecasting system - Workflow



Output data will pass through a final post-processing step where specific fields will be isolated and prepared for the probabilistic forecast evaluation.

Output from each job will be collected from the WNs (all jobs completed) and passed to the final step that will run locally in the UI and will produce the final probabilistic forecast

Regional scale ensemble forecasting system – Challenges

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- Grid Response times for
  - Resource allocation
  - Job Scheduling and execution
- Proper MPICH support (for the parallelised codes: MM5, WRF/NMM, NCEP/Eta)
- Resource availability
  - 10 CPUs for BOLAM, shouldn't be a challenge, but 

Regional scale ensemble forecasting system – Challenges

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- Resource availability
  - 3*~10*10 CPUs for the other 3 models execution maybe difficult to allocate within the required time limits
  - MM5 sensitive to memory leaks - 2GB+ free memory required from WNs
  - Should be also the case for NCEP/Eta and WRF/NMM
- Storage Requirements
  - ~650MB disk space in WNs for initial+output data
  - Typically small size of output files (~1-2 MB)
  - may require storage for archiving

Regional scale ensemble forecasting system – target community

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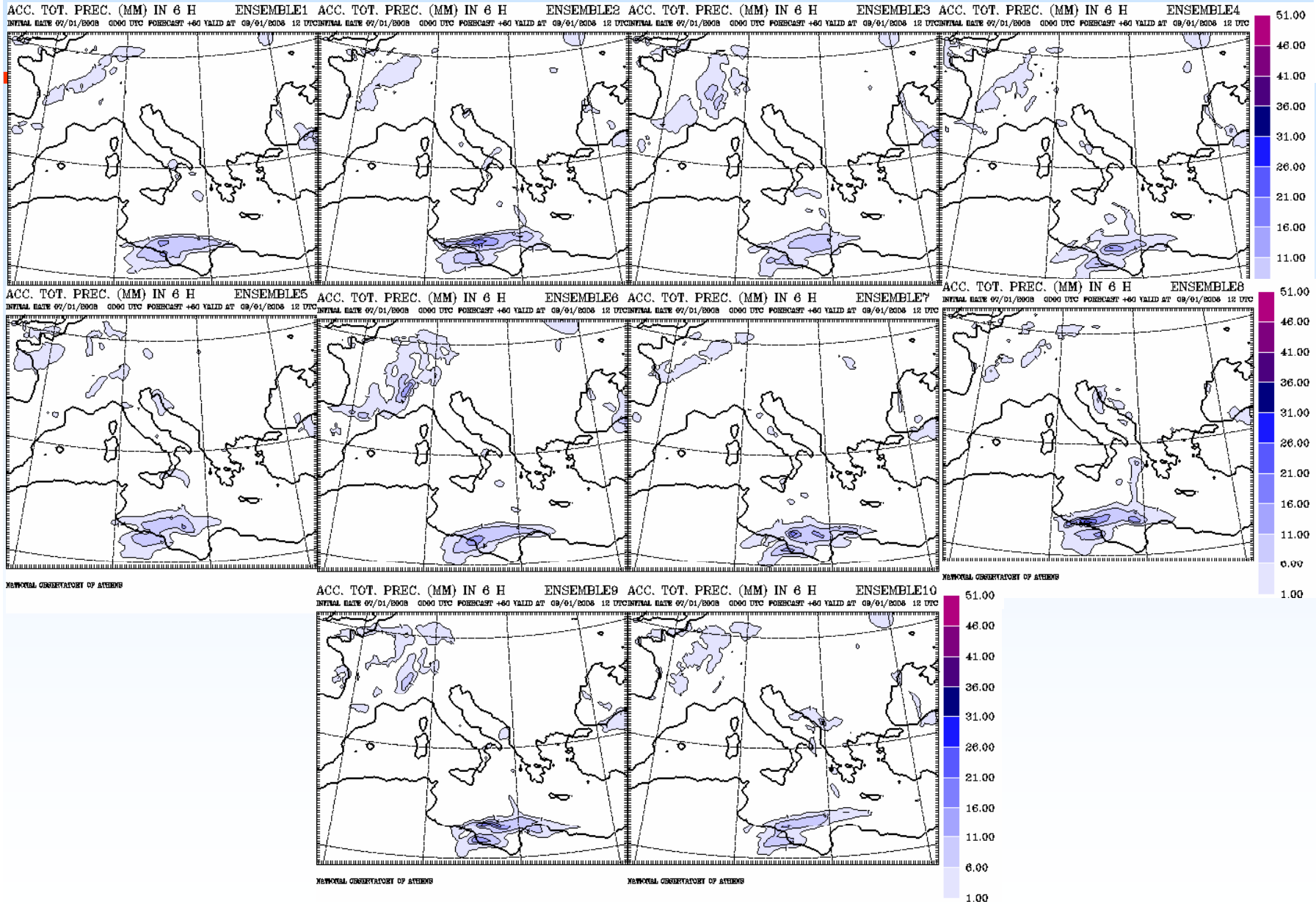
- The final product of the application aims at assessing the probability of a particular weather event to occur and to provide this information
  - to the authorities,
  - the general public, etc,

  in order to help them make the necessary decisions based on this probabilistic information.

  The target community is the general public, the Civil Protection and the Administrations of the Electric Power Distribution and other relevant end-users.

PRECIPITATION FORECASTS: BOLAM 10 members



Example of probabilistic forecasts

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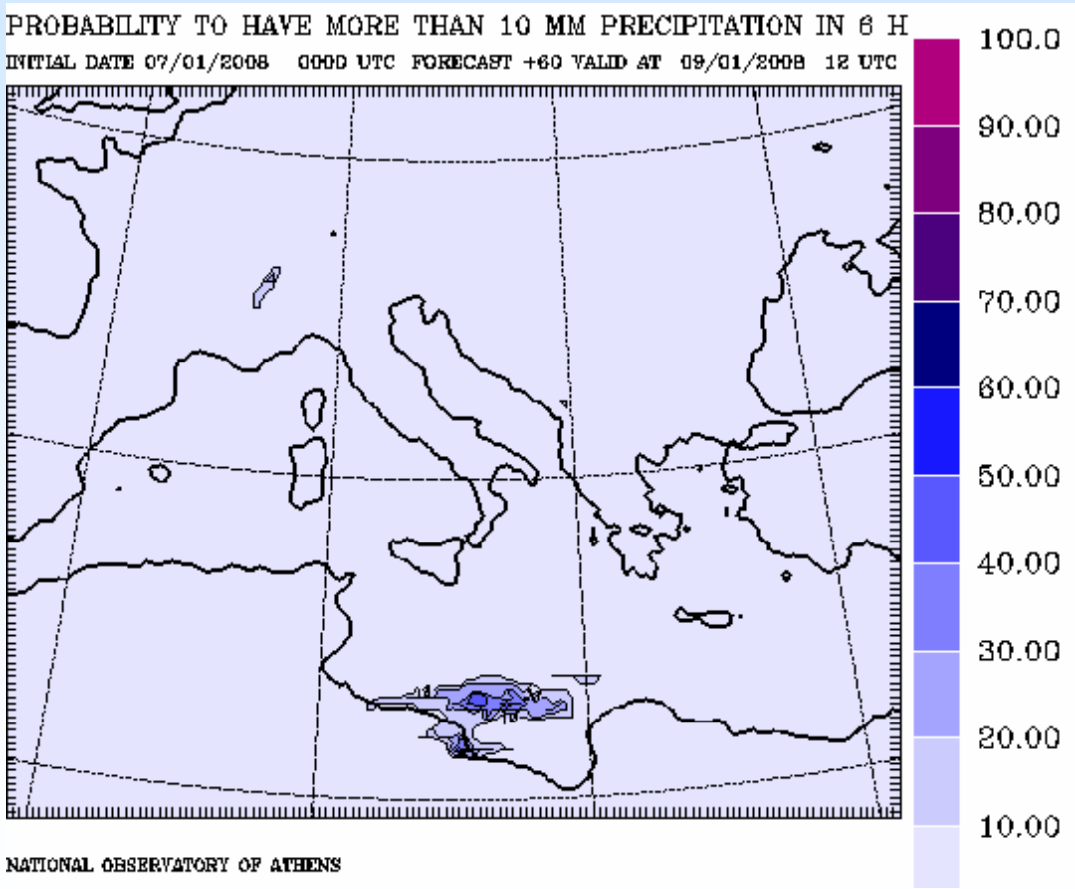
From the multitude of model outputs probabilistic forecasts can be issued like:

Probability of more than:
-1mm of rain
- 5 mm of rain
-10 mm of rain

Probability of exceedance of a temperature threshold

Probability of exceedance of a wind speed threshold



WRF-ARW application – Introduction

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- Application problem description
  - Atmospheric processes over complex terrain bear numerous difficulties in both numerical weather prediction and research
  - The purpose of the application is to study the interaction of airflow with the complex terrain, using high resolution simulations with WRF (Weather Research & Forecasting) model
  - All involved countries (CRO, BiH and Georgia) are characterised by large areas with terrain obstacles.

WRF-ARW application – Introduction

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- In the frame of SEE-GRID-SCI project the WRF – ARW will be ported to the GRID
  - The WRF system is a public domain weather model and is freely available for community use. It is designed to be a flexible, state-of-the-art atmospheric simulation system that is portable and efficient on available parallel computing platforms. WRF is suitable for use in a broad range of applications across scales ranging from meters to thousands of kilometers.
- Leading partner: RBI – Rudjer Boskovic Institute

WRF – ARW expected results

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- Expected results and their consequences
  - Estimating the effect of improved resolution on the numerical weather prediction quality and improving the forecasting skill
  - Get faster and more reliable weather forecasting model
  - Operational weather forecast at high resolution for BiH
  - Expanding user community that will be able to investigate advances of the model on the grid infrastructure.
- Possible scientific – societal impact
  - Better prognostic and research model for futher scientific applicance
  - the social impact for community includes the improved weather forecast over the region of interest

METEOROLOGY VO APPLICATIONS - Time Plan

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Up to June2009:

- For the REFS application the pilot version of each regional ensemble forecast system will have been ported to the GRID
- WRF –ARW model will have been also ported to the GRID