A Multi-model Statistical Approach to Decadal Projictions

Making Sense of the Multi-model Decadal Prediction Experiments from CMIP5

AGCI June 26-July 1, 2011

A little history

From the REA approach

(Giorgi and Mearns, 2001):

Combine multiple model projections based on bias and agreement at regional scales

- Form weights that are inversely proportional to bias measured on a specific climatological period and directly proportional to agreement when it comes to the future projection
- Use the weighted average as your best guess and/or a reweighted histogram of projections as your PDF.

From a statistical modeling perspective it turns out…

- Forming that kind of weights is equivalent to making very specific assumptions about the statistical properties of your data:
  - Independence between GCMs
  - Model-specific variance of the errors
  - Error distributions with a long tail (outliers!)
  - Discounting of those outliers

So we set out to write down that statistical model that would produce the REA estimates as its optimal estimates…

And we got a lot of flack:

GCMs are not independent!

Outliers are meaningful (you want to span all the uncertainties and more)!

Past performance is no indication of future reliability!

Errors are not normally distributed!

Etc. Etc. Etc.

Can it be that decadal prediction experiments are more appropriate for this kind of statistical modeling?

That's where your input would be very valuable!

- Would you be concerned about dependence between initialized modeling systems? (note: am talking about independence of the errors)
- Does it make sense to think of each model's ensemble as enveloping the truth? Should we rather model a systematic bias?
- Is past performance (evaluated by the hindcasts) indication of future reliability? How much of the past performance?
- Is variance of the forecast (ensemble spread) model specific?

- Are decadal means a useful forecast product? Should we aim at trends? At variability?

The simplest of all statistical models for multi-model initialized projections

$$X_{ij} \sim N(\mu;\sigma_i^2)$$

$$Y_{ij} \sim N(\nu + \beta_i(X_{ij} - \mu);\sigma_i^2)$$

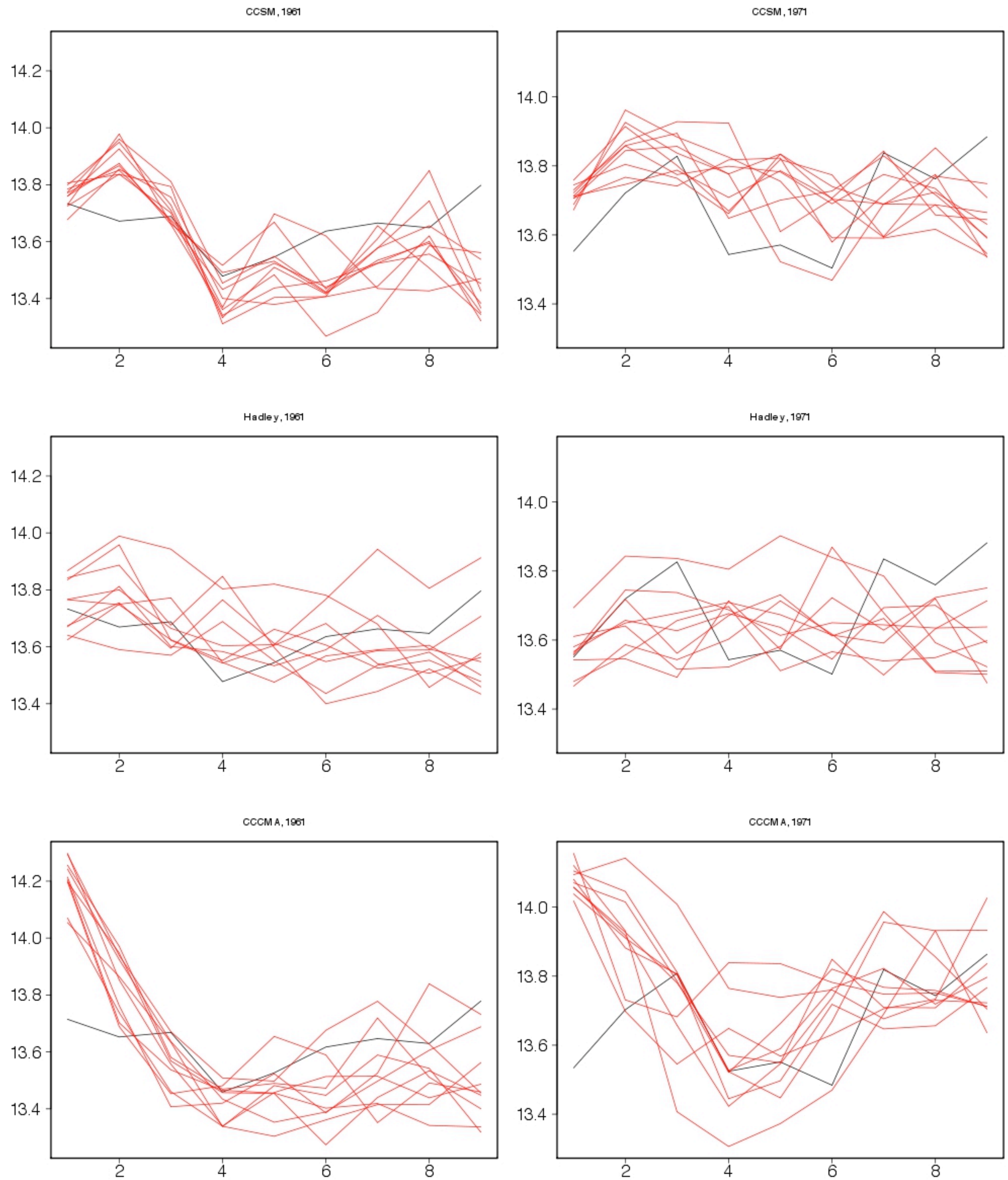
$$\mu = obs$$

i= 1,…M ; j = 1, 2, …, Ni

What does this mean for our ν ?

$$\hat{\nu} \cong \frac{\sum_i \sum_j \lambda_i (Y_{ij} - \beta_i \bar{X}_{ij})}{\sum_i n_i \lambda_i}$$

$$\hat{\lambda}_i \cong \frac{\sum_j [\bar{X}_{ij}^2 + (Y_{ij} - \nu - \beta_i \bar{X}_{ij})^2]}{2(n_i - 1)}$$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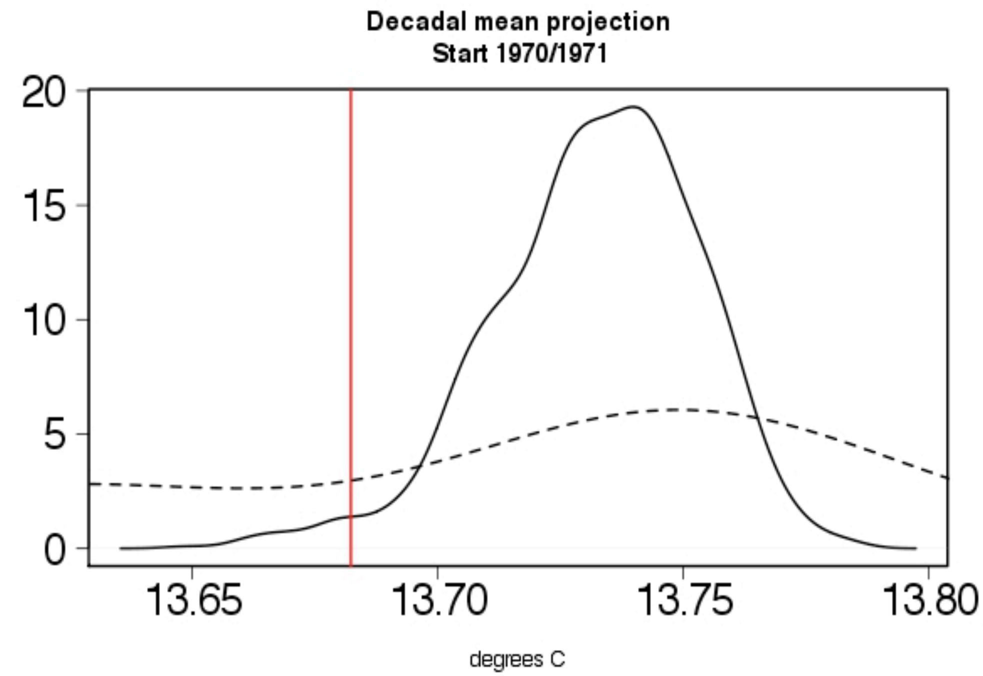
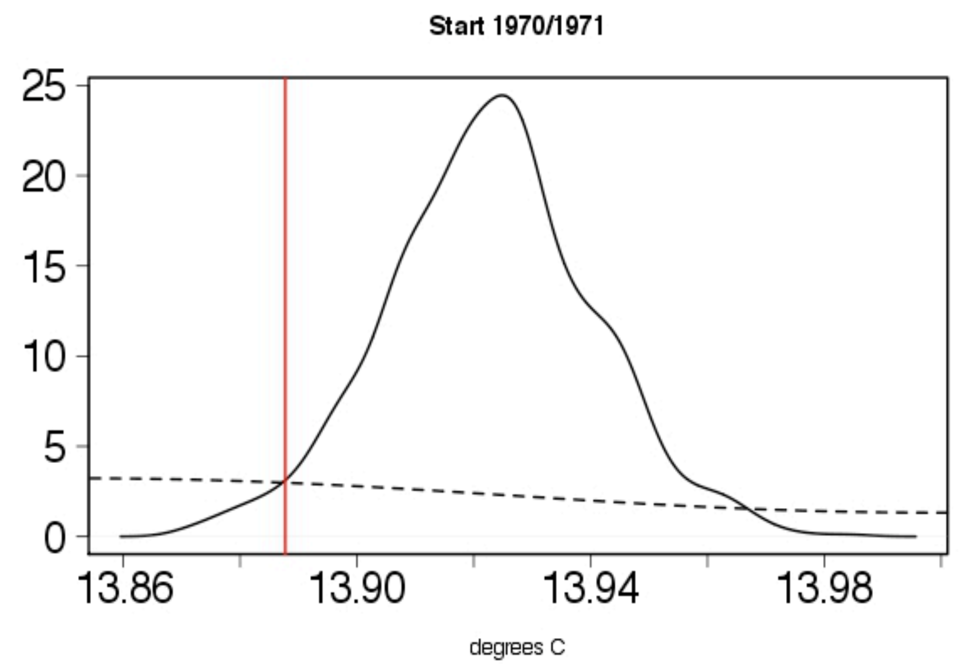

Decadal mean projection
Start 1970/1971
20
15
10
5
0
13.65
13.70
13.75
13.80
degrees C


Start 1970/1971
25
20
15
10
5
0
13.86
13.90
13.94
13.98
degrees C