4th VALUE Training School
Validation of Regional Climate Change Projections

Validation in a Climate Information Distillation Context - The VALUE Framework

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Outline

The context

What a validation should do

Lessons from forecast verification

VALUE

The VALUE framework

Adaptation to climate change...

Müritz-Elde-Wasserstraße, W. Illner

Adaptation to climate change...

in the light of

- competing interests, democratic decisions and
- real money spent

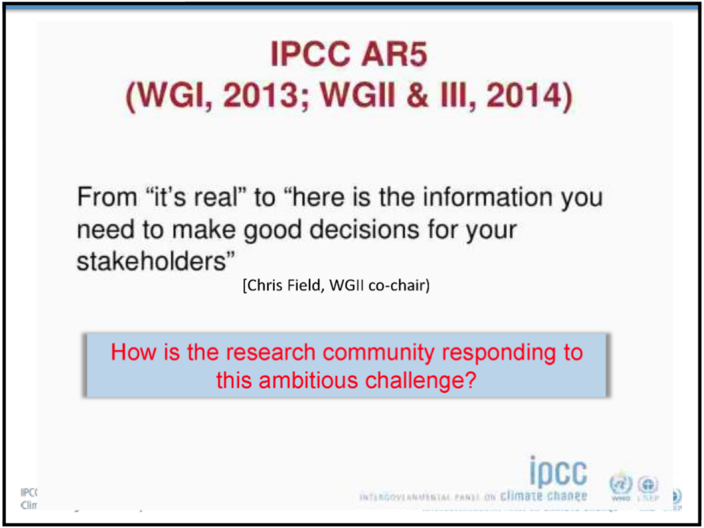
Adaptation to climate change...

...requires **robust regional** information

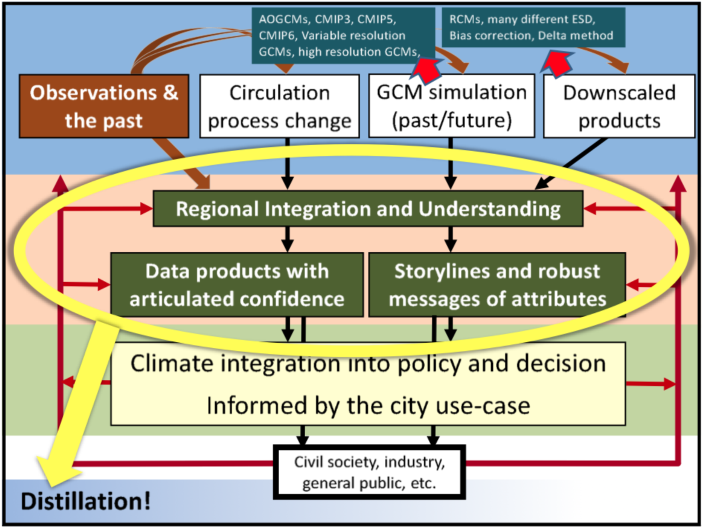
in the light of

- competing interests, democratic decisions and
- real money spent

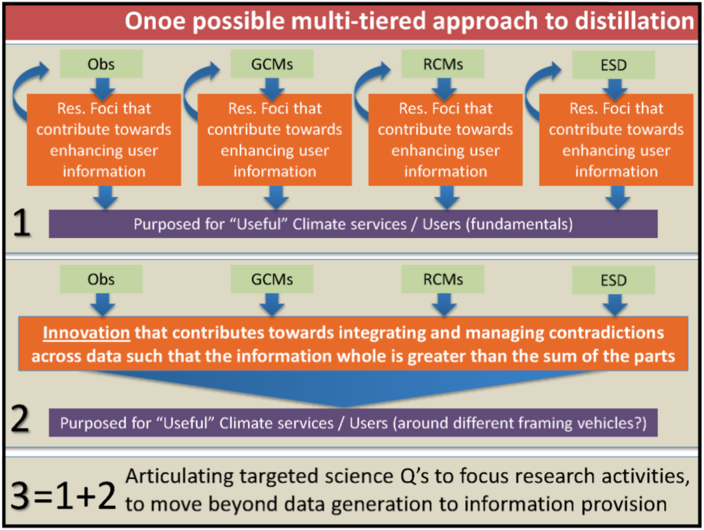
Distillation



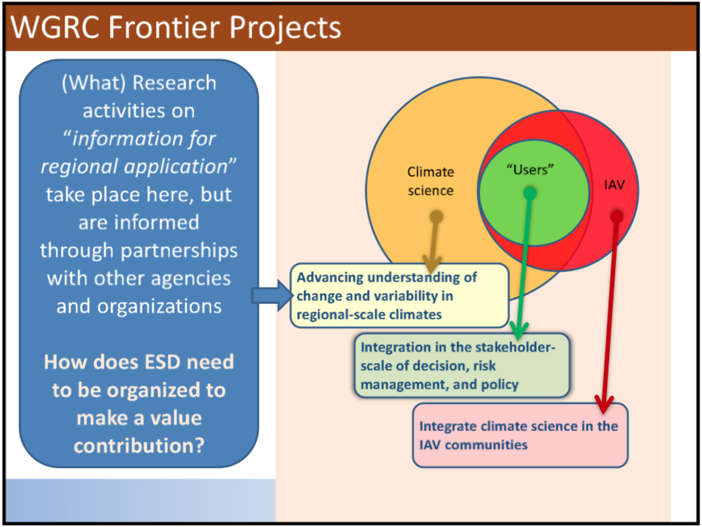
Distillation



Distillation

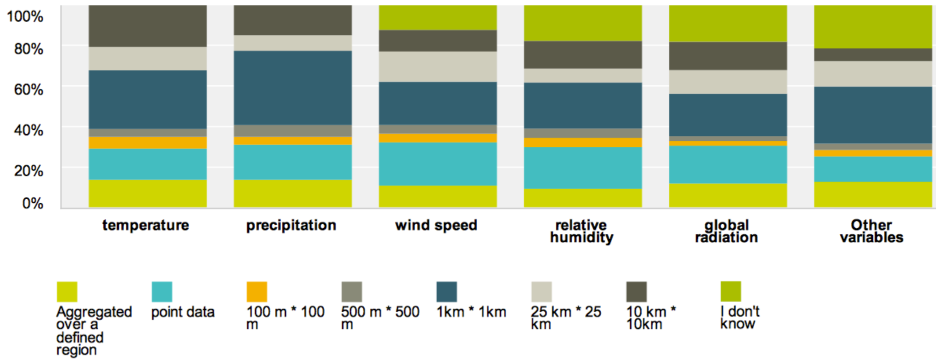


WCRP WGRC Frontier Projects



Requirements I

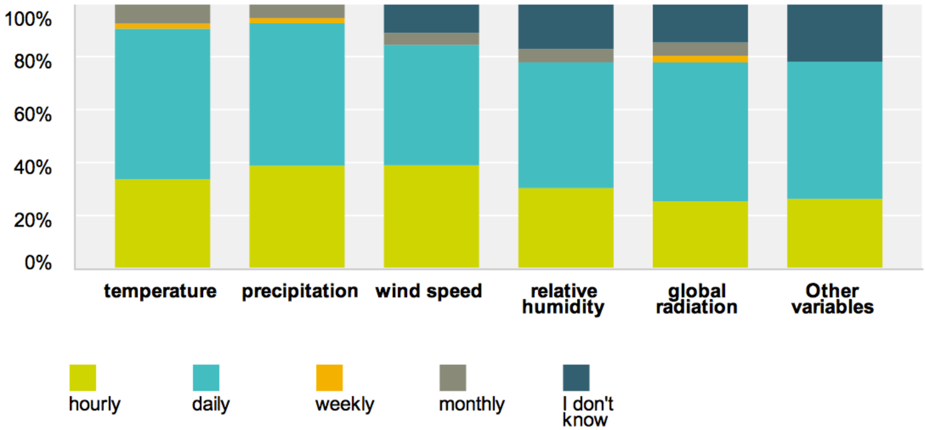
Desired spatial resolution



VALUE end user survey

Requirements II

Desired temporal resolution



VALUE end user survey

The need for validation

- "Researchers are still struggling to develop tools to accurately forecast climate changes for the twenty-first century at the local and regional level." *Nature Editorial, 2010*

- "Validation Required [...] Certainty is what current-generation regional studies cannot yet provide." *Nature Editorial, 2010*

A certain validation tendency

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The need to prioritise

- All models are substantially simplified versions of the complex real world.
- No regional climate simulation can be expected to realistically reproduce all aspects of the system.
- Validation of all aspects would be practically impossible.

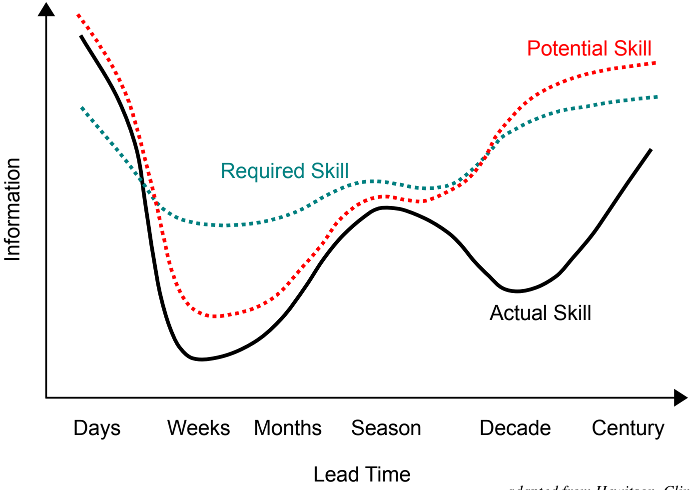
But: in a given application, only a small part of the system will be relevant.

$\Downarrow$

User focussed approach that identifies relevant phenomena

Requirements

Potentials and Limitations for any Given Variable, Resolution, Region and End User



adapted from Hewitson, Clim. Change, 2014

The question is...

...not, whether downscaling is required or not, but...

...for wich variable, region, season lead time and aspect, i.e., for which end user problem is downscaling useful?

Deterministic vs. probabilistic forecasts

Deterministic forecast

- A single value is forecast
- For the same climate model output, always the same value is forecast
- e.g., dry/wet, drizzle/medium rain/heavy rain, number of wet days, temperature value,...

Probabilistic forecast

- A probability distribution/density function is forecast
- For the same climate model output, always the same probability distribution is forecast
- e.g., wet day probability, probabilitiy of drizzle/medium rain/heavy rain, distribution of number of wet days, distribution of temperature,...

Forecast attributes

Accuracy

- Average degree of correspondence between individual pairs of forecasts and observations.

Bias

- Degree of correspondence between mean forecast and mean observation

Reliability/Calibration

- Conditional unbiasedness: given a forecast value, does the expected (average) value of corresponding observations equal that forecast value.

Forecast attributes, continued

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Resolution

- The degree to which the mean observation, conditional on a forecast, differs from the unconditional mean observation, averaged over all forecasts.

Discrimination

- The degree to which the distribution of forecasts differs for different observations.

Sharpness (function of forecast only)

- Degree to which forecasted event probabilities may differ from the mean (climatological) forecast; variability of forecasts as described by distribution of forecasts.

Uncertainty (function of observations only)

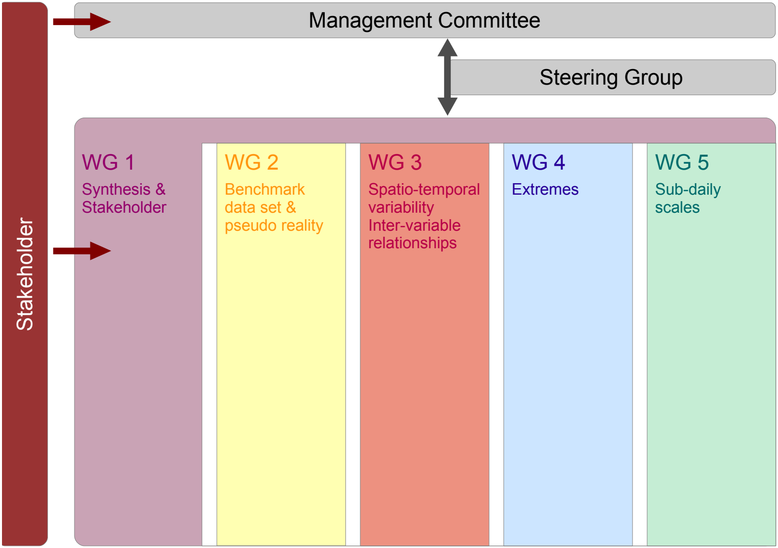
- Variability of observations as described by the distribution of observations.

Aim

The main objective of the Action is to establish a network to systematically **validate** and **improve** downscaling methods for climate change research.

Current Member Countries

Working Groups & Workplan



Steering Group

- Chair: Douglas Maraun (KFU Graz, Austria)
  Co-Chair: Martin Widmann (U Birmingham, UK)
- WG1: Ole Rössler (U Bern, Switzerland)
  WG2: Sven Kotlarski (MeteoSwiss, Switzerland)
  WG3: Martin Widmann (U Birmingham, UK)
  WG4: Elke Hertig (U Augsburg, Germany)
  WG5: Joanna Wibig (U Lodz, Poland)
- Webmaster: Jose Gutierrez (U de Cantabria, Santander, Spain)
- Senior advisors:
  Radan Huth (Charles U Prague, Czech Republic)
  Rasmus Benestad (MetNo, Norway)

Budget & Instruments

Budget:

- Depends on number of participating countries, roughly 150.000 EUR/year

Instruments:

- Meetings
  (Management; Working Groups; Conferences; Workshops)
- Short Term Scientific Missions
- Training Schools

Framework paper

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AGU PUBLICATIONS

Earth's Future

RESEARCH ARTICLE

10.1002/2014EF000259

Key Points:

- VALUE has developed a framework to validate and compare downscaling methods
- The experiments comprise different observed and pseudo-reality reference data
- The framework is the basis for a comprehensive downscaling comparison study

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VALUE: A framework to validate downscaling approaches for climate change studies

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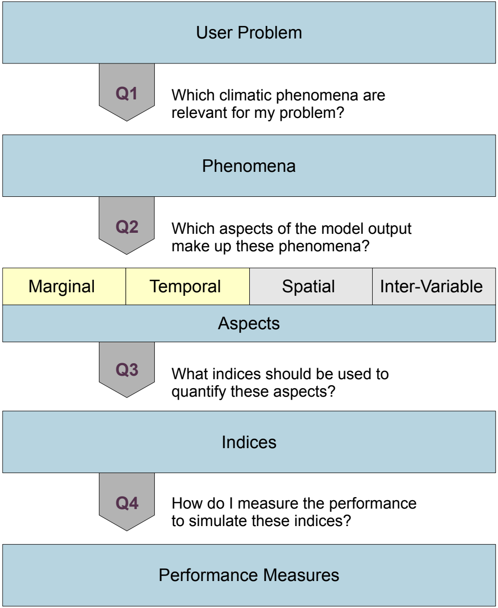
Validation tree



Indices and performance measures

Marginal distribution

Index	Distributionwise	Pairwise
Mean	bias/mean percentage error (mpe)	
Variance	mpe	
Skewness	bias	

Temporal dependence

Index	Distributionwise	Pairwise
Time series		mse
acf lag 1,2,3	just indices	
quantiles/return values	quantile verification score, bias	
threshold exceedance		Brier score
number of threshold exceedances	bias	
amount above threshold	bias	
shape parameter of GEV	bias	
mean/quantiles of spell length distribution	qvs, bias	
transition probabilities	just indices	
time of maximum/minimum of annual cycle	bias	
amplitude of annual cycle	mpe	
proportion of variance in low frequency band	just indices	
sign of the low pass filtered series		Brier score

Indices and performance measures

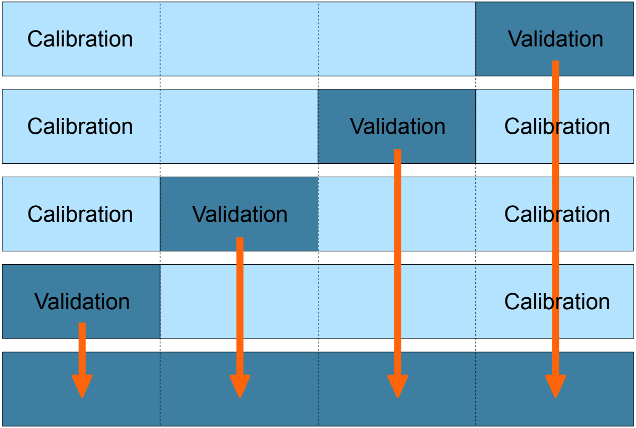
Spatial dependence

Index	Distributionwise	Pairwise
decay length of correlation	mpe	
decay length of tail dependence	mpe	
range of variogram	mpe	
range of madogram	mpe	
distribution of daily relative areas of threshold excesses	qvs/bias	mse

Inter-variable dependence

Index	Distributionwise	Pairwise
correlation	just indices	
variable conditional on (no) exceedance	as marginals	
joint exceedances	as exceedances	
variable conditional on meso-/large scale process threshold	as marginals	

k-fold cross validation



Spatial climatologies/summaries

For all indices look at

- mean absolute error/mean bias;
- absolute errors of spatial means;
- mpe of spatial means;
- means of QVS and Brier scores;
- pattern correlation & standard deviation (Taylor diagrams).

Validation experiment 1 - perfect predictor

Predictor data/boundary conditions from ERA-Interim

Station data (Tier I+II): 50+ stations

- to estimate skill of statistical downscaling methods

Gridded data (Tier I+II): 50+ grid boxes / whole regions

- to compare skill of statistical and dynamical downscaling

Nested station data (Tier II)

- to compare skill (in particular to simulate spatial fields) at different spatial scales

Sub-daily data (Tier II)

- to estimate skill at sub-daily scale

Validation experiment 2 - pseudo reality (Tier II)

Predictand data from RCMs

Perfect predictor (predictor: same GCM/no RCM)

- to test skill of Perfect Prog methods to simulate climate change

Imperfect predictor (predictor: same GCM/different RCM)

- to test the skill of RCM bias correction to simulate climate change

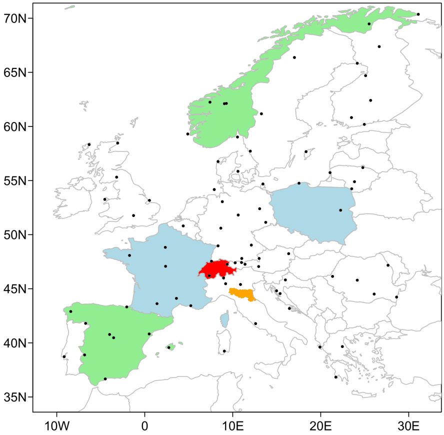
Imperfect predictor (predictor: different GCM/same RCM)

- to test the skill of RCM+GCM bias correction

Validation experiment 3 - GCM predictors (Tier III)

- to test the whole regional simulation including GCM errors

Validation Data



gridded data without registration

gridded data with registration

sub-daily station data

gridded daily data for VALUE use

Different settings/data

- 85 ECA-D stations covering all European climates;
- corresponding grid box data from E-OBS.
- high quality gridded data for large scale comparisons;
- hourly station data for selected regions.

Variables

- where possible: temperature, precipitation, wind, humidity, radiation.

Access

VALUE homepage

- http://www.value-cost.eu/

Experimental protocol

- http://www.value-cost.eu/validation

Reports (incl. list of indices)

- http://www.value-cost.eu/reports