Combining ensembles and very high resolution single runs for probabilistic weather forecasting

The role of the forecaster in 2010

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Deterministic forecasting

1. **Compute initial conditions from observations**
2. **Run a state of the art NWP model**
3. **Get numerical forecast**
4. **Forecast relevant parameters**
5. **Take decision**
   - Protect, buy, sell, etc. in order to save lives, make profit, etc.

Which role for the forecaster?

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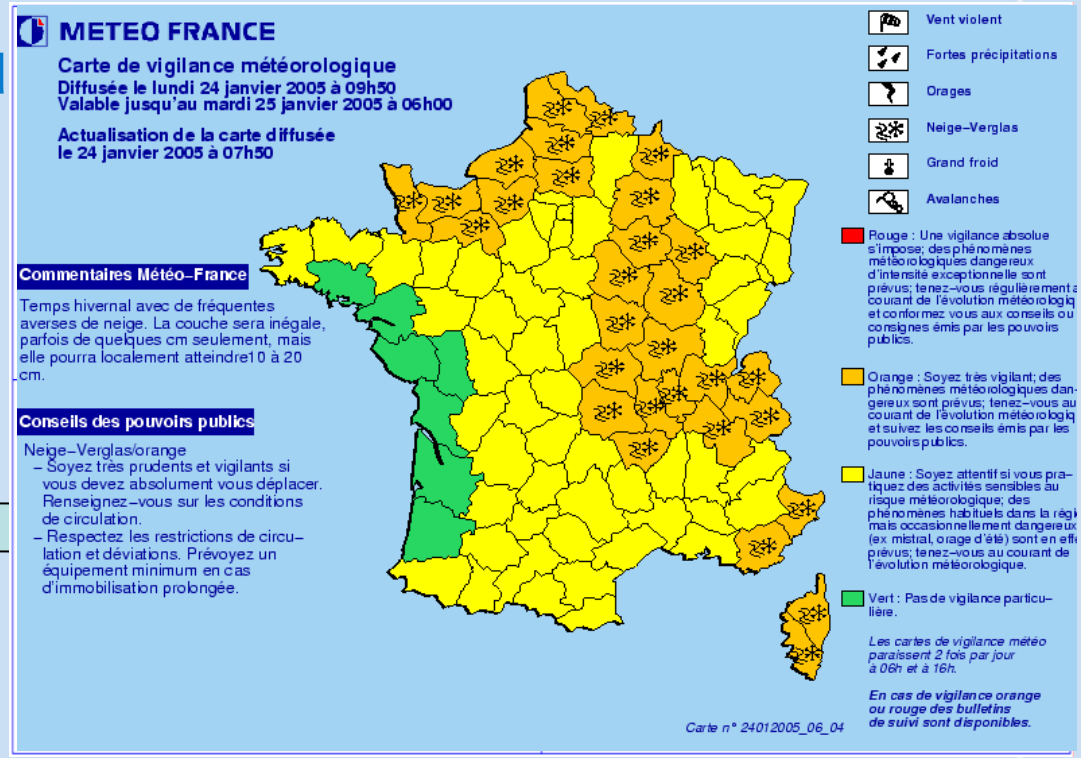
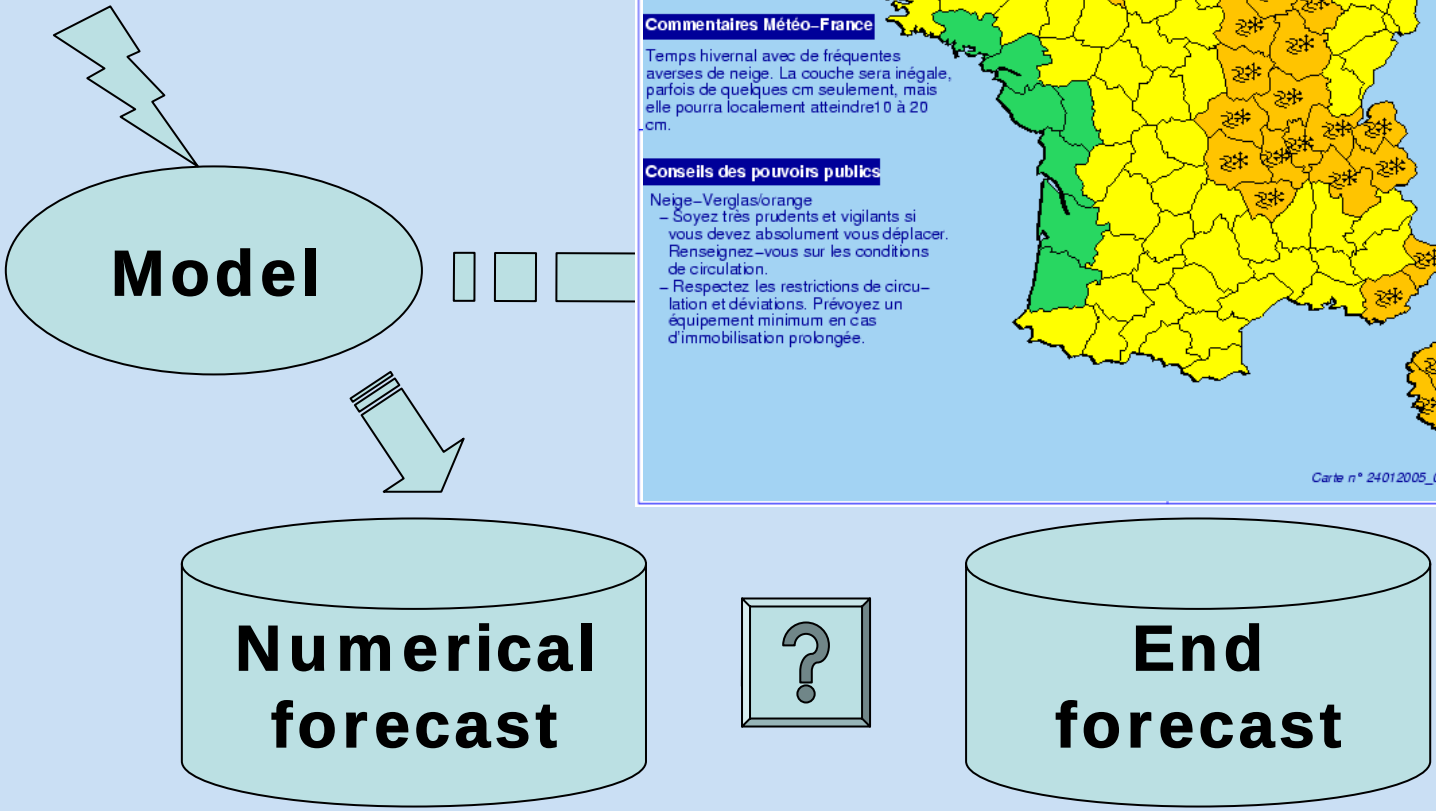
Single model ru

Initial conditions





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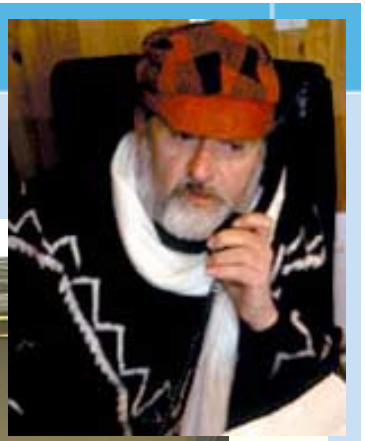
Comes the forecaster



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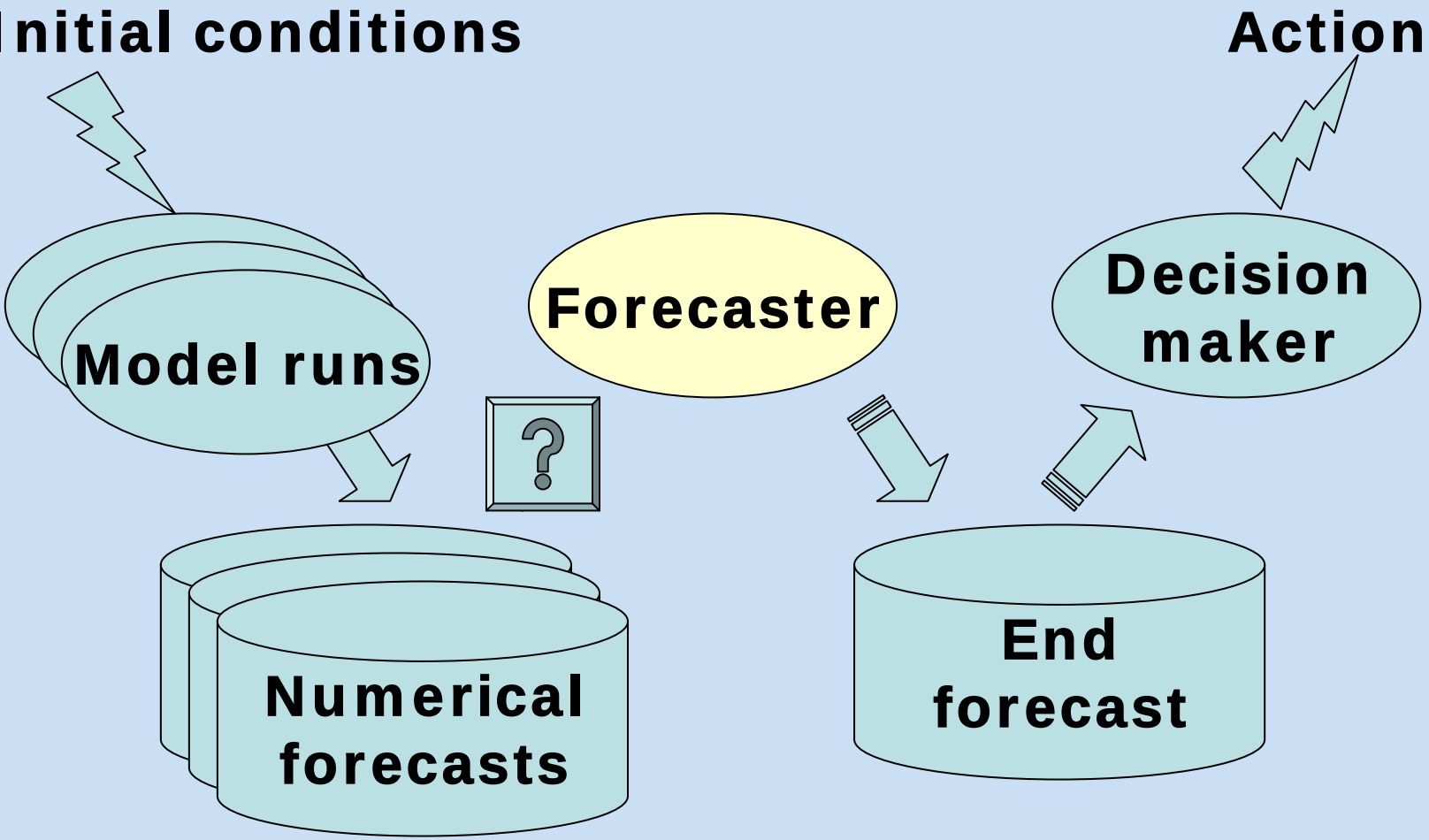
Several model runs



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Dealing with several options

- **Model runs can be:**
  - Runs of different models
  - Consecutive runs from the same model
  - Ensemble runs ("choosing the best member")
- **Some runs can be preferred for empirical, rather intuitive reasons, eg "realism", or ability of a given model to predict certain features**
- **A more rational, efficient strategy consists in preferring the runs whose initial conditions are better, ie closer to observations**
- **Variability among alternatives indicates the level of predictability, ie the uncertainty of the forecast**

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Evaluating the quality of initial conditions

- Evaluate the sensitivity of numerical forecasts to errors in the initial conditions
- Compare first guess, analysis and forecasts at earlier lead times to observations and satellite images

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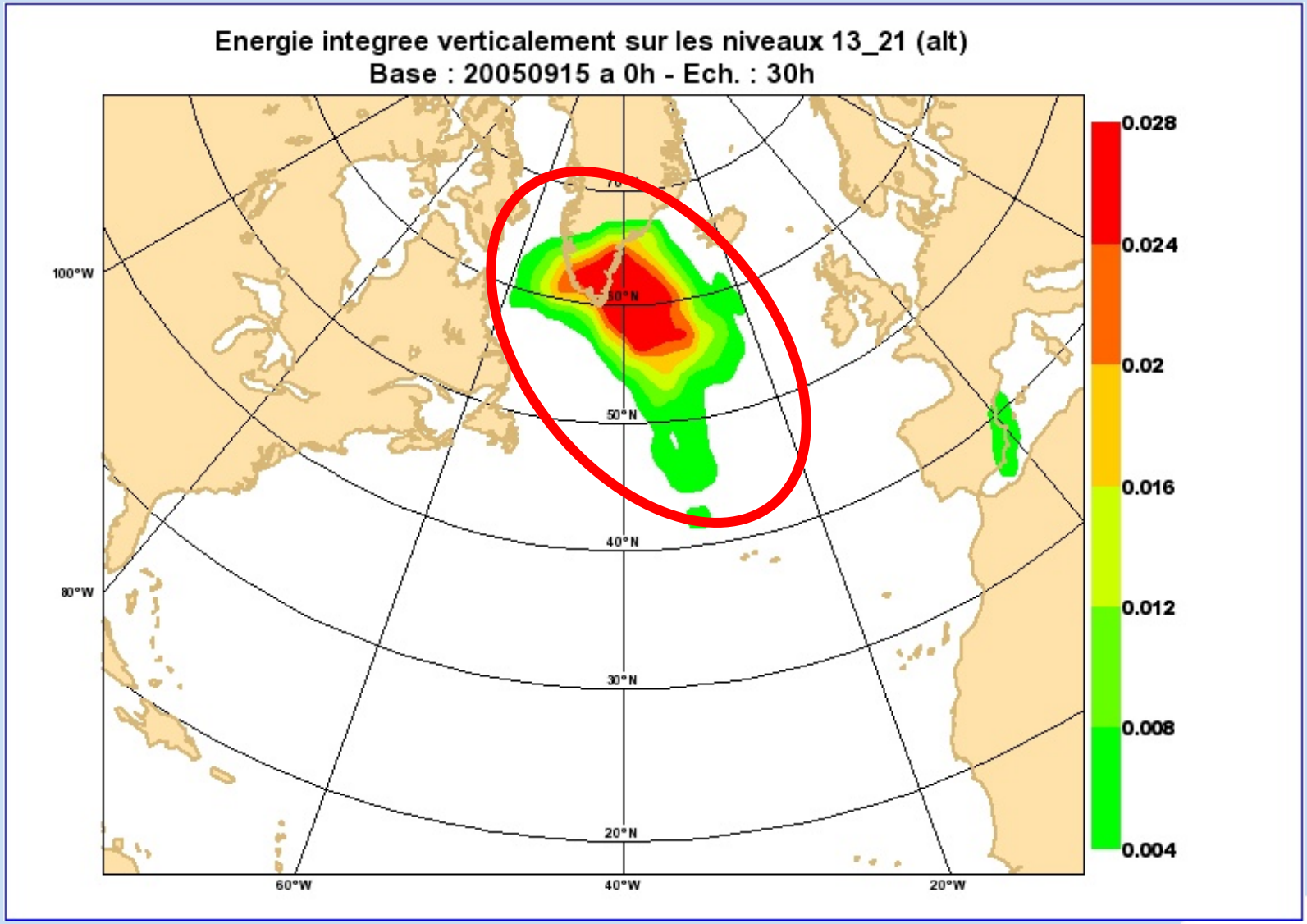
Example: sensitivity at +30h



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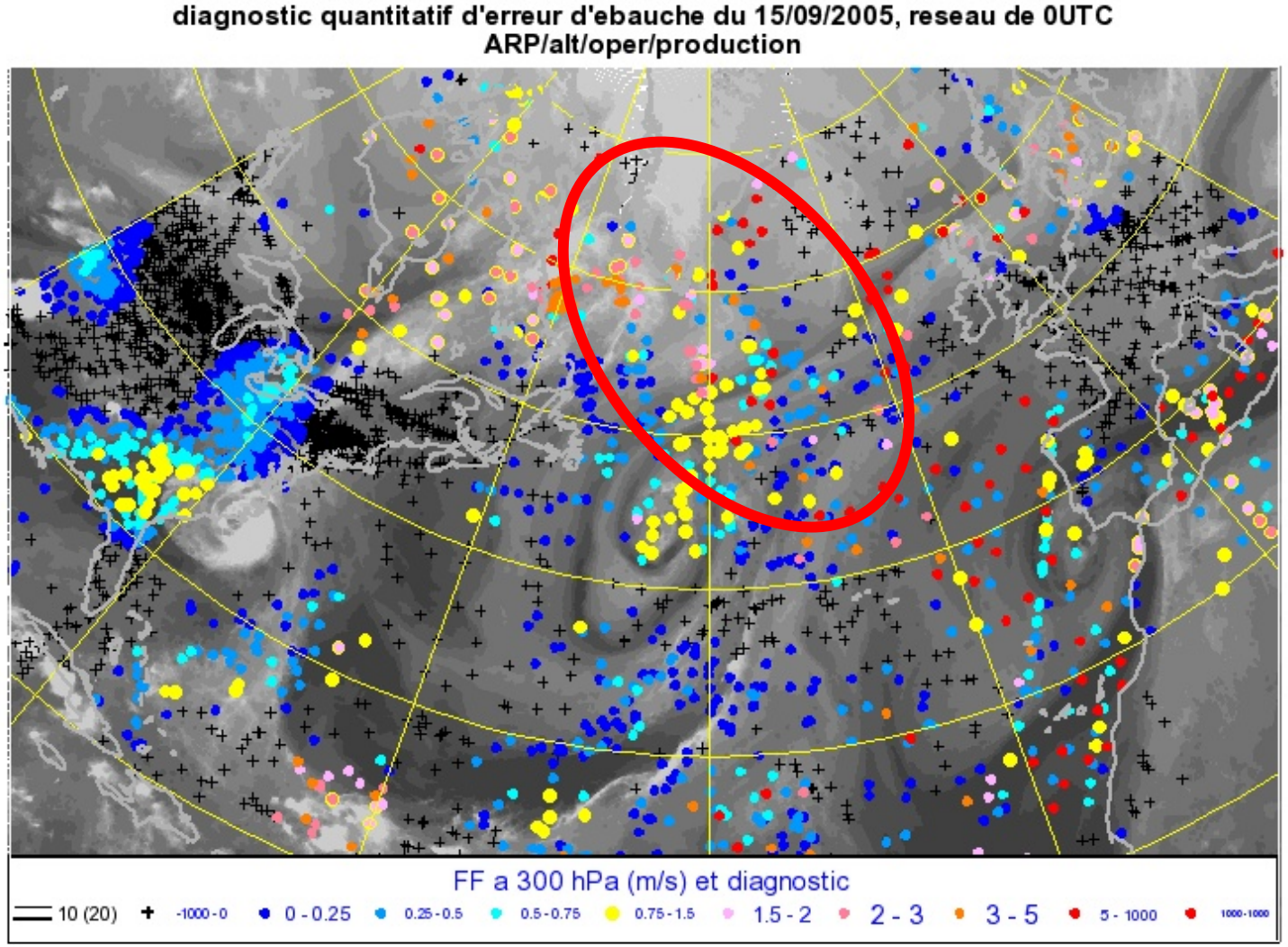
First guess error: run #1



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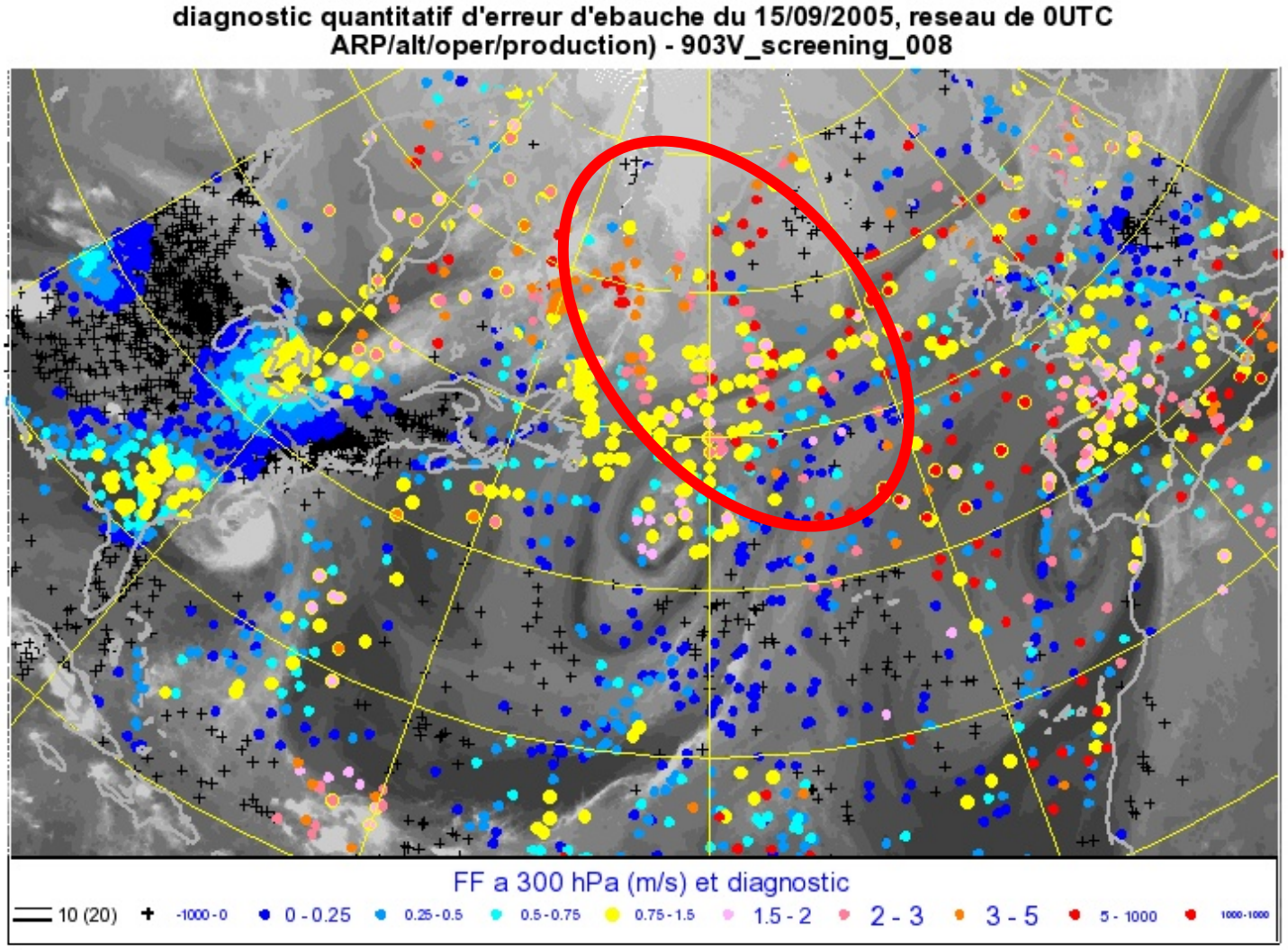
First guess error: run #2



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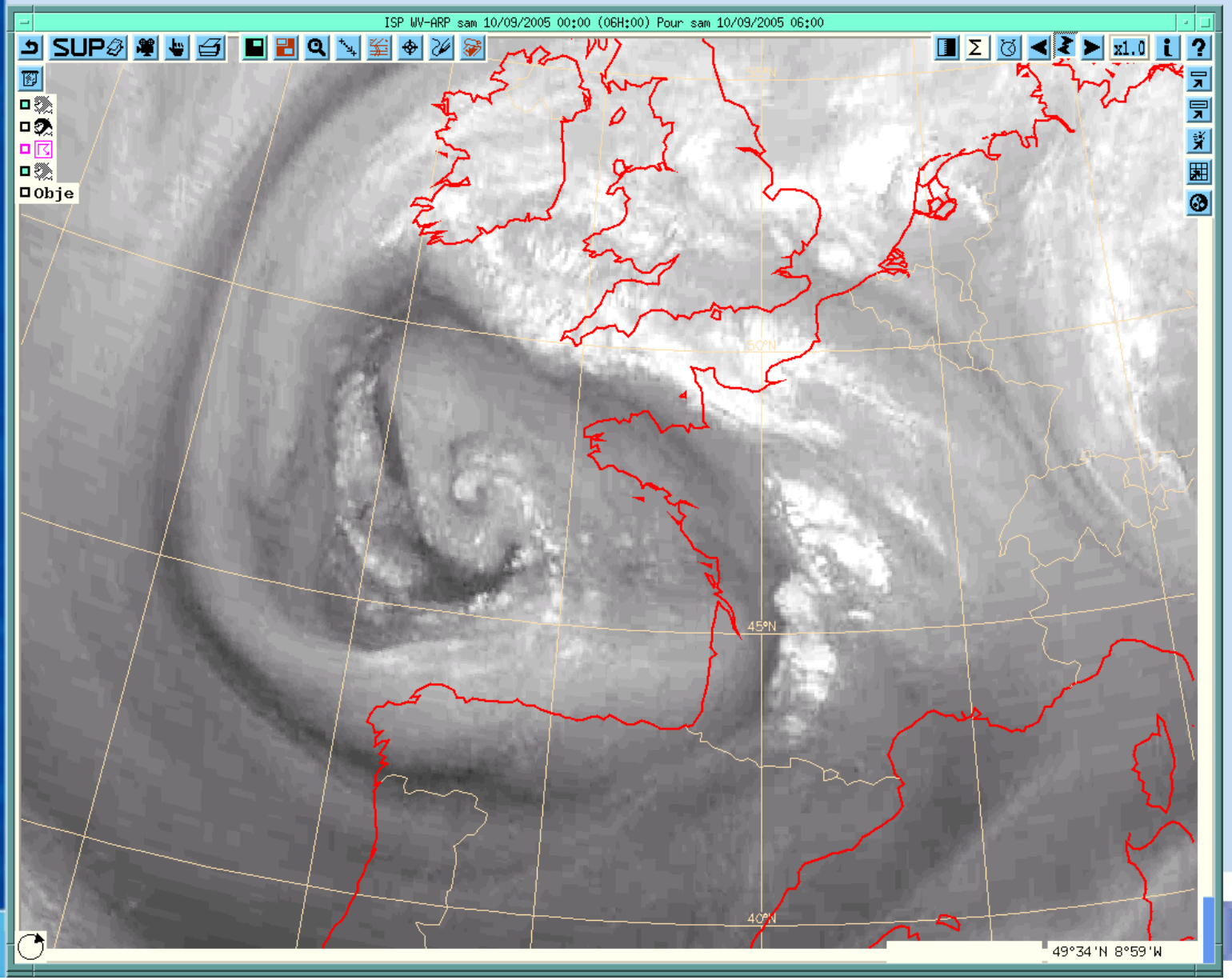
Water vapour synthetic image



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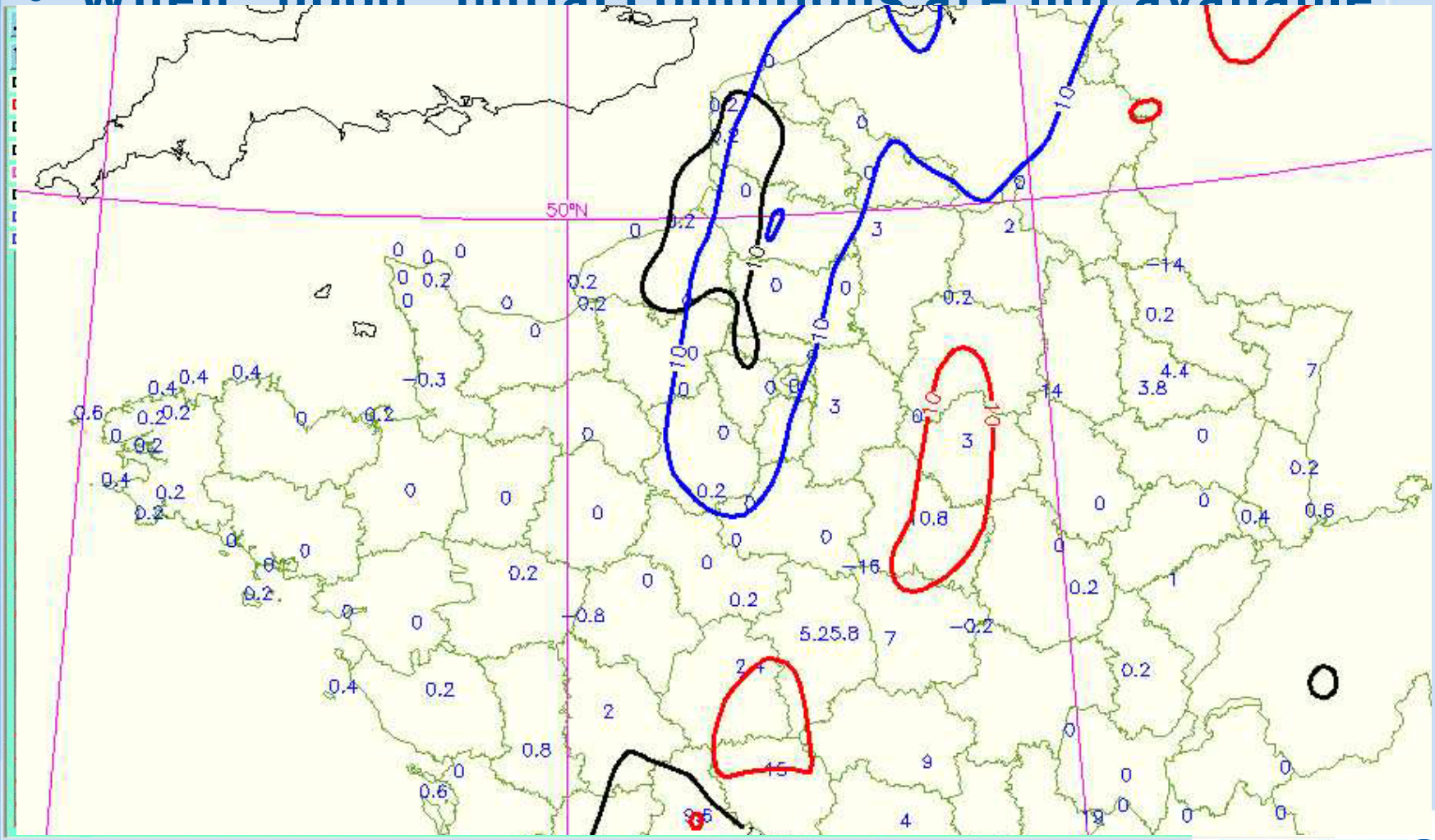
Correcting initial conditions

- When "good" initial conditions are not available



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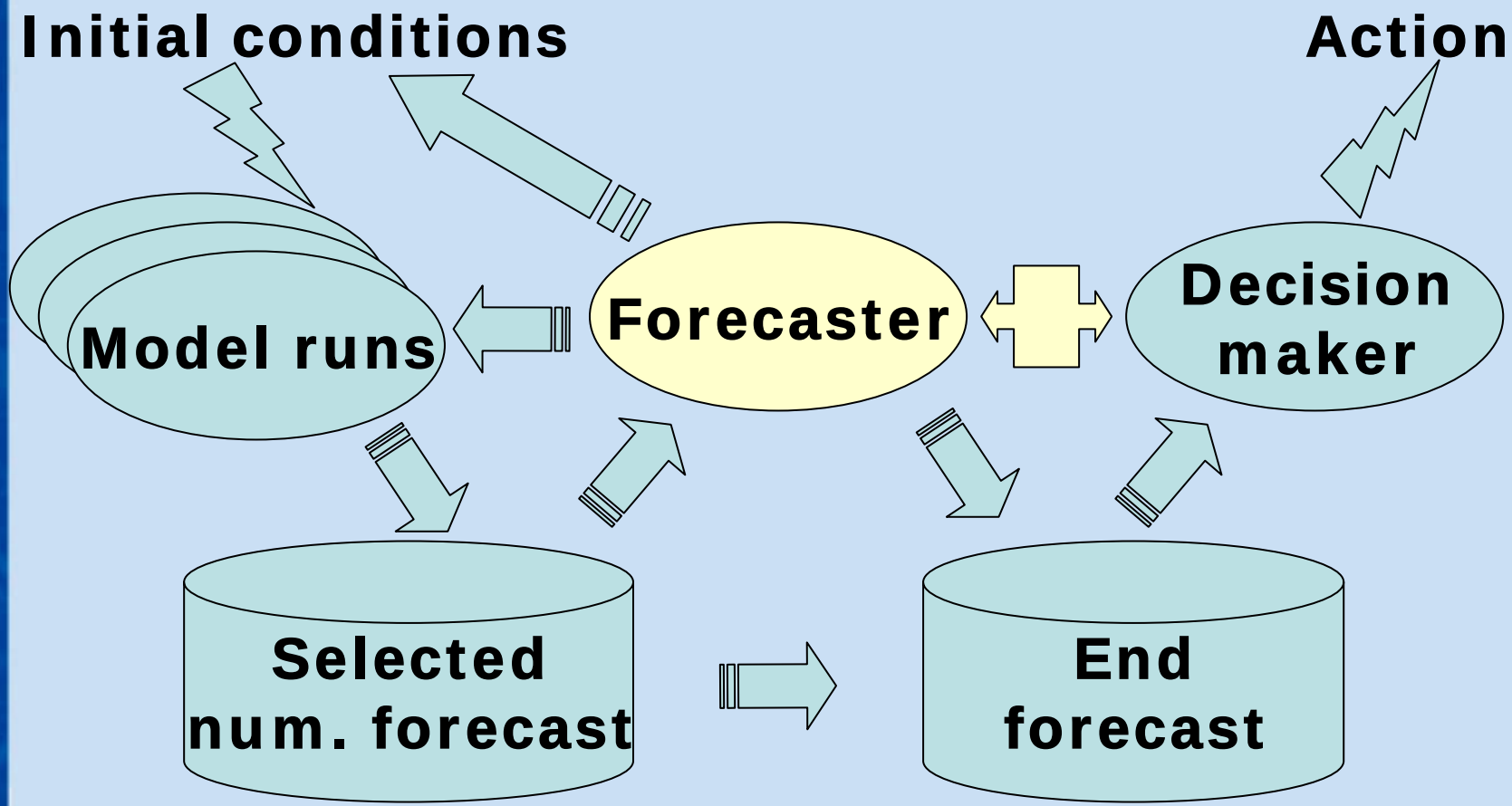
2005: forecasters are becoming experts in generating/selecting model runs



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Producing (det.) weather forecasts

Agglomération toulousaine - 151m - dernière mise à jour le 14/09/2005 15:02 UTC

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	Mercredi 14/09/2005						Jeudi 15/09/2005			
	17h loc.	20h loc.	23h loc.	02h loc.	05h loc.	08h loc.	11h loc.	14h loc.	17h loc.	20h loc.
Temps sensible	Belles éclaircies (3,4 octas)	Ensoleillé (0,1,2 octas)	Nuit claire	Nuit claire	Brouillard dense par place	Brouillard dense par place	Ensoleillé (0,1,2 octas)	Ensoleillé (0,1,2 octas)	Ensoleillé (0,1,2 octas)	Ensoleillé (0,1,2 octas)
Nébulosité										
Température (°C) [151m]	26	24	19	19	16	15	22	26	27	24
Direction du vent										
Vitesse moyenne du vent (km/h)	10	10	10	10	10	10	10	10	10	10
Rafales (km/h)										
Iso 0°C (m)	4600	4700	4800	4700	4700	4700	4800	4800	4800	4700
Limite pluie-neige (m)										
Humidité (%)	60	70	80	90	90	90	80	60	50	60
DD1500m (degrés)										
FF1500m (km/h)	15	20	15	5	10	15	15	15	20	20
DD3000m (degrés)										
FF3000m (km/h)	15	10	5	10	5	10	20	25	30	35
Origine CDM/CMIR	EXPERT	EXPERT	EXPERT	EXPERT	EXPERT	EXPERT	EXPERT	EXPERT	EXPERT	EXPERT

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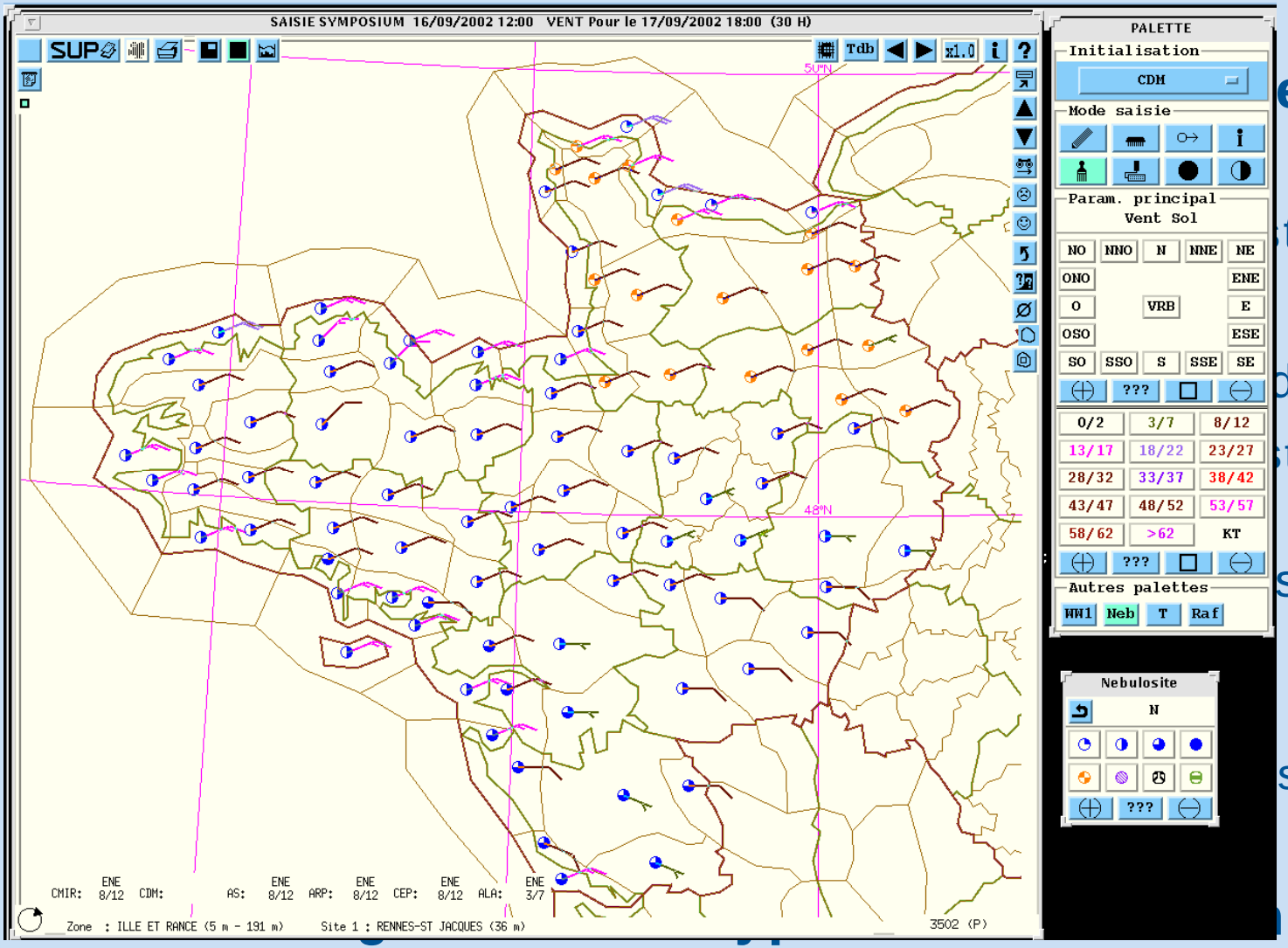
Feeding a production database



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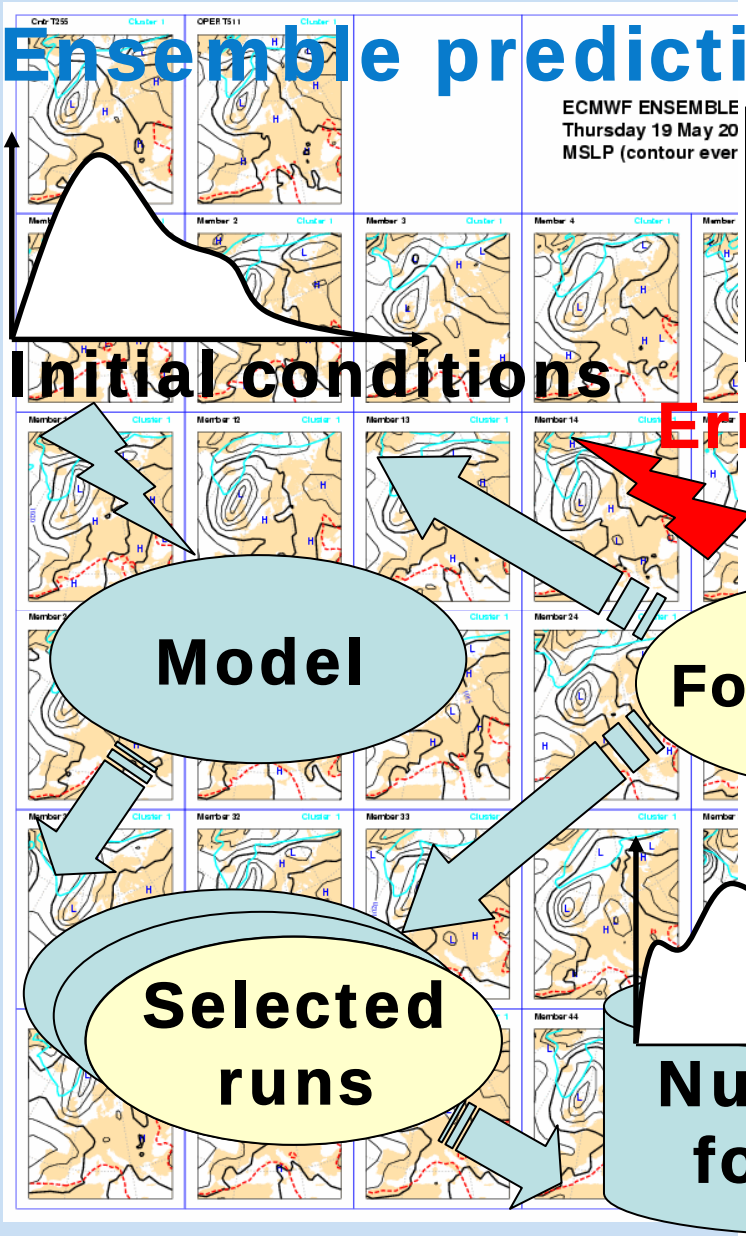
Ensemble prediction



Initial conditions

Errors

Model

Forecaster

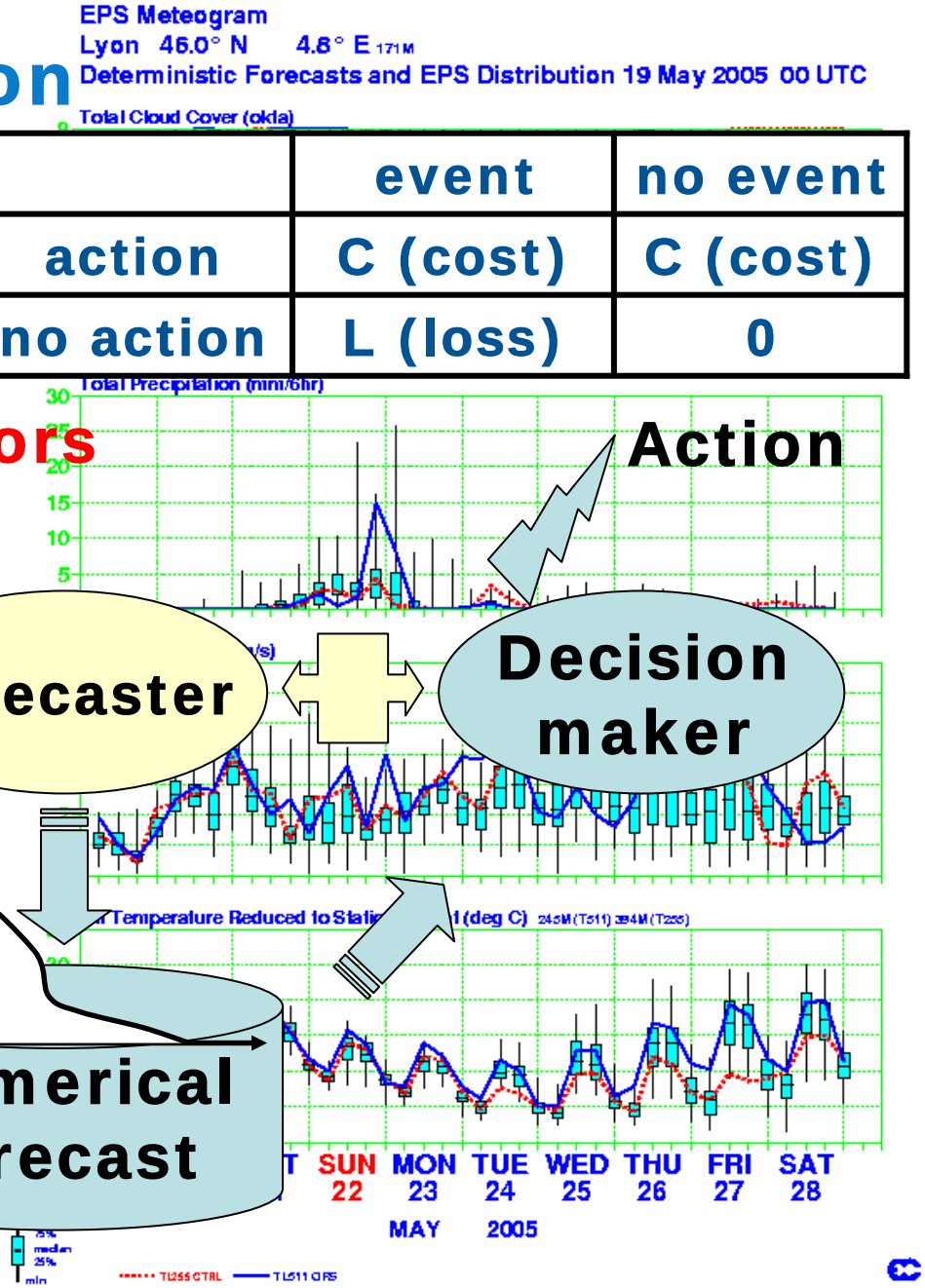
Decision maker

Action

Selected runs

Numerical forecast

	event	no event
action	C (cost)	C (cost)
no action	L (loss)	0



Producing (prob.) weather forecasts

- **Ensemble based probability distributions (pdfs) directly feed a probabilistic database**
  - No forecaster modification of numerical forecast
  - Possible (occasional) modification of some aspects of the pdf, eg quantiles or probabilities of thresholds
- **Some products still elaborated from forecaster interpretation of ensemble distribution**
  - Mostly deterministic but include uncertainty assessment and/or risk estimate
  - Interpretation mainly based on classification products (clustering, tubing)

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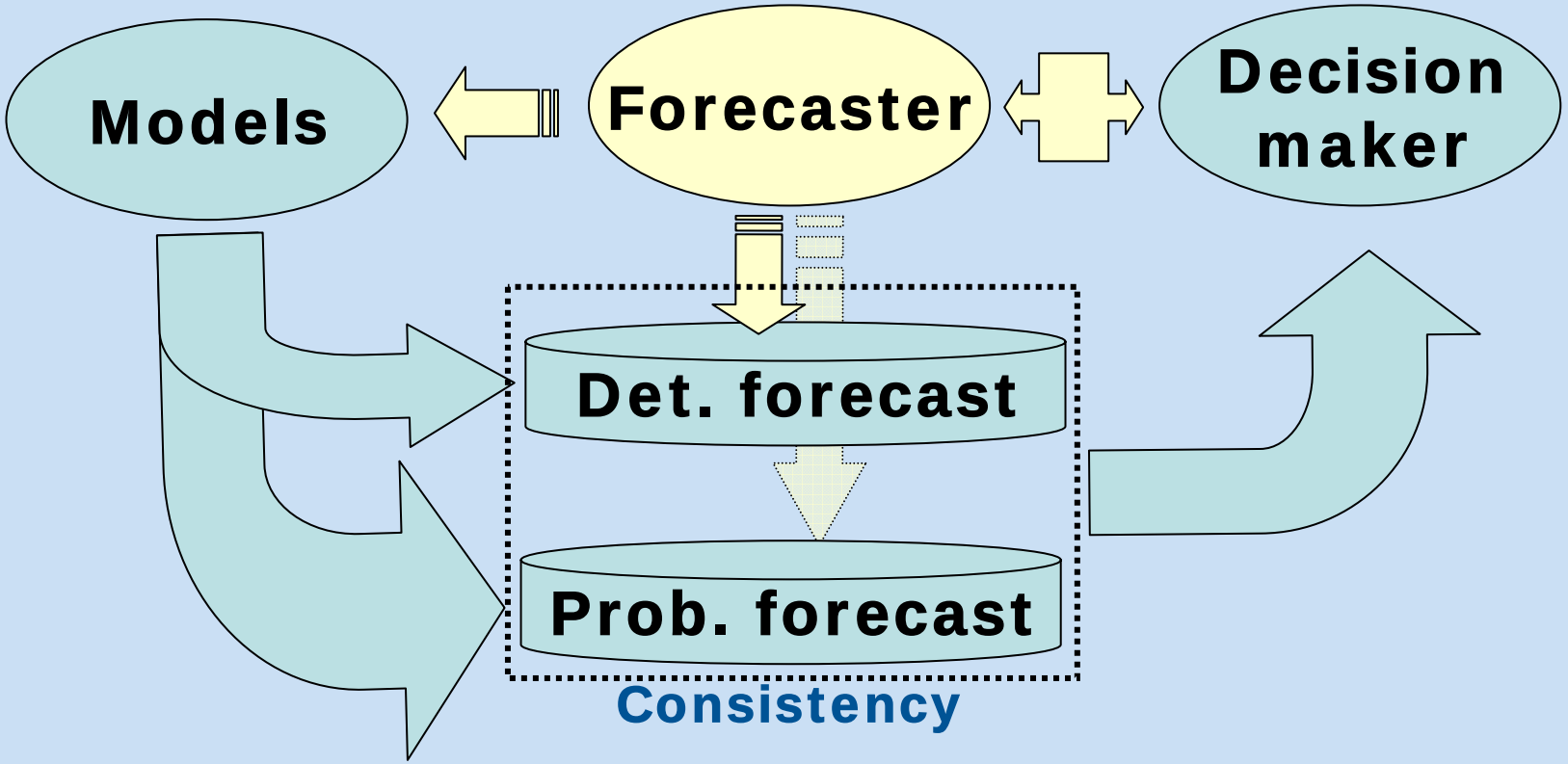
Forecasting in 2005



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Super ensembles (2010)

- **Several ensembles already available in 2005**
- **TIGGE: multi-model, multi-analysis, multi-resolution ensemble**
- **Direct product is an ultimate, multi-variate probability density function**
  - Some calibration will be required
- **Any role for the forecaster?**
  - In principle: selecting ensemble runs from a comparison of initial conditions -but in practice?
  - Handmade production and/or modification of pdfs through comparative interpretation
    - Forecasters need powerful tools for exploring large, multi-system ensembles, eg specific classification products

New generation meso-scale, very high resolution models (2010)

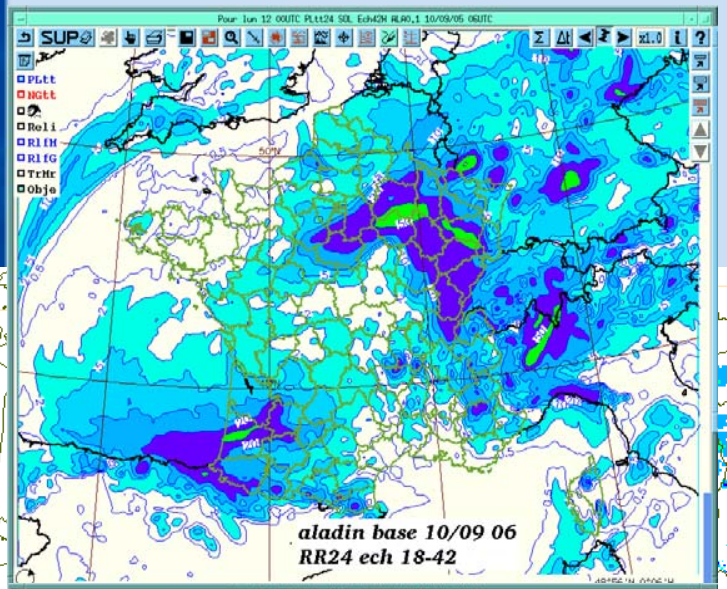
- **Very high resolution (< 2 km)**
- **Non hydrostatic, explicit convection, highly sophisticated (micro) physics**
- **Continuous assimilation of high density observations, incl. precipitation, lightning, etc.**
- **Frequent updates, esp. for shorter lead times**

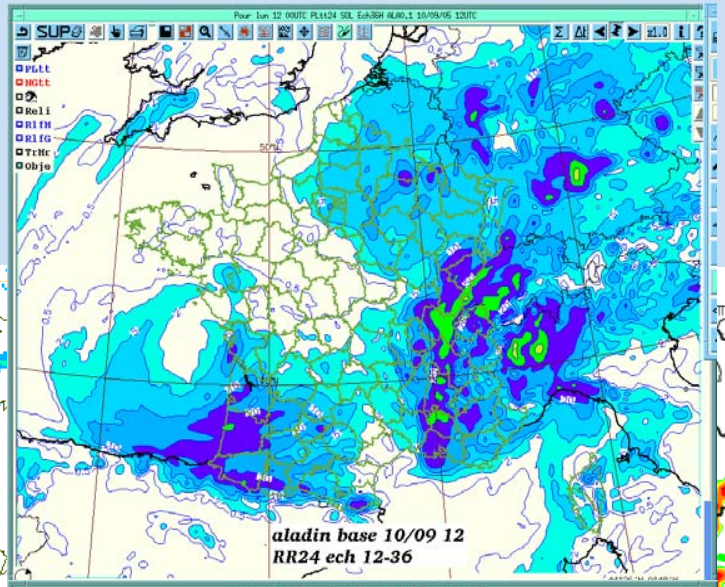
  --> Frequent "jumpiness" expected
- **High computer cost**

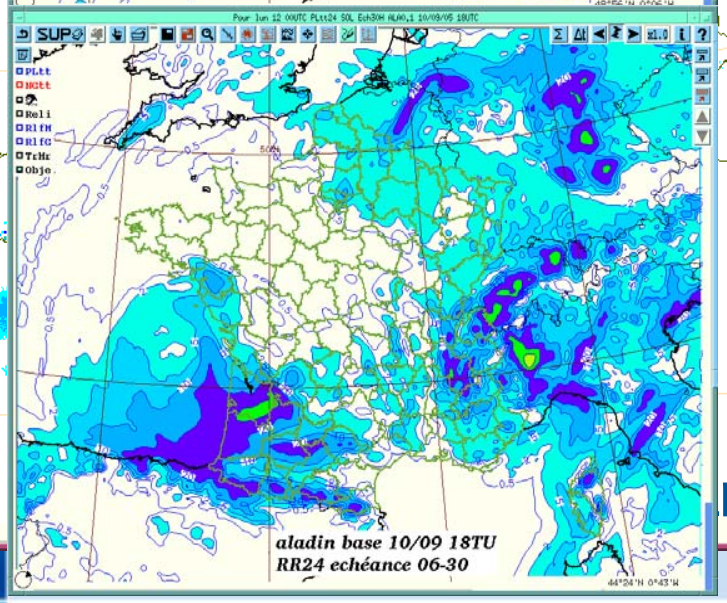
  --> Deterministic mode only (ensemble later...)
- **"A new era"**

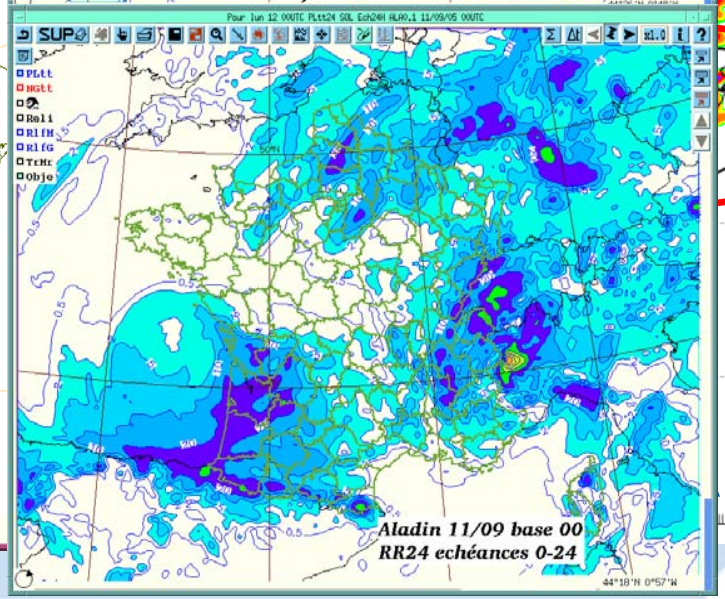
  – Forecaster interpretation?

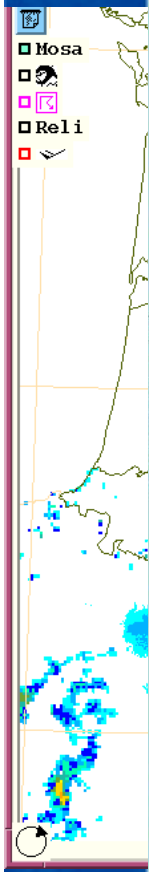
Example

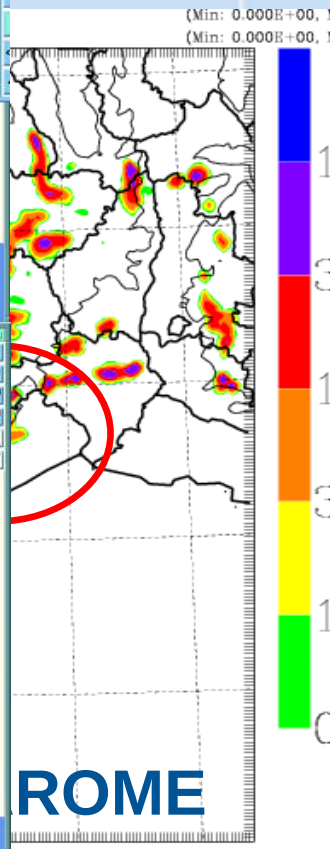












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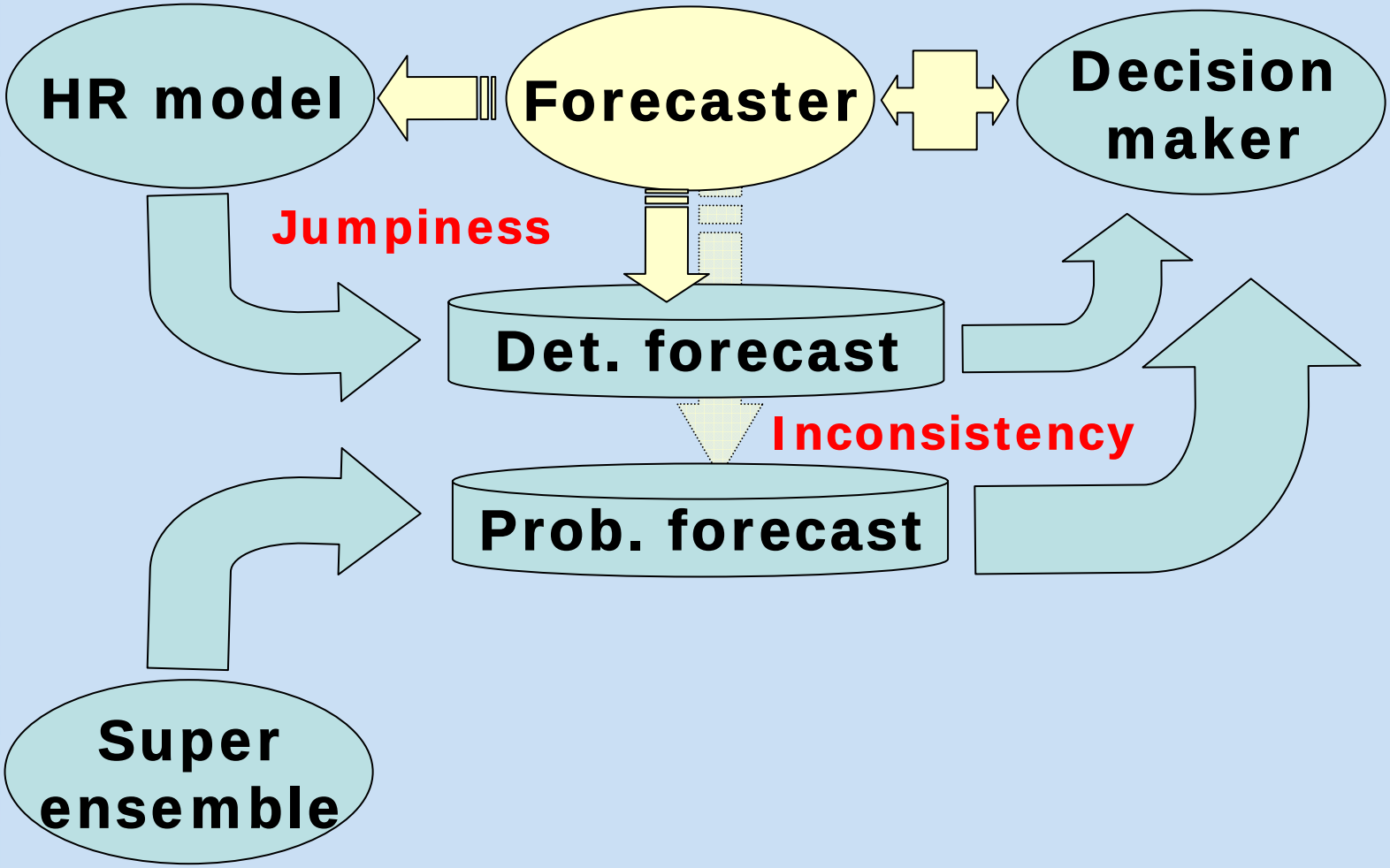
Forecasting in 2010



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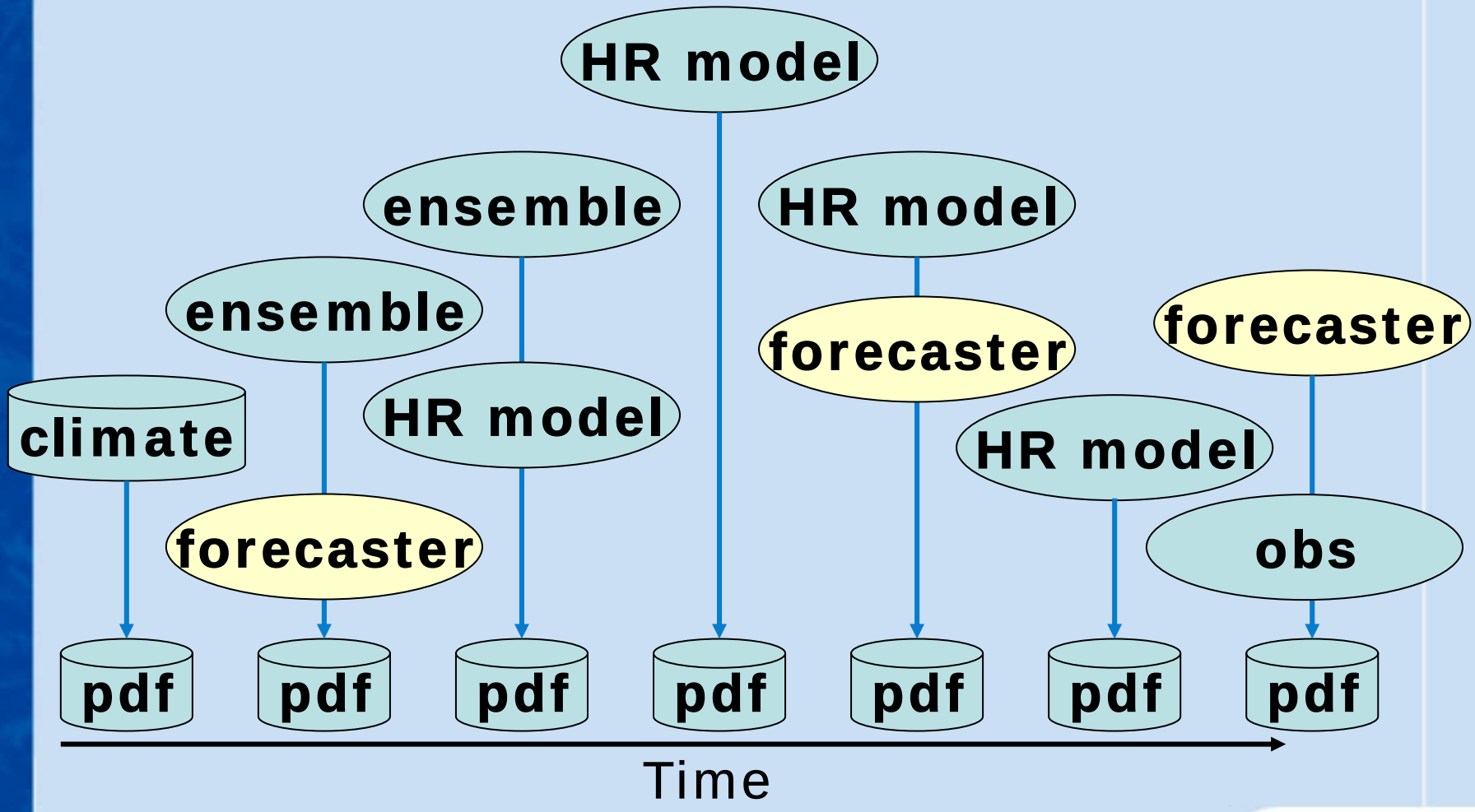
2010: a production challenge

- **Super ensemble**
  - 1/day for medium range, 2-4/day for short range
- **Successive very HR runs**
  - 8/day, up to 24/day for nowcasting
- **Observations and extrapolations**
  - Continuously
- **Forecasters opinions / modifications**
  - As often as needed: 2-8/day, more for nowcasting
- **The solution: updating a probabilistic data base continuously**

Updating a probabilistic forecast



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Bayesian updating

Probability of event A_j after updating with forecast B

Probability of forecast B when event A_j is observed

$$P(A_j|B) = \frac{P(B|A_j)P(A_j)}{\sum_{i=1,k}^{k} P(B|A_i)P(A_i)}$$

Probability of event A_j before updating

Σ for all K events A_i
$\Sigma P(A_i) = 1$

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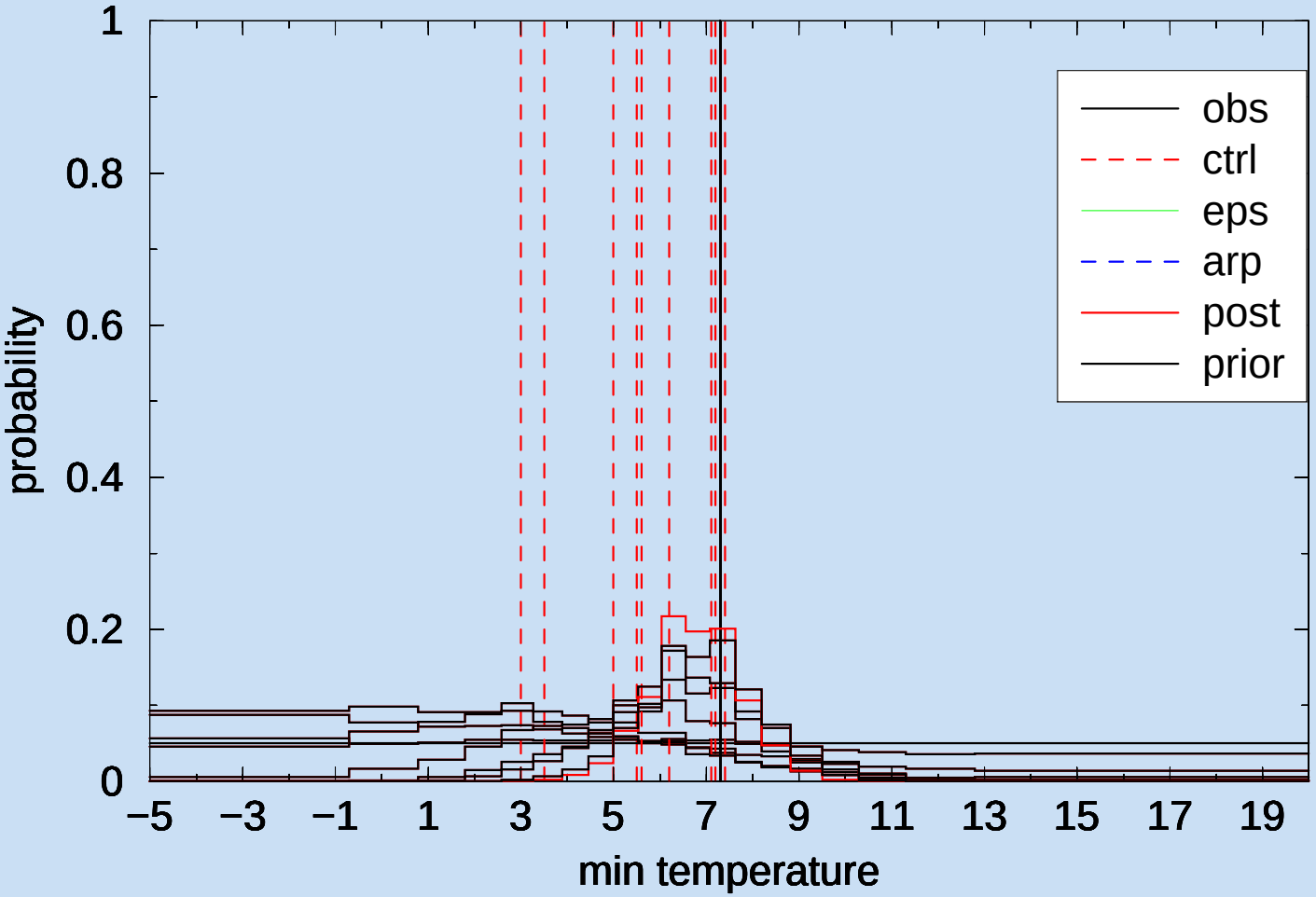
Updating 2m minimum temperature in Toulouse, 12 March 2004, from Day-8, with 9 consecutive single forecasts



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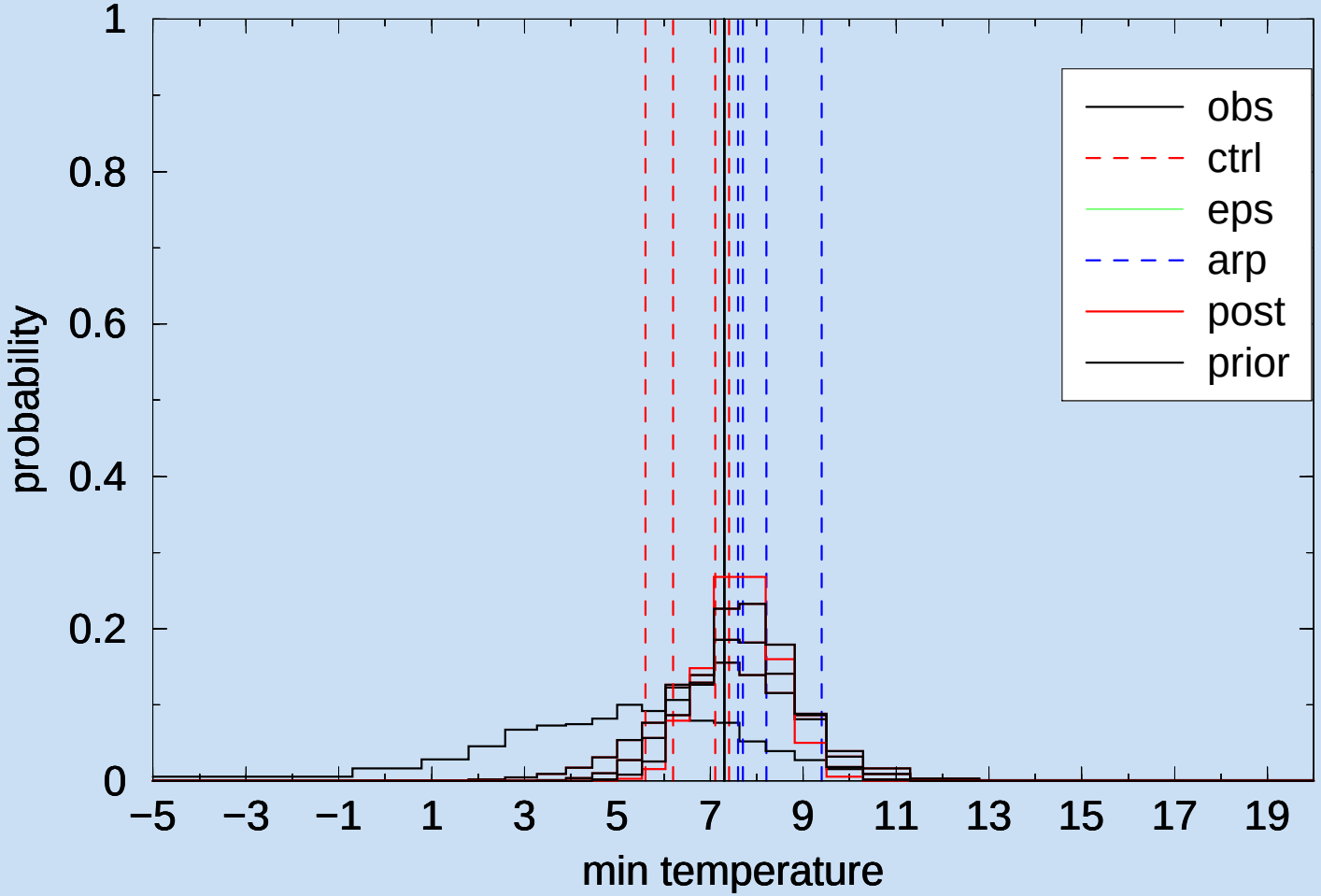
Updating with 2 forecasts every day, from Day-3



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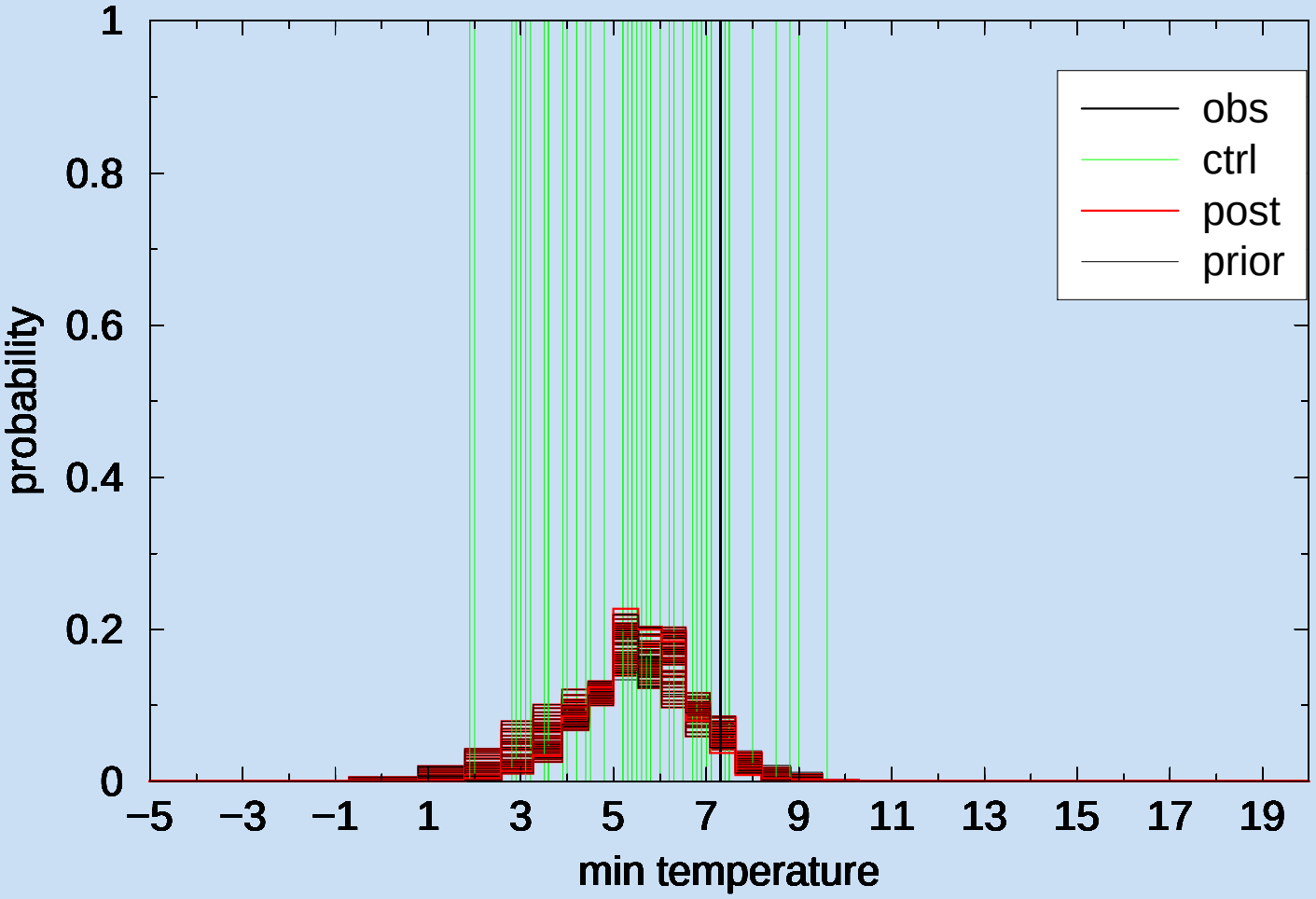
Updating with 51 forecasts



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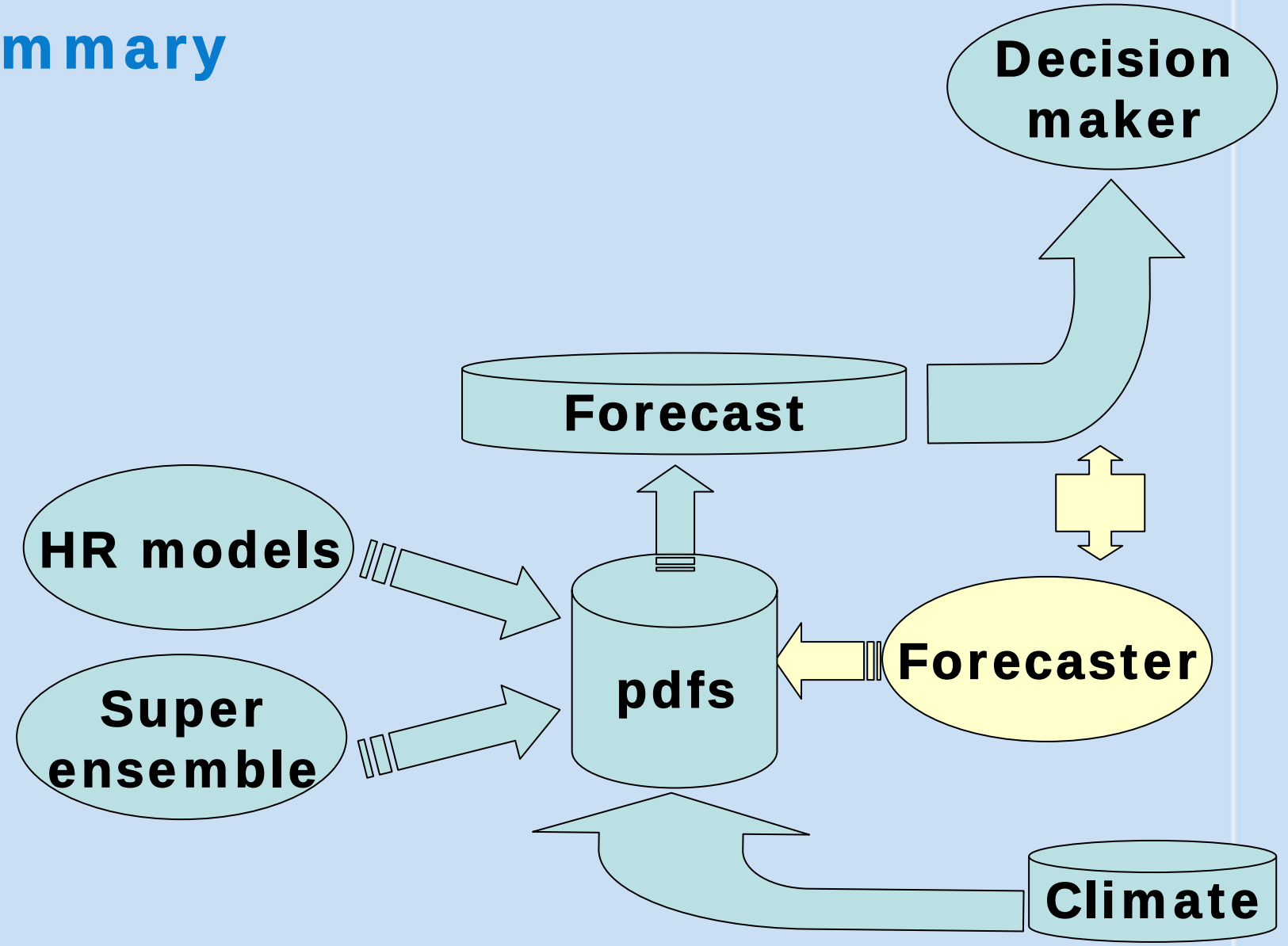
Summary



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