Which strategy for ItaliaMeteo to exploit at best the synergies with ECMWF?

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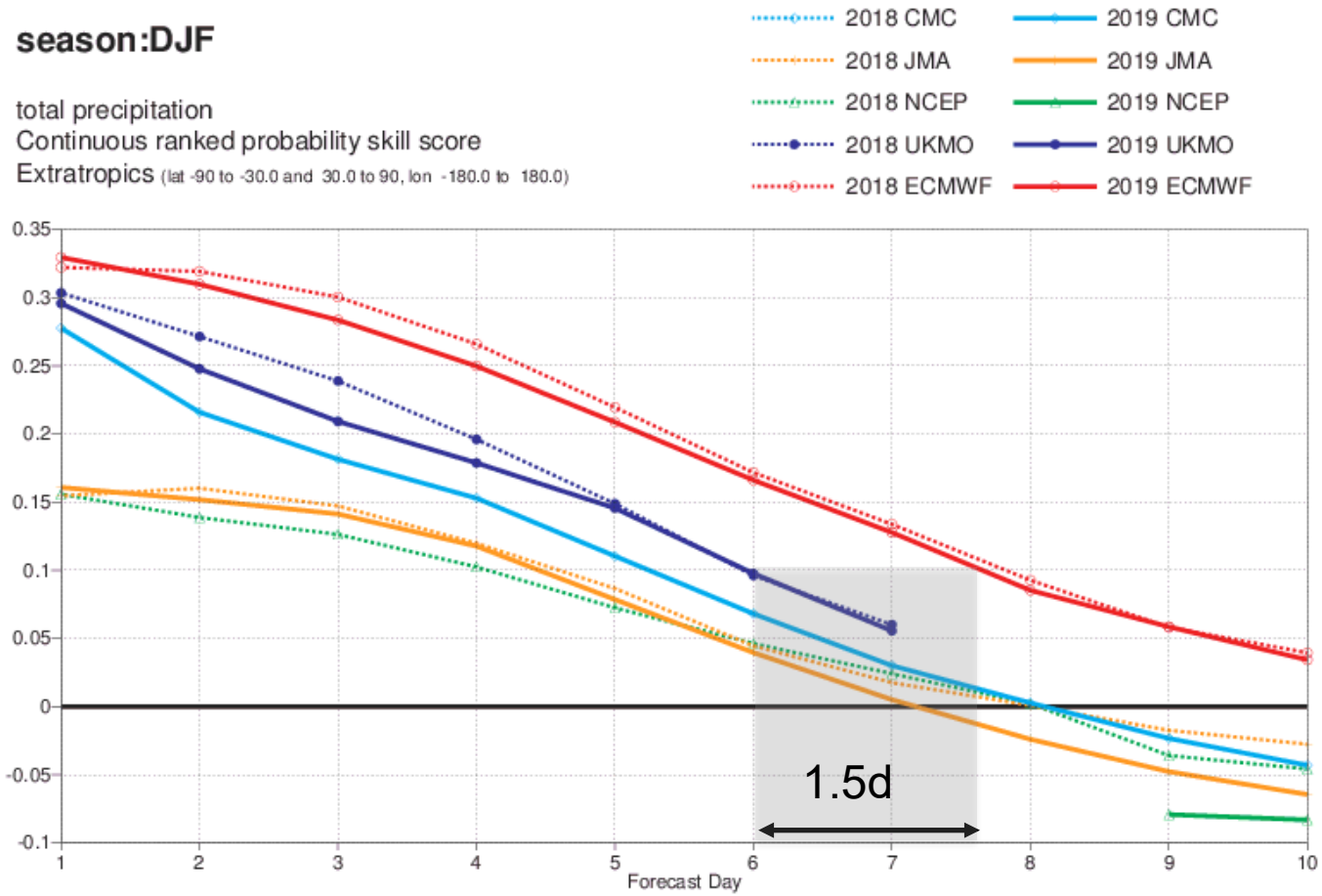
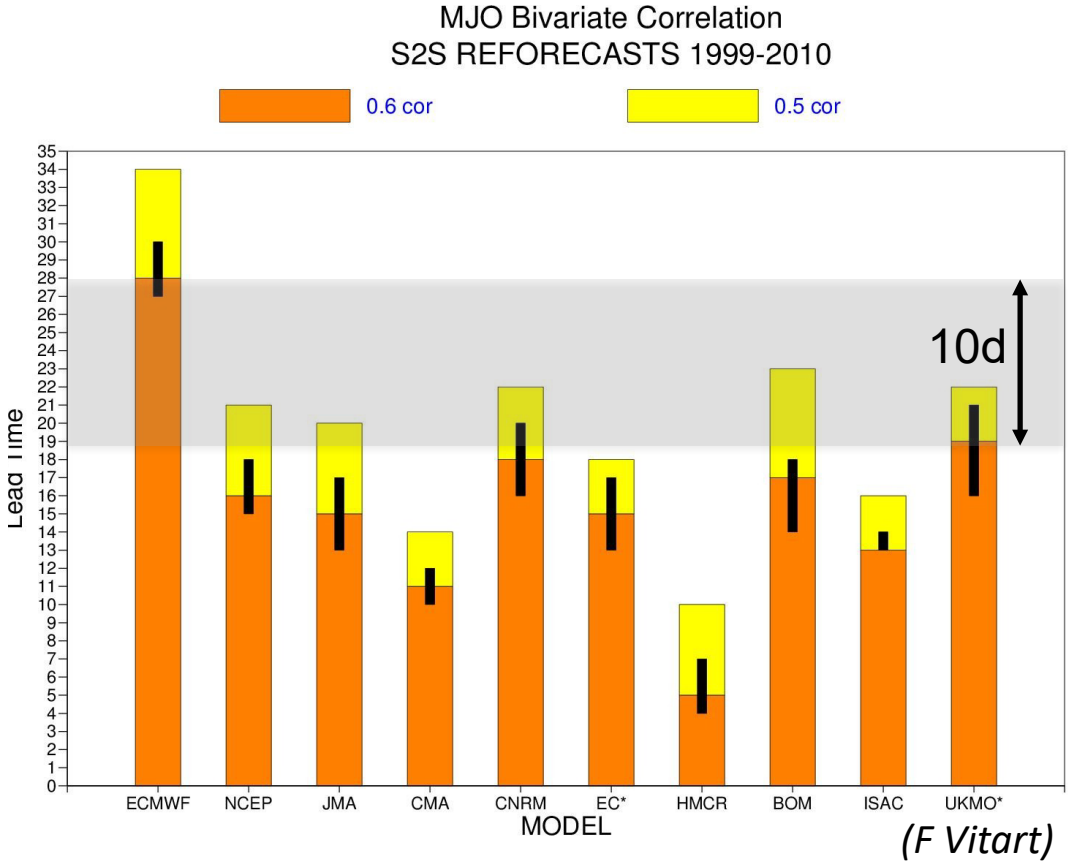
ECMWF provides the best medium-range, monthly & seas fcs



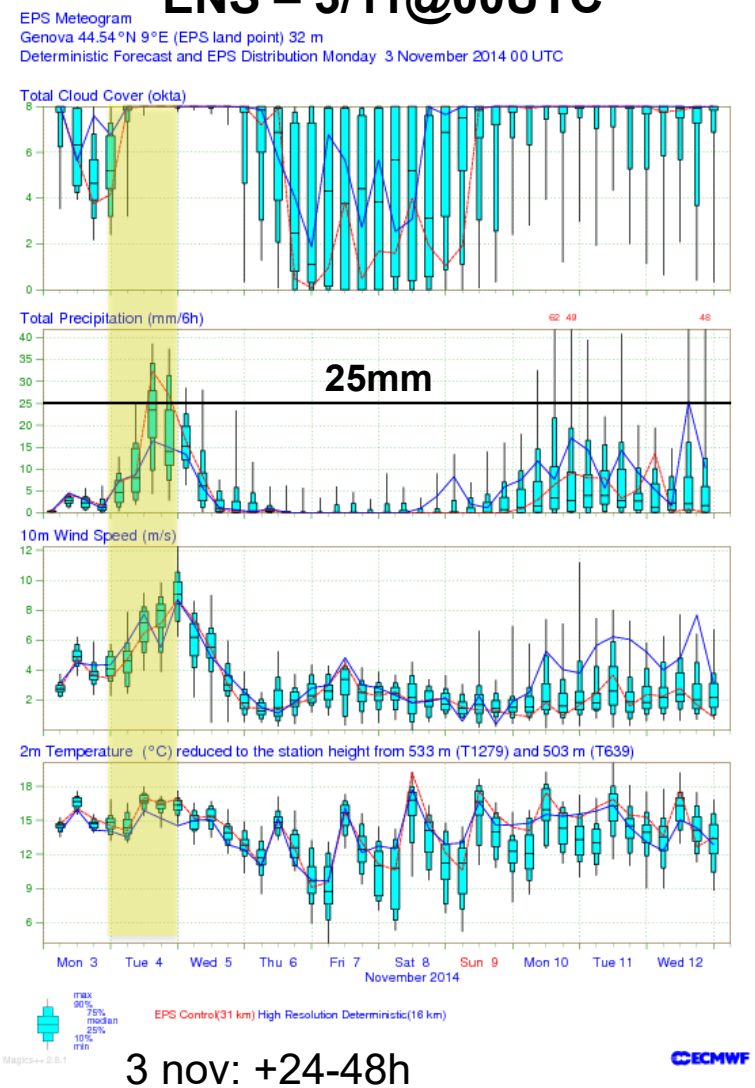


(F Vitart)

ECMWF ENS fcs improve by ~1.5d/decades: thus the **2nd best is ~10-years behind**!
ECMWF MJO monthly fcs improve by ~7d/decade: thus the **2nd best is more than 10y behind**!

Priority for IM: short-range fcs of extremes better than ECMWF

ENS – 3/11@00UTC



3 nov: +24-48h

Genova, 4 November 2014

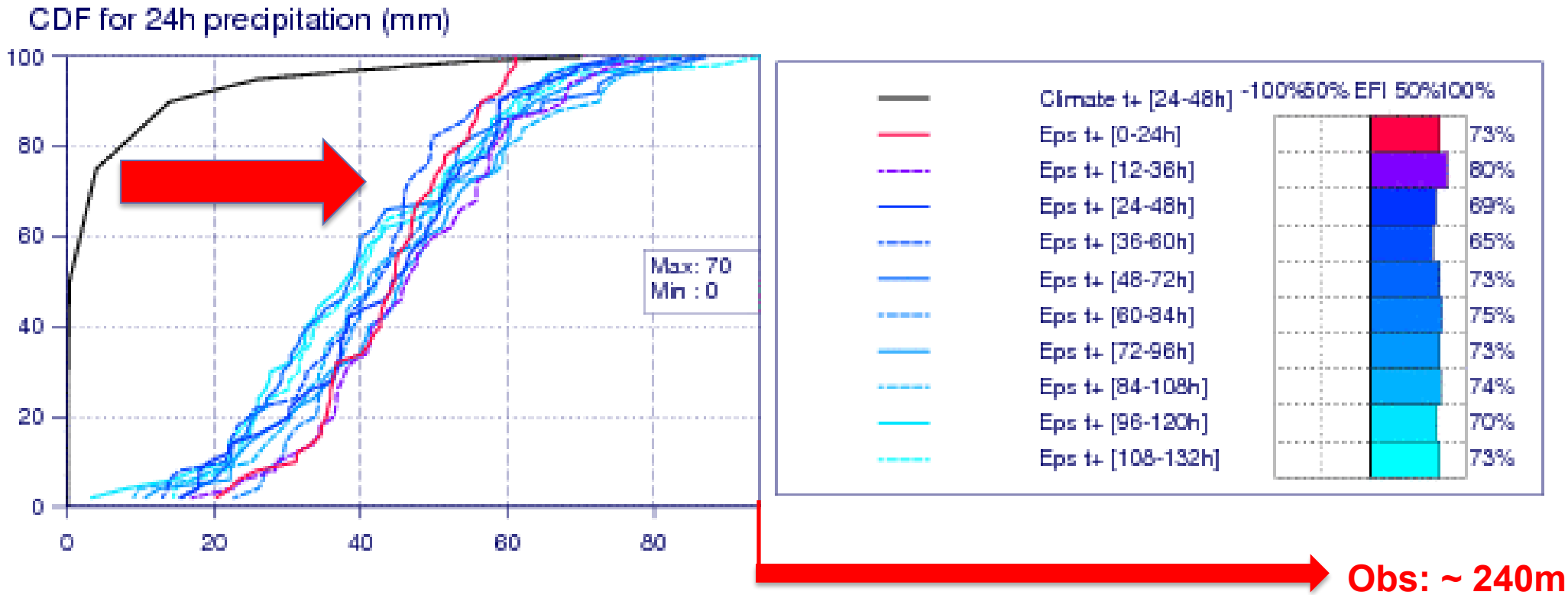
Note 1: the scale of the event is ~ 1-5 km

Note 2: IM should aim to give alerts 24-72h before

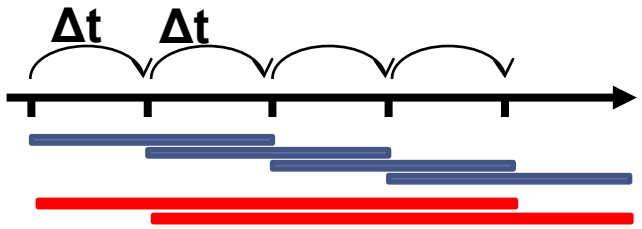
Priority for IM: short-range fcs of extremes better than ECMWF

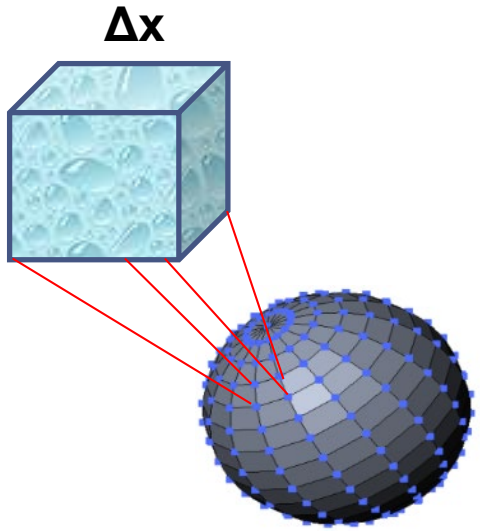
Genova, 4 November 2014

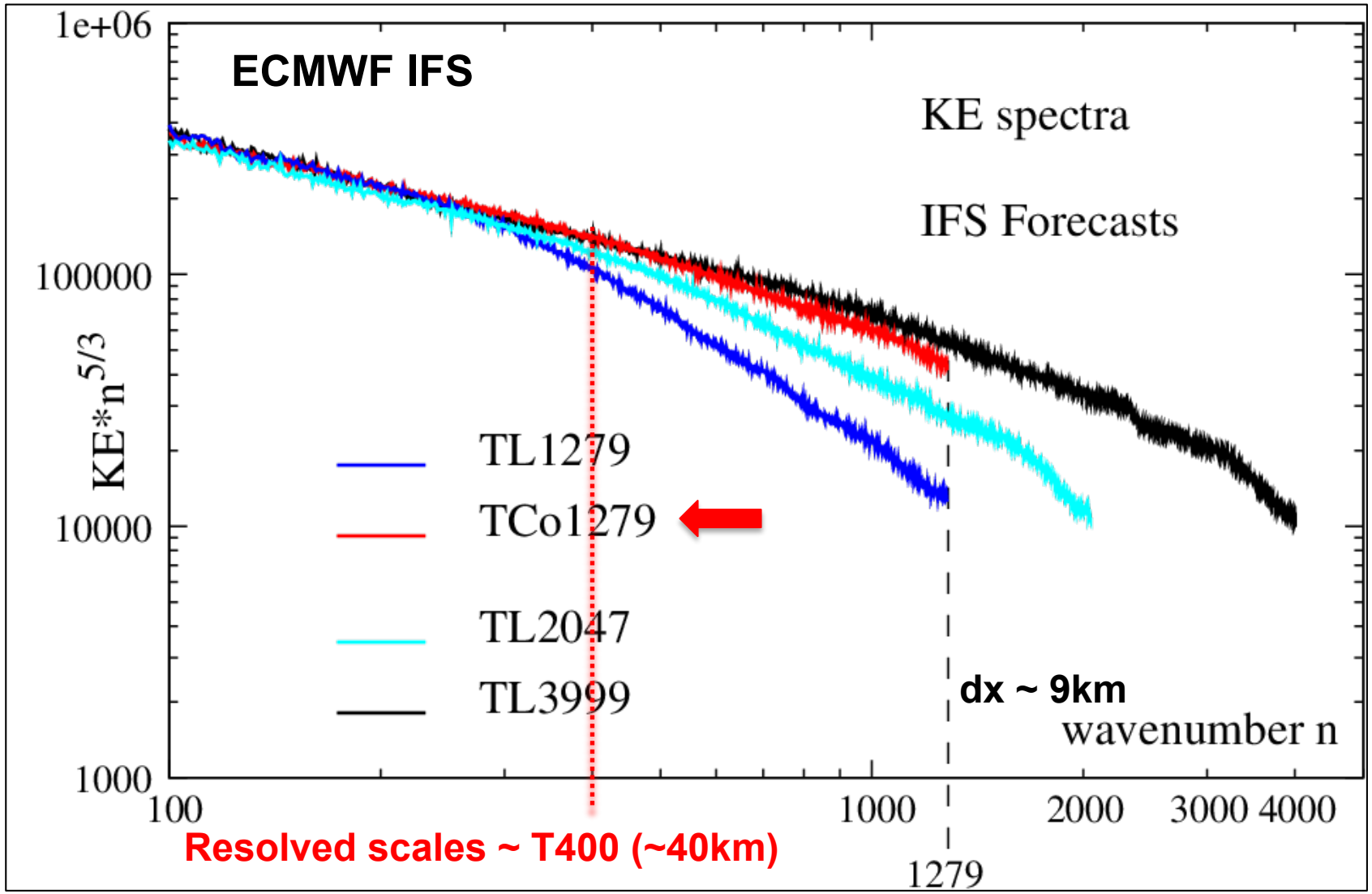
Forecast and M-Climate cumulative distribution functions with EFI values at 44.54° N/9° E
valid for 24 hours from Tuesday 4 November 2014 00 UTC to Wednesday 5 November 2014 00 UTC



Reminder 1: a model resolves only scales down to ~ $5 \cdot \Delta x$



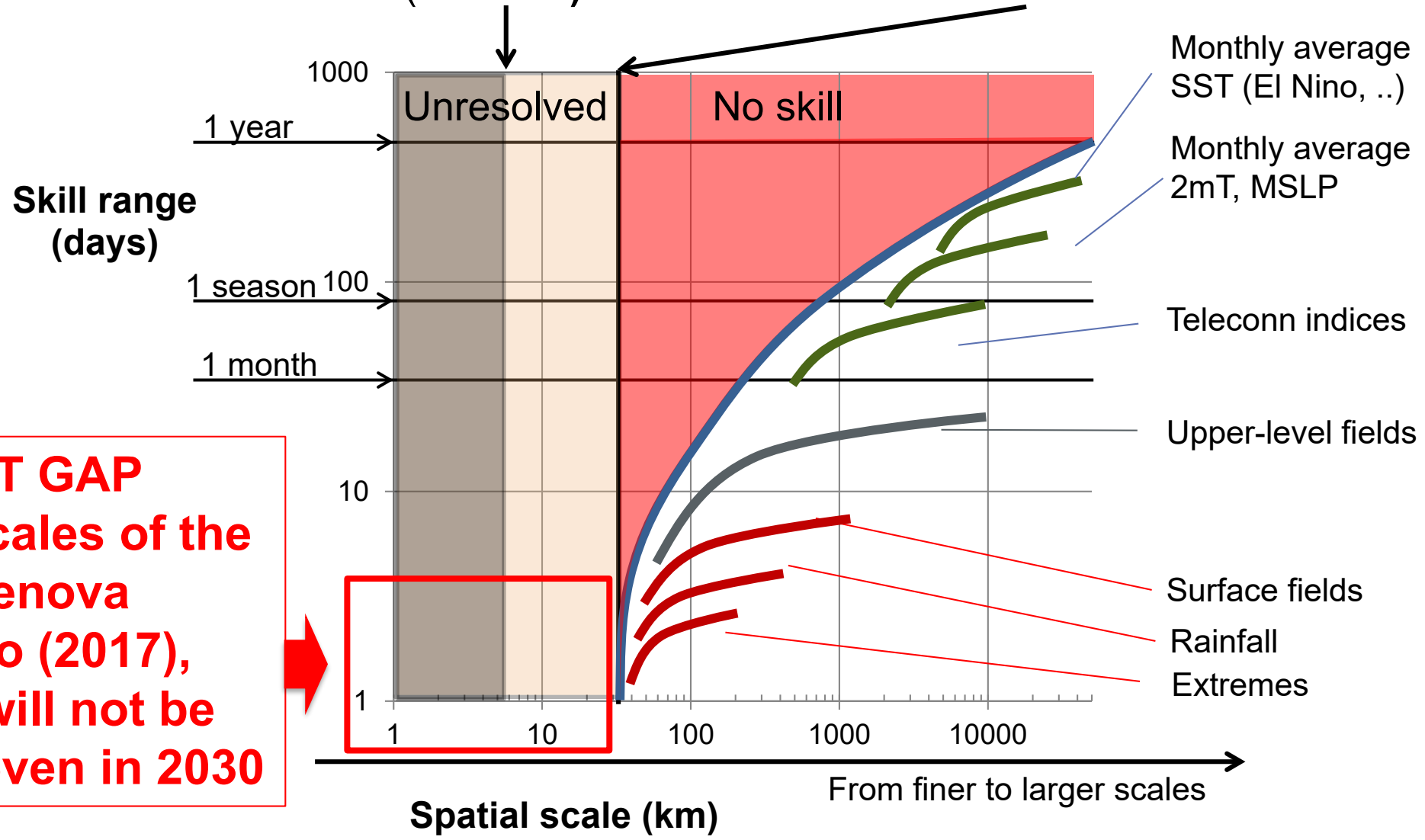




(from Nils Wedi)

Reminder 2: predictability is scale dependent

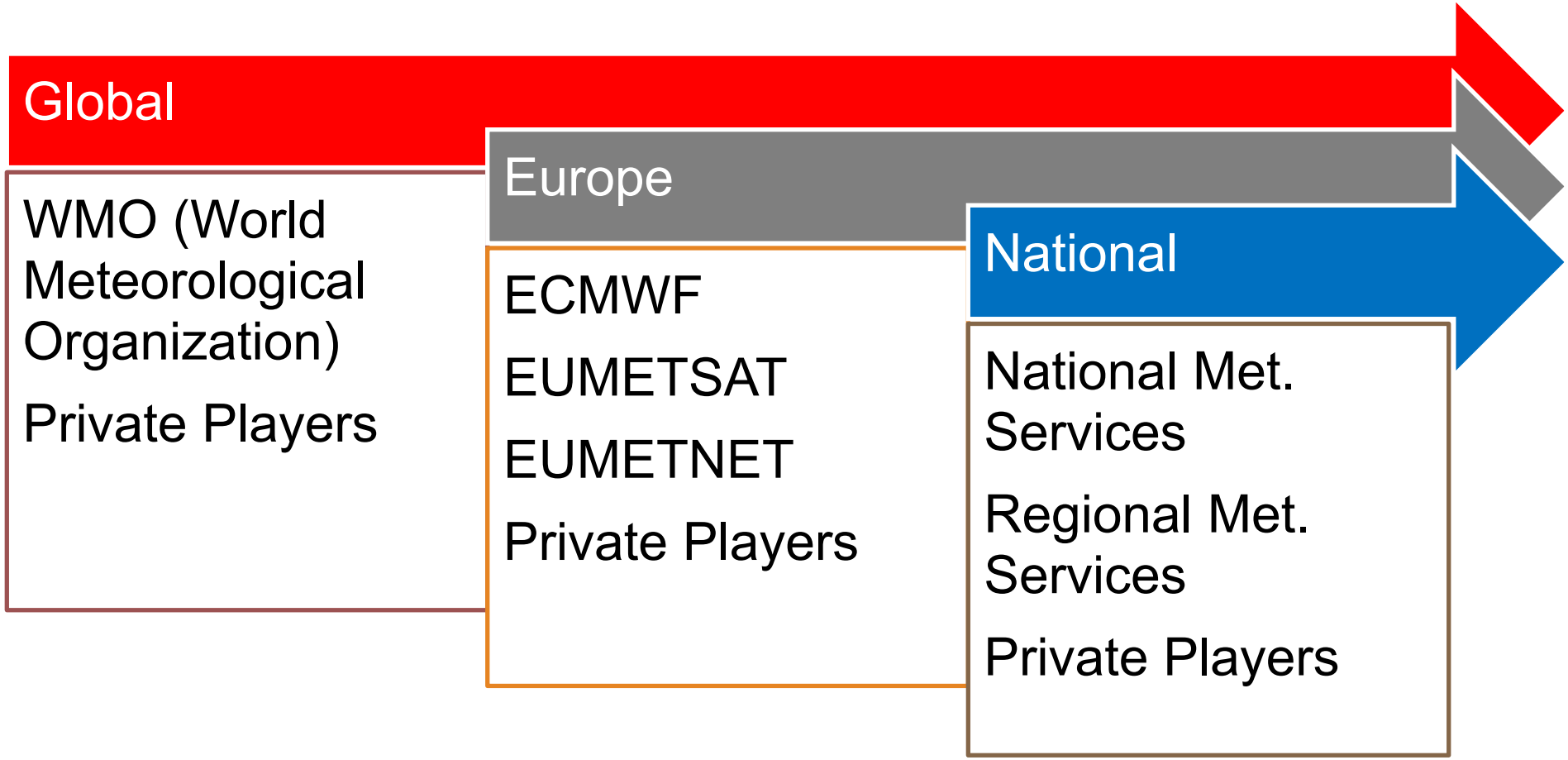
~2030: ECMWF ENS truncation (**dx=5km)** and resolved scales **~25km**



FORECAST GAP

These are the scales of the extremes like Genova (2014) or Livorno (2017), which ECMWF will not be able to predict even in 2030

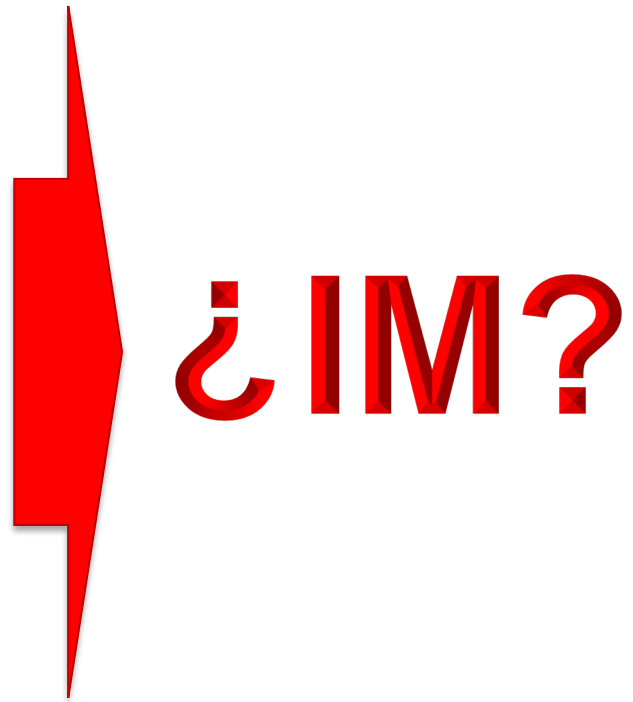
Cost/benefit: there is an existing infrastructure to build upon



NB: Italy is one of the founders and the 4th contributors to the European Meteorological Infrastructure (EMI, which includes EUMETSAT, ECMWF and EUMETNET).

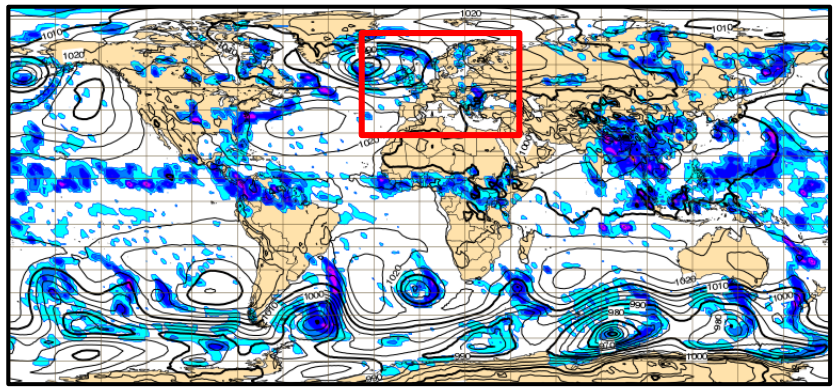
Given 1-9, which strategy is best for ItaliaMeteo?

1. Weather prediction is an initial-value problem
2. Resolution is key to represent well physical processes
3. A model resolves scales only up to $\sim 5 \cdot \Delta x$
4. High-resolution obs. and a proper DA are needed
5. Computer power is key to advance DA and modelling
6. The atmosphere is chaotic: we need ensembles
7. Predictability is scale dependent
8. There is an existing EMI
9. Resources are limited

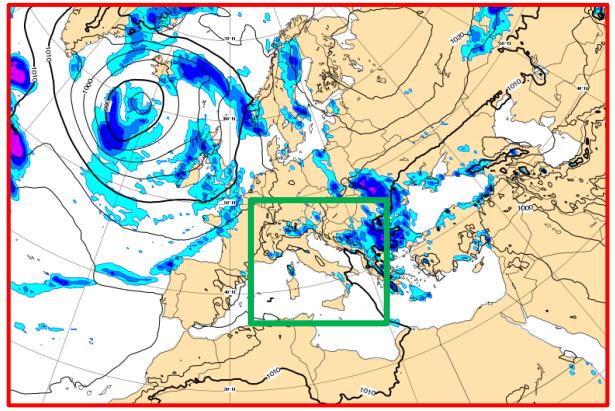


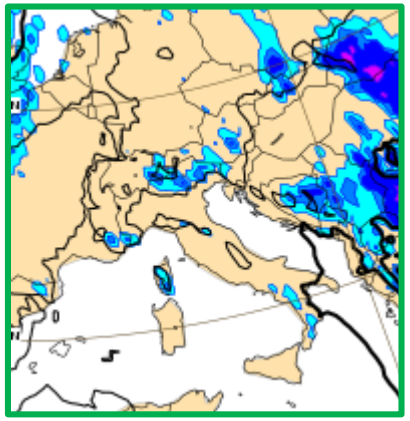
IM strategy depends on its resources: do-it-all or focus?

ECMWF: global, medium-range, monthly and seasonal



National Met Service: (global) regional, short-range (medium-range, monthly and seasonal)

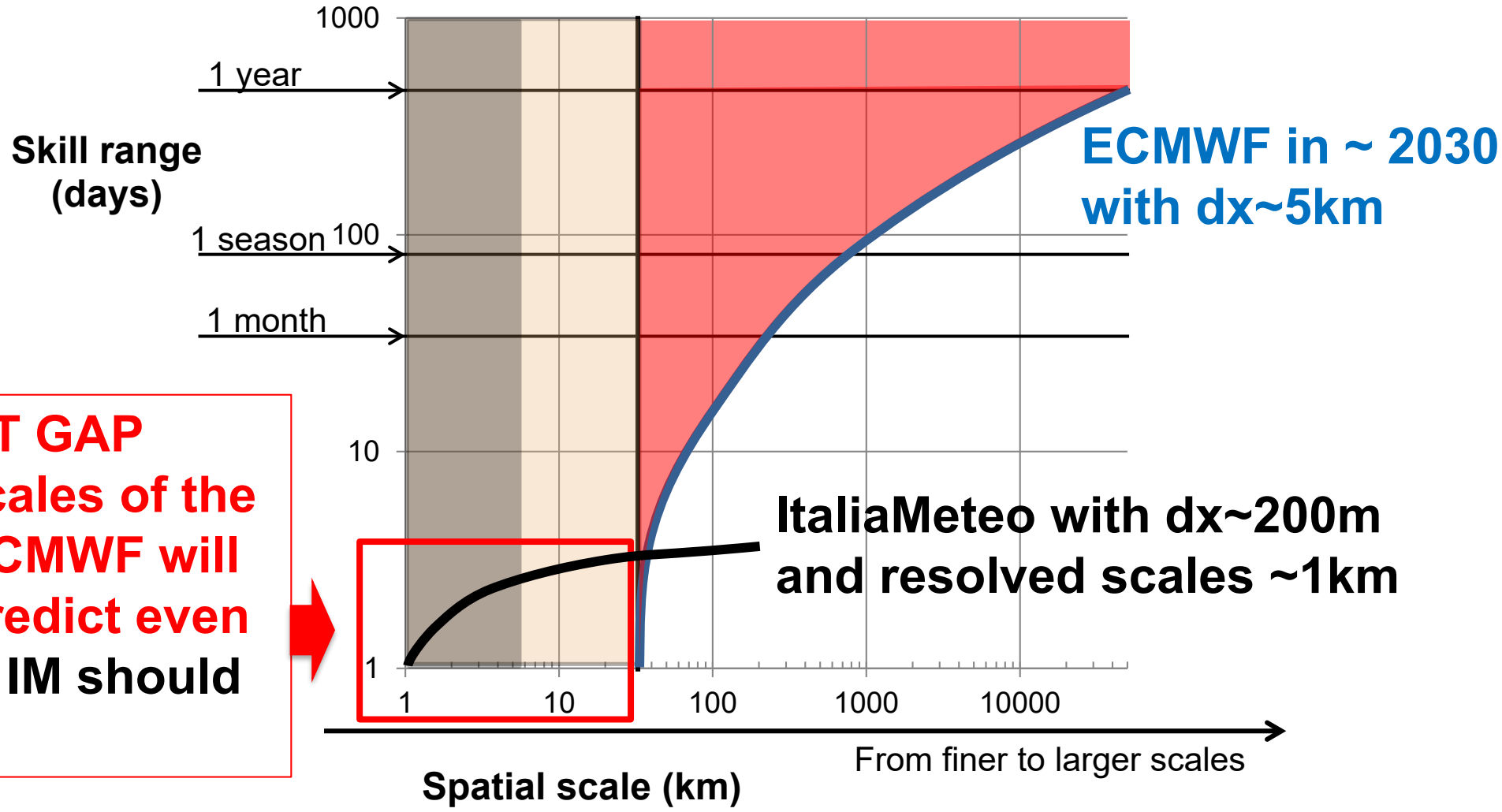




Some statistics of European National Met services (~2016)

Country	Met Service	Budget (M€)	Staff	Location
The 'do-it-all' Met Services: annual budget 250M+, staff 2,000+				
France	Meteo France	380	3,000	Tolouse (HQ); +7 regional offices
Germany	DWD	350	2,300	Offenbach (HQ); +6 branch offices
UK	Met Office	250	2,000	Exeter (HQ)
The 'focussed' Met Services: annual budget 70M+, staff 400+				
Holland	KNMI	70	400	Utrecht (HQ)
Spain	AEMET	121	1,200	Madrid (HQ); +17 regional offices
Sweden	SMHI	70	640	Norrköping (HQ)
Switzerland	Meteo Swiss	85	335	Zurich (HQ); +2 regional offices

The ‘forecast gap’ that ItaliaMeteo must fill?



FORECAST GAP

These are the scales of the extremes that ECMWF will not be able to predict even in 2030 and that IM should aim to predict

How can Italy get better returns on investments in meteo?

1. Avoid **duplications and fragmentation**;
2. **Merge and consolidate groups** to achieve the critical mass required to do top quality NWP, and possibly even to save money;
3. Set **clear priorities;**
4. Should Italy aspire to develop, maintain, continuously upgrade and use in operational production an 'Italian' model and DA?
   - **South Korea** invested **~100M USD over 10y** (2010-2019), to fund ~70 people to develop a model and a DA: they have just completed the challenge on time;
   - **DWD dedicated ~70 people** for many years (5+) to develop the new ICON model, which is now up and running.

Conclusions: which strategy for ItaliaMeteo?

A. **ItaliaMeteo should exploit synergies with ECMWF** (Italy pays for it, and owns its knowledge, software, data, ..),and complement its products to provide the best possible service.

B. The strategy depends on the **resources** ItaliaMeteo will have, and how **effectively and efficiently** they will be used.

C. If resources are limired, priorities must be clearly set: I think firstly ItaliaMeteo must aim to provide better **short-range fcs of extremes** than ECMWF.

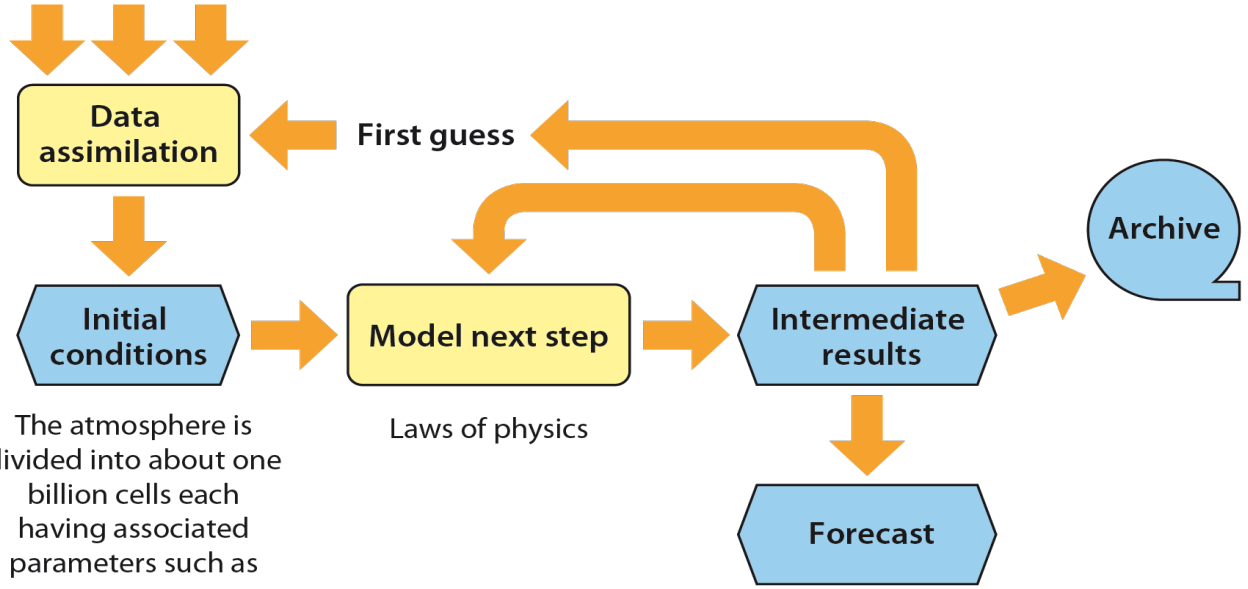
D. The **Italian Met sector must be reformed** to give its tax-payer citizen a top quality service. **ItaliaMeteo has the moral duty to do drive it!**

Extra slides …

Weather prediction is an initial-value problem

$$e_j(d,T) = e_j(d,0) + \int_0^T [A(e_j,t) + P(e_j,t) + \delta P_j(e_j,t)]dt$$

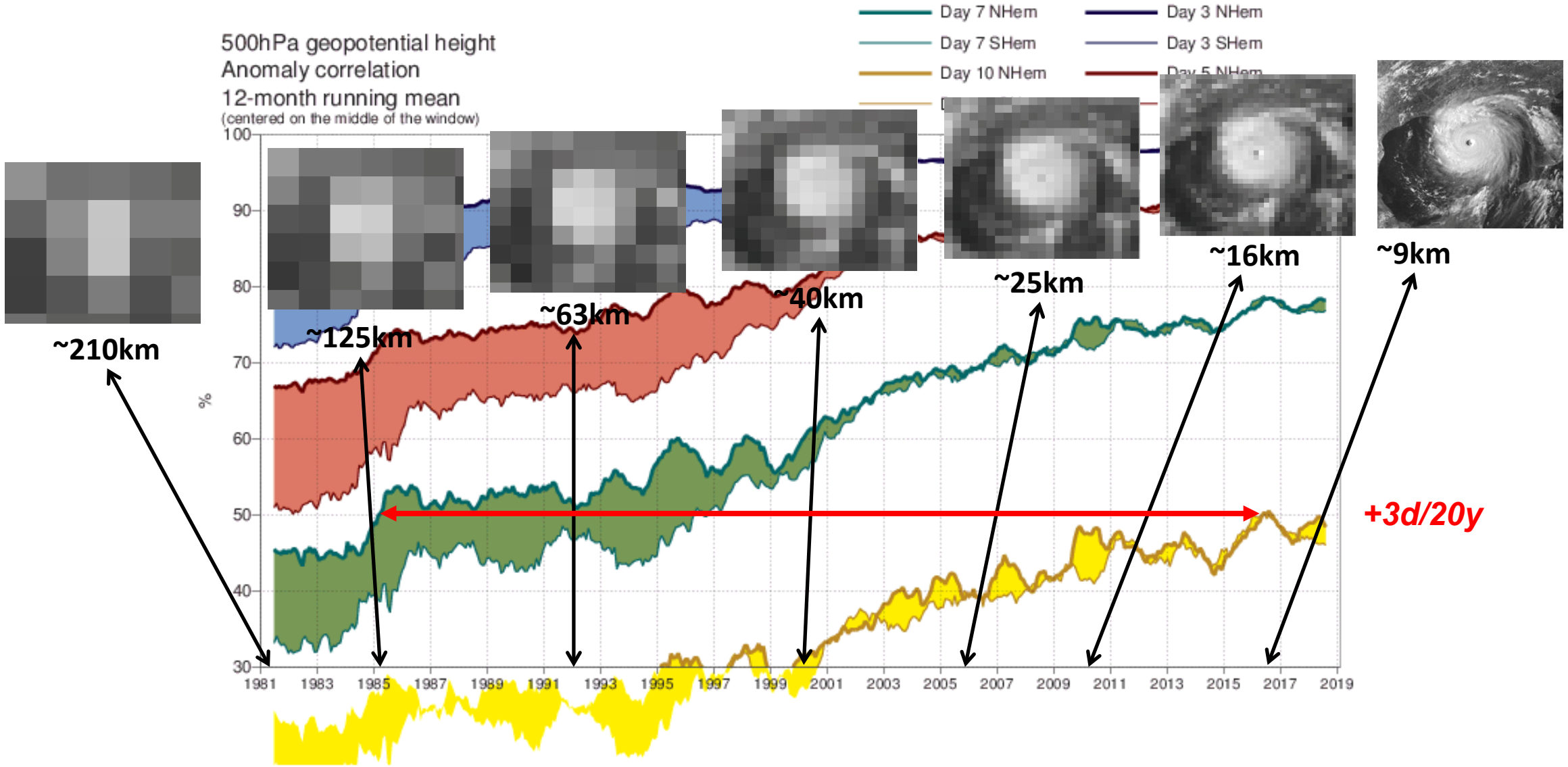
Aproximately 20 million observations



The atmosphere is divided into about one billion cells each having associated parameters such as temperature, pressure, and wind direction.

Laws of physics

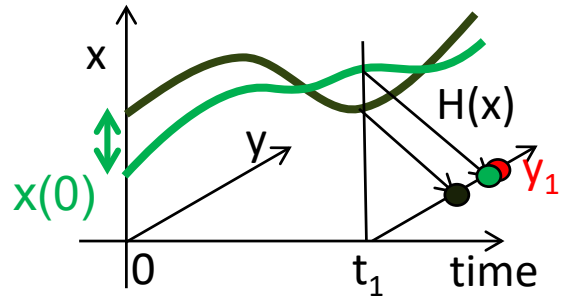
Resolution is key to represent well physical processes



High-resolution observations and a proper DA are needed

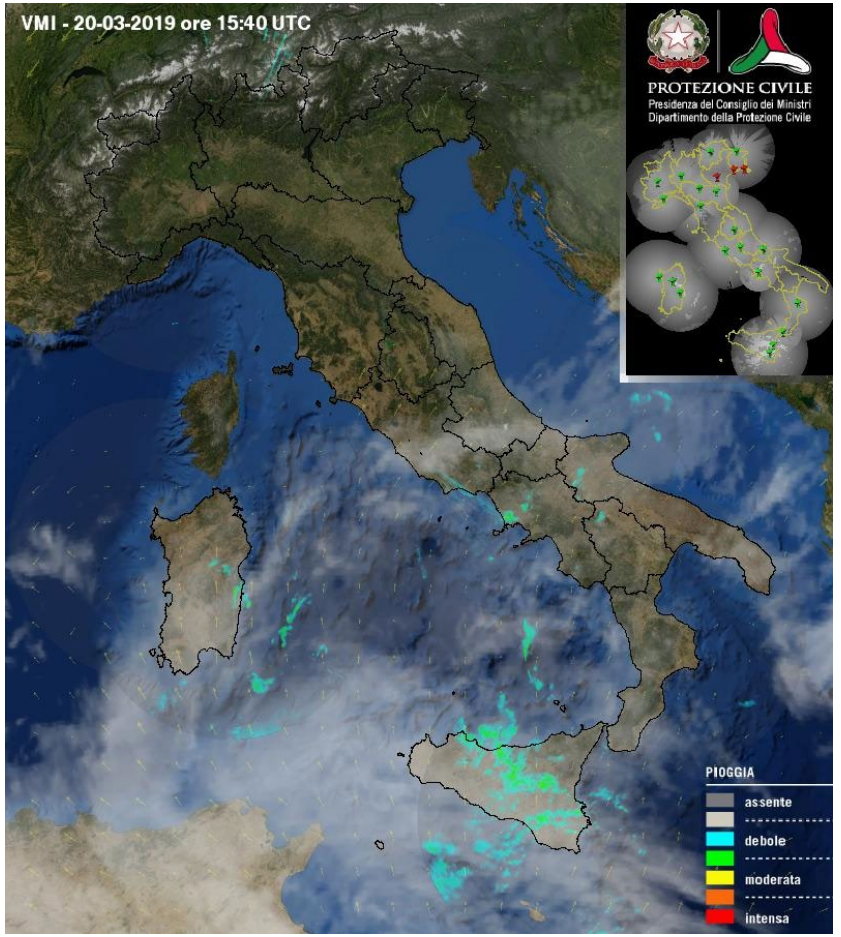
Which data-assimilation method would work best at very high-resolution?

- 4d-Var?
- EnKF?
- Particle filter?



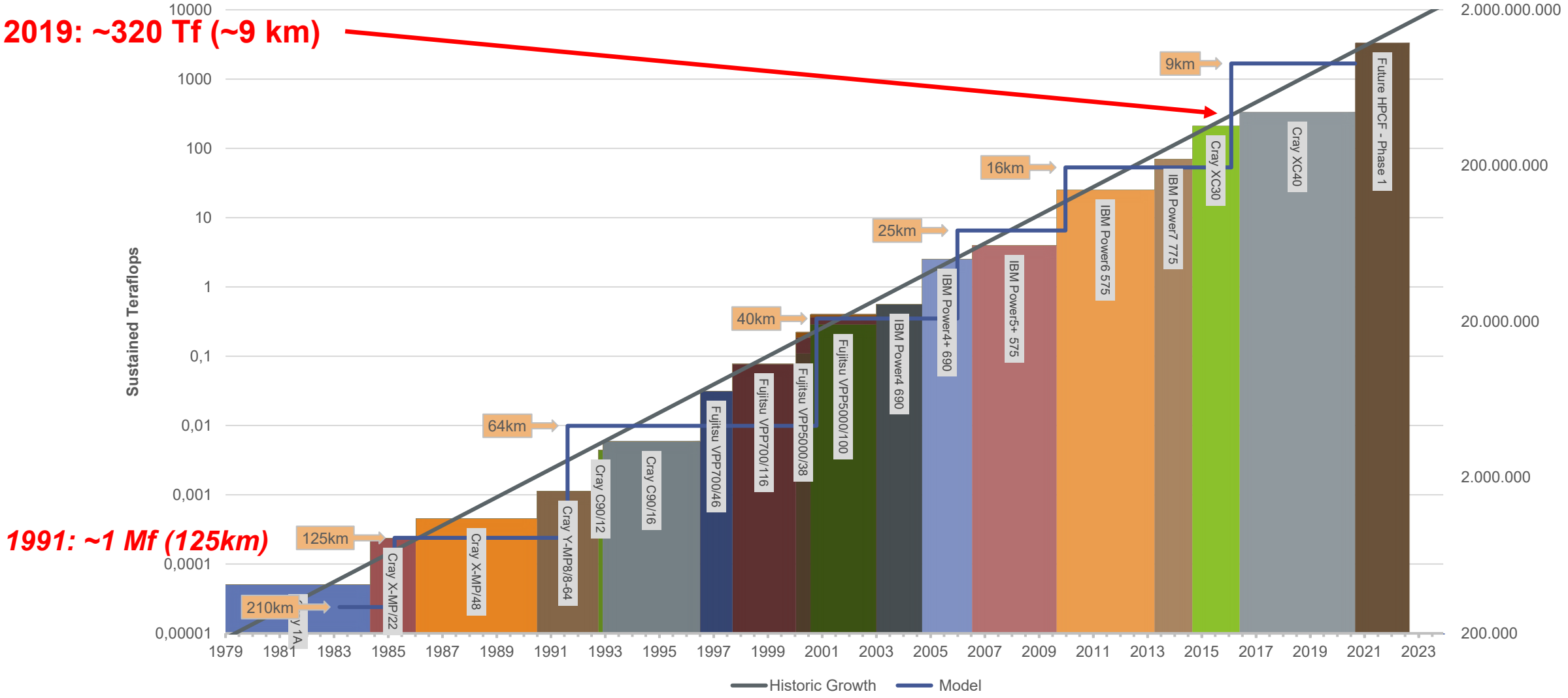
$$P = P_m P_b P_o = \exp(\log P_m + \log P_b + \log P_o)$$

$$\min J = \min(-\log P_m - \log P_b - \log P_o) = \min(J_m + J_b + J_o)$$



(image from Protezione Civile)

Computer power is key to advance DA and modelling



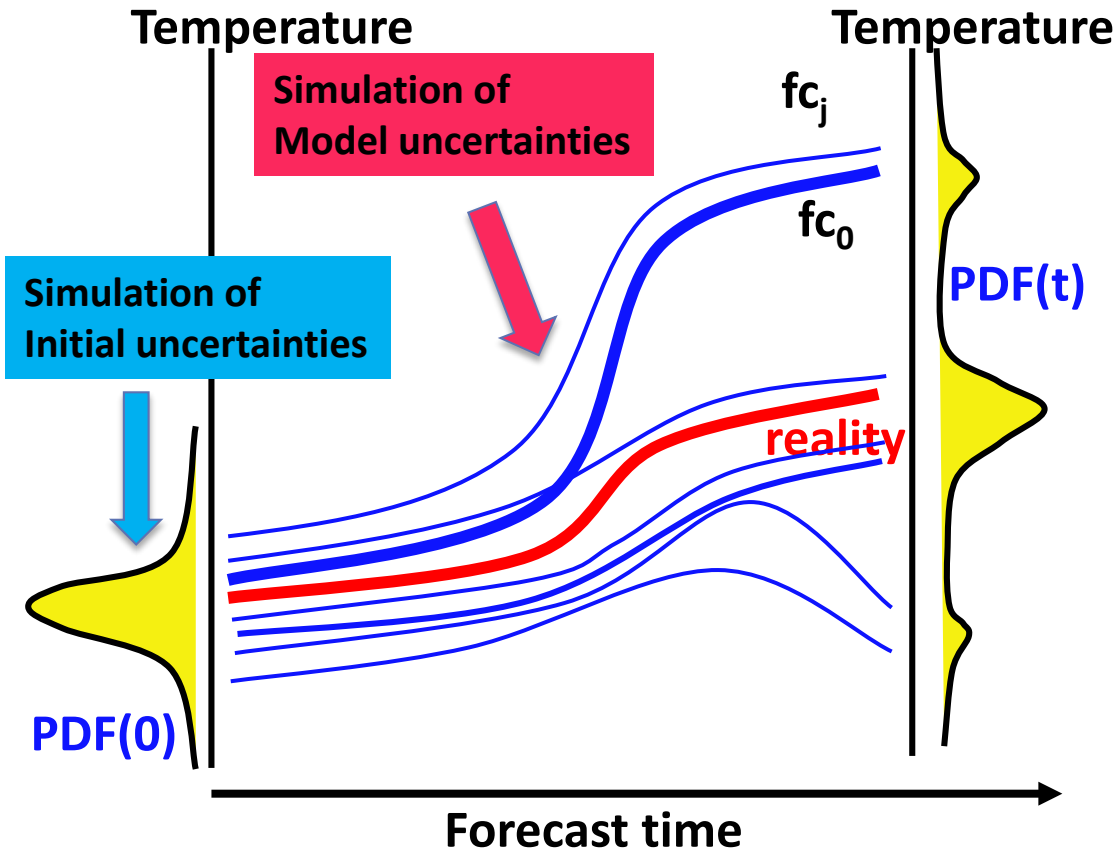
We need ensembles (the system is chaotic)

Lorenz (1969): 3-eq. model for a 2D fluid layer warmed from below and cooled from above.

$$\frac{dx}{dt} = \sigma(y - x)$$

$$\frac{dy}{dt} = x(\varrho - z) - y$$

$$\frac{dz}{dt} = xy - \beta z$$

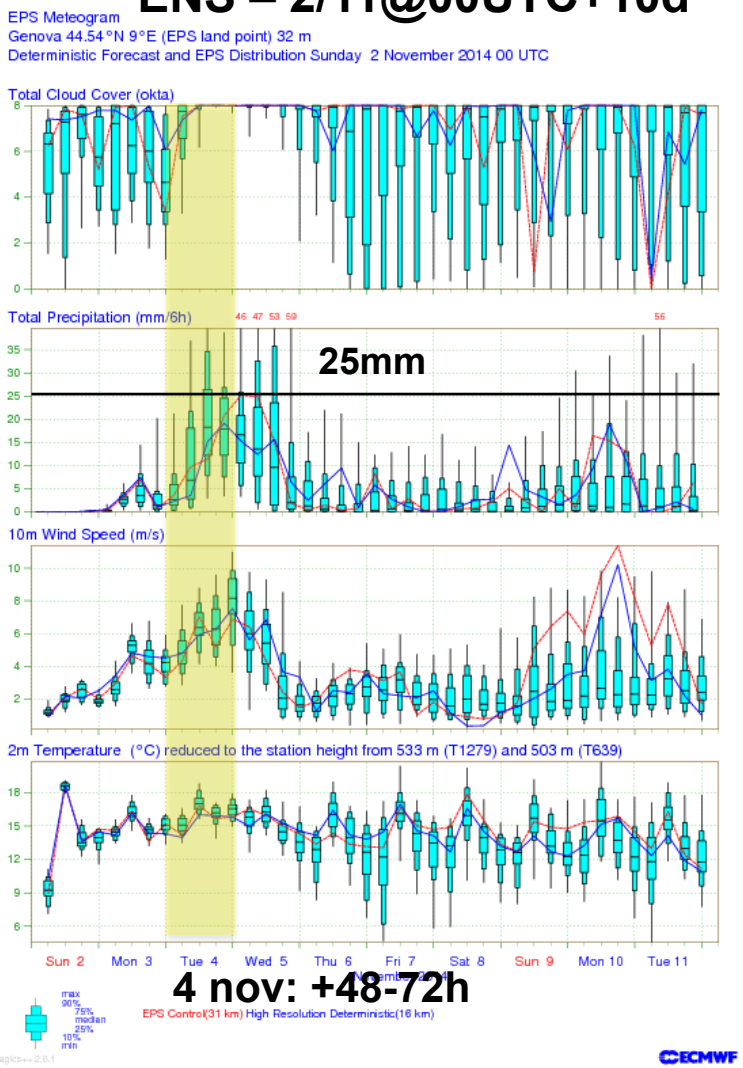


Italian resources for meteorology are limited

	ECMWF	UKMO	Meteo Swiss	Italia Meteo
Annual budget (M EUR)	**80**	**250**	**85**	**?**
Staff: Total	**280**	**2,000**	**335**	**?**
NWP	**240**	**~ 700**	**~ 135**	**?**
RD	*100*	*~ 400*	*~ 50*	
COMP (HPC, IT, ..)	*70*	*~ 100*	*~ 50*	
FC (products, ..)	*70*	*~ 200*	*~ 35*	
Other (Adm, Obs, ..)	**40**	**~ 1,300**	**~ 200**	

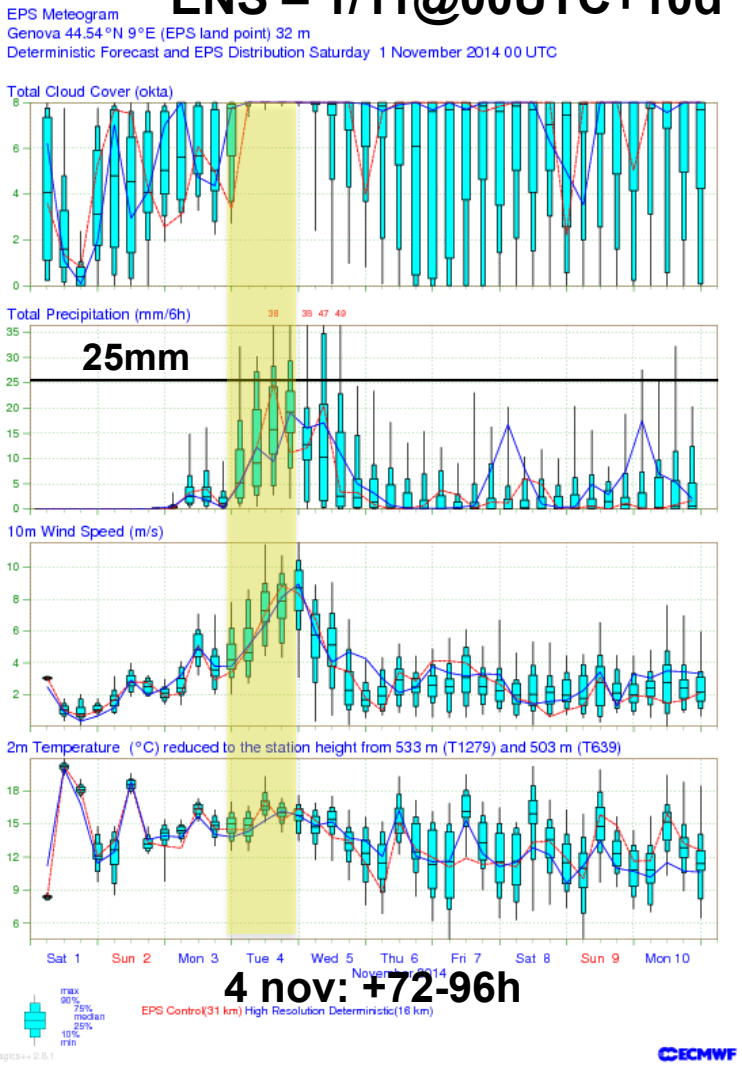
Extreme events (Genova; 4 November 2014)

ENS – 2/11@00UTC+10d



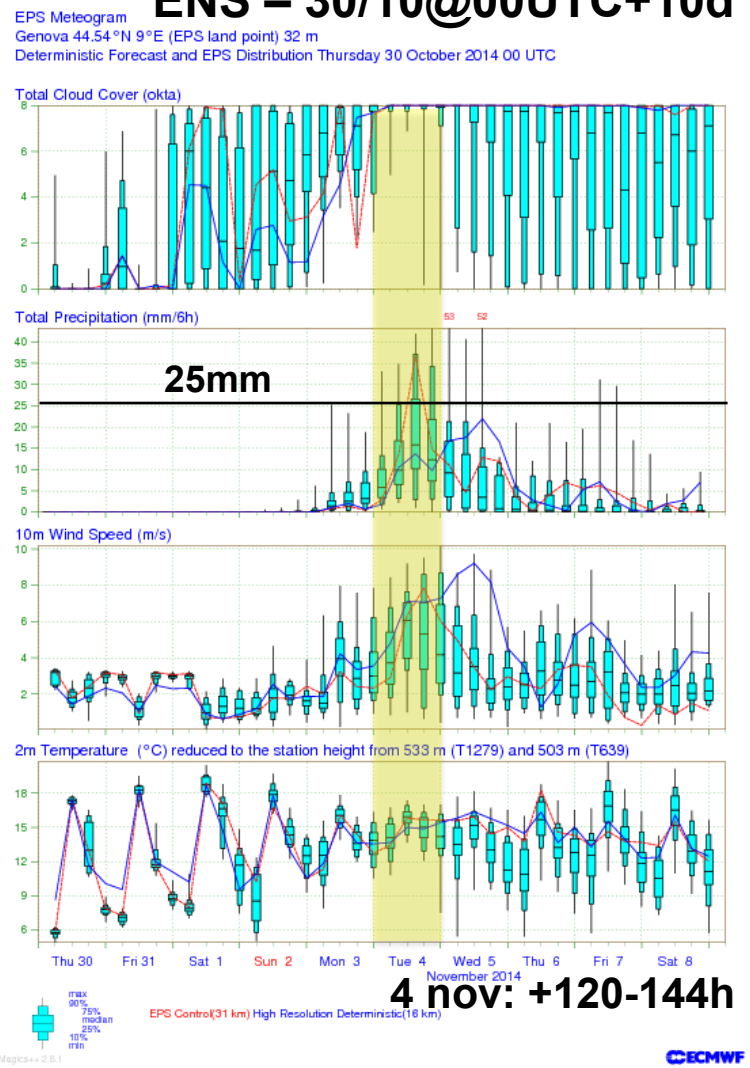
4 nov: +48-72h

ENS – 1/11@00UTC+10d



4 nov: +72-96h

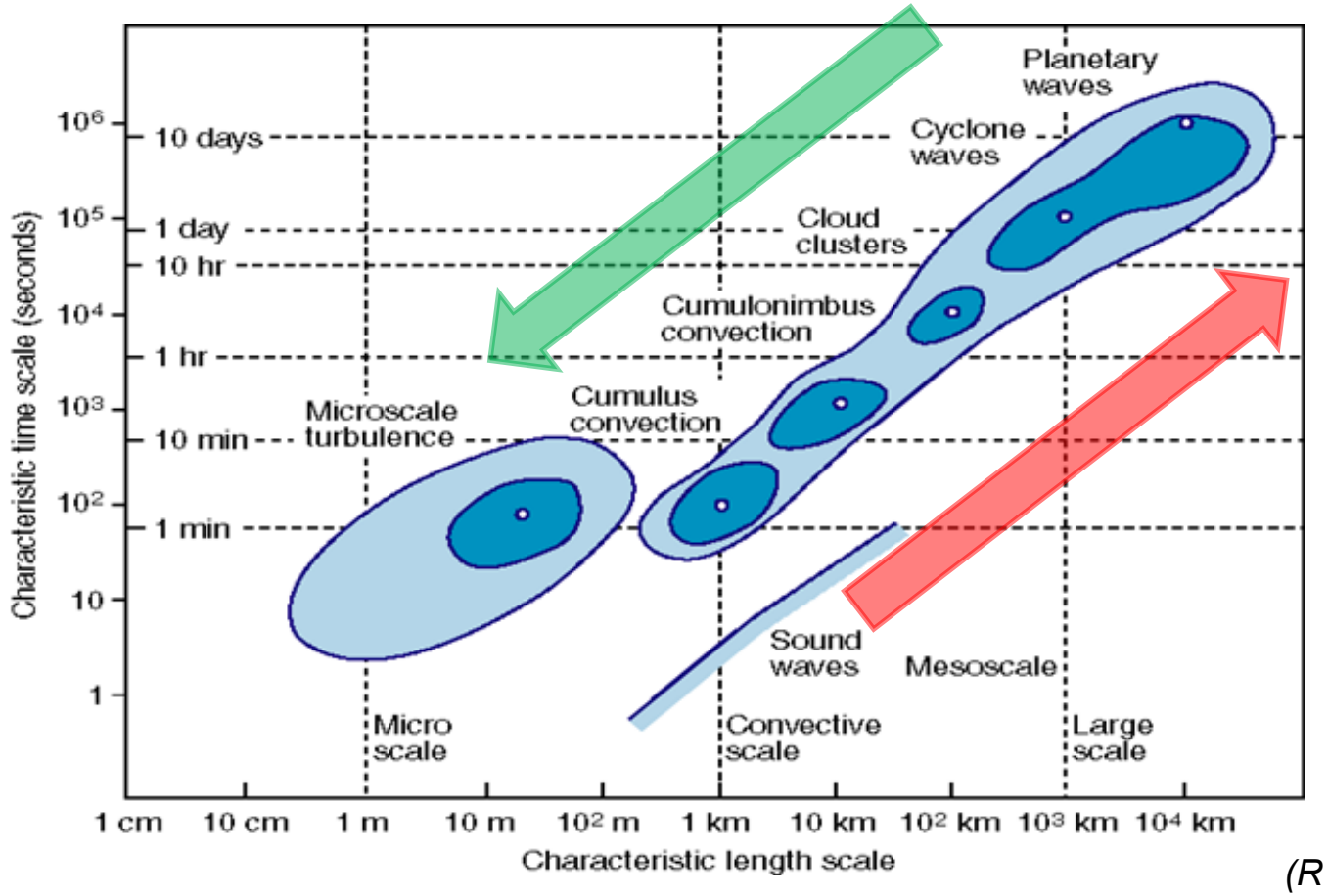
ENS – 30/10@00UTC+10d



4 nov: +120-144h

Predictable signals versus errors

Predictable signals propagate from the better-initialized and more predictable scales ('mainly' the large scales, the slowly evolving components) to the less predictable (small/fast) scales



Errors propagate from poorly initialized scales ('mainly' the smaller scales) thus reducing the predictive skill

(R Buizza and M Leutbecher, QJRMS 2015)

How can we get investments in IM of ~ 80M/y?

Talk about 'investments' and estimate the returns they can bring to Italy as a country, the gaps they can fill!

A WMO report talks about R.O.I. of between **2 and 36**:

- 4:1 to 36:1, if measured in terms of impact (cost) linked to extremes;
- 2:1 to 14:1, if measured in terms of impact on strategic investments;
- At least 4:1, if measured in terms of impact on citizen of North America;
- 3:1 to 6:1, if measured in terms of impact of droughts over Ethiopia;
- 2:1 to 3:1, if measured in terms of impact of TC on the oil sector;

A UK report talks about R.O.I. in the public sector of **10:1** (Gray 2015).