Local Ensemble Prediction Systems in the SIM Project

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METEO EXPERT
Meteo Operations Italia (MOPI) srl

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Via XX Settembre, ROME, Italy

METEO EXPERT (formerly known as Centro EPSON Meteo until 2018)

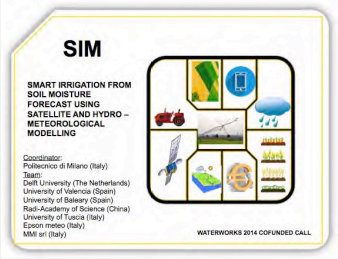
* An Applied Research Centre

_ Internal and external multi-cluster computing centre for sophisticated operations

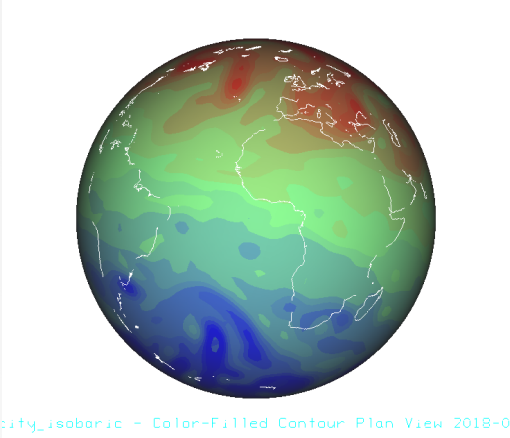
_ National and international collaborations on scientific projects

_ Weather and climate modelling research and simulations.

_ Provide data and services to all major companies



* An advanced Centre for weather forecast from global to local scale

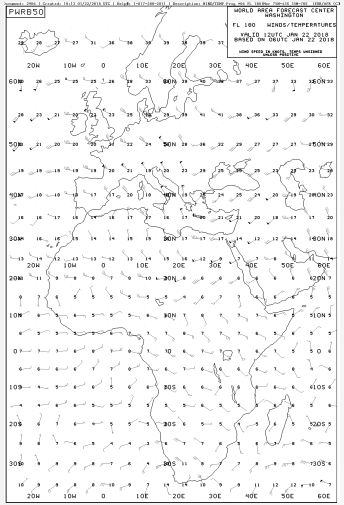


_ Operative group of atmospheric physicists

_ Synergy between research and executive processes

_ At the service of the main industry, service and media companies

- ENAC/EASA Certified for ANSP-MET aviation data



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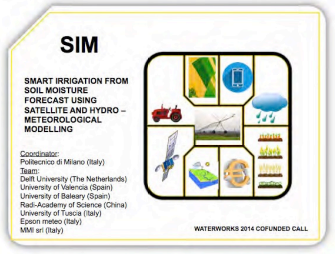
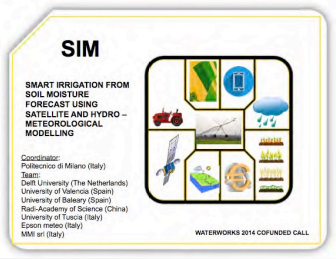
Resume of CEM activities



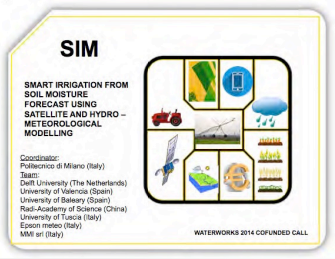
- In SIM-WaterWorks2014 METEO EXPERT (Centro Epson Meteo until 2018) trade mark of Meteo Operations Italia, which provides meteorological and climate services) has been involved in the generation of high-resolution weather forecasts.
- A Local Ensemble Prediction System (LEPS) has been applied to the SIM studied areas in Italy. The system provides probabilistic forecasts to be used in any other application. This LEPS has been upgraded during 2018.
- Tests have been made at the global scale about predictability and weather parameters performance.
- All LEPS ensemble members forecasts have been provided to SIM projects for the aim of the project. After upgrade whole domain over Italy has been provided for all applications.
- Analyses of LEPS performance have been made for selected parameters

Agenda



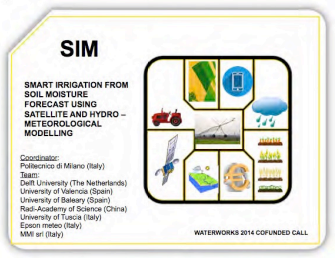
- Introduction.
- Modeling systems
  - From Global to Local Prediction
  - LEPS
- LEPS Upgrade
- Conclusions

Introduction

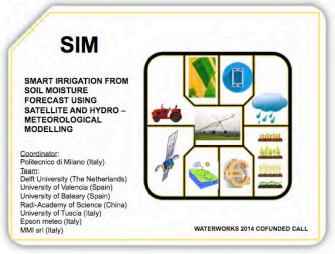


- Three EPS in the last years:
  - **A Multi-Model Global Ensemble**
  - A Regional Ensemble Prediction System
    - Used in the Project Pre.G.I.
  - **Local Ensemble Prediction Systems**
    - Used in SIM

Global Multi-Model Ensemble Prediction System



The starting point is the construction of a Multi-Model Ensemble, based on the two operational global ensembles and a few deterministic models used in the multi-model. This Global Multi-Model Ensemble Prediction System is then based on a mixing of global models from main centres, including ECMWF, NCEP, DWD and Meteofrance.



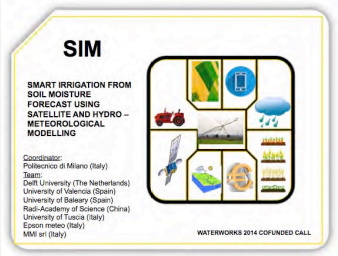
Why a Global Multi-Model Ensemble ?

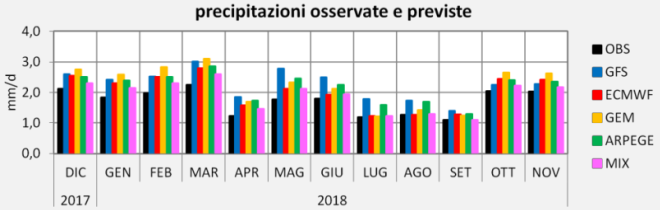
- The reason for creating a multi-model forecasting system is that research has consistently shown that better and more reliable forecasts can be created by combining the output from several models, rather than taking just one model. In most cases, the multi-model combination is better than the best single model
- Even if this is especially true in the extended and long range, several benefits are evident in the short and medium range forecasts

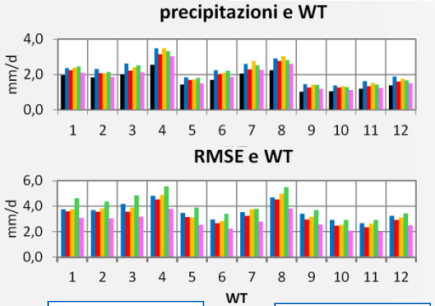
Mix vs. single models

Global ensemble mean (Mix):

some individual model performance







I modelli sovrastimano:

1) la quantità, soprattutto

✓GEM → precipitazioni sinottiche da ottobre a marzo

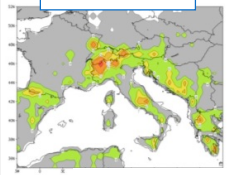
✓GFS & ARPEGE → piogge convettive dei mesi più caldi

2) la frequenza degli eventi estremi, soprattutto

✓ARPEGE

ARPEGE - RMSE

MIX - RMSE

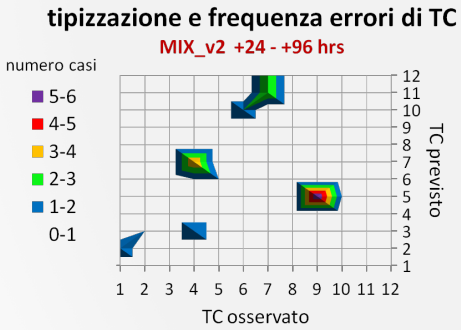


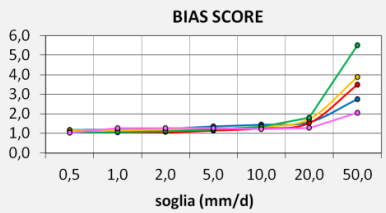
MIX & ECMWF sono i più abili a prevedere:

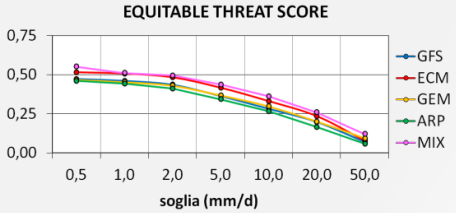
✓ la quantità di precipitazione, ovunque e con tutti i WTs

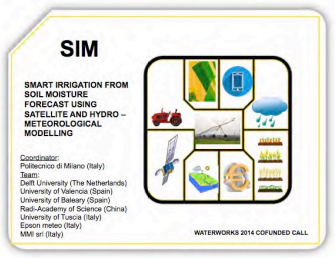
✓ la distribuzione spaziale di tutti gli eventi di precipitazione

ARPEGE è il meno abile







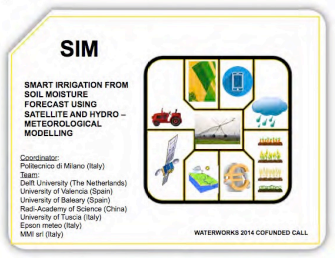


The clustering procedure

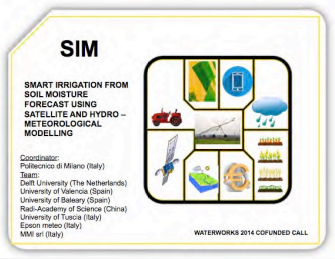
The first step of the procedure to arrive to local ensemble is the application of a Cluster Analysis procedure to all output of global models.

Number of cluster are fixed.

From Global EPS to LEPS in the SIM Project

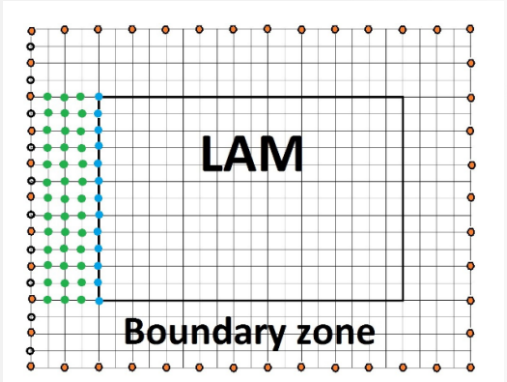


- Multivariate hierarchical cluster analysis
- Clustering variables: geopotential height, temperature, horizontal wind and the humidity at two pressure levels (500 and 850 hPa) and at two forecast times (12h time lagged).
- Domain for regional application: 30N-60N and 10W-35E
- Clustering times: frc+72 and frc+96
- Within each cluster, one RM is selected according to the fact that the each RM must be the element closest to the members of its own clusters and most distant from the members of the other clusters
- A reduced number of cluster may give advantages in the computations, however the results may be somewhat degraded. On the contrary, a higher number of clusters may be computationally expensive and it is not necessarily able to make the system more predictable.



From Global EPS to LEPS in the SIM Project

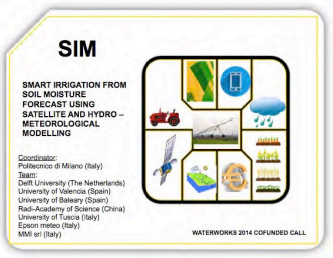
- Each RM provides boundary conditions for the integrations of each member of LEPS.
- It has been assumed a relationship between cluster population and the probability of occurrence of its associated RM, and probability maps were generated by assigning to each model integration a weight proportional to the population of the cluster from which the RM was selected.
- It is also necessary to take into account the distance between extreme members of each cluster. Hence, the weight assigned to each model integration is proportional to the population of the cluster and inversely proportional to the distance between the extreme members of the cluster



First LEPS application in the SIM Project

Based on a combination of three models (two based on WRF, Skamarock et al., 2008), the third is based on the latest version of ETA model (Mesinger, 2012). The two-based WRF code uses different physics options (WRF Thompson 6-class scheme for microphysics ,Thompson et al., 2008;, the RRTMG Scheme for shortwave and long-wave radiation, Iacono et al., 2008; the QNSE scheme for planetary boundary layer ,Sukorianski et al., 2005) and the Noah land surface model. Convection is not explicitly resolved in the simulations For ETA model the physics options are, among others, a modified Kain-Fritsch (Kain 2004) convection scheme and the Ferrier scheme (NOAA, 2001) for cloud mycrophysics. Turbulence and PBL use Mellor-Yamada 2.5, and Monin-Obukhov similarity theory in the surface layer, with Paulson stability functions.

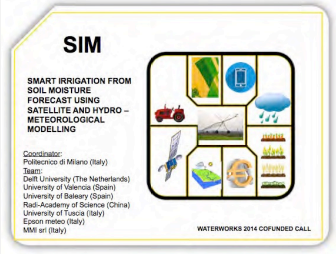
•Data provided on limited areas around Capitanata (Puglia region) and Chiese Basin (Lombardia)



Updated LEPS application in the SIM Project

- Based on a combination WRF-ARW
- Resolution passed from 5.5 km and 48 levels to 3.5 km and 60 levels
- Data provided all over Italy for any present or future application

ens	mphysics	shortwave	longwave	cu	pbl	clay	landsurface	maxtstep	hybrid coord	bldt(min)
	8	1	1	1	1	91	1	40	2	5
1	Thmopson	Dudhia	Dudhia	KF	YSU	MM5	5 layer thermal			
	5	1	1	1	4	4	2	45	2	5
2	Ferrier	Dudhia	Dudhia	KF	QNSE	QNSE	NOAA			
	8	5	5	1	2	2	2	45	2	5
3	Thompson	NewGoddard	NewGoddard	KF	MYJ	Eta similarity	NOAA			
	5	4	4	2	7	1	4	55	2	5
4	Ferrier	RRTMG	RRTMG	BMJ	ACM2	Rev MM5	NOAA MP			
	6	1	1	2	7	1	1	60	2	5
5	WSM6	Dudhia	Dudhia	BMJ	ACM2	Rev MM5	5 layer thermal			
	6	1	1	2	1	91	4	45	2	5
6	WSM6	Dudhia	Dudhia	BMJ	YSU	MM5	NOAA MP			
	14	1	1	1	1	91	1	40	2	5
7	WDM5	Dudhia	Dudhia	KF	YSU	MM5	5 layer thermal			
	4	4	1	0	5	5	2	45	2	5
8	WSM5	RRTMG	Dudhia	NO-CU	MYNN2	MYNN2	NOAA			
	4	4	1	1	1	91	1	36	2	5
0	WSM5	RRTMG	Dudhia	KF	YSU	MM5	5 layer thermal			


SIM
SMART IRRIGATION FROM SOIL MOISTURE FORECAST USING SATELLITE AND HYDRO – METEOROLOGICAL MODELLING
Coordinator:
Politecnico di Milano (Italy)
Team:
Delft University (The Netherlands)
University of Valencia (Spain)
University of Baleary (Spain)
Rad-Academy of Science (China)
University of Tuscia (Italy)
Epson meteo (Italy)
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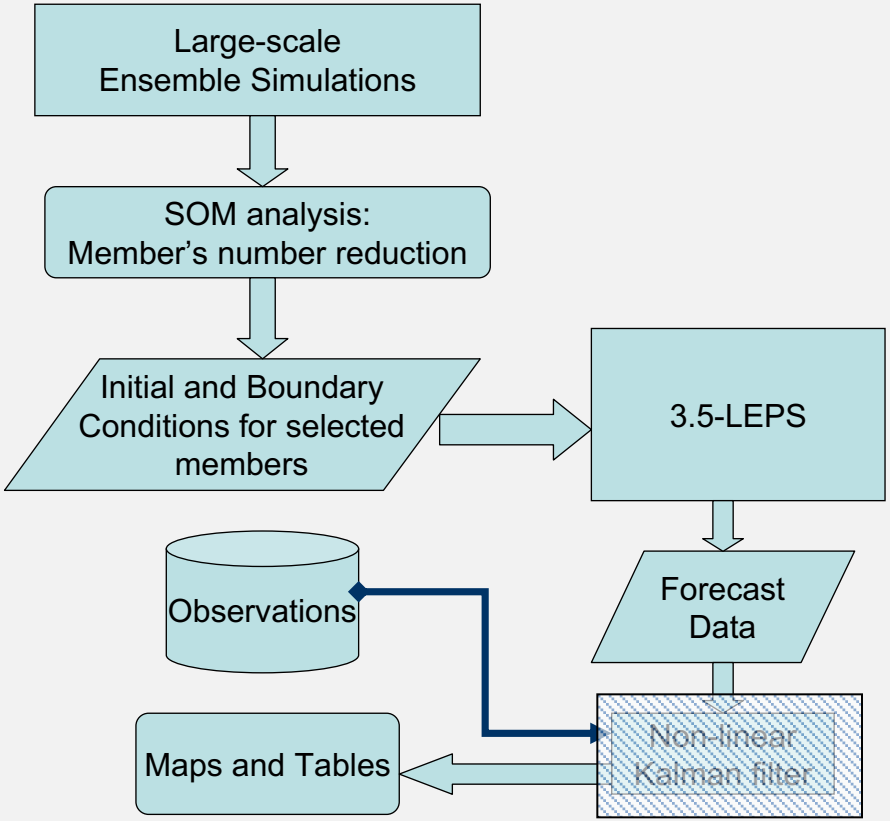
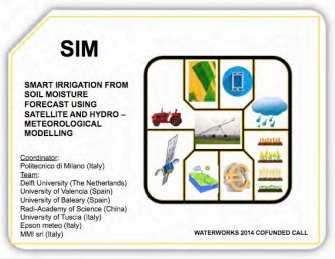
WATERWORKS 2014 COFUNDED CALL

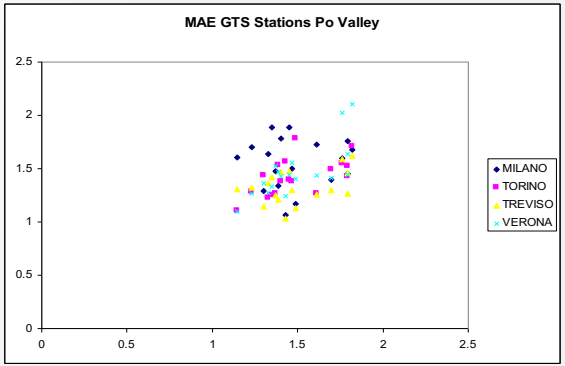

Large-scale Ensemble Simulations
SOM analysis: Member's number reduction
Initial and Boundary Conditions for selected members
3.5-LEPS
Observations
Forecast Data
Maps and Tables
Non-linear Kalman filter

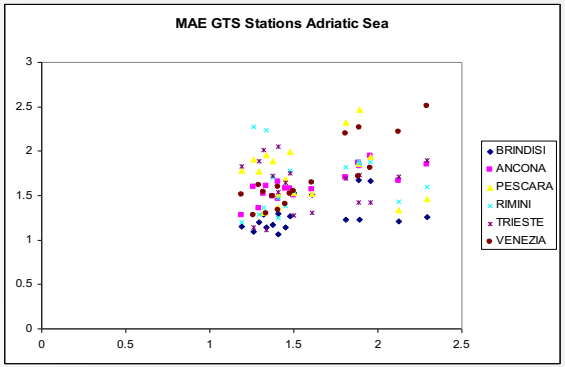
LEPS application in the SIM Project



• Test have been made for past event to analyze the ensemble performance and behavior, also in other projects. For example temperatures have been regularly checked against weather GTS stations measurements in the Po valley for the northern Italy and in the centre-south Adriatic region for Puglia area.

5.5-LEPS

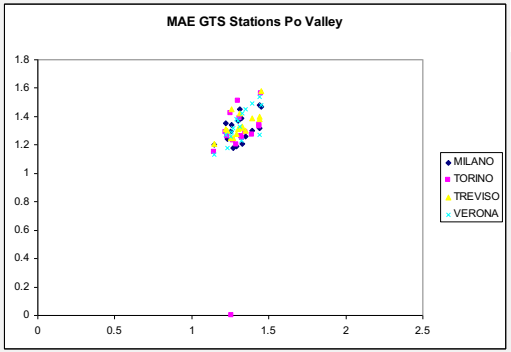


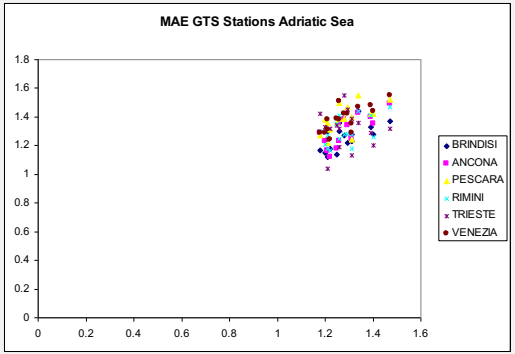


hourly MAE of ensemble mean in the Po Valley and forecast at 24-48 and 48-72 hours

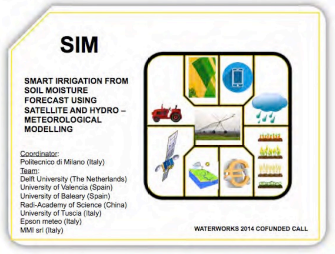
hourly MAE of ensemble mean in the Adriatic area and forecast at 24-48 and 48-72 hours.

3.5-LEPS

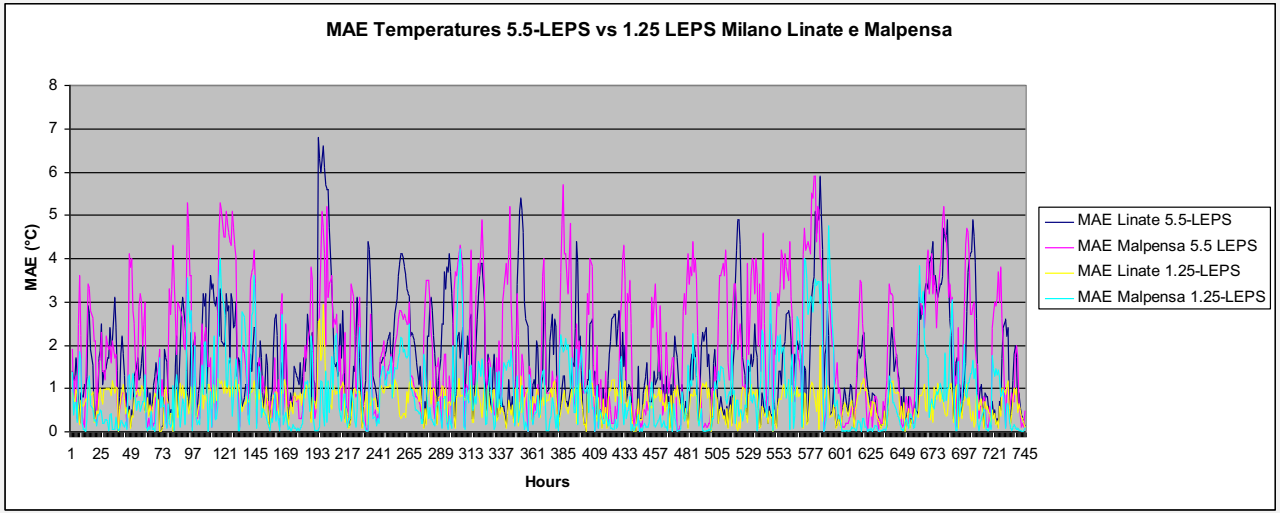




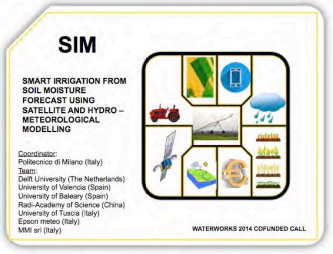
LEPS application in the SIM Project



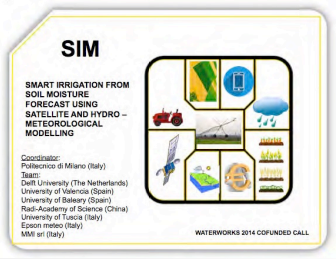
- Tests have been made at 1.25 km following the suggestions from another project.
- Retrospective tests for limited times in a sub-alpine area have been made and results have been compared to 5.5-LEPS



Conclusions

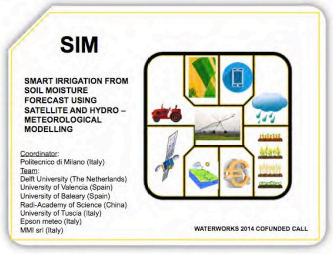


- Starting from a Multi-Model Global Ensemble, a Local Ensemble Prediction System (LEPS) has been applied to the SIM studied areas in Italy. LEPS have shown all capabilities for any operational application in a limited area.
- Developed in 2018 and became operational in early 2019, an upgraded LEPS has been applied to SIM
- Provided data have been extended to all Italy
- Some analyses of 3.5-LEPS results have been made showing improved performances compared to 5.5-LEPS
- Some retrospective tests have been made by a 1.25-LEPS (horizontal grid 1.25 km, 60 levels)



Future

- All forecast will be provided for present and future applications in the framework of the project and beyond
- Analysis of 3.5-LEPS performances routinely checked.
- We will continue supporting SIM Consortium



Thank you!

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