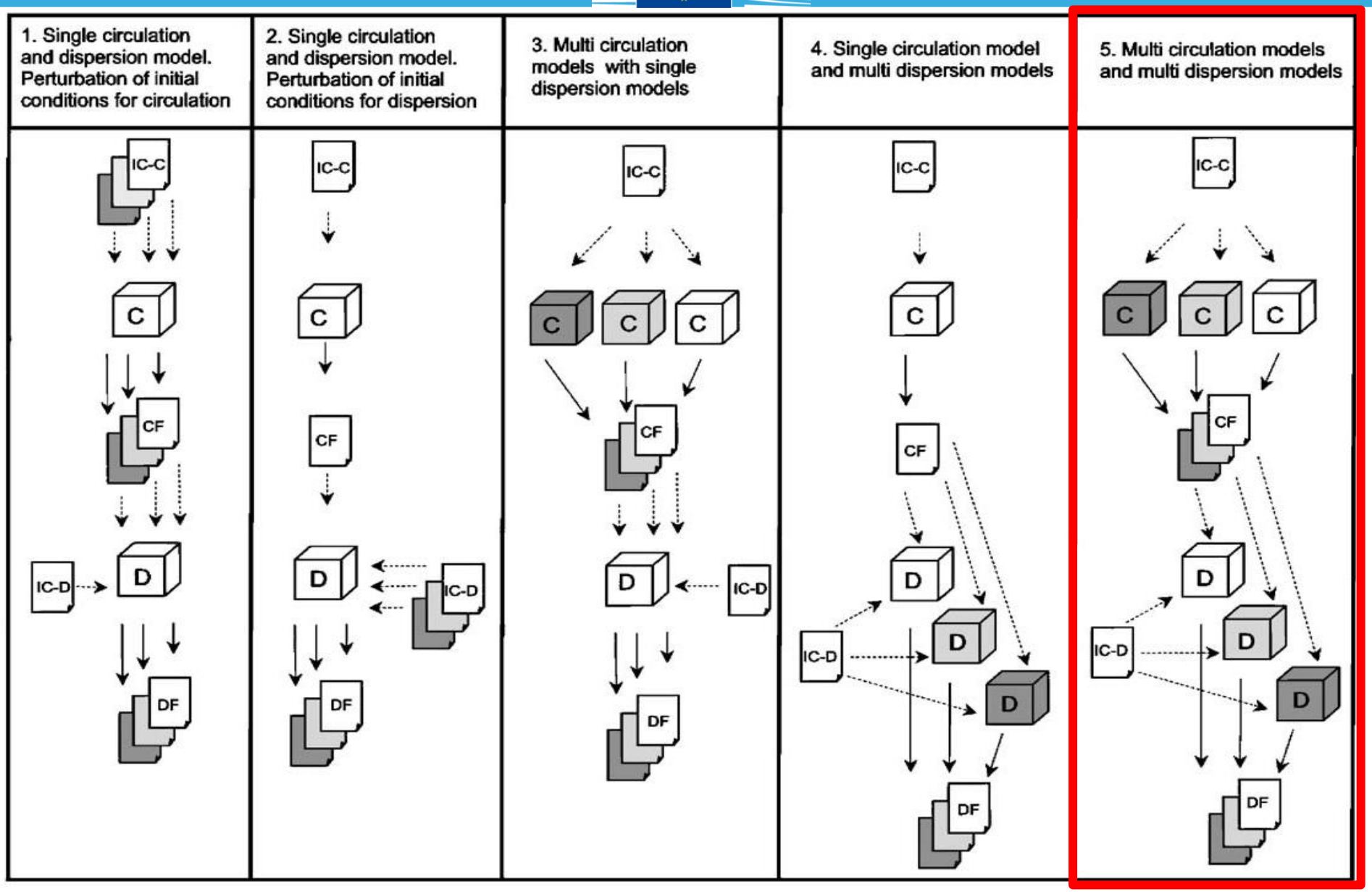
There **A**in't **N**o **S**uch **T**hing **A**s **A** **F**ree **L**unch: issues to keep in mind when using multi-model ensembles

Stefano Galmarini

European Commission, JRC/IES

Outline

- Multi model ensemble
- Phonotypical model difference and ensemble of convenience?
- Inspect your ensemble prior to using it: how?
- A way to evaluate models and to exploit ensemble for forecast
- To know more



(Galmarini et al. AE 2004)

Ensemble of convenience!

- Models are not selected out of physical arguments but only on **those available for the activity**
- Models are only **phenotypically** different
- There is no screening of the level of complementarity of the results, of the difference
- Our models **are not independent**!

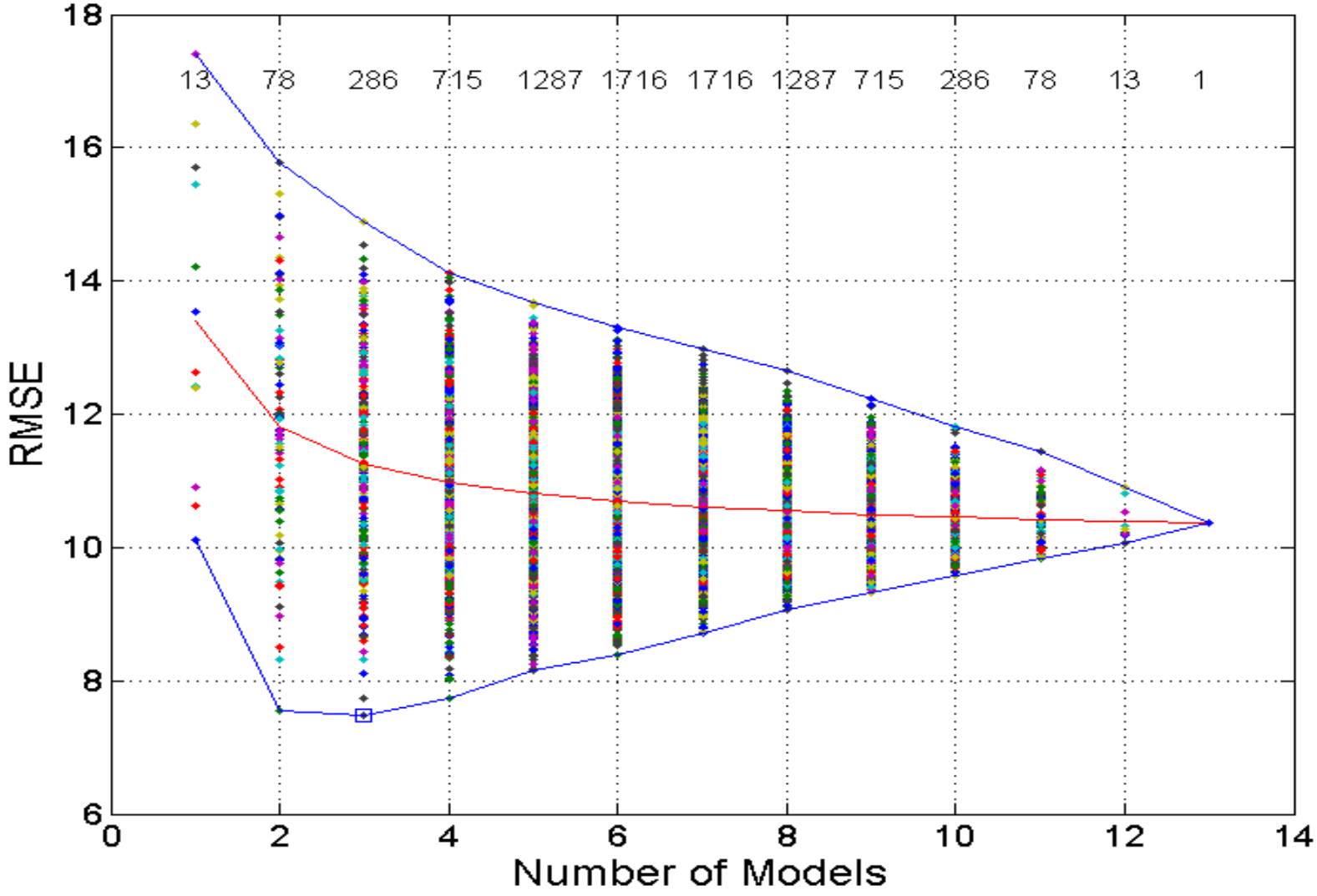
***Est modus in rebus*: analytical properties of multi-model ensembles, ACP,2009**

S. Potempski and S. Galmarini,

What if models are independent or not ?

Independent models
$P(12)=P(1)P(2)$

Dependent models
$P(12)\neq P(1)P(2)$


13
78
286
715
1287
1716
1716
1287
715
286
78
13
1
RMSE
Number of Models
18
16
14
12
10
8
6
0
2
4
6
8
10
12
14

The performance of a multi-model ensemble is limited by the following equation

$$MSE(\bar{f}) = \overline{bias}^2 + \frac{1}{M}\overline{var} + \left(1 - \frac{1}{M}\right)\overline{cov}$$

- The more ensemble members we have, the closer is *var* to *cov*
- $bias^2$ and *var* are always non-negative, but *cov* can be negative.

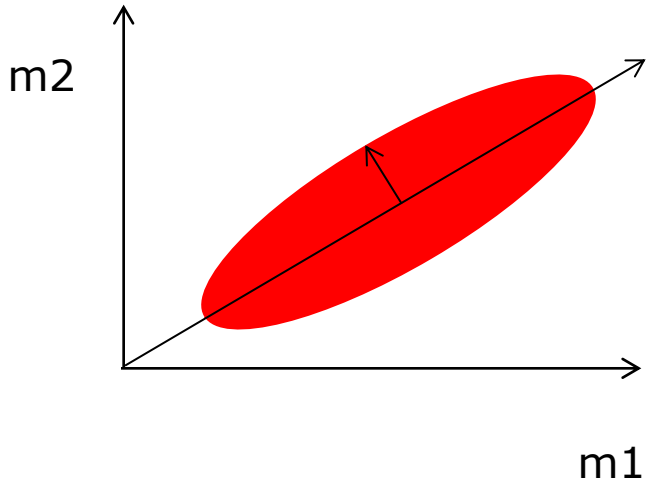
Hence, the *bias-variance-covariance* decomposition provides the theoretical grounding of negative correlation between members

***Pauci ex tanto numero*: reduce redundancy in multi-model ensembles, ACP, 2013**
E. Solazzo, A. Riccio, I. Kioutsioukis, and S. Galmarini

Inspecting an ensemble ?

Identify to what extent the combination of all model results is meaningful with respect to the case considered

$$M_{eff} = \frac{\left(\sum_{k=1}^{M} \lambda_k\right)^2}{\sum_{k=1}^{M} \lambda_k^2}$$



- if $\lambda_k=1$ for all k's => $M_{eff} = M$ => all model results are relevant for the ensemble
- if all results are similar, only one eigenvalue would be non-zero and $M_{eff} = 1$
- All values in between 1 and M will return the number of relevant models

Inspecting an ensemble ?

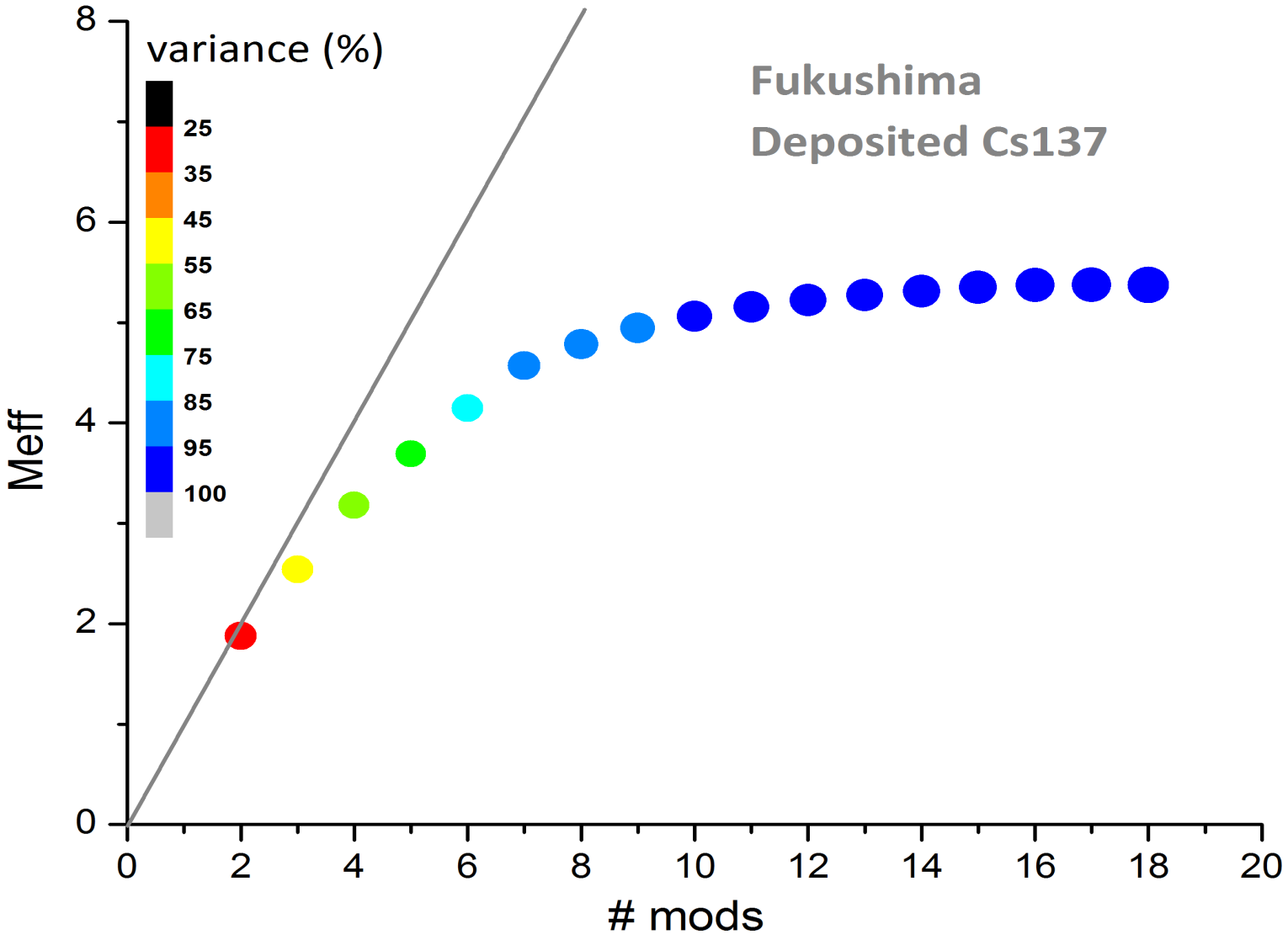
Results from

- Fukushima deposition
- 18 model results from WMO-RSMCs
- 543 sampling points

Collective analysis mostly presented as averaged result for the sake of synthesis

The Fukushima-Cs137deposition case study: properties of the Multi-Model ensemble.

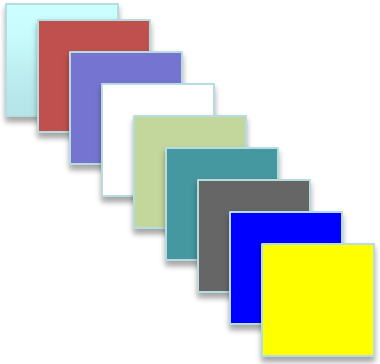
Solazzo E., S. Galmarini, u.r. JER, 2013


variance (%)
25
35
45
55
65
75
85
95
100
Fukushima
Deposited Cs137
Meff
mods
0
2
4
6
8
10
12
14
16
18
20

Model results

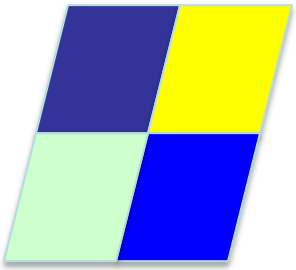
Monitoring data TS

Spectral decomposition



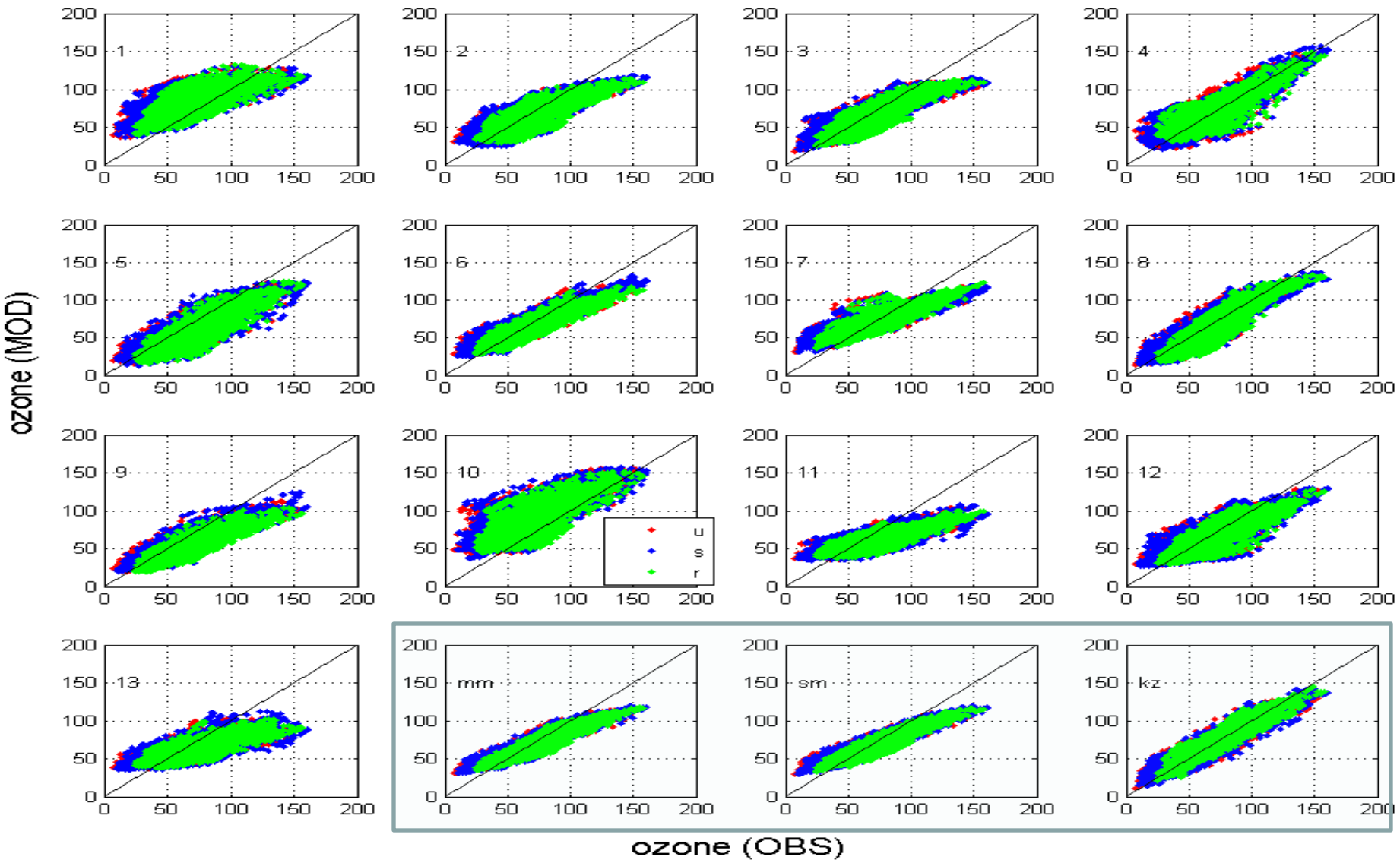
Comparison of model modes with measurements modes

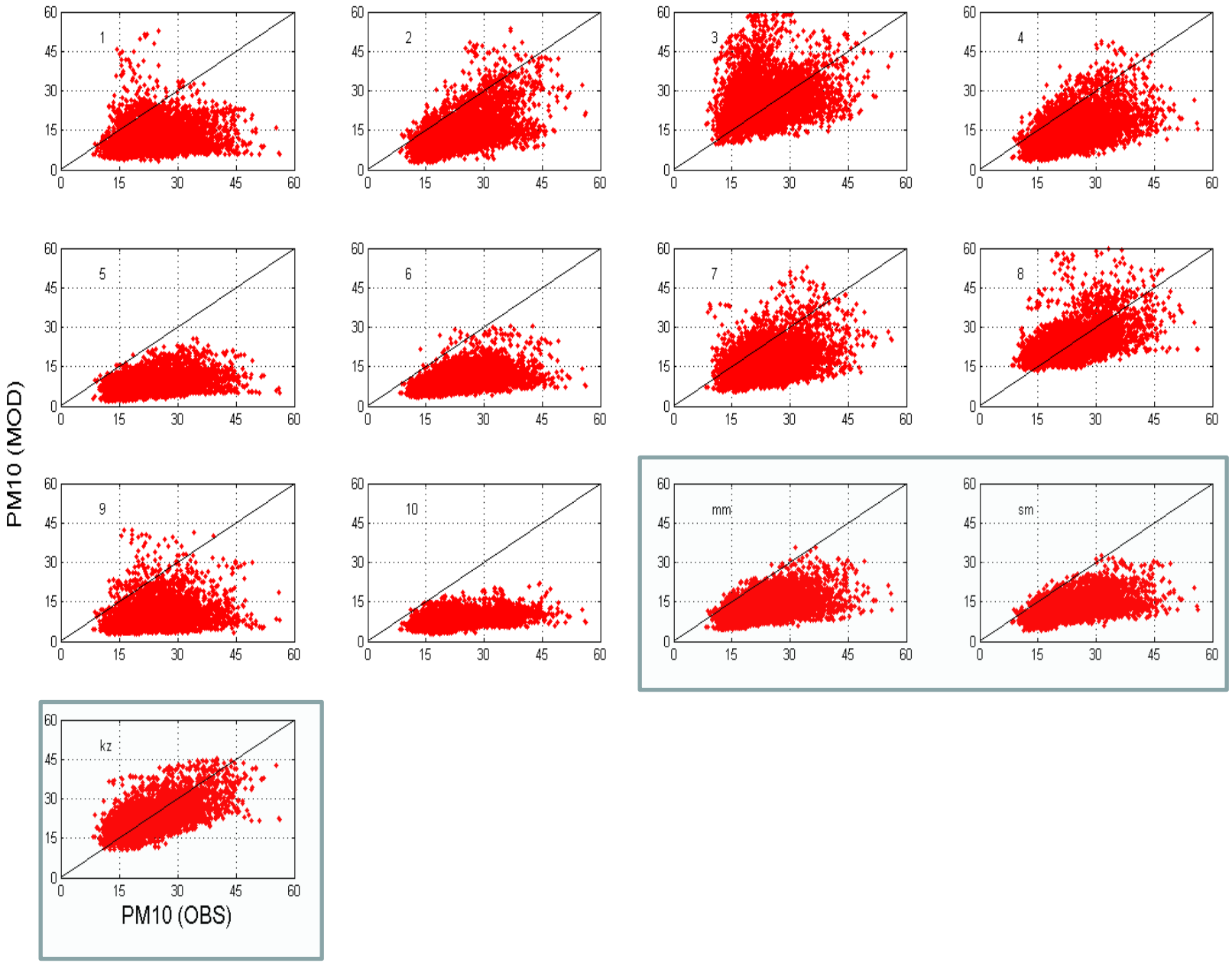
Best matching modes are retained from potentially different models



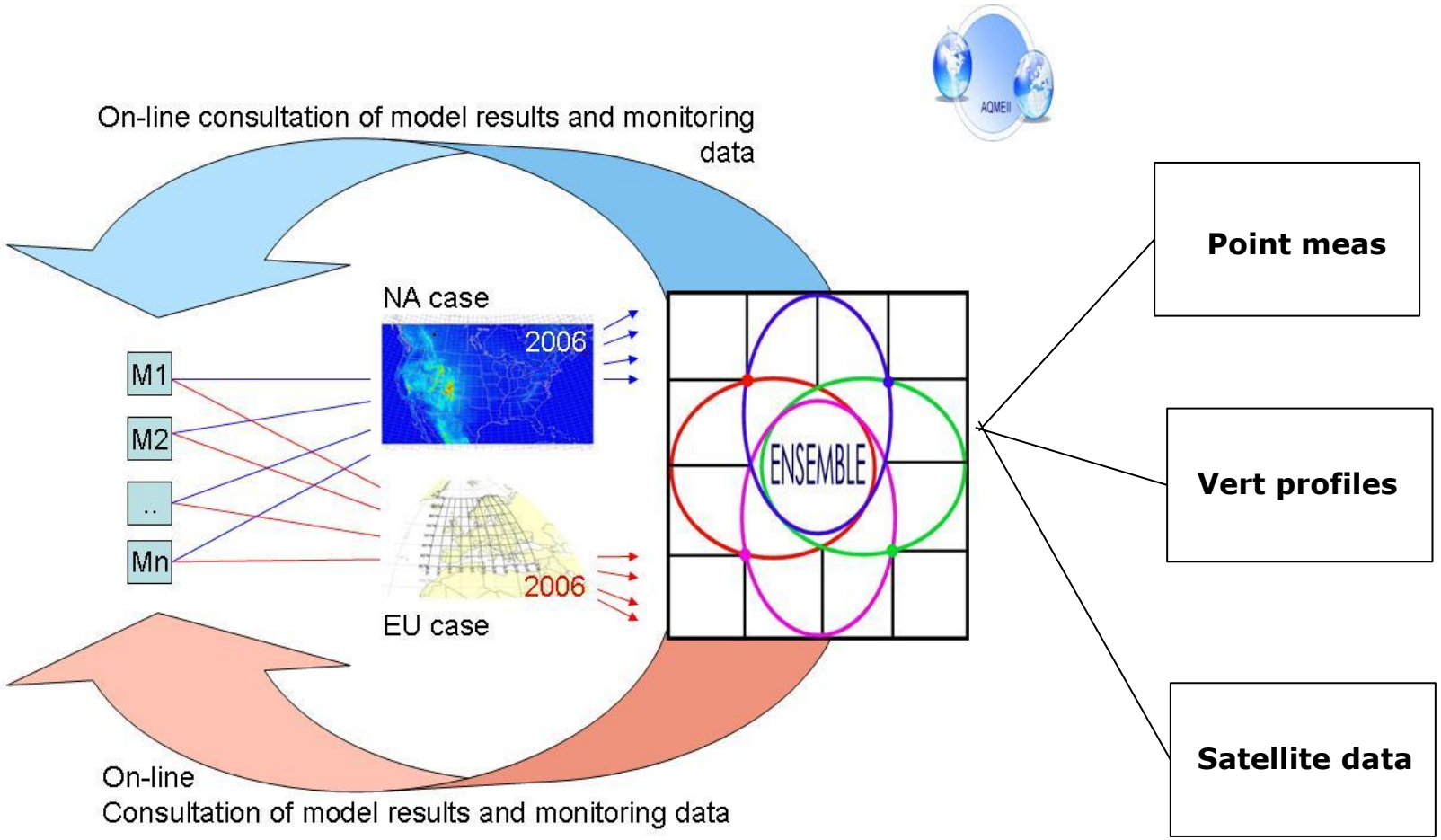
Modes are composed back in a new model result

***E pluribus unum*: ensemble air quality predictions,** ACP, 2013
S. Galmarini, I. Kioutsioukis, and E. Solazzo,ACP


ozone (MOD)
ozone (OBS)
1
2
3
4
5
6
7
8
9
10
11
12
13
mm
sm
kz
u
s
r
0
50
100
150
200


PM10 (MOD)
PM10 (OBS)
1
2
3
4
5
6
7
8
9
10
mm
sm
kz
0
15
30
45
60

http://ensemble.jrc.ec.europa.eu/



To know more

***Est modus in rebus*: analytical properties of multi-model ensembles**
S. Potempski and S. Galmarini, ACP

***Pauci ex tanto numero*: reduce redundancy in multi-model ensembles**
E. Solazzo, A. Riccio, I. Kioutsioukis, and S. Galmarini, ACP

***E pluribus unum*: ensemble air quality predictions**
S. Galmarini, I. Kioutsioukis, and E. Solazzo,ACP

http://ensemble2.jrc.ec.europa.eu/publications