

# La modellistica previsionale del laboratorio LaMMA

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Consorzio LaMMA

Laboratorio di Meteorologia e Modellistica Ambientale per lo sviluppo sostenibile

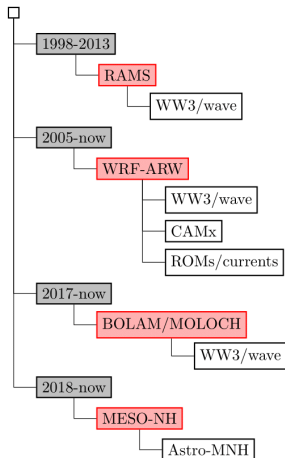
“A 25 anni dall’alluvione del Piemonte 1994”  
UPO - Alessandria - 6/Nov/2019

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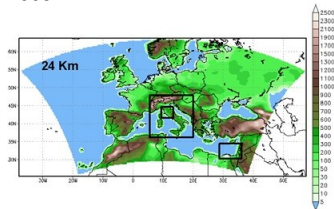
# LaMMA

Consorzio Regione Toscana (67%)/CNR (33%)

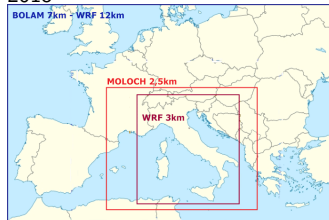
## Modelli NWP @ LaMMA



2003



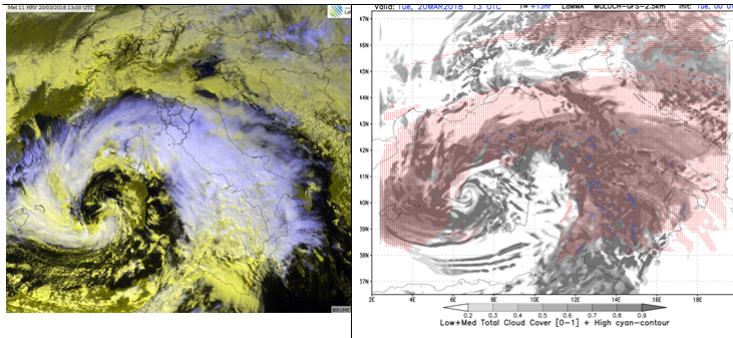
2018



1

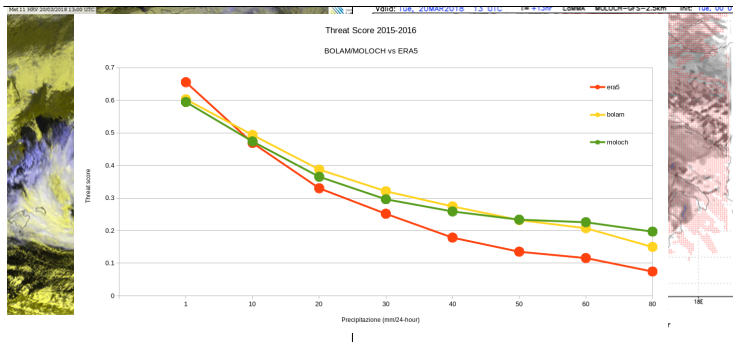
## Prodotti atmosferici operativi

- **ICs & BCs:** ECMWF, GFS
- **Init hour:** 00, 06, 12, 18 UTC
- **Resolution  $\Delta x$ :** 12km, 7km, 3km, 2.5km
- **Forecast length:** from 120 hours to 48 hours



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## Prodotti atmosferici - ricerca

**Firenze 1/Ago/2015:** severe weather, wind gust  $\gg$  100 km/h



$\Delta x = 2.5$  km



$\Delta x = 0.5$  km

# Prodotti mare

- Model WAVEWATCH III
- +120 ore
- altezza e periodo d'onda

Mar Mediterraneo,  $\Delta x = 10$  km

Mar Ligure,  $\Delta x = 2.5$  km

# Prodotti qualità dell'aria

- Model CAMx
- +60 ore
- PM10, PM2.5, Ozono, NO<sub>2</sub>

PM10

Ozono

## Data Center

- **Nr nodi**  $\simeq 24$
- **Nr CPU/Cores**  $\simeq 1050$
- **Processori età**  $\rightarrow 2012-2019$
- **Storage**  $\simeq 100$  TB
- **Personale**  $\simeq 2$  (!)
- **Consumo di energia**  $\simeq 30$  kW/h
- **Temperatura media ambiente**  
 $\simeq 26^\circ$  C
- **Dotazioni di sicurezza**  $\rightarrow$   
incendio, anti-intrusione,  
condizionamento, allarme guasti...





## Data Center | Nuovo cluster (2019) |

- **Nr nodi:** 32
- **Nr CPU/Cores:**  $32 \times 32 = 1024$
- **Storage**  $\simeq 75$  TB
- **Software** gestione delle code/job & risorse computazionali
- **Consumo di energia** ↗
- **Costi di assistenza** (eventuali) problemi hardware/software
- **Nuovi prodotti:** modelli su dominio Mediterraneo  $\Delta x=3$ km, data assimilation, ensemble dynamical downscaling, ...



## Inquadramento sinottico/mesoscala

- “October 1994 noticeable variability in the weather, with stormy precipitation and snowfall” (*Cassardo et al, 2002*)
- “meridional flow bringing moist and unstable air” (*Buzzi et al, 1998*)
- “**orographic precipitation && convective cells** embedded in ascending motion” (*Buzzi et al, 2000*)
- “exceptionally heavy precipitation from the 3 to 6 November 1994” (*Lionetti, 1996*)

## Elenco (incompleto) di esperimenti numerici per la re-forecast dell'alluvione in Piemonte Nov 1994

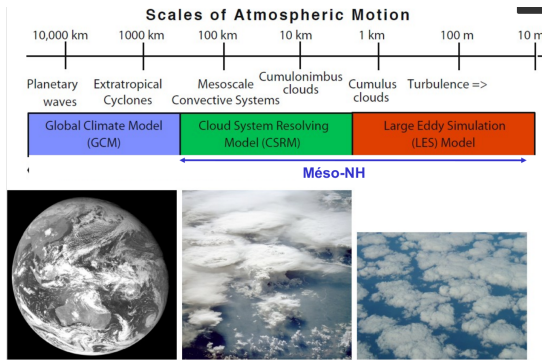
Reference	Model	Resolution	Vertical Levels	Forecast Length
Petroliagis et al 1996	IFS (EPS)	T213 (T63)	31 (19)	120 hours
Ferretti et al 1996	MM5	30&10 km	23	48 hours
Buzzi et al 1998 a,b	BOLAM	30&10 km	36	36 hours
Romero et al 1998	SALSA	20 km	30	30 hours
Jansa et al 2000	HIRLAM	40 km	31	48 hours
Cassardo et al 2002	RAMS	15 km	35	84 hours

Test di sensitività:

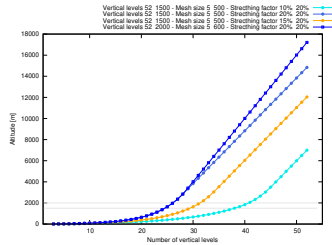
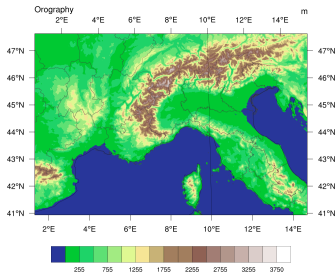
- no-orography, no-sea (*Cassardo et al, 2002*)
- orography=100 m, no latent heating (*Ferretti et al, 1996*)
- reduced-orography, no latent heating, no evaporative cooling, no condensational heating (*Buzzi et al, 1998*)
- ... etc ...

## Meso-NH model

A research model for **synoptic** ( $\Delta x \approx 100-10^3$  km), **meso** ( $\Delta x \approx 10-10^3$  km) and **micro- $\gamma$**  ( $\Delta x \approx 10^3-10^4$  m) scale, developed by CNRM (Meteo-France/CNRS) and Laboratoire d'Aérodynamique



# Griglia e settaggi MNH per Piemonte Nov 1994



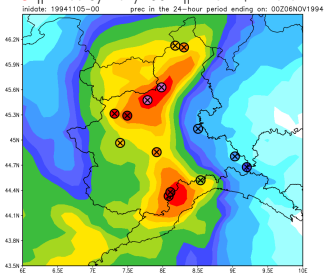
- Res oriz  $\Delta x=2.5$  km, vert levels=52,  $450 \times 300$  punti griglia
- freq di output = 1 hour
- time step = 10 sec
- **convection-permitting** (ie no parametrizzazione della convezione)

**Meso-NH model**,  $\Delta x=2.5$  km, Init: 00 UTC 4/Nov + 72 ore

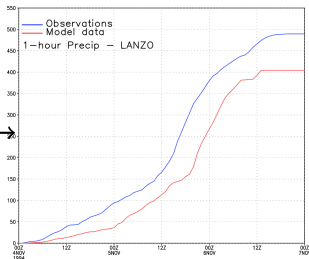
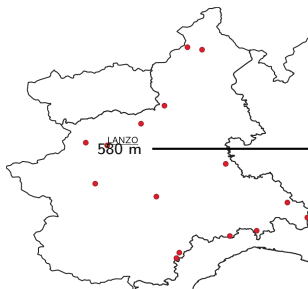
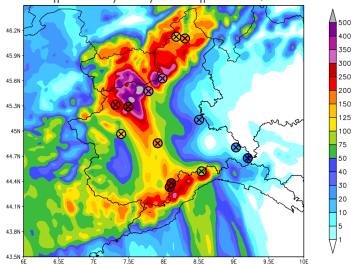
**Precipitazione oraria**

Vento @ 10 m

IFS || Prec 5/Nov/1994 || Previ +24 ore



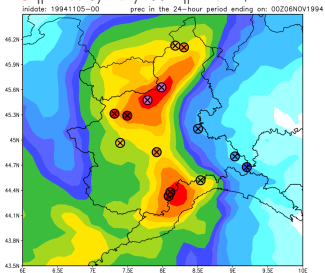
MNH || Prec 5/Nov/1994 || Previ +24 ore



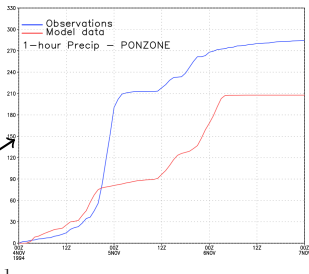
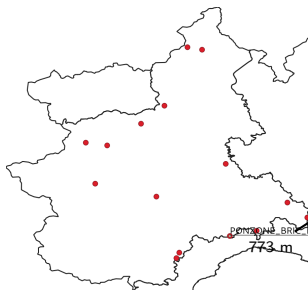
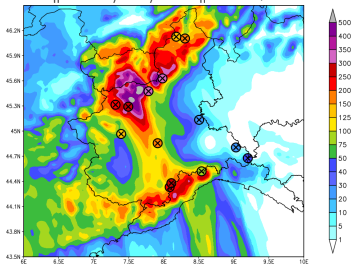
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Sottostima  $\approx 15\%$

IFS || Prec 5/Nov/1994 || Previ +24 ore



MNH || Prec 5/Nov/1994 || Previ +24 ore



Sottostima  $\approx 25\%$



## Conclusioni 1/2 | Re-forecast Piemonte Nov 1994 |

### Considerazioni finali

- 1 **buon accordo** tra precipitazioni osservate e simulate
- 2 res  $\Delta x \simeq 3$  km **sufficiente** a descrivere precipitazione max
- 3 possibile **pre-avviso** di 72 ore (init 3/Nov 00 UTC)
- 4 probabile **avviso** di 48 ore (init 4/Nov 00 UTC)

### Questioni aperte

- 1 descrizione celle convettive?
- 2 ensemble alta risoluzione?
- 3 previsione a medio termine/mensile? (vedi pres GP Balsamo)

## Conclusioni 2/2 | Sfide modellistica 2019-2025 |

- **Modellistica globale:** alta risoluzione  $\Delta x \simeq 5$  km & ensemble  $\Delta x \simeq 9$  km entro 2025 (*Strategy 2016-2025*)
  - **Modellistica ad area limitata:** ensemble  $\Delta x \leq 3$  km, data assimilation oraria, nowcasting  $t + 12$  ore
  - LaMMA ( $\simeq 5-10$  unità)  $\rightarrow$  implementatori di modelli
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  - **Centro di calcolo**  $\rightarrow$  distribuito o centrale? (costi manutenzione, elettrici, aggiorn. hardware/software, ...)

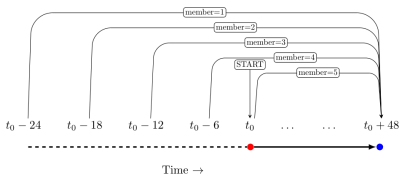
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  - **Prodotti numerici**  $\rightarrow$  quali modello/i? approccio “re-forecast” Piemonte 1994 (ie tanti modelli)? quali scale spaziali/temporali?

empty slide

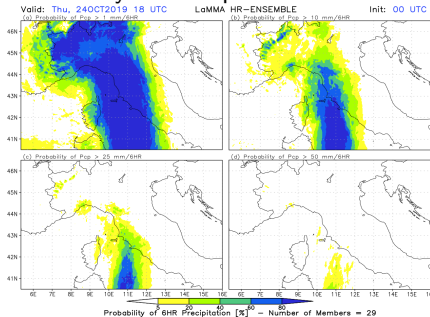
# Prodotti atmosferici operativi

## Time Lagged Ensemble



	Lead Time (hours)	Number of members
Day-0	[06-12]	28
	[12-18]	28
	[18-24]	24
	[24-30]	20
Day-1	[30-36]	16
	[36-42]	16
	[42-48]	12

## Probability of Precipitation



## ICs & BCs

- ICs & BCs = **ECMWF exp 3738** (analysis-mode,  $\simeq$  ERA5, model cycle 41r2)
- MP\_option=ICE3, orography=YES

INIT_DATE	FCST_LEN	END_DATE
1994/Oct/30_00	24 h	1994/Oct/31_00
1994/Oct/31_00	24 h	1994/Nov/01_00
1994/Nov/01_00	24 h	1994/Nov/02_00
1994/Nov/02_00	24 h	1994/Nov/03_00
1994/Nov/03_00	24 h	1994/Nov/04_00
1994/Nov/04_00	24 h	1994/Nov/05_00
1994/Nov/05_00	24 h	1994/Nov/06_00
1994/Nov/06_00	24 h	1994/Nov/07_00



# ICs & BCs

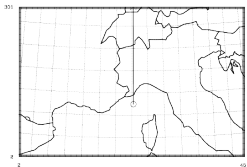
- ICs & BCs = **ECMWF exp h6bg** (forecast-mode, model cycle 45r1)

INIT_DATE	FCST_LEN	END_DATE	MP_option=KESS		MP_option=ICE3	
			ORO=Y	ORO=N	ORO=Y	ORO=N
1994/Oct/30.00						
1994/Oct/31.00						
1994/Nov/01.00						
1994/Nov/02.00						
1994/Nov/03.00	72 h	1994/Nov/06.00	✓		✓	
1994/Nov/04.00	72 h	1994/Nov/07.00	✓		✓	
1994/Nov/05.00	48 h	1994/Nov/07.00	✓	✓	✓	✓
1994/Nov/06.00	24 h	1994/Nov/07.00	✓		✓	

### transetto

REMIU CV

06/10/19 00:00:00Z  
 47°10'N 106° 0'00" E

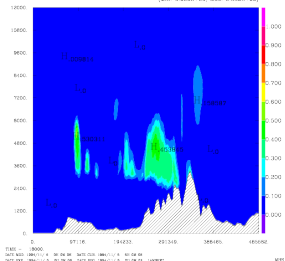


Latitude,Longitude    ○ ( 43.00, 0.10)    × ( 47.00, 0.10)

### neve 6 UTC 5/Nov

Vertical section LAT,LOn (HIGGS)-(INM)-( 43.5, 0.1)-( 47.9, 0.1)    06/10/19 00:00:00Z  
 47°10'N 106° 0'00" E

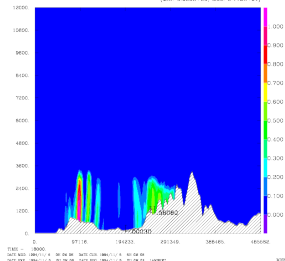
[Min: 0.0000(-0), Max: 0.0000(-0)]



### pioggia 6 UTC 5/Nov

Vertical section LAT,LOn (HIGGS)-(INM)-( 43.5, 0.1)-( 47.9, 0.1)    06/10/19 00:00:00Z  
 47°10'N 106° 0'00" E

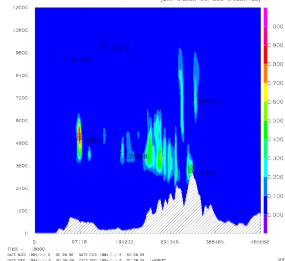
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### ghiaccio 6 UTC 5/Nov

Vertical section LAT,LOn (HIGGS)-(INM)-( 43.5, 0.1)-( 47.9, 0.1)    06/10/19 00:00:00Z  
 47°10'N 106° 0'00" E

[Min: 0.0000(-0), Max: 0.0000(-0)]

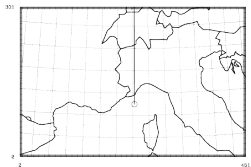


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## transetto

REMIU CV

09/10/19 00:01:04  
47°1'00.000 9°50'00.000

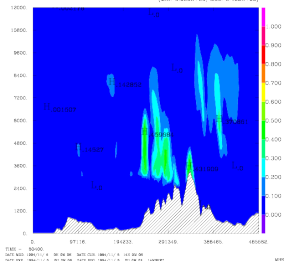


Latitude,Longitude    ○ ( 43.00, 9.10)    × ( 47.00, 9.10)

## neve 15 UTC 5/Nov

Vertical section LAT,IGN (HIGSN)-(IGN)-(43.5, 9.1)-( 47.9, 9.1)    09/10/19 00:00:00  
47°1'00.000 9°50'00.000

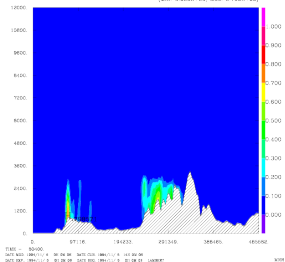
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## pioggia 15 UTC 5/Nov

Vertical section LAT,IGN (HIGSN)-(IGN)-(43.5, 9.1)-( 47.9, 9.1)    09/10/19 00:00:00  
47°1'00.000 9°50'00.000

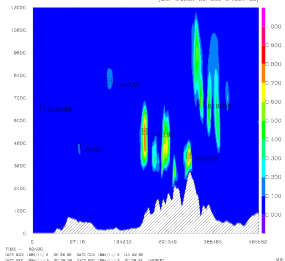
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## ghiaccio 15 UTC 5/Nov

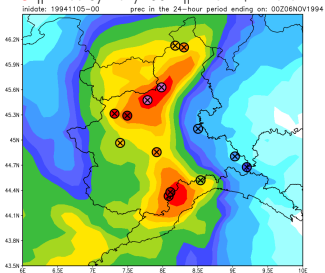
Vertical section LAT,IGN (HIGSN)-(IGN)-(43.5, 9.1)-( 47.9, 9.1)    09/10/19 00:00:00  
47°1'00.000 9°50'00.000

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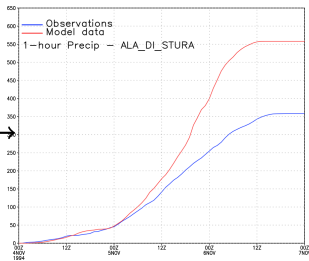
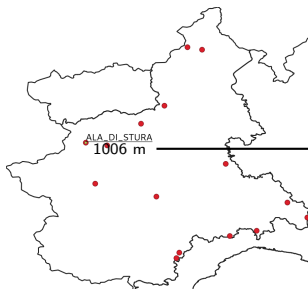
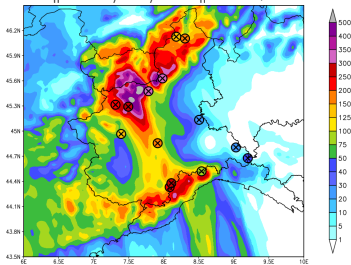


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IFS || Prec 5/Nov/1994 || Previ +24 ore



MNH || Prec 5/Nov/1994 || Previ +24 ore



Sovrastima  $\approx 55\%$