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UERRA
Uncertainties in Ensembles of Regional ReAnalyses

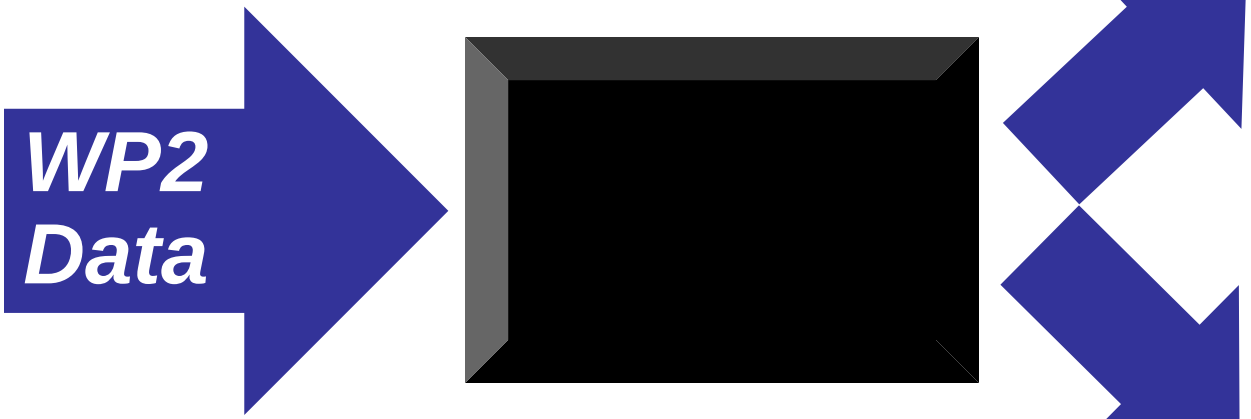
http://www.uerra.eu/

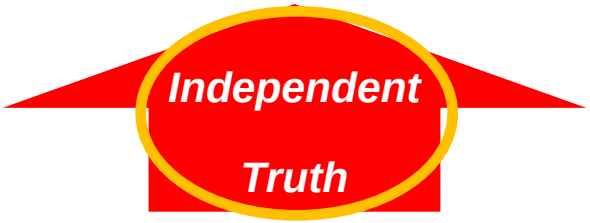
Validation & Independent Obs.

A WP2 perspective

Peter Jermey

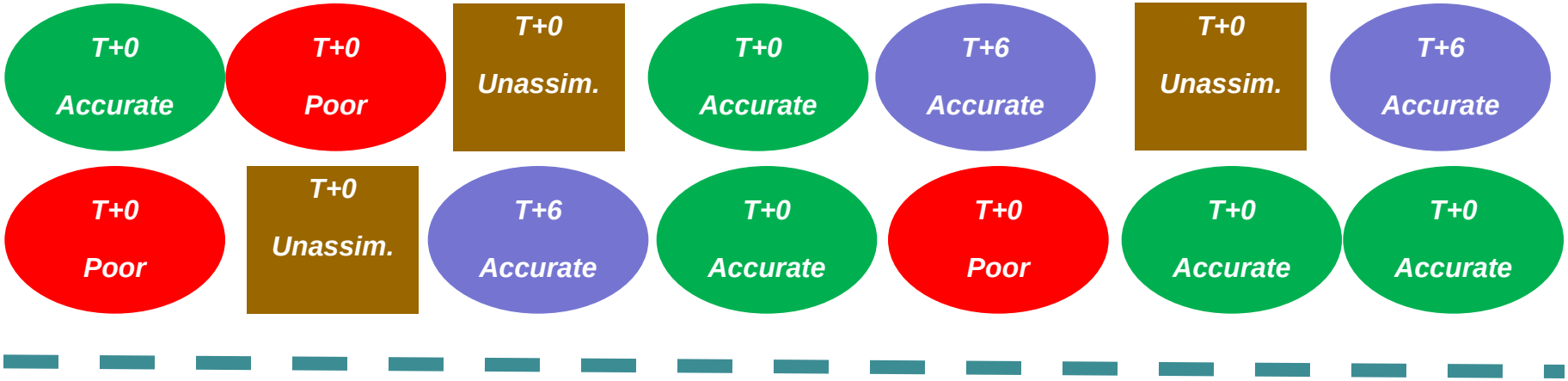
What we want…





The Problem!!!

Independent Truth



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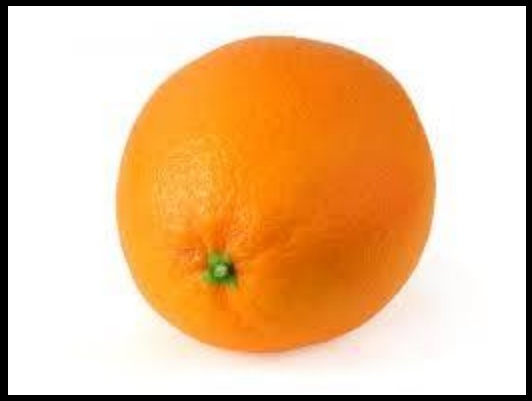
Deterministic reanalysis



Ensemble of reanalyses

Validation (Deterministic)

- Lots of possible measures: RMSE, skill, ETS, Pierce, FSS, SEEPS etc

- All of these attempt to estimate the distance between the truth and our reanalysis

$$\epsilon^* = x - x^*$$

O-A's, O-B's and Forecast Error

O-A: Obs – analysis: comparing with

O-B: Obs – background: comparing with

Forecast Error: comparing with

or with

Not Independent Truth

Independent Truth

NB O-B's are a special case of forecast error

Time Shifted 'Truth'

T+6

Accurate

$$\epsilon^* = x - x^*$$

- Straight-forward
- Assimilated observation types
- Useful for comparing different models
- Gives an upper bound on the reanalysis error
- Difficult to estimate actual reanalysis error
- Includes model error (and obs error)

$$M_t(x) - y_t \quad \approx \quad Q_t + x_t - x_t^* + \epsilon_y$$

Unassimilatable Obs.

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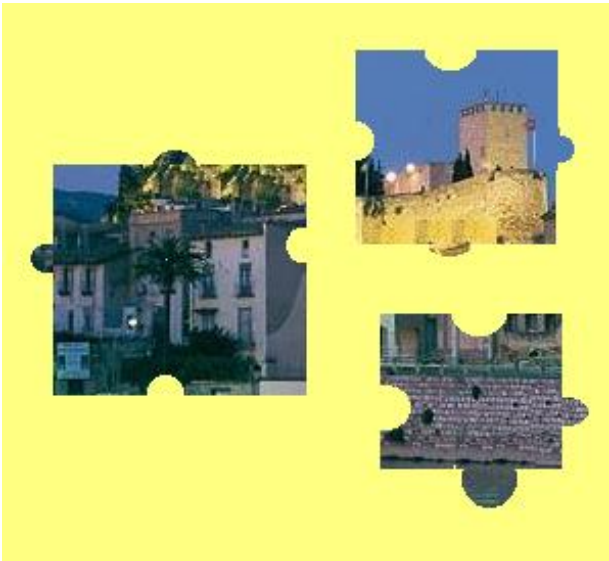
T+0 Unassim.

$$\epsilon^* = x - x^*$$

- Could be for technical reasons or downstream/irrelevant reasons
  - **Limited** observation types/positions
  - Useful for estimating error in reanalysis
  - Includes obs error
  - Downstream operator may contain errors

$$H(x) - y \approx R + x - x^* + \epsilon_y$$



Poor Quality Obs.

- **Observation error dominates ... No confidence in results!!**

T+0

Poor

$$\epsilon^* = x - x^*$$

Degrade Reanalysis...

T+0 Accurate | T+0 Poor | T+0 Unassim. | T+0 Accurate | T+6 Accurate | T+0 Unassim. | T+6 Accurate

T+0 Poor | T+0 Unassim. | T+6 Accurate | T+0 Accurate | T+0 Poor | T+0 Accurate | T+0 Accurate

'OK' Reanalysis

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Deterministic reanalysis

Ensemble of reanalyses

Ensemble Primer

Ensembles represent uncertainty

We want the ensemble to represent the span of all possible reanalyses fixing everything except the random errors

$$\mathrm{RMSE}\left(\bar{x}_j\right) \approx \mathrm{Std.Dev.}\left(x_{ij}\right)$$

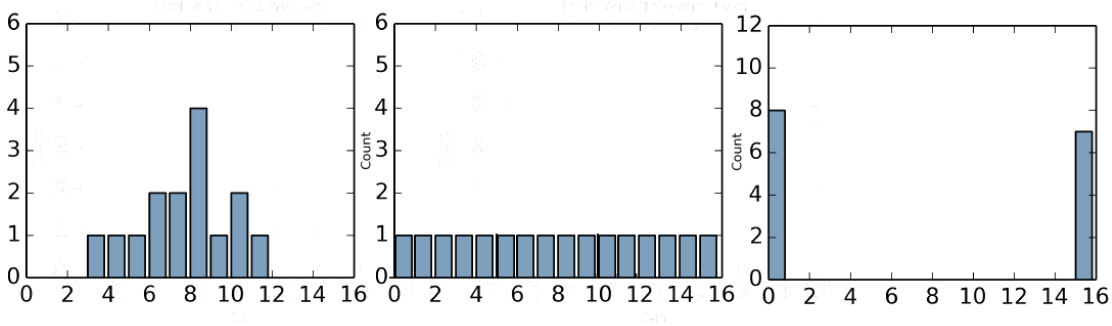
What does a good ensemble look like..?

1. Each member is equally likely
2. Mean error < Control error
3. Ensemble spread = **Mean** error
4. Modelled freq. = Observed freq.

Validating Ensembles

1. Each member is equally likely

- Rank Histogram

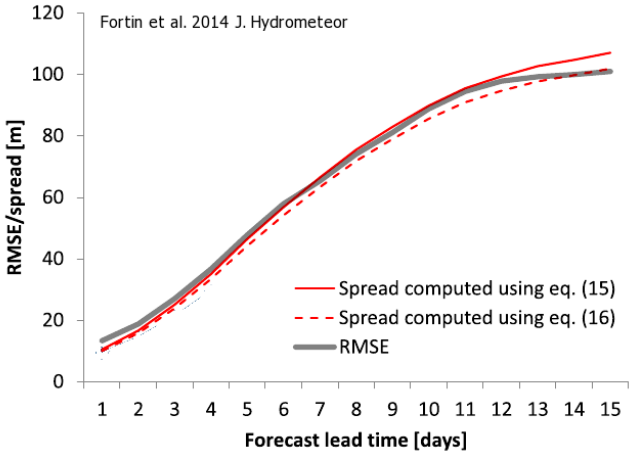


2. Mean error < Control error

- Use deterministic validation techniques

3. Ensemble spread = Mean error

- Plot ensemble RMSE and spread



4. Modelled freq. = Observed freq.

$$BSS = 1/N \sum (f_t - o_t)^2$$

$$IGN = -\log_2(p_e((ob)))$$

$$RPS = 1/(K-1) \sum (CDF_{obs} - CDF_{en})^2$$

Truth for Ensembles

- Particularly spread vs error

T+6

Accurate

- Spread increases with forecast time (but could look at trend!)

T+0

Unassim.

- Limited variables, downstream modelling issues (as before)

T+0

Accurate

- Not independent unless held back from assimilation

- **Should do a bit of everything!!**

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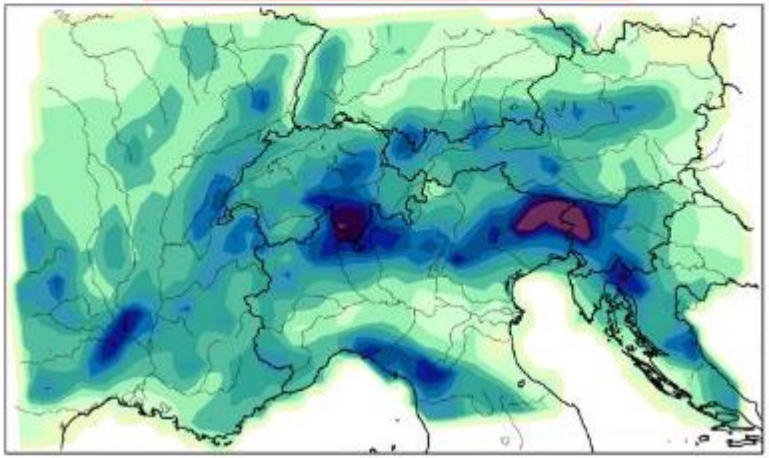
Gridded Truth

Gridded Truth

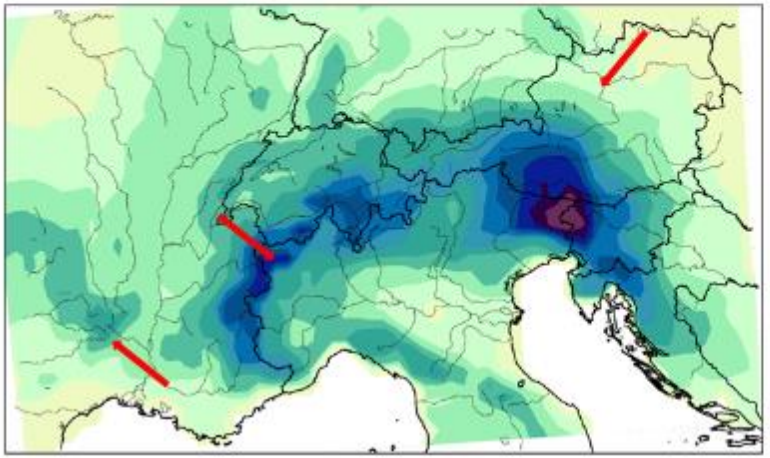
- For some (determinstic) scores we require gridded truth
- Better than points for comparing like-with-like
- Problem! If available at higher quality than the reanalysis (truth) then ...
  why are we doing the reanalysis?!
- Might be available in certain variables/scales
- Some datasets are based on high res obs that are not directly available

Mean annual precipitation 2008

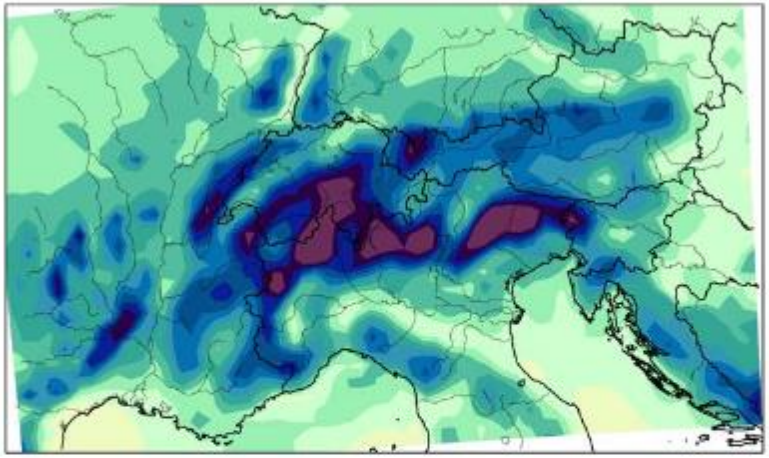
APGD (upscaled ~22 km)



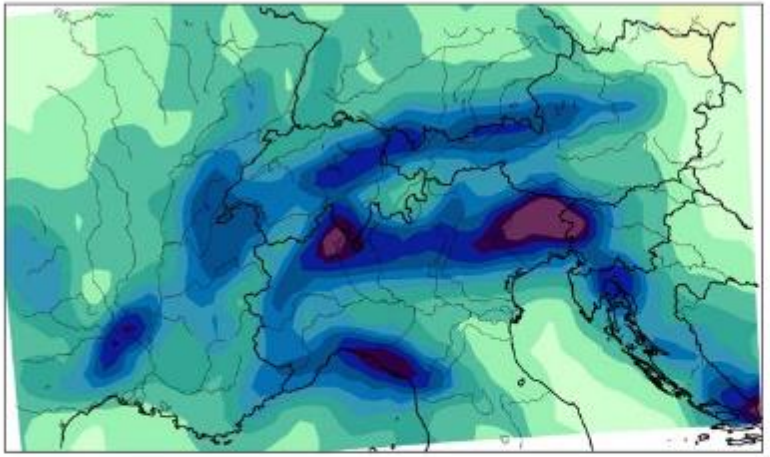
E-OBS

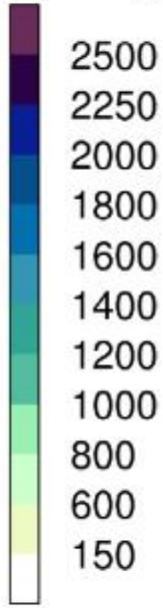


HIRLAM



UK Met Office (upscaled ~22 km)





Summary

- As producers we want to have a measure of accuracy for our product
- We also need a measure of how well our ensemble estimates uncertainty
- Both of these require a measure of truth independent from the reanalyses
- Any ‘truth’ has associated problems ... So it is best to use lots of different truths

Thank you for listening...

...Questions?

Ensemble Primer

We use ensembles to predict uncertainty

We want the ensemble to represent the span of all possible reanalyses fixing everything except the random errors

We want the ensemble to spread to be a measure of uncertainty in our deterministic/mean reanalysis.

$$\mathrm{MSE}\left(\bar{x}_j\right) = \frac{1}{J}\sum_{j=1}^{J}\left(\bar{x}_j - y_j\right)^2$$

$$\mathrm{MSE}\left(\bar{x}_j\right) \approx \mathrm{Var}\left(x_{ij}\right)$$

$$\mathrm{RMSE}\left(\bar{x}_j\right) \approx \mathrm{Std.Dev.}\left(x_{ij}\right)$$

$$\frac{1}{J}\sum_{j=1}^{J}\left(\bar{x}_j - y_j\right)^2 \approx \frac{1}{J}\sum_{j=1}^{J}\left(\bar{x}_j - x_{ij}\right)^2$$

$$\frac{1}{I}\sum_{i=1}^{I}\frac{1}{J}\sum_{j=1}^{J}\left(\bar{x}_j - y_j\right)^2 \approx \frac{1}{I}\sum_{i=1}^{I}\frac{1}{J}\sum_{j=1}^{J}\left(\bar{x}_j - x_{ij}\right)^2$$