recent Météo-France work on AROME-EPS

Robert Osinski & François Bouttier - CNRM, Toulouse

Evolution of the preoperational system

- Architecture
- New resolution & domain

Coping with small ensemble size

- Space/Time tolerance

Aviation & Verification against reflectivities : see poster

Preoperational evaluation

- Impact of clustering on ensemble spread
- Unrepresented model errors

Plans

METEO FRANCE

AROME-France-EPS configuration

Experimental ensemble based on Arome-France :

- 12 members, resolution dx=2.5km (vs 1.3km in deterministic Arome-France)
- coupled to global French PEARP ensemble
- 2016 operational config :
  - 2x productions/day (09 & 21UTC)
  - usable range 9h-45h (too little spread at shorter ranges)

Perturbations :

- **Large-scale:** representative members of 35-member PEARP ensemble clusters
- **Initial:** PEARP perturbations centered on Arome-France high-resolution analysis
- **Model:** stochastic physics (SPPT scheme) in mid-troposphere
- **Surface:** static autocorrelated perturbations of SST, sea fluxes, snowdepth, soil moisture & temperature, albedo, roughness, vegetation (cover, leaf area, thermal coeff)

refs : Nuissier et al NHESS 2012 ; Bouttier et al MWR 2012 ; Bouttier et al QJ 2015 ; Descamps et al MWR 2015

METEO FRANCE

AROME-France-EPS recent evolution

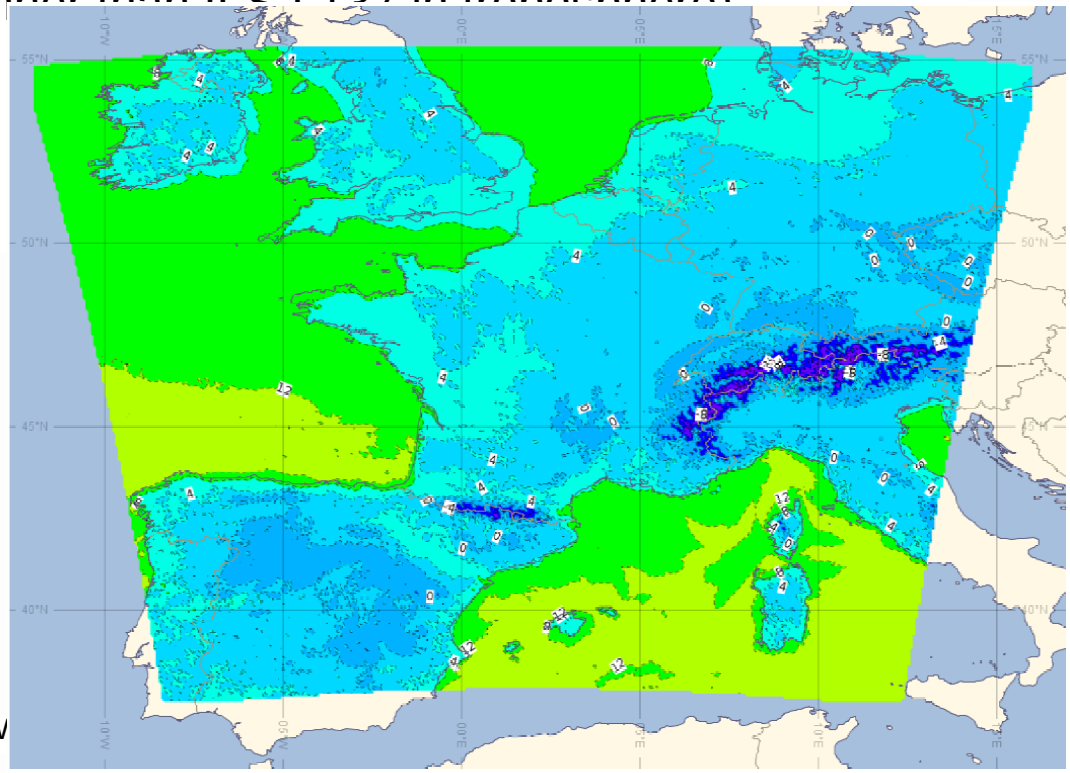
Major resolution upgrades in April 2015 :

PEARP

- initial perturbs from improved EDA (6 -> 17 members used, higher resol)
- higher horizontal resolution : T538->T798 i.e. 10km over Europe
- higher vertical resolution (same as current IFS L137 in troposphere)
- updated physics (new PCMT convection scheme in multiphysics mix)

AROME-France-EPS model

- vertical resolution L60->L90 (now 30 % thinner than IFS L137 in troposphere)
- Canopy SBL scheme deactivated
- geographical domain extended northwards



EW

AROME-France-EPS objective evaluation

Focus on T2m, RH2m, ff10m, gusts, precipitation, radar reflectivities

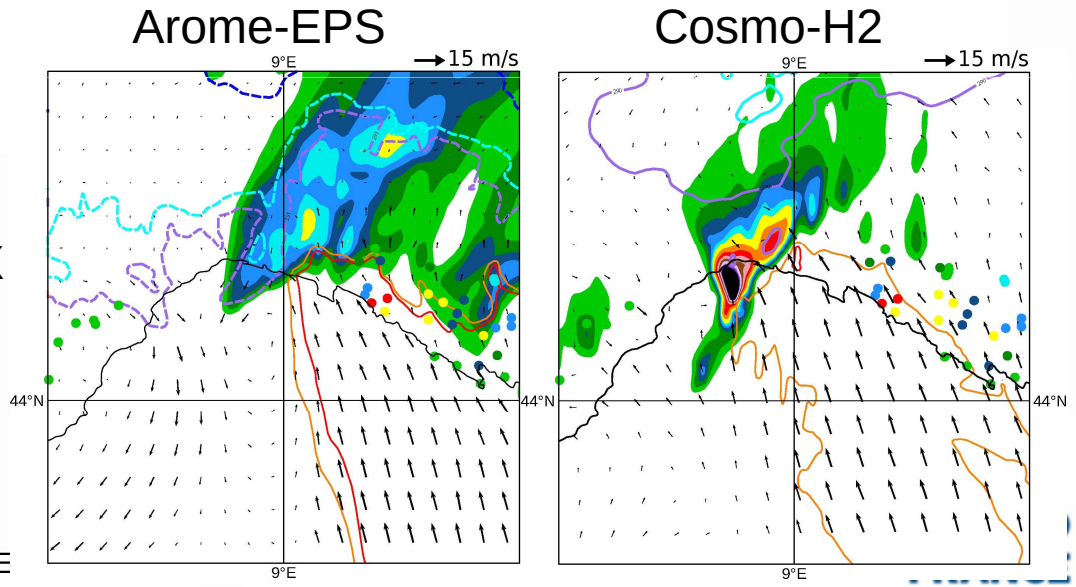
- better than PEARP for low-level parameters and high precip events
- intercomparisons with COSMO-DE-EPS, UK-MOGREPS and COSMO-H2 (HyMeX runs) are favourable.

Main weaknesses :

- lack of short-range spread (inadequate IC perturbations)
- lack of 10m wind spread (issue with PBL physics)
- frequency biases for precipitation (complicated problem : focus on post-processing & calibration)

Quite good detection of high precipitation (important for hazardous weather warnings)

Best members for rr3 in an HyMeX intense precipitation event :



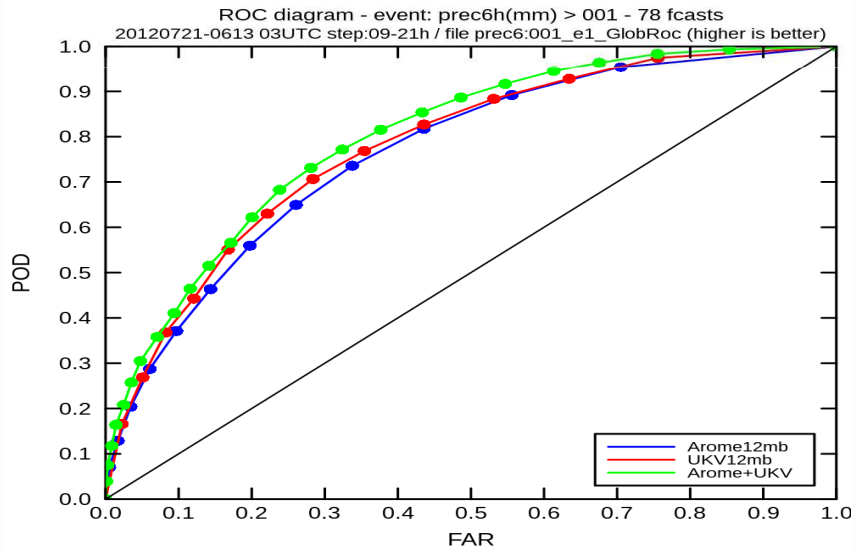
E

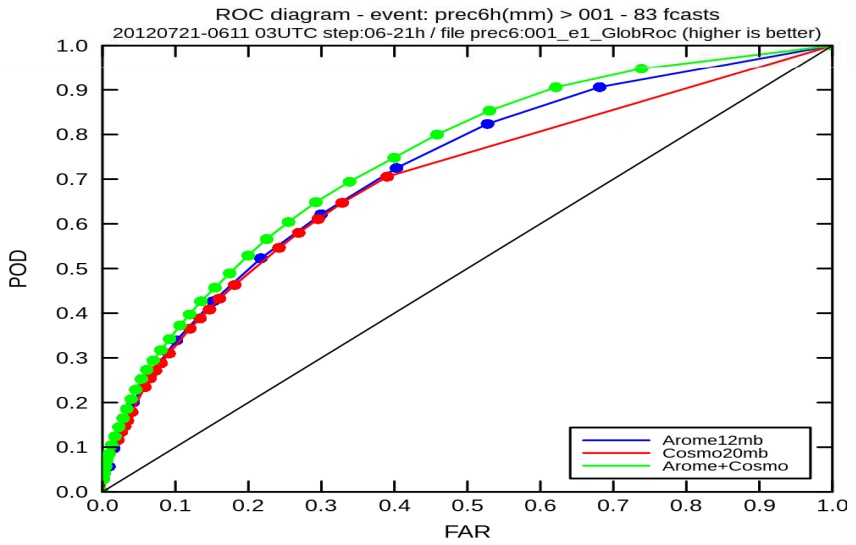
intercomparison: Arome-France-EPS vs UKV-MOGREPS and COSMO-DE-EPS

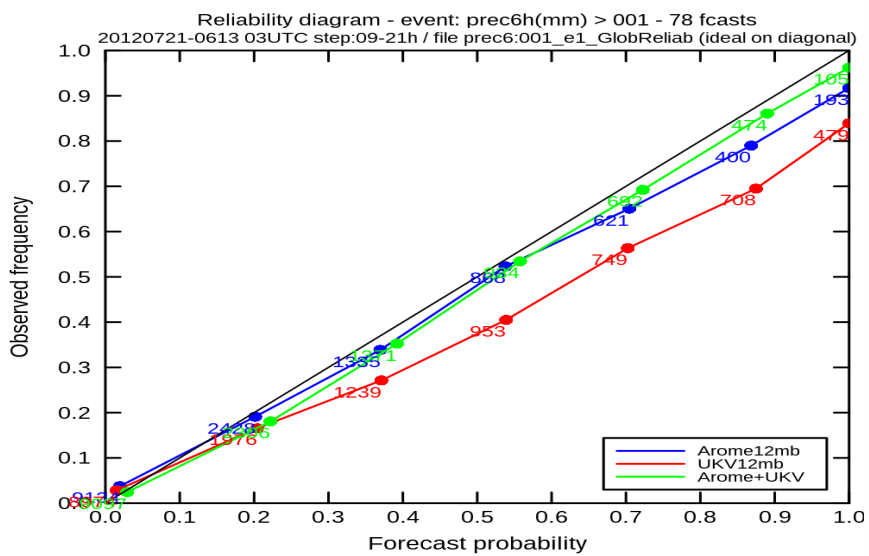
On overlap domains, over Summer 2012 + Spring 2014 ; event : rr6>1mm

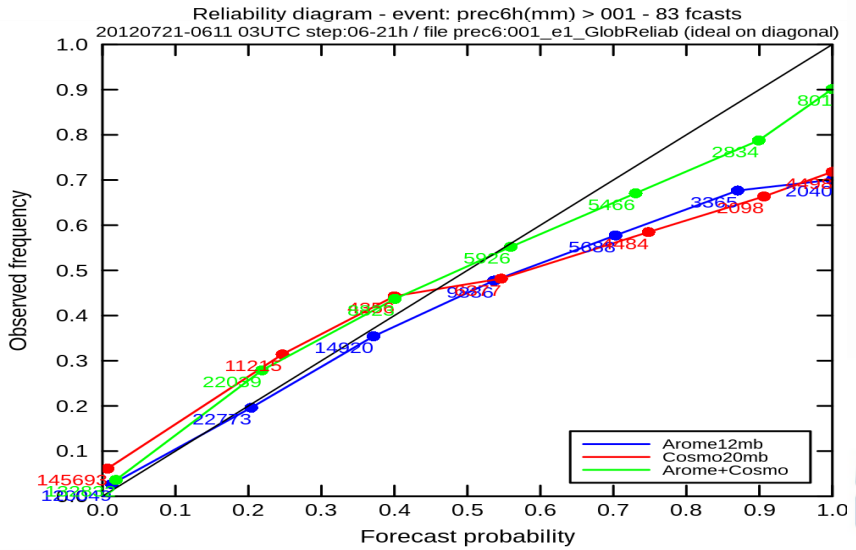
green curve = superensemble *(in submitted paper : Beck et al QJRMS)*

- Similar ensemble performance from country to country
- Superensemble has nearly always the best reliability & ROC statistics.









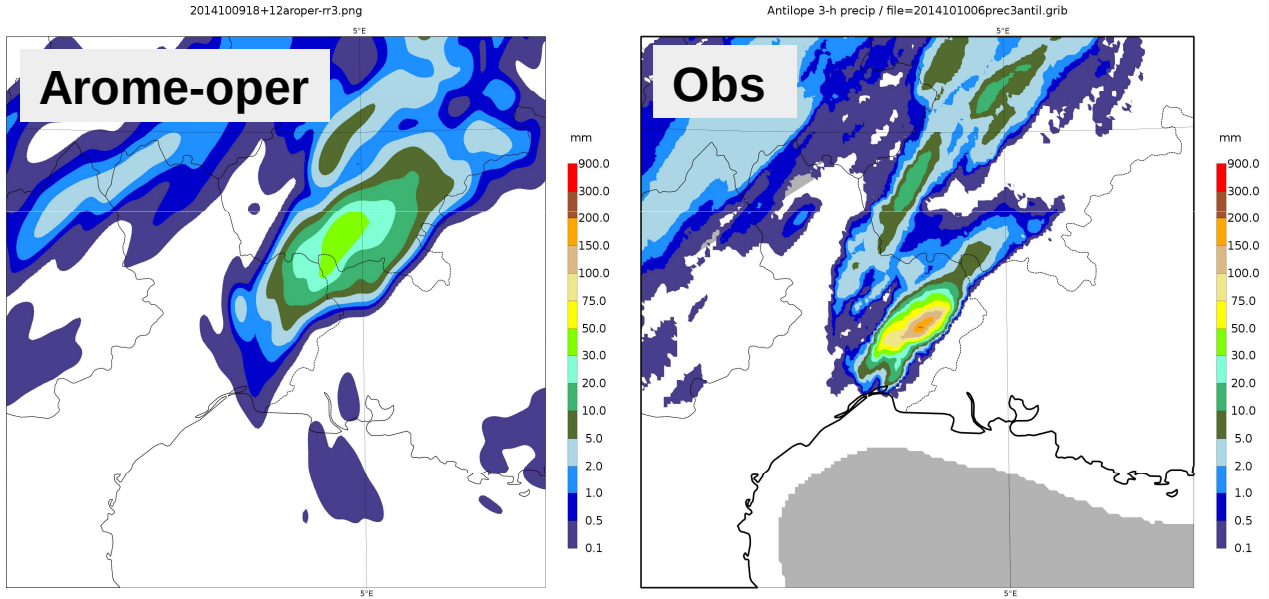
EWC

METEO FRANCE

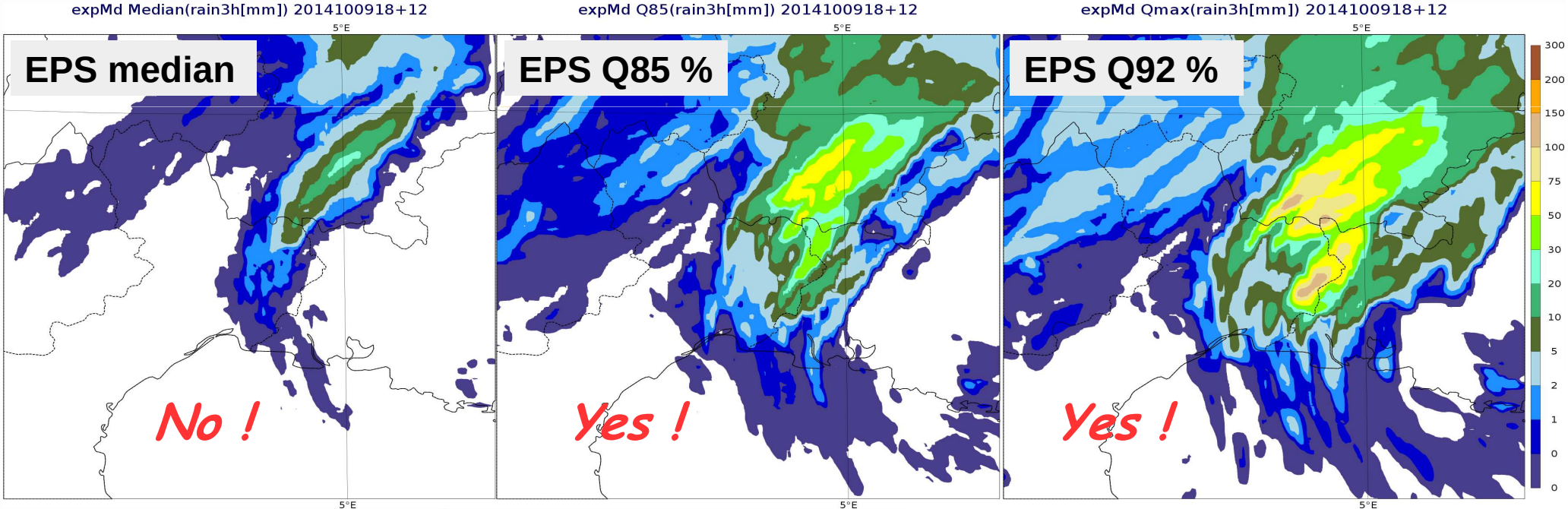
Usefulness for high precipitation forecasts

For optimal hazardous weather warnings, one needs to use fairly high output quantiles :
(because users have low cost/loss ratios)

rr3h
base 9 oct 2014
step 12h



exp Md - plot e842

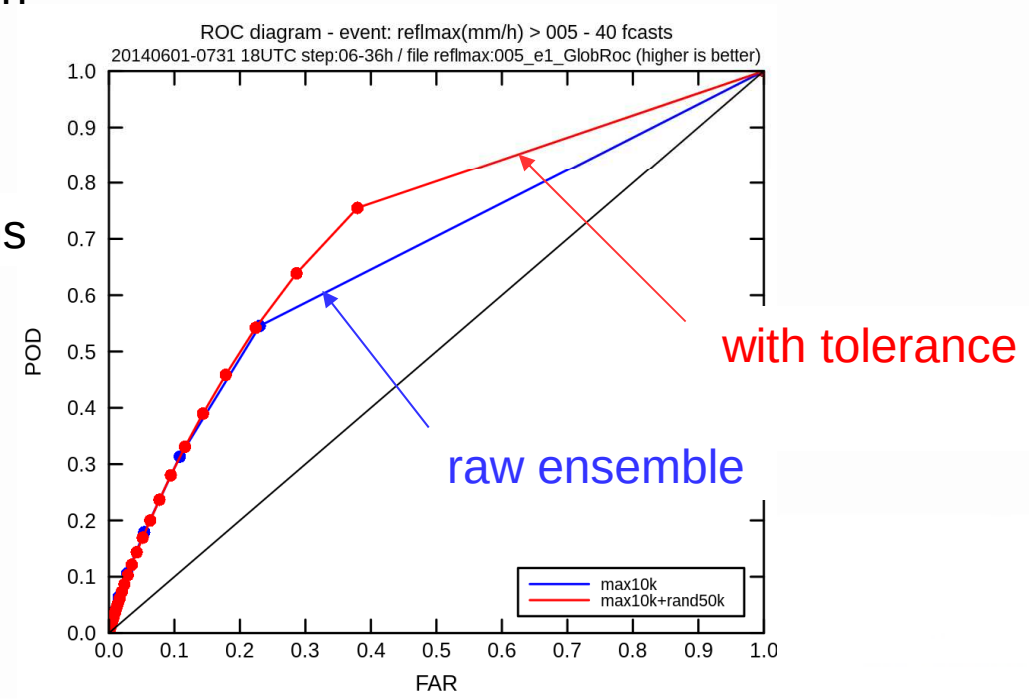


Coping with small ensemble size : Space/Time tolerance

Principle : increase membership of point forecasts by mixing forecasts at neighbouring gridpoints (idea similar to Theis et al 2005) - evaluated using precip & reflectivities

- good results by randomly picking members in 30-km x 1h domain
- no measurable degradation by location error
- clear improvement in reliability and ROC score, particularly for 'rare' events
- no impact on ensemble spread
- benefit saturates at ~50-100 members (=optimal ensemble size?)
- benefits add up with calibration

ROC score over 2 months



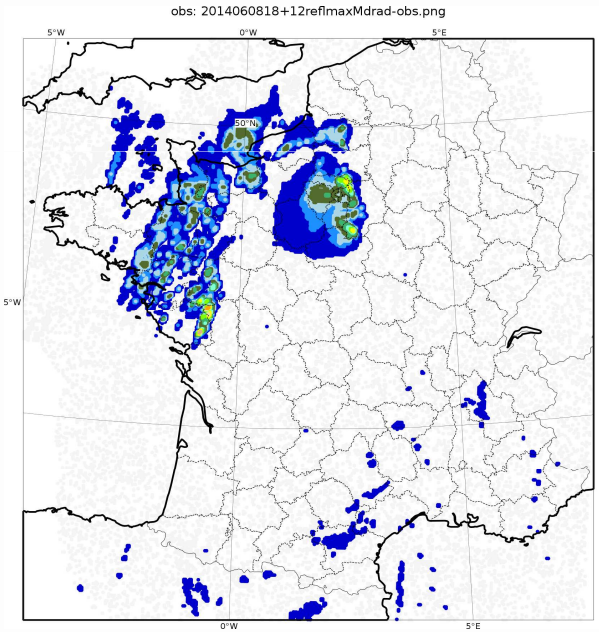
Aviation & Verification against reflectivities (IMET/SESAR EU projects)

Heavy convection and instant precipitation forecasts can be verified using simulated radar reflectivities : with an ensemble, the 'double penalty' is not such a big problem.

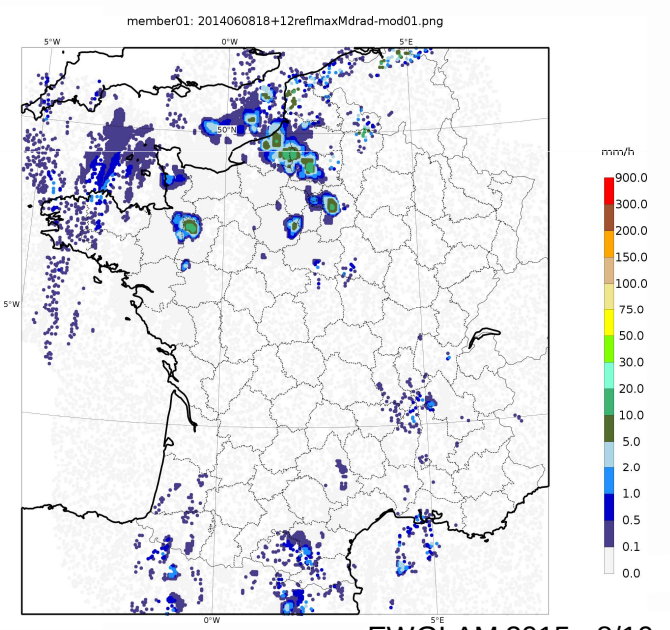
High-level hydrometeors can be used for aircraft trajectory planning, to avoid dangerous convection.

***** see poster *****

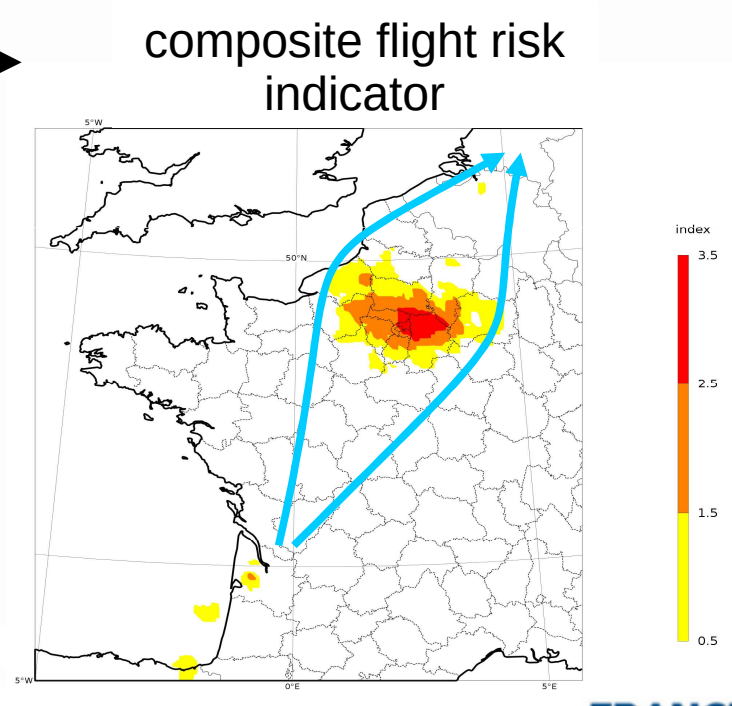
obs



EPS member 1



composite flight risk indicator



AROME-EPS preoperational evaluation

AROME-EPS is being extensively evaluated as a human forecasting tool :

- ~20 selected test cases (snow, thunderstorms, fog...) analyzed
- quasi real-time runs since Sept 2015 (ongoing)

Forecasters' criticisms are useful to identify research priorities :

- **upper-level forcings** can have ''too much'' spread :
  - PEARP LBC clustering adds ~5 % to PEARP spread, but is not the main issue
  - PEARP is overdispersive at short-range, high levels -> AROME-EPS upper-level spread is tightly linked to PEARP -> Ongoing R&D to improve PEARP.
- lack of spread for some events point to **missing model error representation** :
  - snow/rain transition
  - PBL errors
  - poorly resolved valleys
- **R&D on visualization tools** is still needed :
  - for intense, mobile phenomena (e.g. squall lines, thunderstorms)
  - to separate (low impact, highly likely) events from (high impact, low probability) ones
  - to blend EPS with deterministic model information

METEO FRANCE

AROME-EPS future plans

- increase ensemble size ; 4 productions/day
- better representation of model error in PBL & microphysics
- improve very short ranges (1-6h) ; implement Arome EDA for IC perturbations
- studies of ensemble correlations - link with EnVar algorithm

METEO FRANCE