Empirical Statistical Downscaling

Robustness & limitations

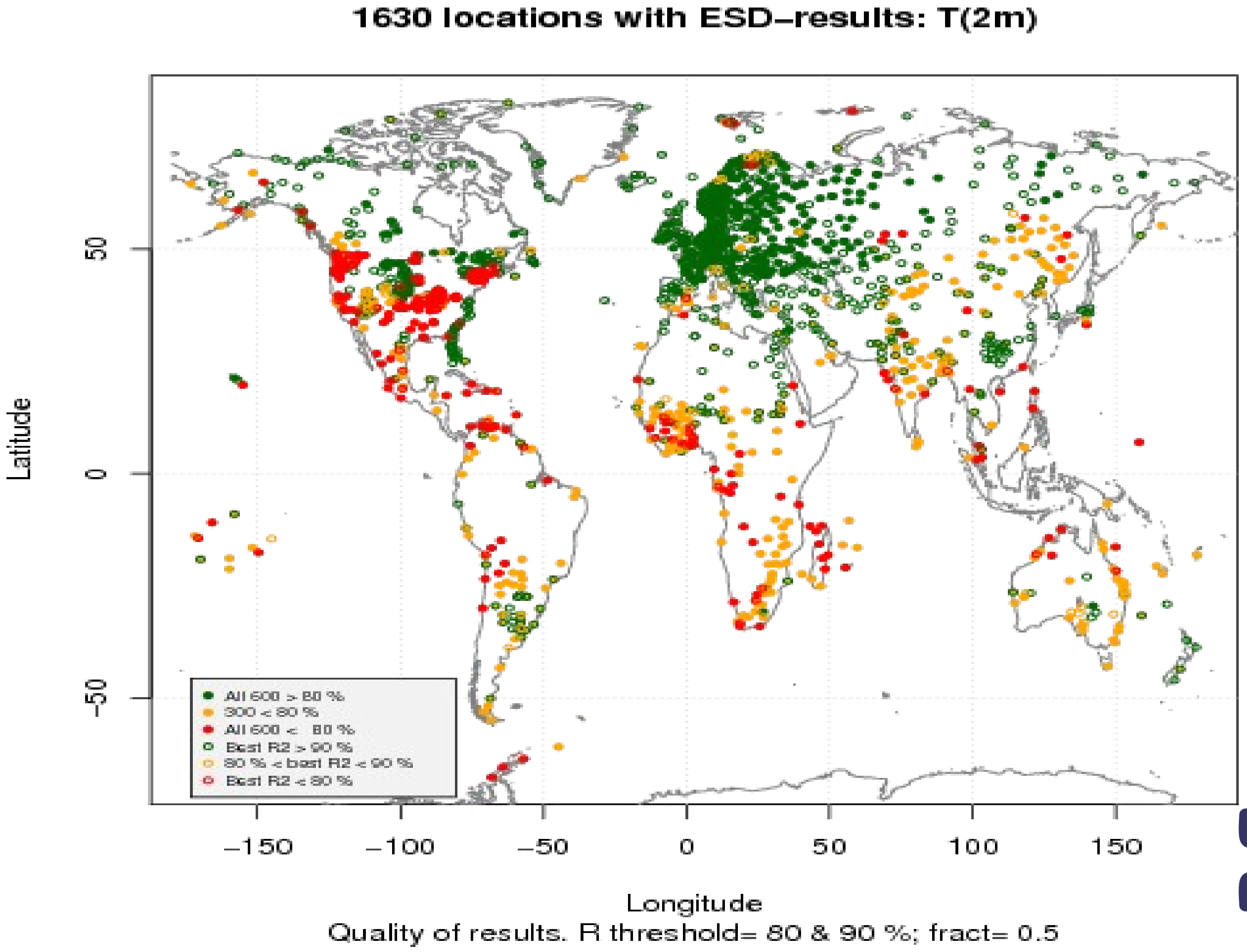
Limitations: Observations

- Can only model variables for which there is sufficient observations.
- Observations are also needed for evaluation of all simulations.
- Gridding can provide a means of filling in informations where the variable is a smooth function in space and dependent on geographical character
- Time scales limitations – depends on observations and dependencies.

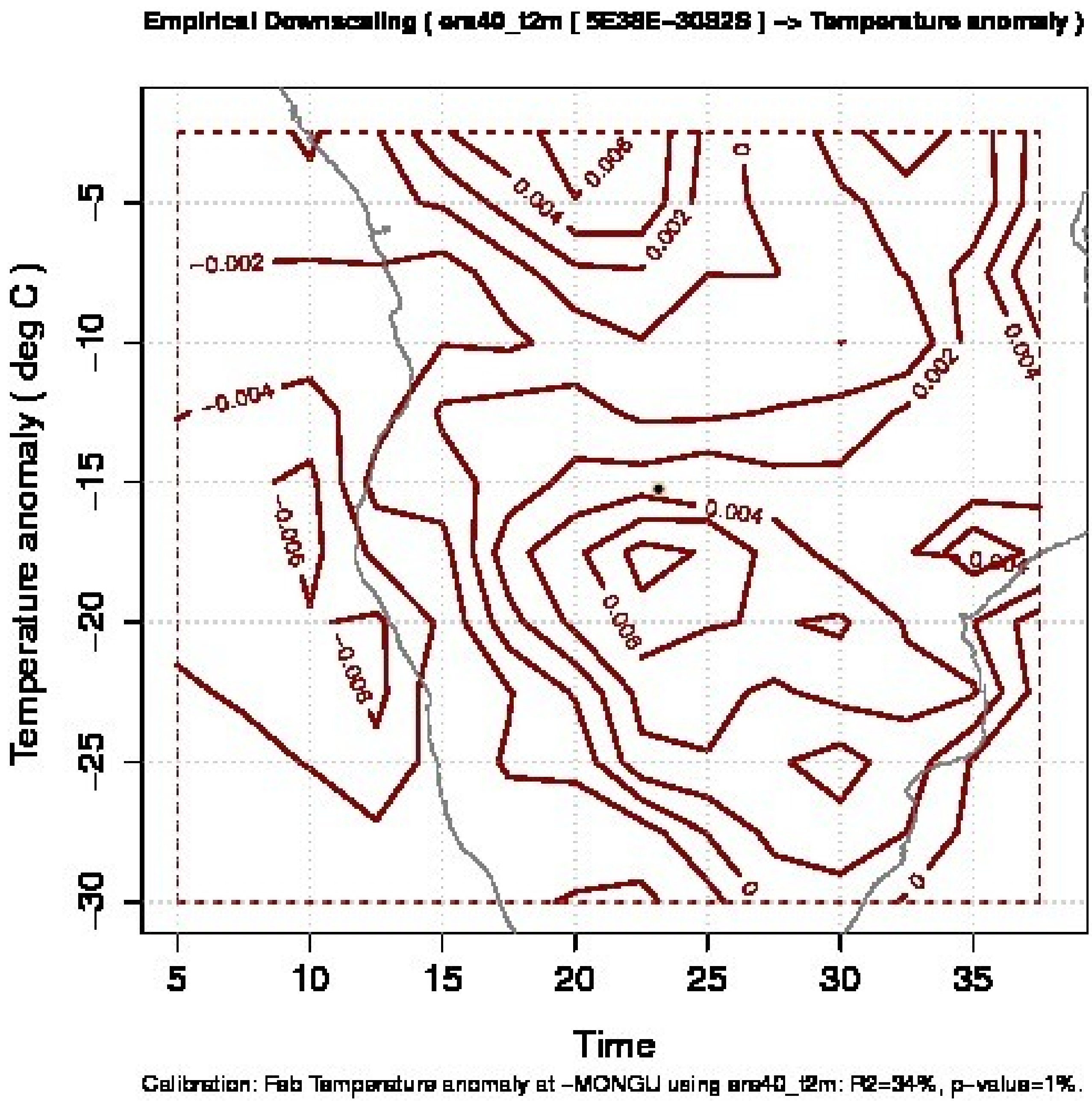
Quality of observations

- The observations may contain errors.
  - Instrument
  - Digitising & logging.
- Homogeneous?
  - History of observer
  - Relocation
  - Environment
  - Instruments
  - Practices (time of day)
  - Quality control?

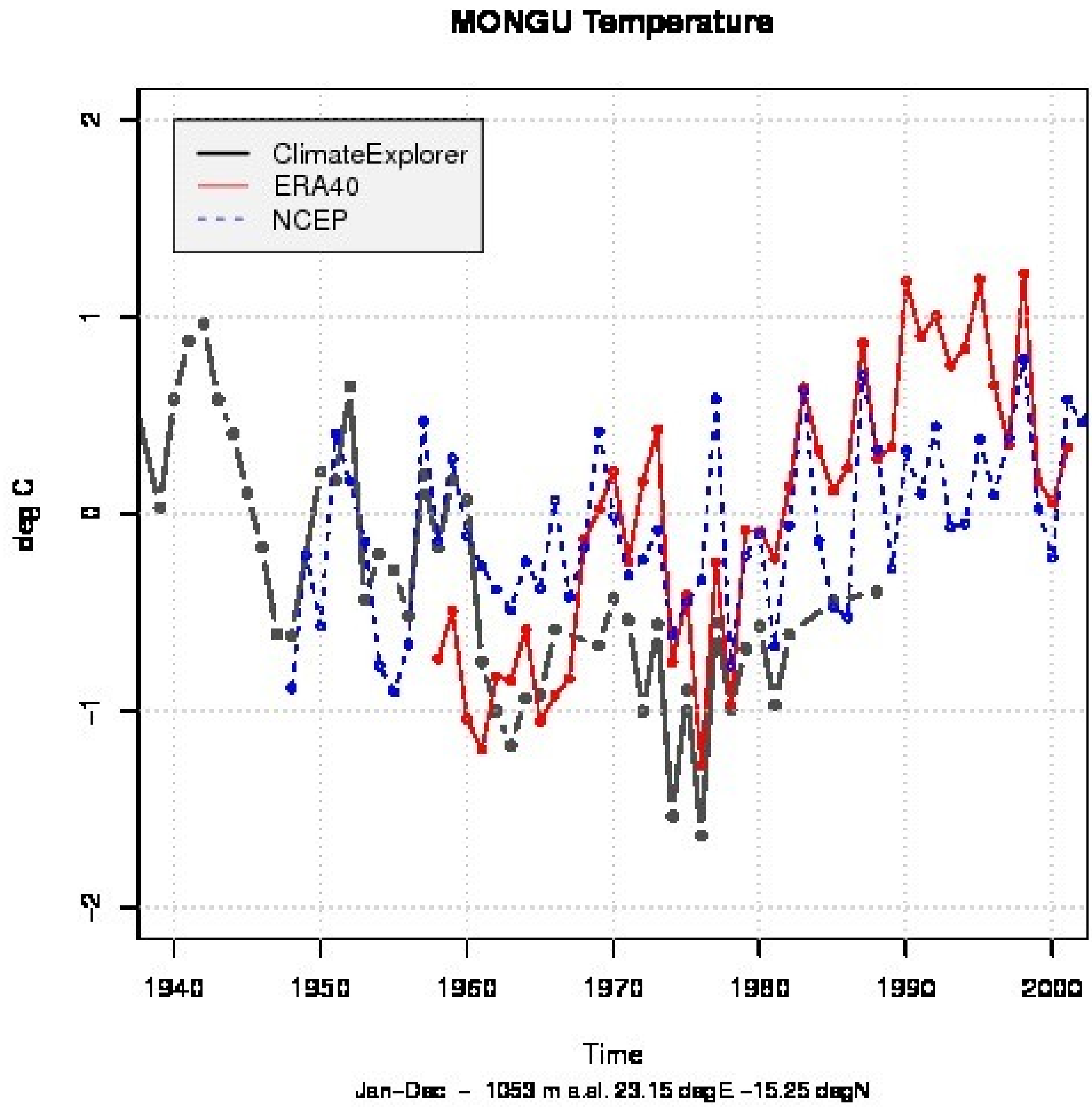
Quality flags



Large-scale pattern



Why the poor scores?

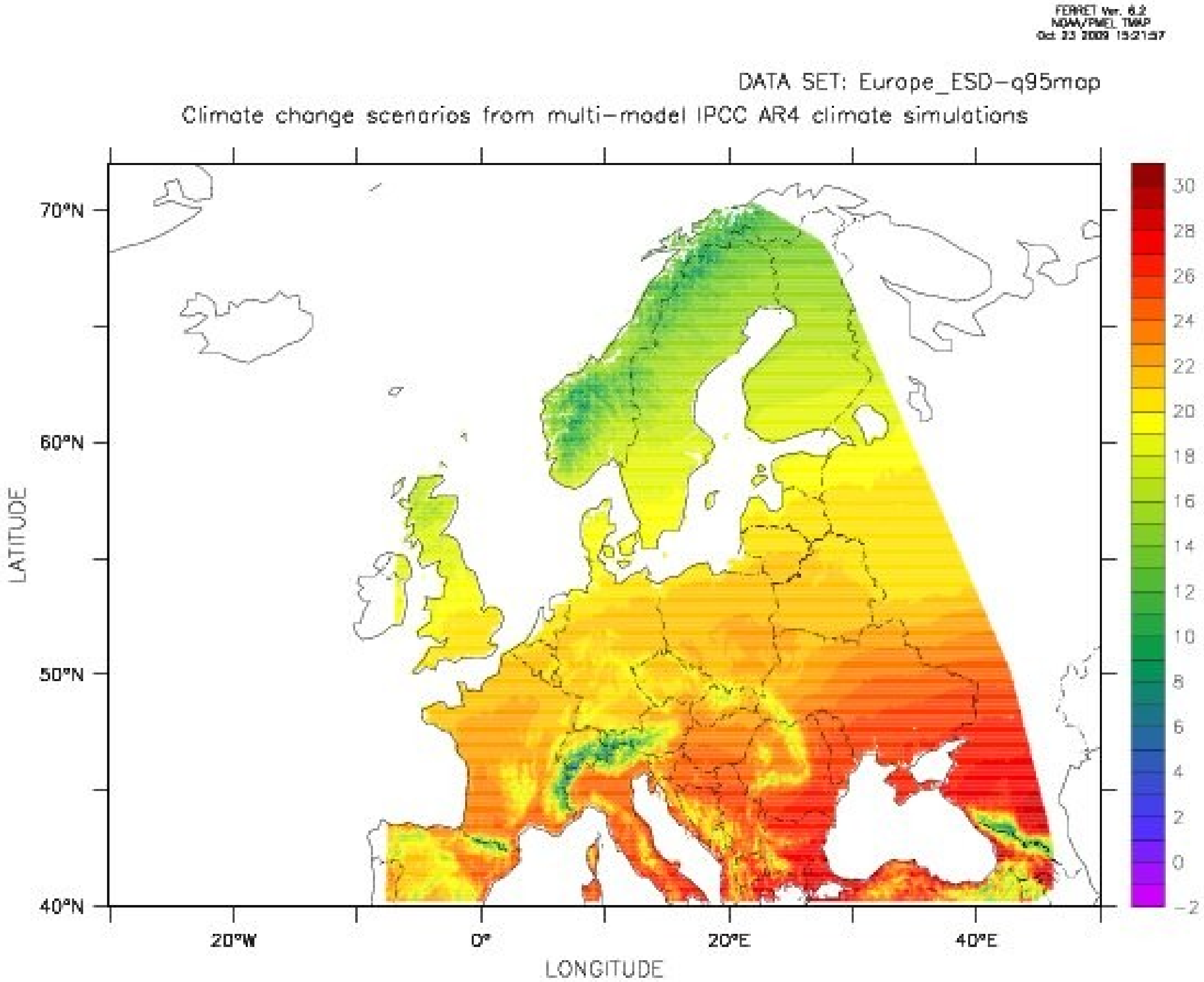


Geographical gaps

- Locations with no useful observations of the required variable.
- Nothing can replace measurements – but we can nevertheless make som tentative estimates...

Geographical information

- Expect some geographical dependency
- Gridding (geographical regression models) can provide some indication of skill (ANOVA).
- Cannot evaluate results where there is no data.
- Can test by witholding data from some locations and then compare these with gridded results.
- Useful to apply ESD to locations from different regions for testing purposes – robustness.



q95 for JJA mean T(2m) in year 2050 (none)

Stationarity

- This is a limitations for all models (parameterisation)
- Depends on the choice of predictors – physics basis...
- Can be tested using RCMs/GCMs as pseude-reality.
  - Sign in the results suggesting changing character between large and small scale dependency?
- Test: predict past trends in a split sample exercise.

Spatial coherence/consistency

- Also temporal structure and dependencies between quantiles (consistent PDF).
- Some types of models (analogs) can provide description of a set of variables
- Variable-inter-dependencies depend on choice of predictors.
- Perfect DS should capture large scales. Question about intermediate scales.

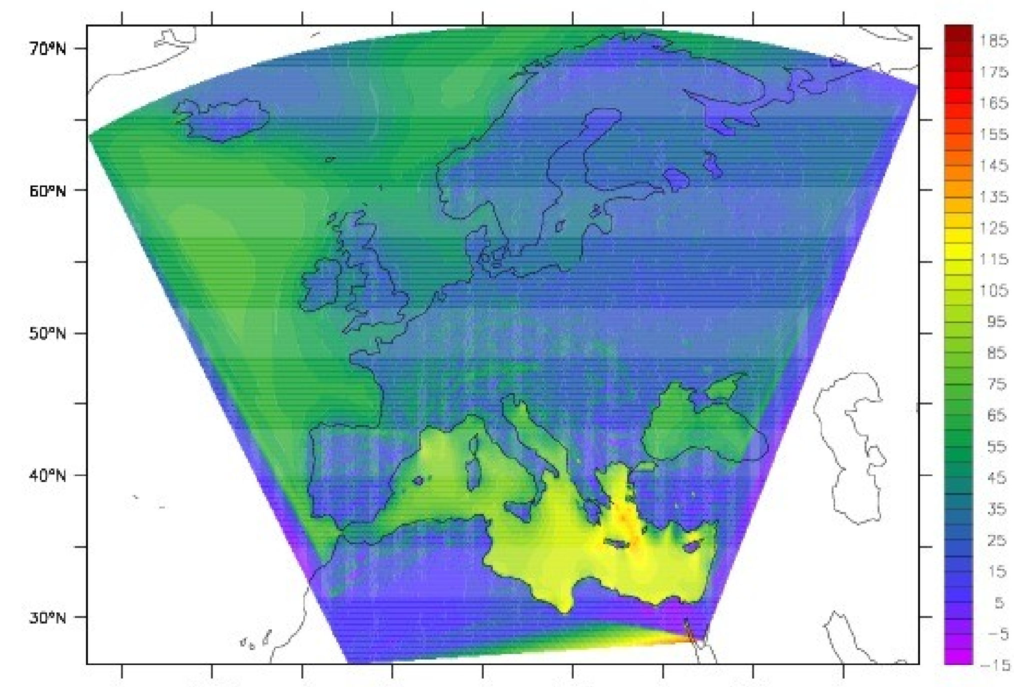
Physical, scale, & internal consistency?

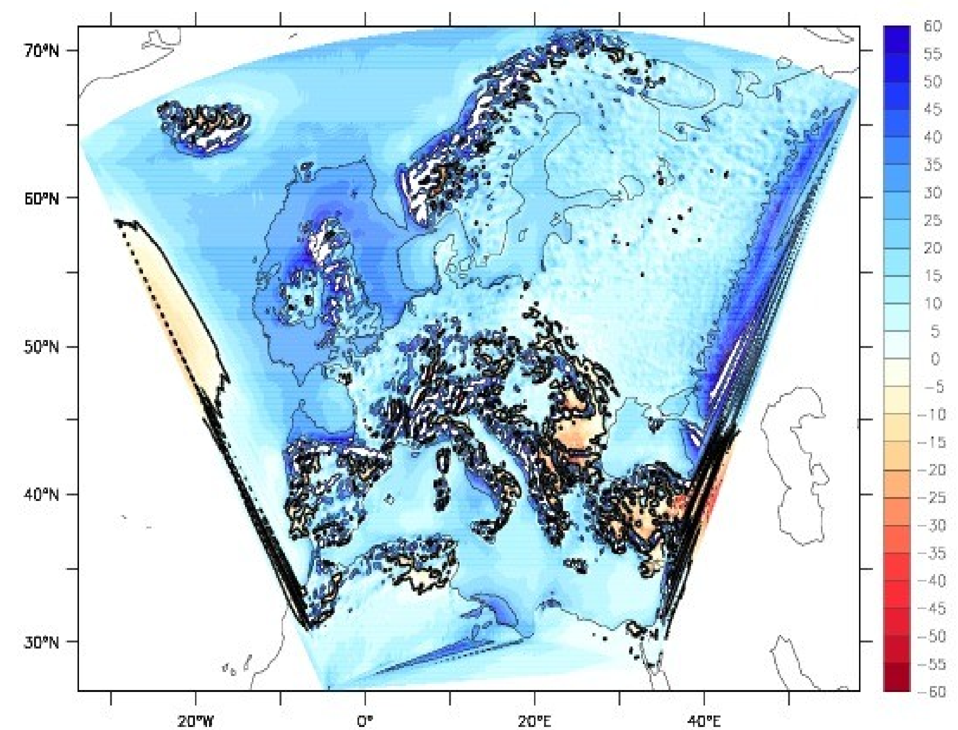
- No downscaling is guaranteed physical consistent.
- There should be scale consistency – aggrigation should give the same answer as the original predictor/GCM.
- Fluxes & energy budgets: rate of evaporation & precipitation.
- Inter-relation between different variables and spatial/temporal coherency?
- Validation: both in terms of statistics & physics.
- Remedy: two-way coupling for RCMs.

Misconceptions

- Wrong to regard RCMs as 'physical consistent'
- Non-stationarity ***not*** only an ESD-relevant issue

Latent heat flux at surface/precip: METNOHIRHAM driven by ERA40 - ERA40.





Implications for the large-scale vertical heat flow

Extreme tails

- The upper tail is often not well captured.
- Methods resampling past (analogs) not able to predict new record-breaking values.
- Possible solution: predict the PDFs.

Scarce information space

- Only a few variables (those observed)
- Not a comprehensive picture.

Changes to local conditions

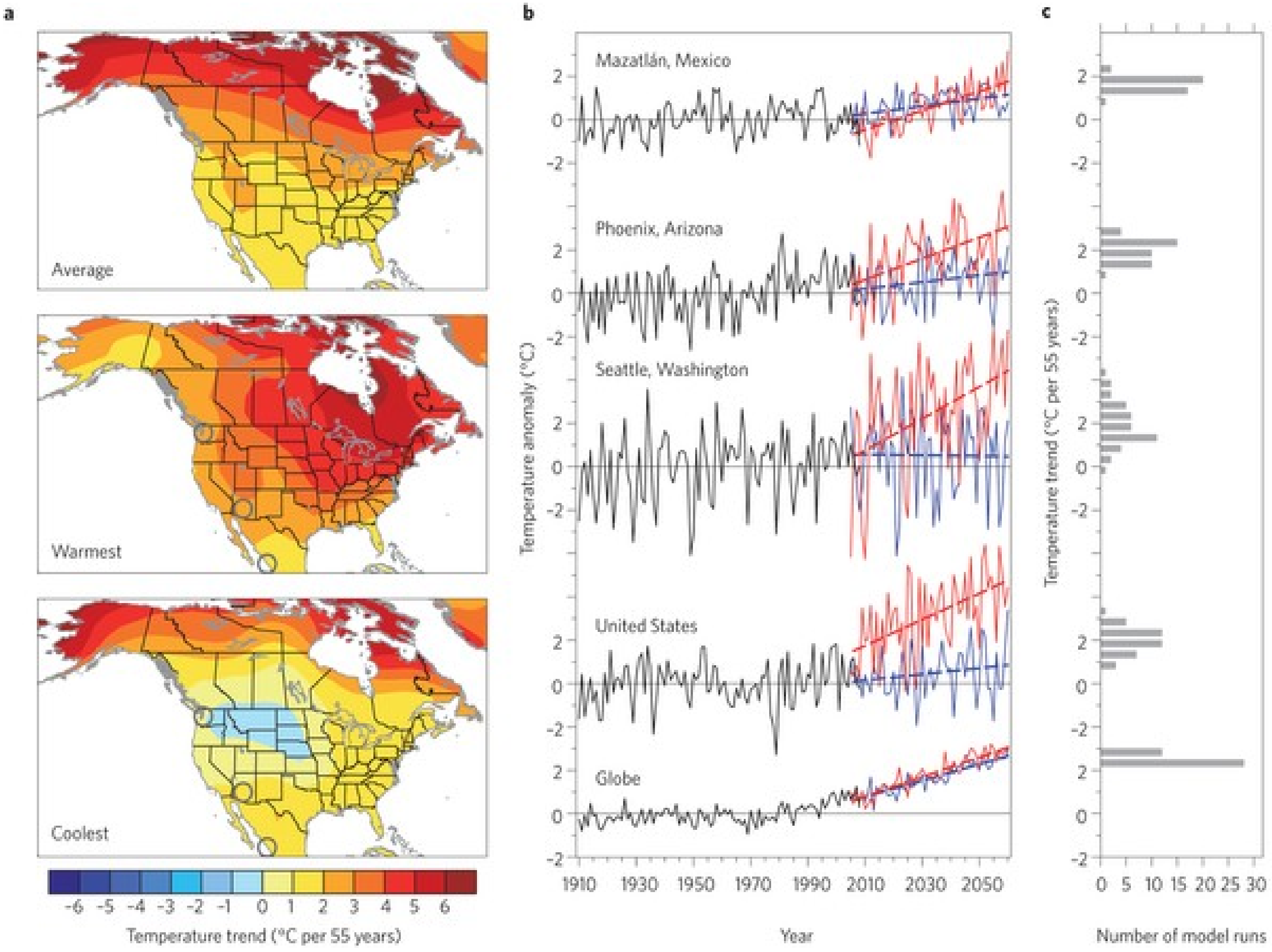
- Changes in vegetation & landscape.
- Pollution or urbanisation.
- Need to account for in calibration – depends on f(.) in $y = f(X)$.

The important thing to remember

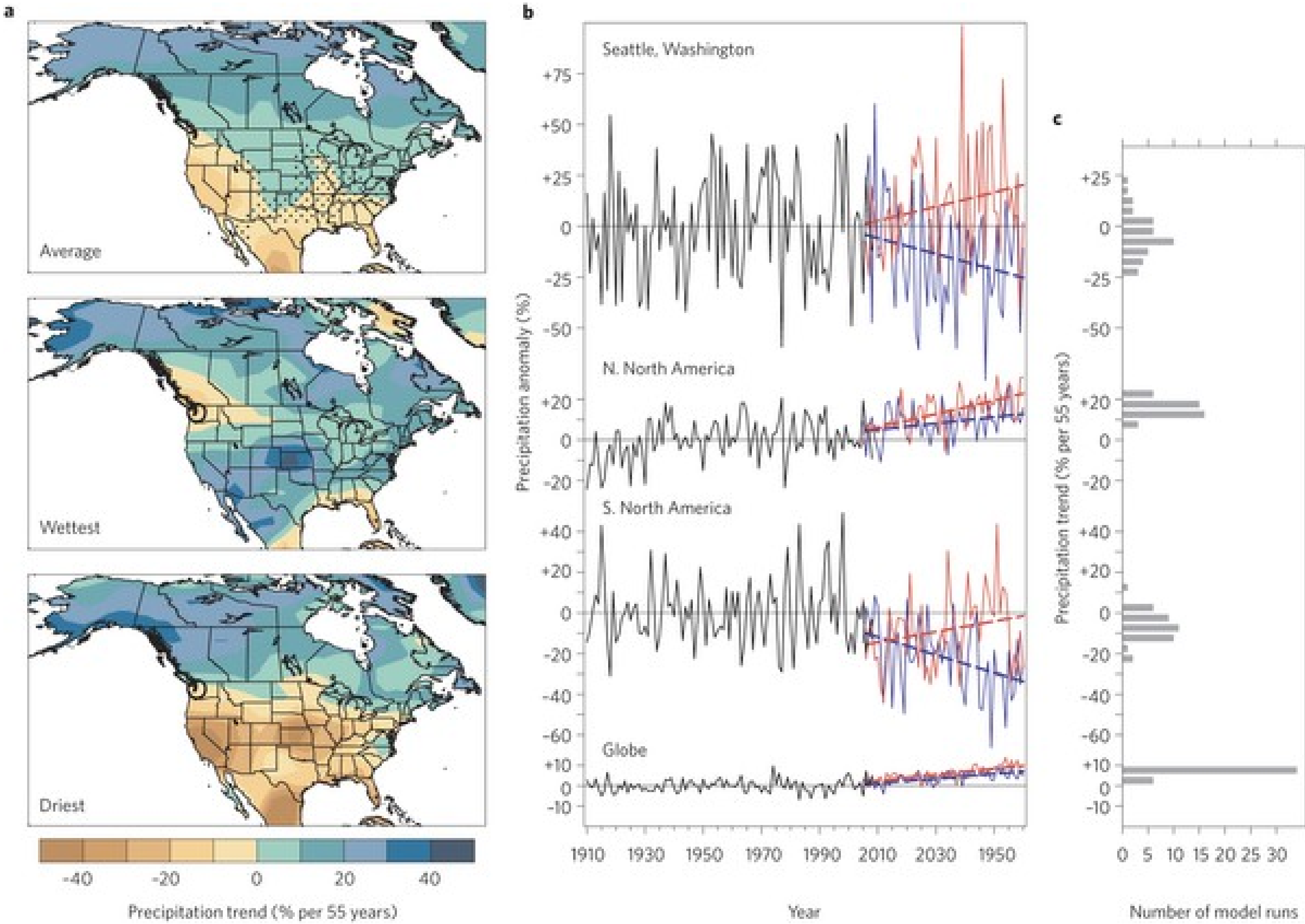
- **Testing, evaluating, and assessing.**
- Independent data.
- Sensitivity tests.
- Use all relevant information.
- Apply method to other locations.
- Pseudo-reality.
- Look for physics.

Dependency to large scales

- **Cannot correct** invalid GCM predictions.
- Account for GCM-predicted ranges – use ensembles.
- Ensemble spread ≠ PDF.
- Some idea of range.



Deser et al (2012), Nature Climate Change

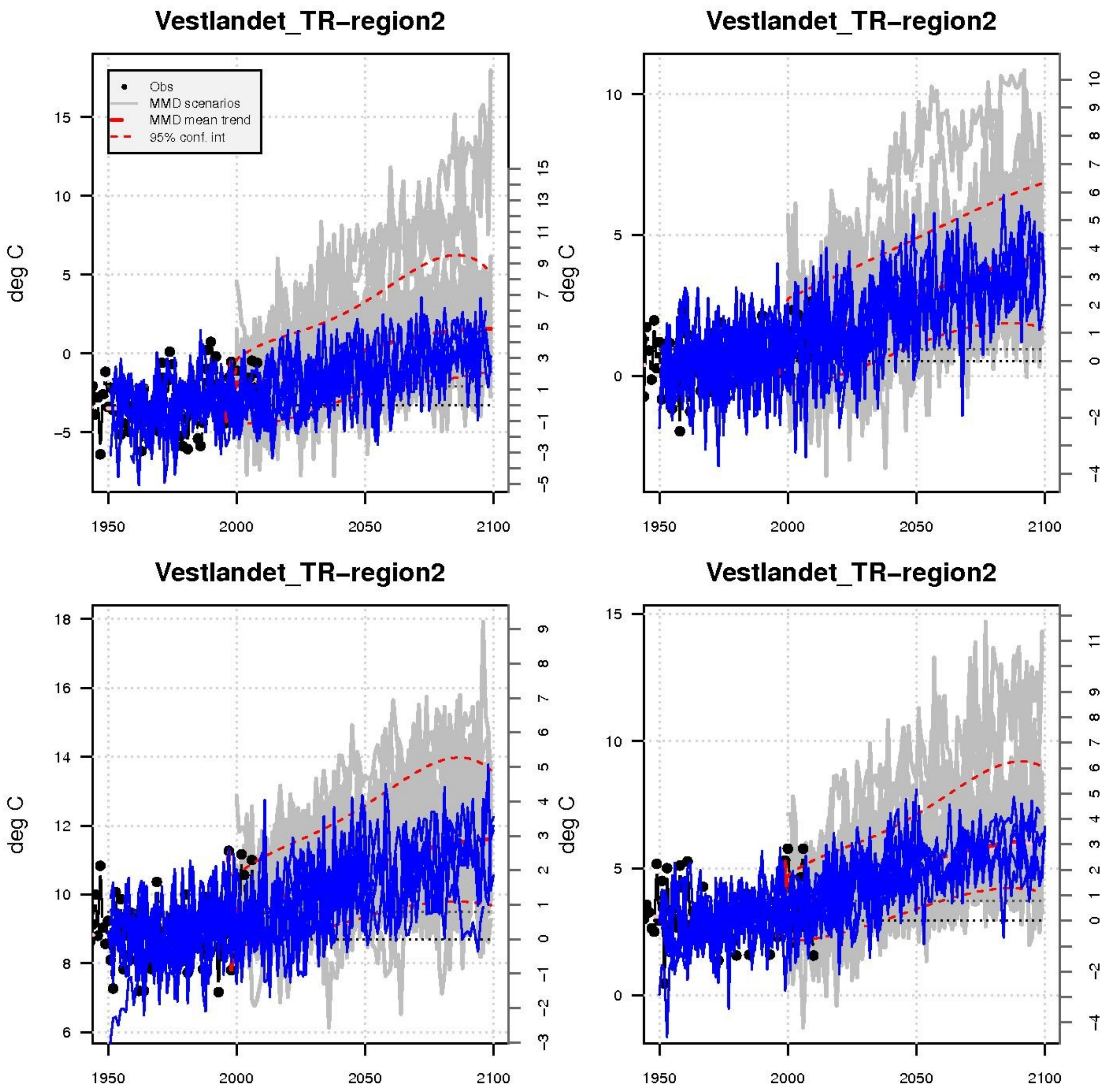


Deser et al (2012), Nature Climate Change

Uncertainties:

- Large-scales.
  - Sampling, GCMs, emission scenario,...
- Downscaling.
  - Independent and different to RCMs.
- Observations.

ESD & RCMs: compllimentary!



T(2m):

ESD & ENSEMBLES

After bias Correction:

Consistent picture
Robust response

Summary: Caveats associated with ESD

Stationarity & non-stationarity (detrend, split sample, physics, perfect model studies, pseudo-reality)

Signal & predictors (past trends, physics)

Strength of dependency (R^2)

Risk of coincidental fit (cross-validation, split sample, stepwise, geographical distribution)

Skillful simulation (common EOFs, diagnostics of PP-fit, past trends, climatology)

Remedy – always test, explore, and validate!