

L'alluvione di Firenze: la previsione del 1966 con gli strumenti di oggi

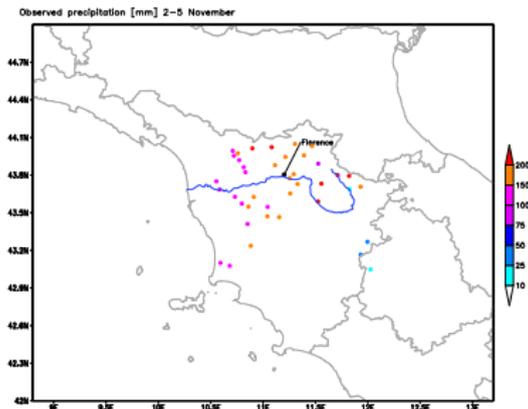
Cosa avrebbero previsto i modelli attuali nel caso dell'evento
del 4 Novembre 1966?

V Capecchi⁽¹⁾, S Lang⁽²⁾, R Buizza⁽²⁾

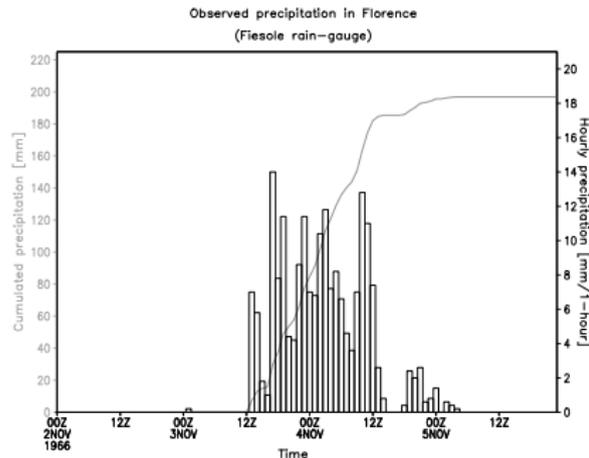
(1) LaMMA, (2) ECMWF

Accademia dei Georgofili, 3 Nov 2016

Precipitazioni osservate



Precipitazioni cumulate 2-5 Nov
(media bacino Arno $\simeq 120\text{mm}$)



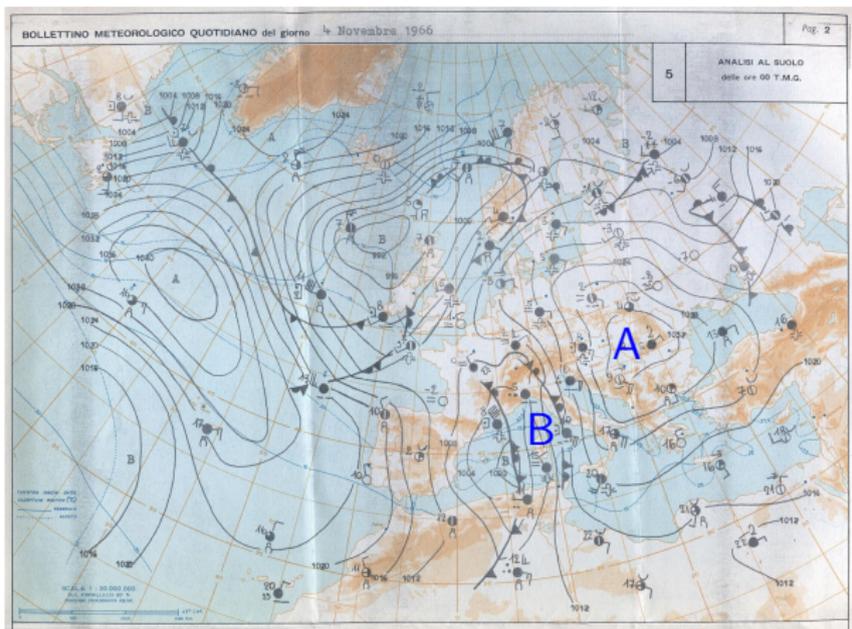
Fiesole $\simeq 180\text{ mm}/24\text{ h}$

- **Ottobre '66**: scarsi scambi termici (\updownarrow) tra zone polari e tropicali
 - raffreddamento zone polari ($< 6^{\circ}$ C)
 - anomalia temperatura superficiale Tirreno ($> 2^{\circ}$ C) e zone temperate ($> 4^{\circ}$ C)
 - piogge abbondanti (+152% Italia centrale)

Fonte: Commissione Interministeriale 1969

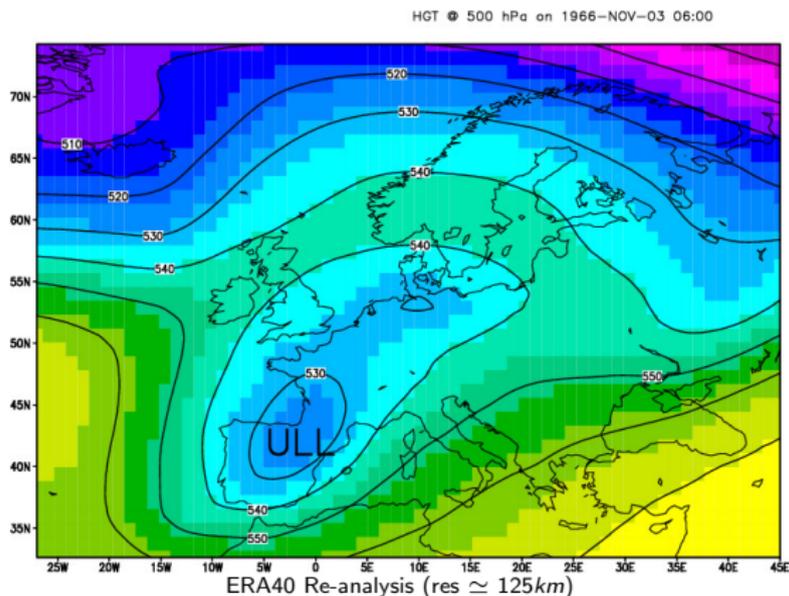
2-4 Nov 1966 large scale system over central/north Italy:

- minimo in quota penisola iberica
- massa di aria calda e umida da sud verso l'Italia
- “blocco” a Est (alta pressione sui Balcani)



2-4 Nov 1966 large scale system over central/north Italy:

- minimo in quota
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3-4 Nov 1966

Obiettivo: *valutare la capacità previsionale del sistema attuale (2016) sia per i modelli globali che ad area limitata con approccio di tipo probabilistico*

	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	ECMWF-ENS	ECMWF-ENS

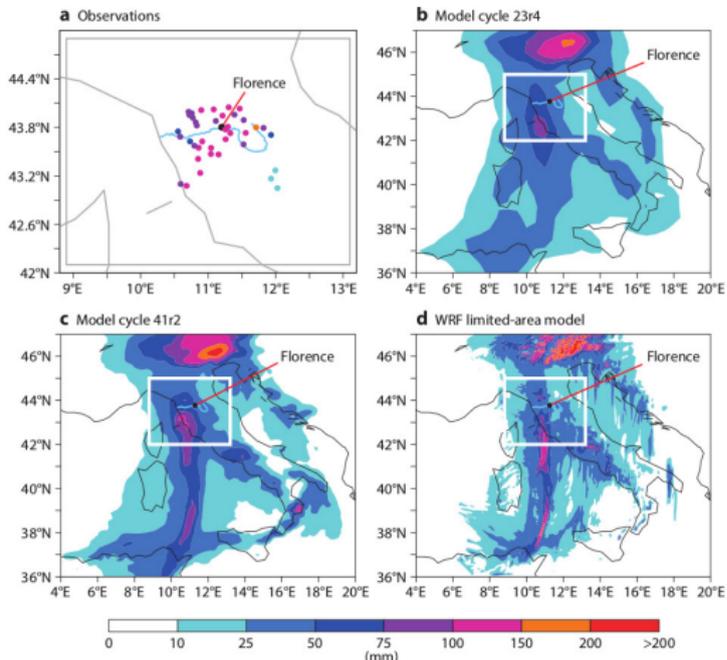
- Era predicibile l'evento? Con quanto anticipo?
- Qual'è il valore aggiunto delle simulazioni d'ensemble?
- Qual'è il valore aggiunto delle simulazioni ad alta risoluzione?

¹ Operational at ECMWF since March 2016

² Convection-permitting

Previsione a breve termine

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

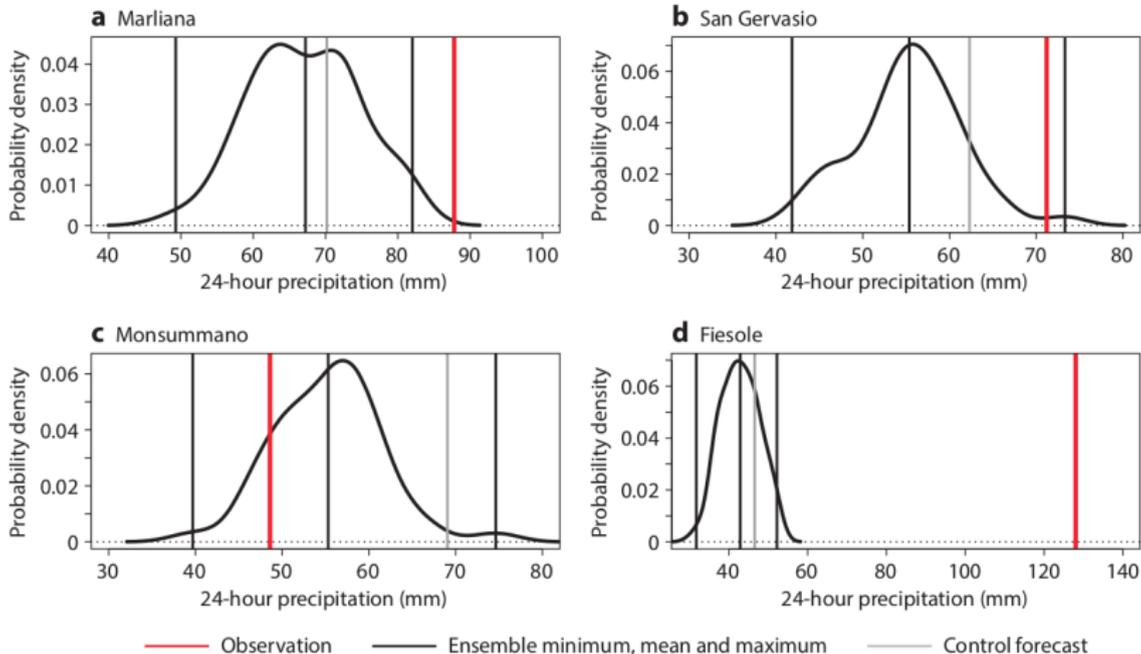


(a) Observations,
(b) ECMWF model cycle
23r4 (2006)^a,
(c) ECMWF model cycle
41r2 (2016),
(d) WRF model (2016)

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

Previsione a breve termine

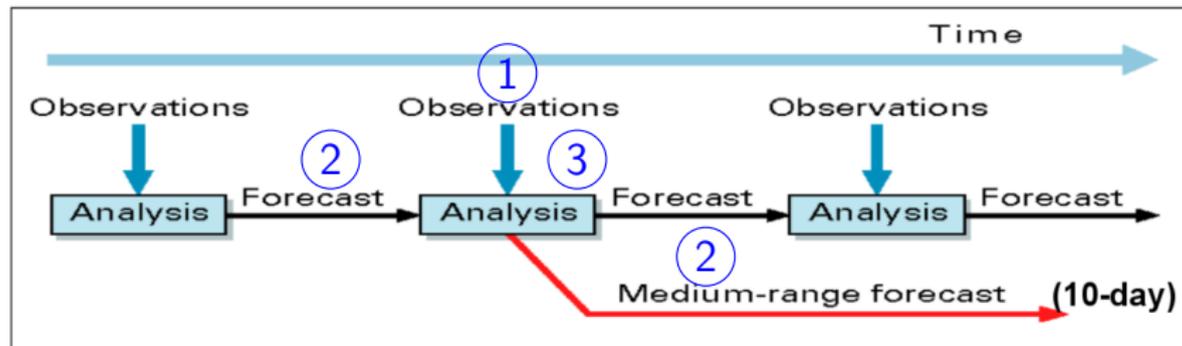
Precipitation on 4 Nov: **ensemble forecast** distributions at selected locations at t_0+24 h (init: 00 UTC 4 Nov)



→ run controllo ed ensemble: **sottostima** dei cumulati puntuali

Ingredienti previsione numerica

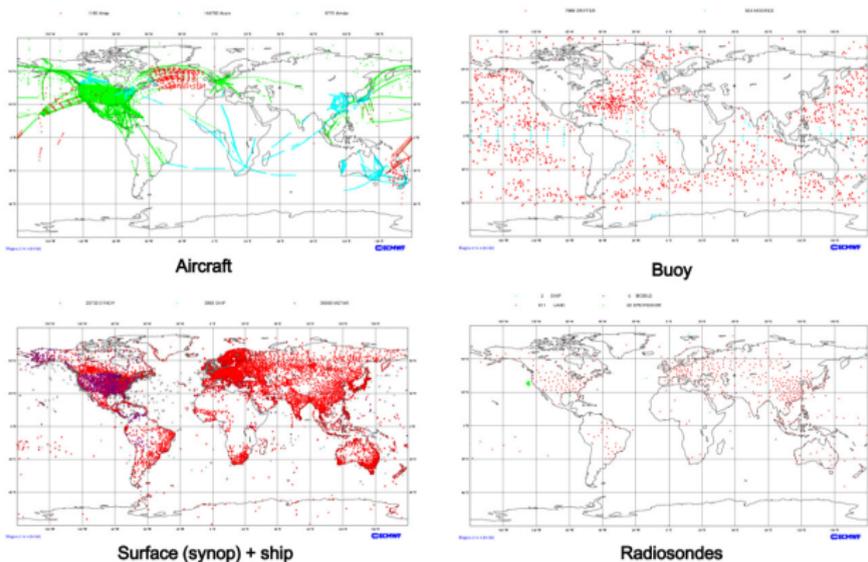
- 1 osservazioni
- 2 modello numerico
- 3 metodo di analisi (integrazione tra osservazioni e modello numerico)



Limite dello studio: osservazioni disponibili per l'inizializzazione

of observations in 2015

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

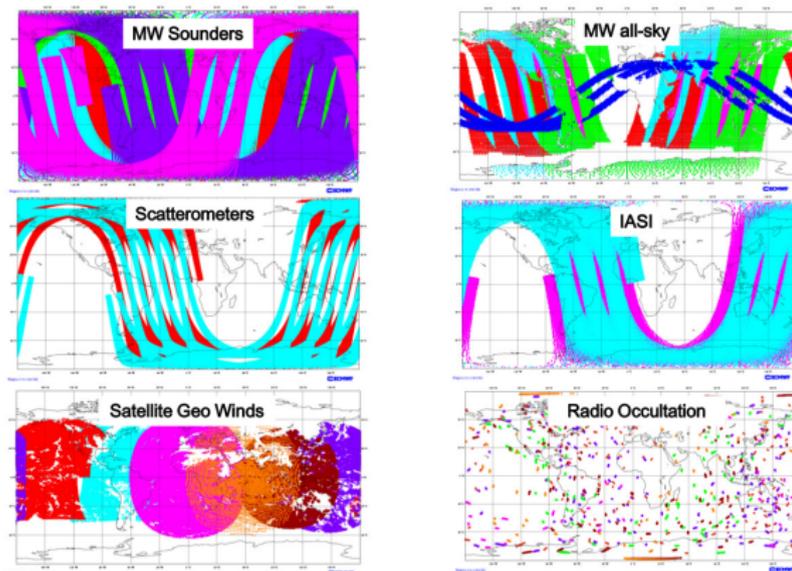


From ECMWF Training Course (Apr 2016)

Limite dello studio: osservazioni disponibili per l'inizializzazione

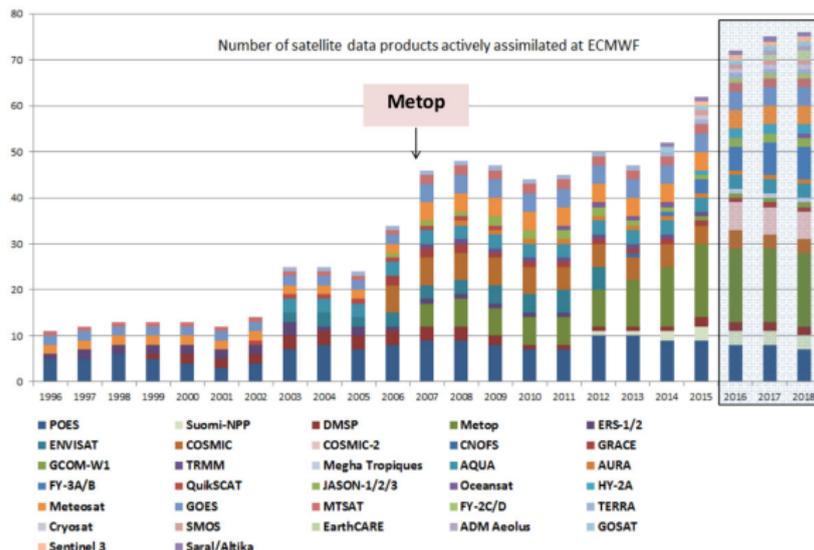
osservazioni disponibili nel 2015

Example of 6hr satellite data coverage: 28 Jan 2015



From ECMWF Training Course (Apr 2016)

Limite dello studio: osservazioni disponibili per l'inizializzazione



Ogni 12 ore $\simeq 7 \times 10^7$ osservazioni (sia convenzionali che da remoto) sono assimilate nei modelli globali

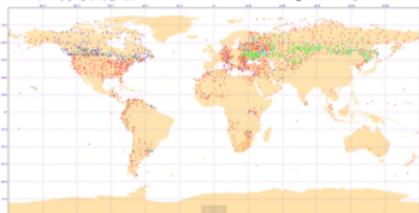
Courtesy of ECMWF TC (Apr 2015)

Limite dello studio: osservazioni disponibili per l'inizializzazione

di osservazioni disponibili negli anni '60

ERA-40 Number of BUFR reports in 1° degree boxes
average daily number of SYNOP at different levels
altogether: 36387 reports in the month

Synop



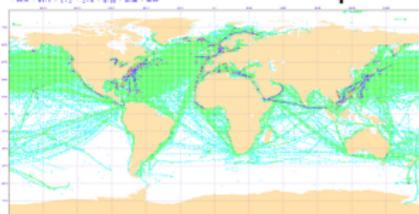
ERA-40 Number of BUFR reports in 1° degree boxes
average daily number of PLOZF and Profiles
altogether: 2076 reports in the month

Sounding



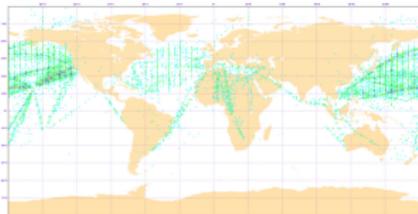
ERA-40 Number of BUFR reports in 1° degree boxes
average daily number of SHIP at different levels
altogether: 16193 reports in the month

Ship



ERA-40 Number of BUFR reports in 1° degree boxes
average daily number of Aircraft (AOSD-AOSM-AOSG)
altogether: 30362 reports in the month

Aircraft

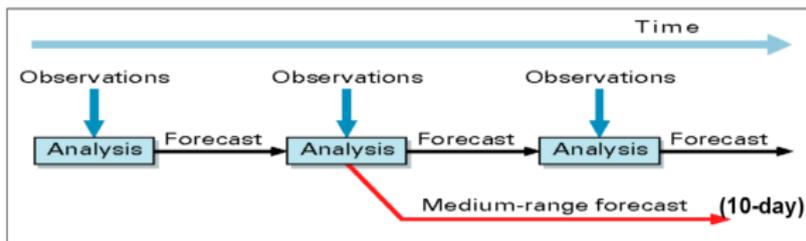


Media giornaliera $\simeq 18000$ osservazioni³ (solo convenzionali)

³ Uppala, et al. "The ERA40 reanalysis" *QJRMS* 131.612 (2005)

Ingredienti previsione numerica

- 1 osservazioni → oss in 2016 $O(10^7)$ \gg oss in 1966 $O(10^4)$ ☹️
- 2 modello numerico → ECMWF-ENS Marzo 2016 (ensemble) & WRF Agosto 2015 (ensemble) 😊
- 3 metodo di analisi (integrazione tra osservazioni e modello numerico) → ECMWF-4DVar 😊

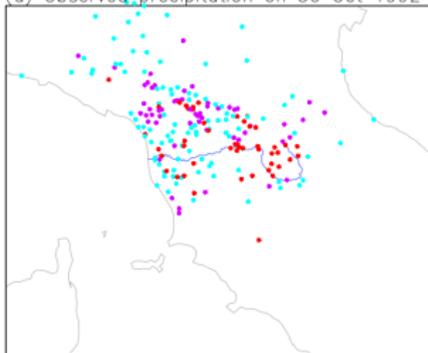


Conclusione

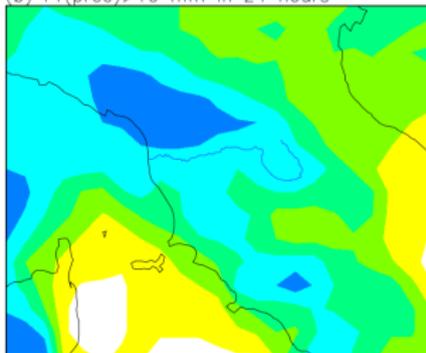
“poor-data” scenario

Caso studio 30 Ottobre 1992: global model init 1992-10-27 12 UTC

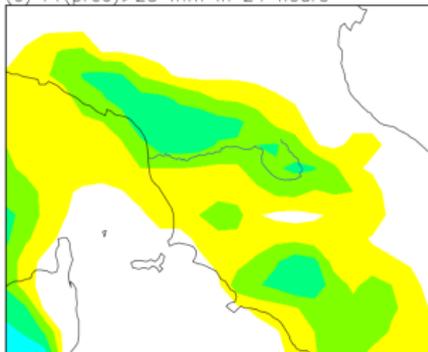
● >10 ● >25 ● >50
(a) Observed precipitation on 30 Oct 1992



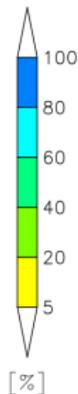
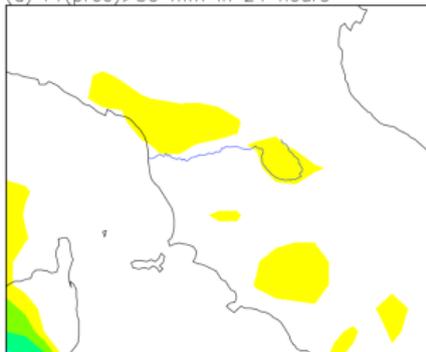
Analysis date: 1992-10-27_12
(b) Pr(prec)>10 mm in 24 hours



Analysis date: 1992-10-27_12
(c) Pr(prec)>25 mm in 24 hours

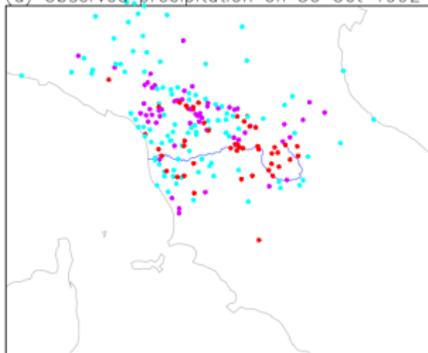


Analysis date: 1992-10-27_12
(d) Pr(prec)>50 mm in 24 hours

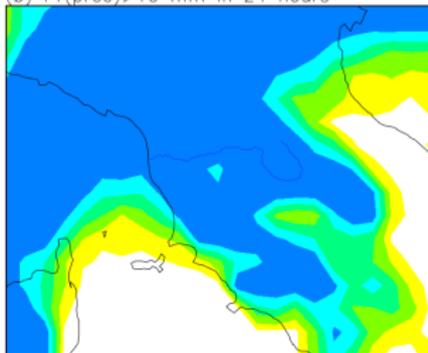


Caso studio 30 Ottobre 1992: global model init 1992-10-29 12 UTC

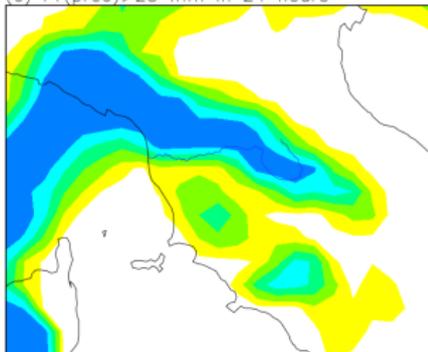
● >10 ● >25 ● >50
(a) Observed precipitation on 30 Oct 1992



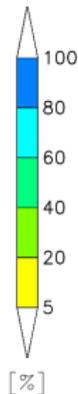
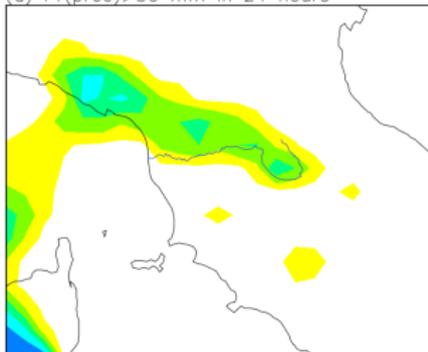
Analysis date: 1992-10-29_12
(b) Pr(prec)>10 mm in 24 hours



Analysis date: 1992-10-29_12
(c) Pr(prec)>25 mm in 24 hours

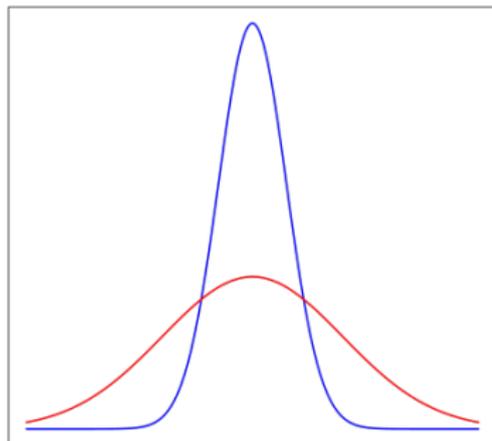


Analysis date: 1992-10-29_12
(d) Pr(prec)>50 mm in 24 hours



TEST: Larger initial condition perturbation amplitude

Initial Conditions Distributions



— 1966 Standard Cond

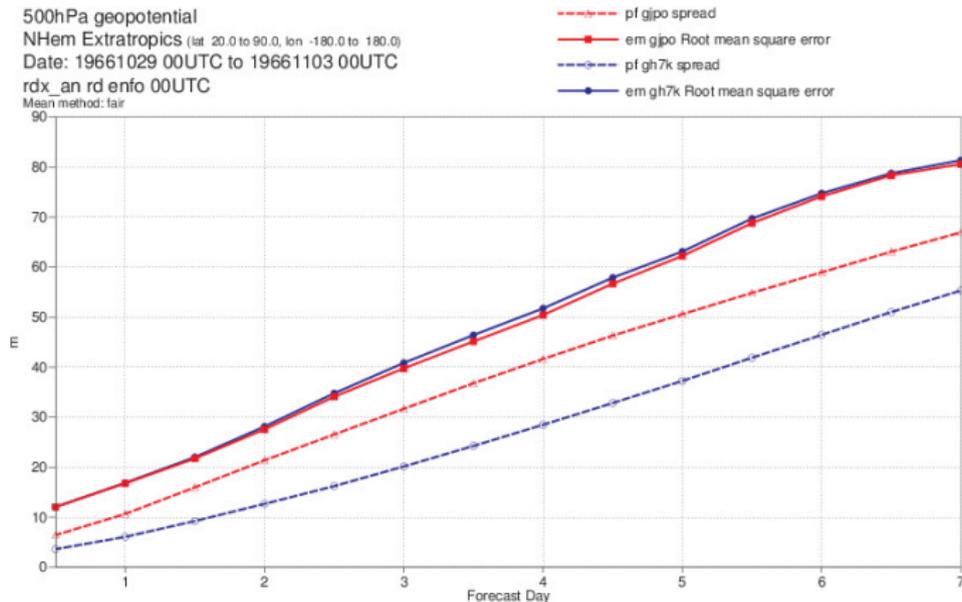
— 1966 Larger Cond

$$AN_{pf} = AN_{Hres} \pm (EDA_i - \overline{EDA}) \pm SV_{pert_j}$$

$$SV_{pert_j} = \sum_l \sum_k \alpha_{lk} SV_{lk}$$

TEST: Larger initial condition perturbation amplitude

RMSE & spread 500 hPa altezza geopotenziale (emisfero N)



— RMSE Standard Init Cond

- - - Spread Standard Init Cond

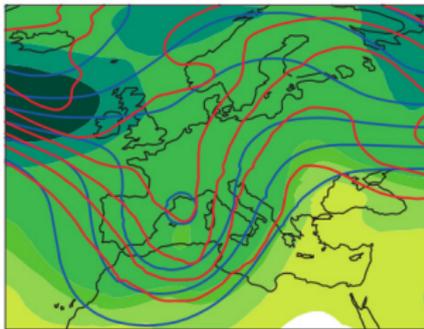
— RMSE Larger Init Cond

- - - Spread Larger Init Cond

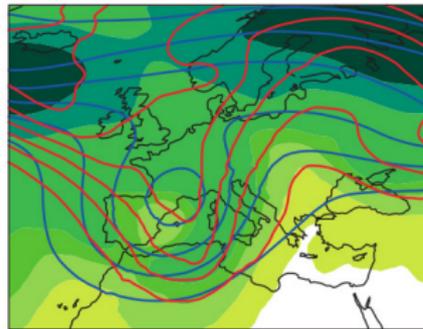
Previsione a medio termine

Mean & Spread altezza geopotenziale @ 500 hPa (linea rossa=“realtà”)

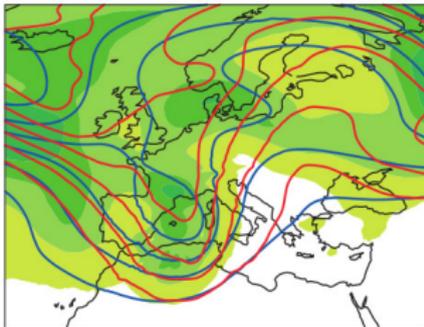
a 174-hour forecast



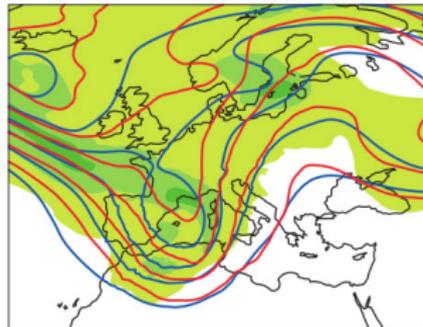
b 126-hour forecast



c 78-hour forecast

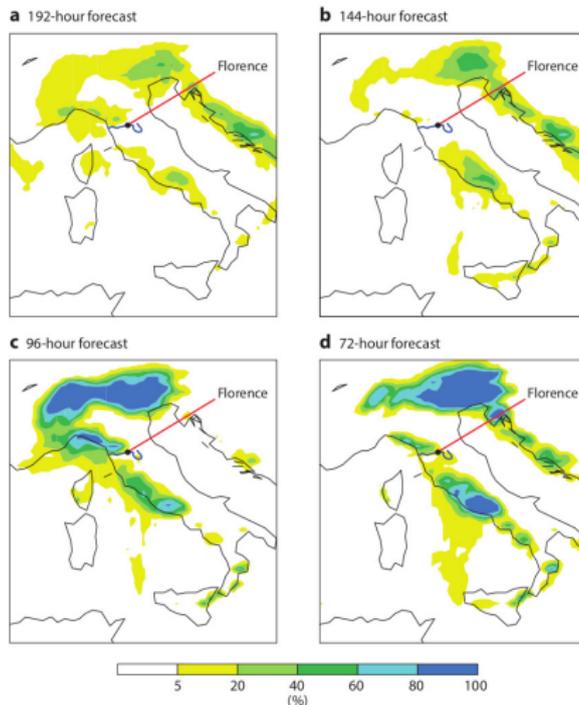


d 54-hour forecast



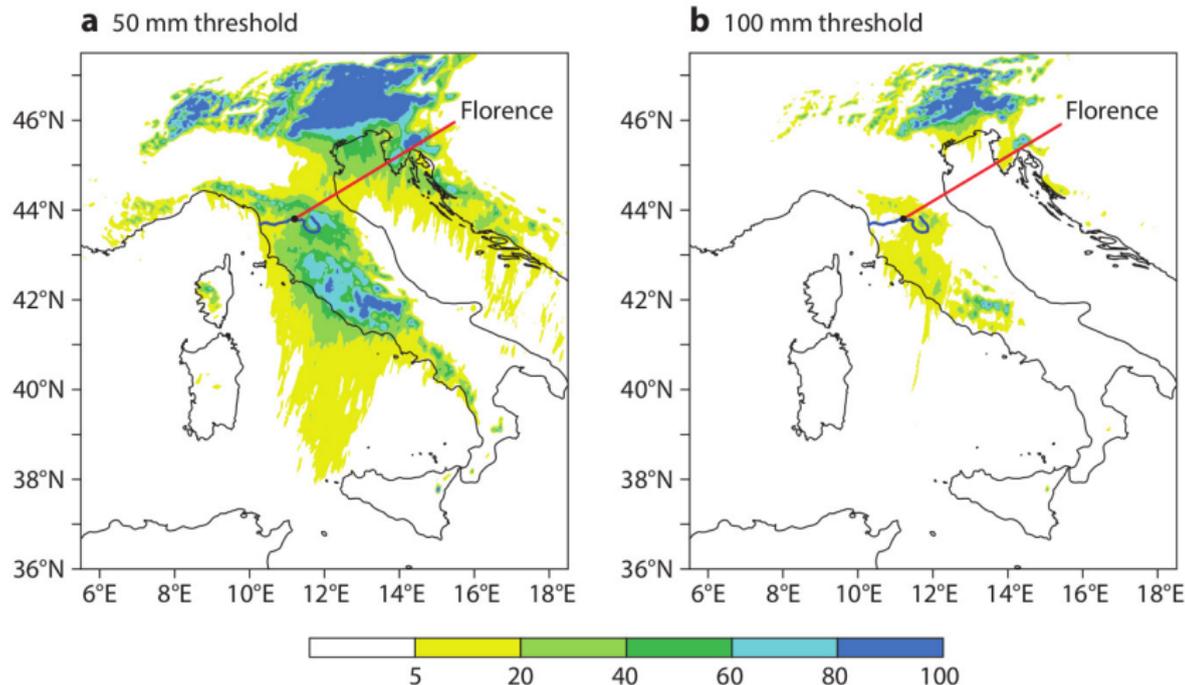
Previsione a medio termine

Probabilità di precipitazione >50 mm a **(a)** t_0+192 h, **(b)** t_0+144 h, **(c)** t_0+96 h, **(d)** t_0+72 h



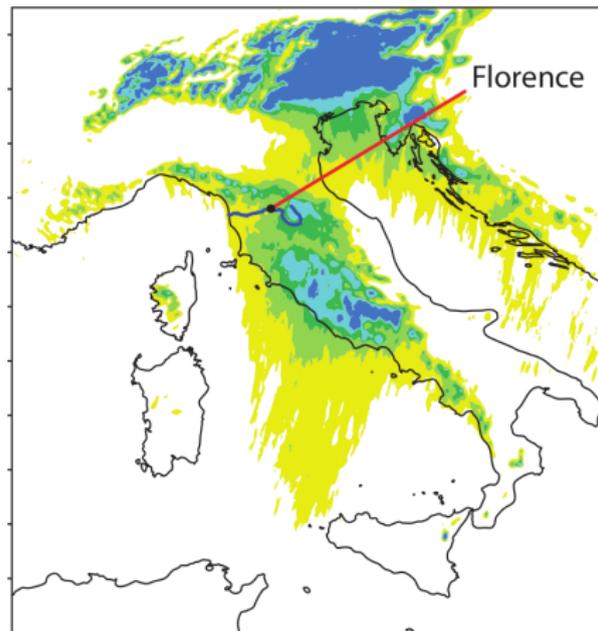
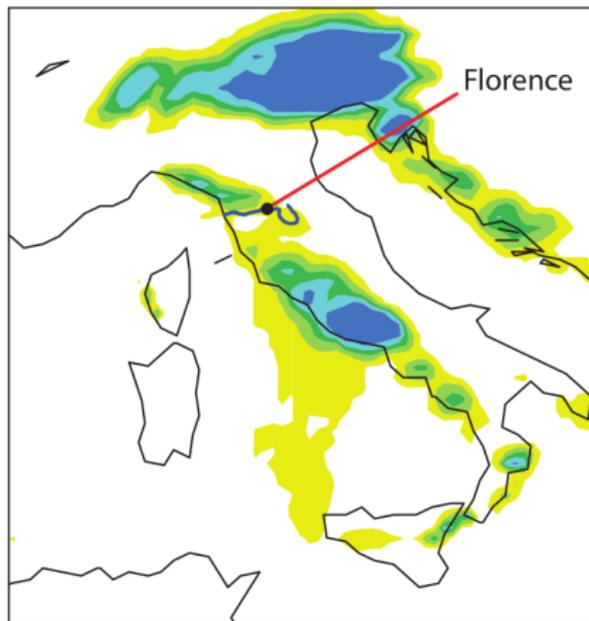
Previsione a breve termine, modello ad area limitata

Probabilità di precipitazione **(a)** >50 mm e **(b)** >100 mm a t_0+72 h forecast



Previsione a breve termine: modello globale vs modello ad area limitata

Probabilità di precipitazione >50 mm
modello globale (sn) e modello ad area limitata (dx) a t_0+72 h



Cosa avrebbero previsto i modelli attuali nel caso dell'evento del 4 Novembre 1966?

Conclusioni

- t_0+24 skill limitato per la **singola corsa deterministica**
- **Previsione d'ensemble:**
 - t_0+72 h fornisce informazioni circa la formazione di condizioni sinottiche favorevoli all'occorrenza di fenomeni potenzialmente severi
 - $t_0 + 24 < t < t_0+72$ fornisce probabilità > 0 di eventi estremi
- **Poche osservazioni** influiscono sull'accuratezza del sistema previsionale attuale
- **Previsioni piú accurate** a t_0+168 h sono ottenute "mimando" la disponibilità di piú osservazioni
- **Previsioni d'ensemble ad alta risoluzione** (3 km, con convezione non parametrizzata) forniscono un ulteriore valore aggiunto (cioé probabilità piú alte di precipitazione estrema) fino a t_0+72 hours