



National Research Council of Italy



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**Moloch: a numerical meteorological model for
weather forecasting and scientific research**



Moloch is a model developed by the hydrodynamic modelling group at the CNR-ISAC in Bologna.

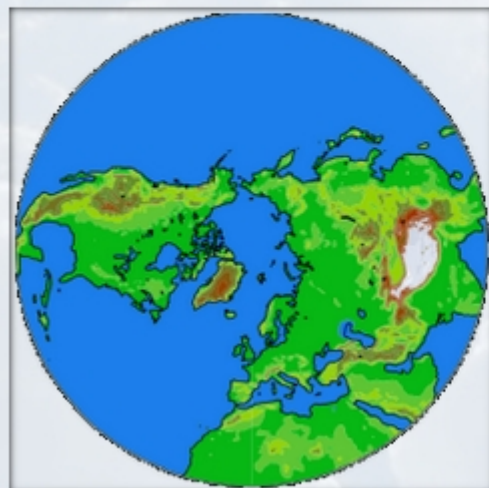
This group represents the Italian national scientific school in the field of studying physical and dynamic processes in the atmosphere and the physical and mathematical modelling of these processes. The scientific school was formed in the 1980s at the CNR in close cooperation with the Air Force Meteorological Service, which is the Italian national meteorological service.

The scientific school has created a whole range of meteorological models: hydrostatic limited area model, “**Bolam**”; non-hydrostatic limited area model, “**Moloch**”; and hydrostatic global model, “**Globo**”. All developed models have been thoroughly tested and used in numerous national and international projects of both scientific and applied nature.

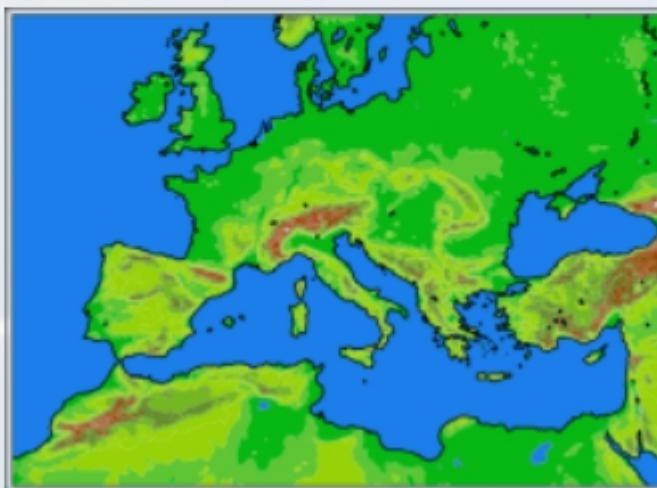


Previsioni meteorologiche CNR-ISAC GLOBO - BOLAM - MOLOCH forecasts

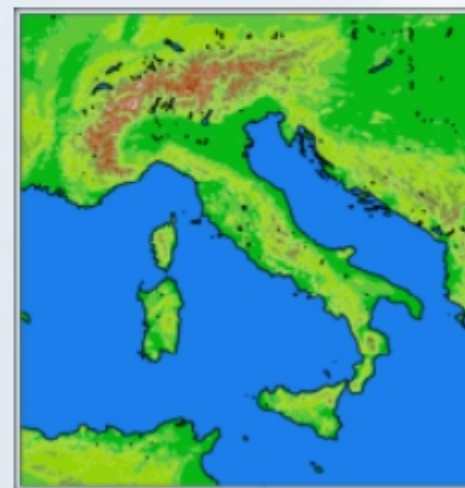
CNR-ISAC, Bologna



GLOBO, 19 km
7 days



BOLAM, 8.3 km
3 days



MOLOCH, 1.25 km
2 days

Globo monthly forecasts

Blended precipitation

Bolam cross-sections

Bolam meteograms

Moloch high res. wind

Moloch cross-sections

Moloch meteograms

Presso l'Istituto [CNR-ISAC](#), sede di Bologna, sono prodotte quotidianamente previsioni numeriche utilizzando i modelli meteorologici sviluppati nell'ambito delle ricerche in meteorologia dinamica (tema di ricerca [CAMEO](#)). Le previsioni sono effettuate a supporto della ricerca sulla circolazione e composizione dell'atmosfera e per la sperimentazione ed il miglioramento della modellistica meteorologica dalla scala globale a quella locale. Questa attività è svolta nell'ambito di un'Intesa con il [Dipartimento della Protezione Civile](#) (DPC) nazionale.

At the [CNR-ISAC](#) Institute in Bologna daily numerical forecasts are issued, by applying the meteorological models developed in the context of research in dynamic meteorology (research field [CAMEO](#)). The forecasts are produced in support of research on the atmospheric circulation and composition and in order to test and improve the meteorological models operating from the global to the local scales. This activity has been set up as part of an agreement with the [National Department of Civil Protection](#).



The **dynamic core**, **numerical solution algorithm**, and most of the **parameterisations of the physical processes** of the models are original **developments** of the ISAC's research group.

The models are easy to set up for any part of the world and offer flexible parameter configuration. These models are internationally recognised as some of the most advanced meteorological models, meeting all the requirements of the **latest advances** in hydrodynamic numerical modelling of the atmosphere.

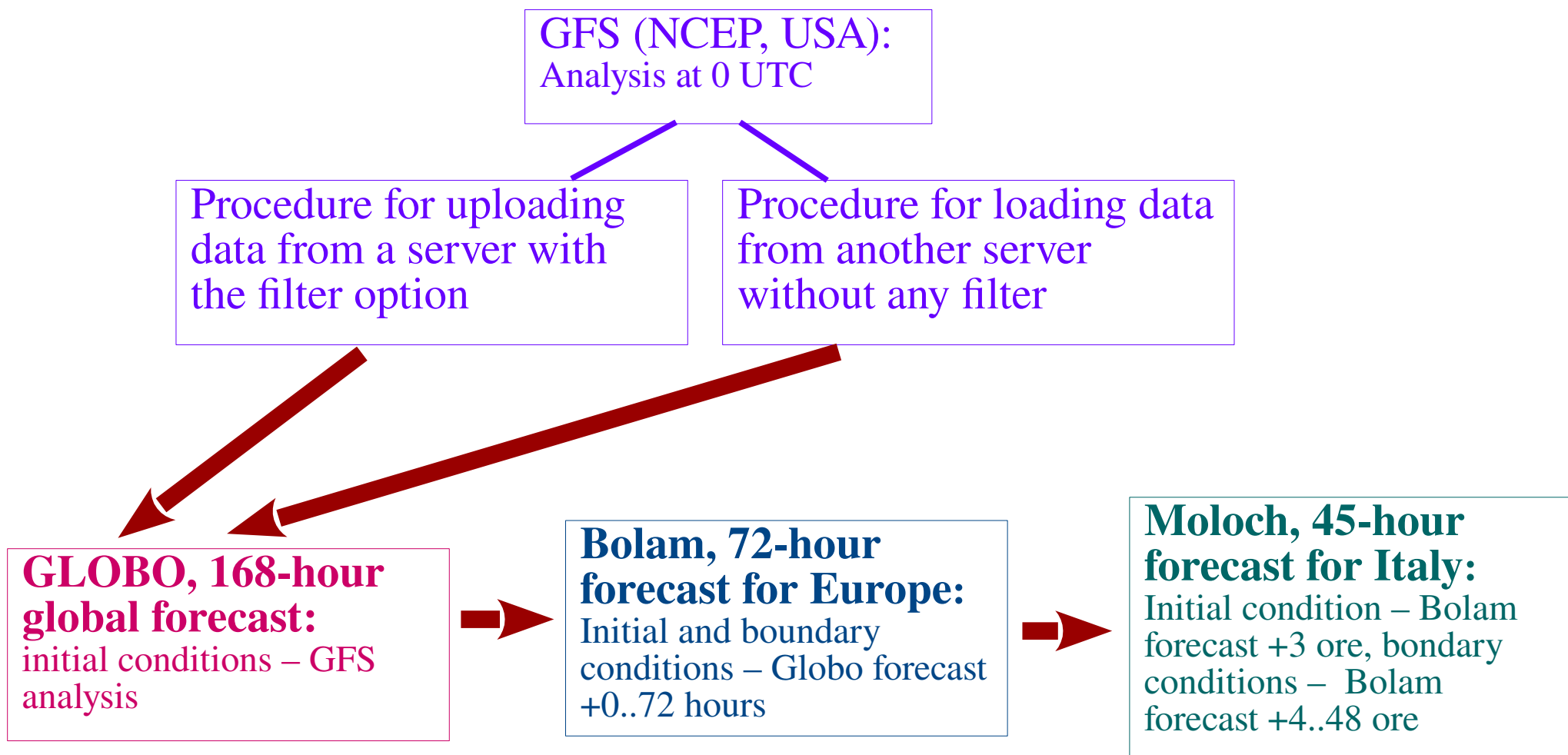


The Moloch model is successfully used for operational meteorological forecasting at national institutes: the Italian Institute for Environment Protection and Research (**ISPRA**) and Environmental Monitoring and Modeling Laboratory for the Sustainable Development (**LaMMA**), as well as regional meteorological services in **Liguria**, **Sardinia**, and **Lombardy**. Since 2008, the Moloch model has been used by the CNR-ISAC for operational numerical weather forecasting on the national domain for the National **Department of Civil Protection**, in close collaboration with the Department's weather forecasting division.





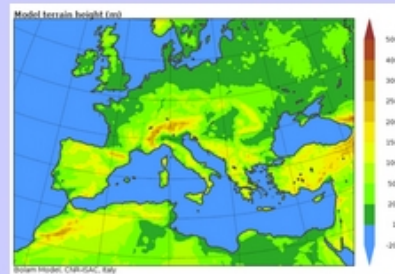
Daily operational numerical forecast chain using ISAC's models for the National Civil Protection Department:



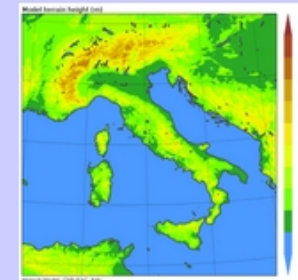


Short and medium range weather forecasts made by the NWP models of CNR-ISAC

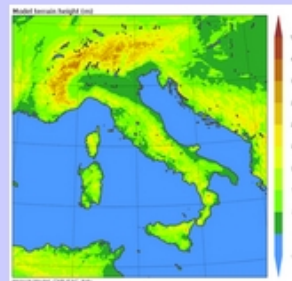
BOLAM: Europe, 3 days



MOLOCH: Italy, 2 days

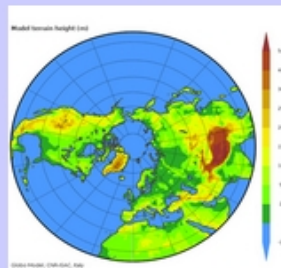


BOLAM + MOLOCH: blended precipitation

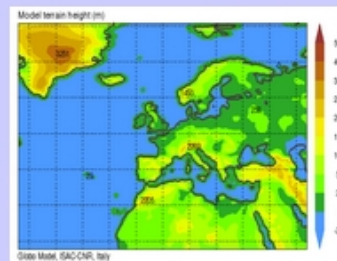


MOLOCH: snow cover products

GLOBO: Northern Hemisphere, 7 days



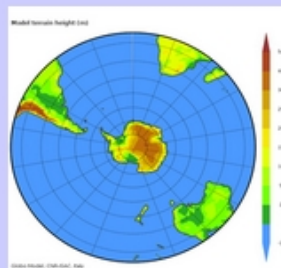
GLOBO: Europe, 7 days



GLOBO: Italy, 7 days



GLOBO: Southern Hemisphere, 7 days





The Moloch model has been used in **numerous scientific projects** carried out directly by the ISAC's research team and by meteorological centers with which the institute cooperates.

The Moloch model was developed for scientific research and is characterized by its **flexibility in terms of configuration and module upgrades**. This model has been used in scientific and applied projects in **various parts of the world**: in the Sahel, the Amazon basin, Siberia, Alaska, the Norwegian sector of the Arctic Ocean, Antarctica, Central Europe, and, of course, the Mediterranean region.



In addition to its characteristics related to adaptability to scientific research and geographical areas, Moloch is distinguished by its **very high computational efficiency**.

One example of execution **time comparison** between **WRF** and **Moloch** models according the study in LaMMA Consortium:

<http://www.lamma.rete.toscana.it/modelli/atmo/bolam-e-moloch-info-sui-modelli>

The same forecast runs performed by WRF and Moloch model: Moloch has a more narrow horizontal spacing and demonstrates execution time in **2.6 times better**.

Over the past year, the numerical algorithm has been improved and now uses 15% fewer resources.

Modello	Risoluzione	Dominio (NXxNY)	Livelli Verticali	Time-step	Numero di processori utilizzati *	Tempo di calcolo x 24 ore di simulazione (minuti)
WRF	3 km	400x440	50	20	106 / 108	44
MOLOCH	2.5 km	498x626	50	22.5	96 / 108	17

* Not all available nodes (108) are used for model run because of some nodes are used for output product creation in real time, also Moloch has some restrictions for number of calculation cores used depending on domain grid points number.



Unfortunately, the ISAC's scientific school and its scientific and practical developments and achievements have not enjoyed institutional support (CNR, national meteorological service) over the last two decades. Nevertheless, the **scientific team continues its work successfully**, and the **models are constantly being developed and improved**, largely thanks to the support of the Department of Civil Protection and colleagues from regional and national scientific and practical centres.

Source code:

The complete **sources code of the CNR-ISAC NWP models** (Bolam, Moloch, Globo) is **freely available** in the repository:

<https://gitlab.com/isac-meteo/globo-bolam-moloch>

The **forecast verification scores** of CNR-ISAC NWP models for the meteorological variables and comparisons of this scores with the IFS-ECMWF scores over a long period can be seen here:

https://www.isac.cnr.it/dinamica/projects/forecast_verif/

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