

Florence 1966: how far ahead can we predict such extreme events with current, state-of-the-art ensembles?

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(1) LaMMA, (2) ECMWF

EMS Annual Meeting, Sep 2016



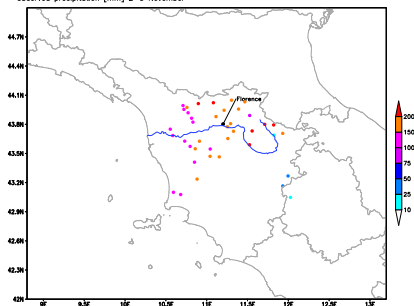
2-5 Nov 1966 large scale system over central/north Italy:

- low over Ligurian Sea
- warm and moist air south-to-north
- 'block' over the Balkans



Arno river flooded Florence

Observed precipitation [mm] 2-5 November



Observed precipitation 2-5 Nov
in the Arno river basin (avg
 $\approx 120\text{mm}$)

1966-2016: 50th anniversary of the Arno River flooding

Aim of the work: *evaluate the forecasting skills of the current (ie 2016) global and limited-area NWP models with an ensemble approach*

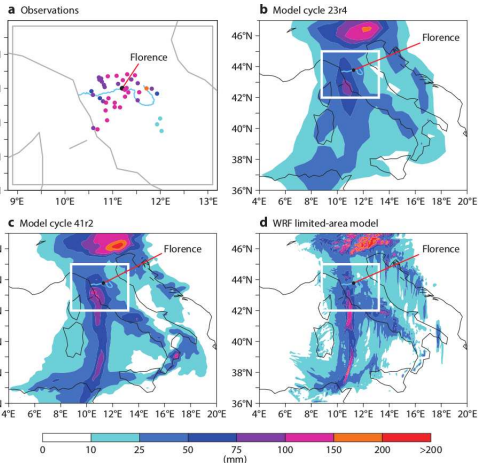
	Area	Resolution	Members	Initial conditions	Boundary conditions
ECMWF-ENS	Global	ECMWF TCo639L91 ¹ (18 km, 91 levels)	51	ECMWF TL511L60 (40 km, 60 levels)	N/A
WRF-ENS	Limited area	3 km, 60 levels ²	50	ENS	ENS

¹ Operational at ECMWF since March 2016

² Convection-permitting

Short-range global forecasts

Precipitation on 4 Nov: **single deterministic** forecast at t_0+24 h
(init: 00 UTC 4 Nov)

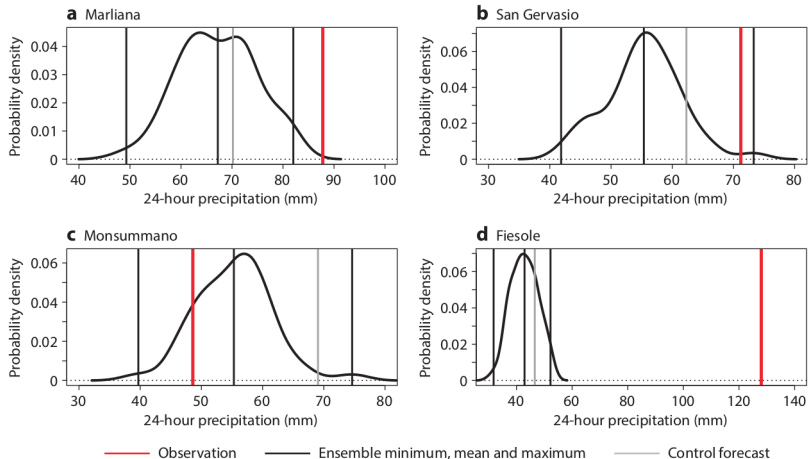


(a) Observations,
(b) ECMWF model cycle 23r4 (2006)^a,
(c) ECMWF model cycle 41r2 (2016),
(d) WRF model (2016)

^a Malguzzi et al. "The 1966 century flood in Italy: A meteorological and hydrological revisitation." JGR (2006)

Short-range global forecasts

Precipitation on 4 Nov: **ensemble forecast** distributions at selected locations at t_0+24 h (init: 00 UTC 4 Nov)

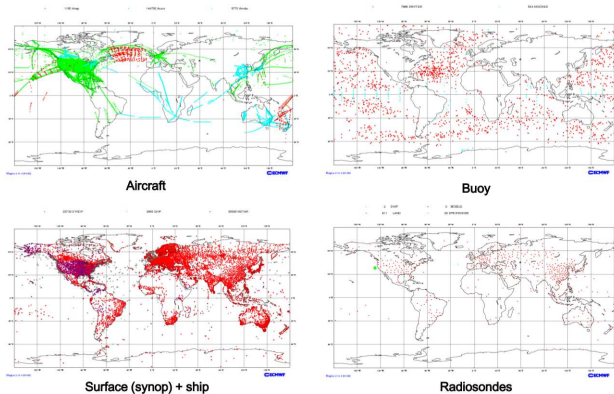


→ both control and ensemble forecasts largely under-estimate rainfall

Limitation of the study: observations available to initialise the forecasts

of observations in 2015

Snap-shot Example of 6hrs data coverage : 28 Jan 2015

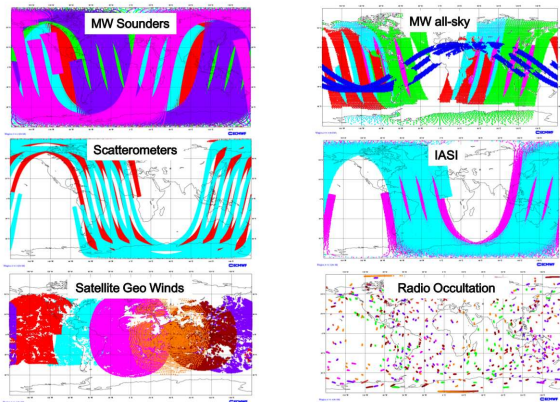


From ECMWF Training Course (Apr 2016)

Limitation of the study: observations available to initialise the forecasts

of observations in 2015

Example of 6hr satellite data coverage: 28 Jan 2015

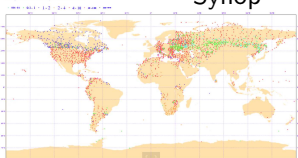


Every 12 hours $\simeq 7 \times 10^7$ observations (both conventional and remote sensed) are assimilated in global models

Limitation of the study: observations available to initialise the forecasts

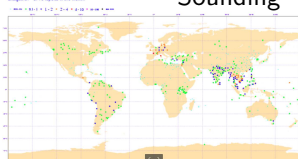
of observations in the '60s

ERA-40 Number of BUFR reports in 1°1 degree boxes,
average daily number of 10107 of different kinds
altogether: 304567 reports in the month.



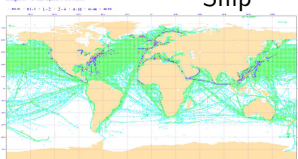
Synop

ERA-40 Number of BUFR reports in 1°1 degree boxes,
average daily number of 19127 of different kinds
altogether: 5776 reports in the month.



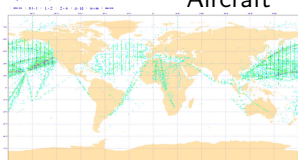
Sounding

ERA-40 Number of BUFR reports in 1°1 degree boxes,
average daily number of 10107 of different kinds
altogether: 304567 reports in the month.



Ship

ERA-40 Number of BUFR reports in 1°1 degree boxes,
average daily number of 10107 of different kinds
altogether: 304567 reports in the month.



Aircraft

Daily average $\simeq 18000$ observations (only conventional)

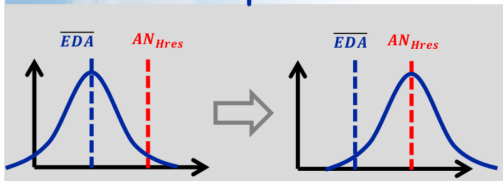
“poor-data scenario”

of obs in 2016 $O(10^7) \gg$ # of obs in 1966 $O(10^4)$

Larger initial condition perturbation amplitude

Generation of initial conditions for the ensemble:

$$AN_{pf} = \underbrace{AN_{Hres} \pm (EDA_i - \overline{EDA})}_{\text{perturbation}} \pm SVPERT_j \quad \begin{array}{l} i = 1..25 \\ j = 1..25 \end{array}$$



Re-centre EDA-Distribution on Hres-Analysis

$$SVPERT_j = \sum_l^{NSET} \sum_k^{NSV_l} \alpha_{lk} SV_{lk}$$

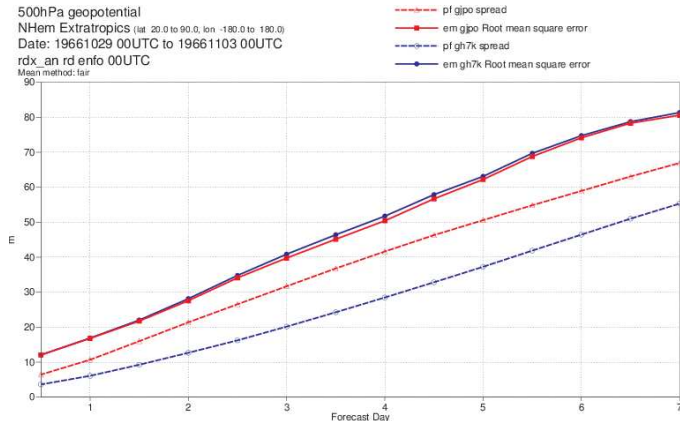
α random number drawn from Truncated gaussian

NSET : nhem, shem, TCs1-6

NSV : 50 for nhem and shem, 5 for TCs

Larger initial condition perturbation amplitude

RMSE & spread 500 hPa geopotential Northern Hemisphere

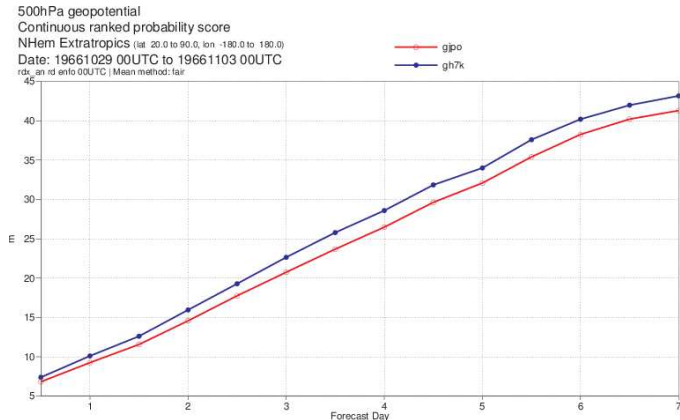


—— RMSE Standard Init Cond
- - - - Spread Standard Init Cond

—— RMSE Larger Init Cond
- - - - Spread Larger Init Cond

Larger initial condition perturbation amplitude

Continuous Ranked Probability Score 500 hPa geopotential Northern Hemisphere



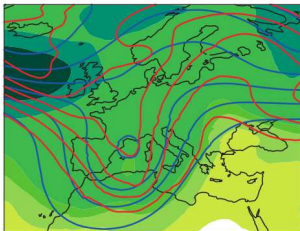
CRPS Standard Init Cond

CRPS Larger Init Cond

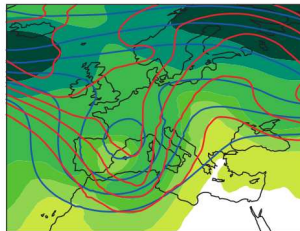
Short-to-medium-range global forecasts

500 hPa Ensemble Mean & Spread geopotential height

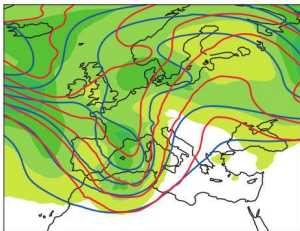
a 174-hour forecast



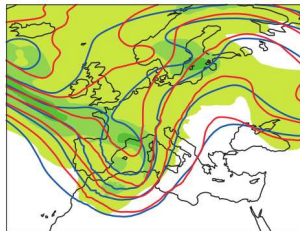
b 126-hour forecast



c 78-hour forecast

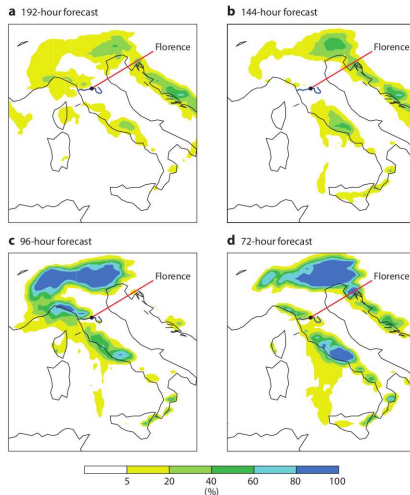


d 54-hour forecast



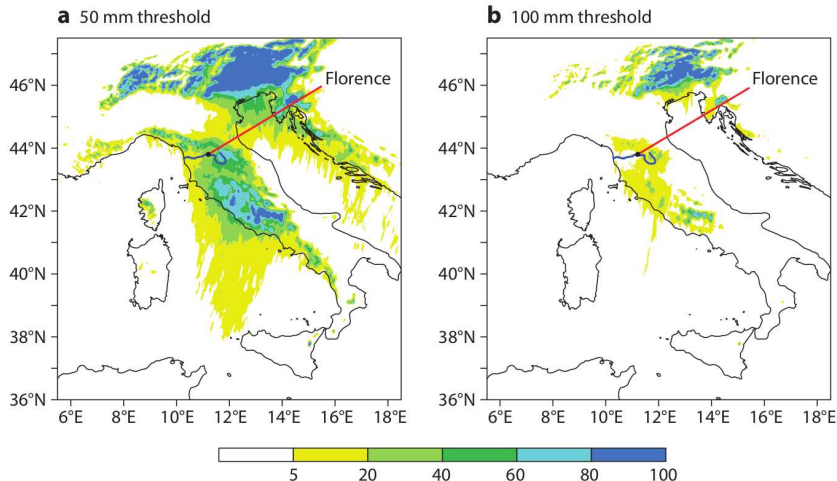
Short-to-medium-range global forecasts

Probability of Precipitation exceeding 50 mm at **(a)** t_0+192 h, **(b)** t_0+144 h, **(c)** t_0+96 h, **(d)** t_0+72 h



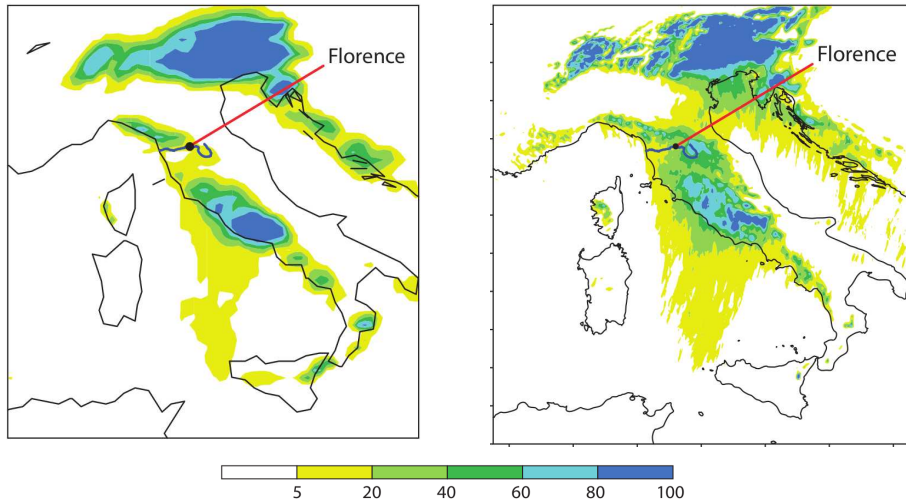
Short-range LAM convection-permitting forecasts

Probability of Precipitation exceeding **(a)** 50 mm and **(b)** 100 mm at t_0+72 h forecast



Short-range global forecast vs Short-range LAM forecasts

Probability of Precipitation exceeding 50 mm for global forecast (left) and LAM forecast (right) at t_0+72 h forecast



Question

Florence 1966: how far ahead can we predict such extreme events with current, state-of-the-art ensembles?

Answers

- Single deterministic global forecasts have limited skill at t_0+24 h
- Ensembles global forecasts:
 - Provide valuable information on the synoptic conditions associated with potential severe weather up to three days in advance
 - $t_0 + 24 < t < t_0+72$ provide probabilities that extreme weather can occur
- The poor number of obs available affects the reliability
- At t_0+168 h improvements in accuracy are achieved when ensemble initial perturbations are properly set
- Nested convection-permitting LAM ensemble forecasts (at 3 km) provide even more valuable information up to t_0+72 hours