Evaluation of the present and future general circulation over western Europe simulated by the IPCC AR4/CMIP3 GCMs with the help of a circulation type classification

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GCM-based atmospheric circulation

- Used as forcing for downscaling methods
  - Biases of the GCM-based circulation are not corrected

- Independent from surface and local features

- Large-scale variations (general circulation)
  ⇒ Supposed to be better simulated by GCMs

- Essential predictor variable for ground variables
  ⇒ Important to evaluate and compare GCM-based circulation
General Circulation Models

- Data for only 6 GCMs available (IPCC AR4/CMIP3)
  - BCCR-BCM2.0 (No)
  - CCCma-CGCM3.1/T47 (Ca)
  - CCCma-CGCM3.1/T63 (Ca)
  - IPSL-CM4_v1 (F)
  - UKMO-HadCM3 (UK)
  - UKMO-HadGEM1 (UK)

  - CMIP5 model outputs availability delayed

- Compared to 2 reanalysis datasets
  - NCEP-NCAR 1 (USA)
  - ERA-40 ECMWF (Europe)

- Periods
  - 1961-1990 20C3M
  - 2046-2065 & 2081-2100 A1B
Circulation type classification

- Daily 500 hPa geopotential height for summer (JJA)

- Correlation-based method (similar to Lunds method)
  - Number of classes fixed by the user (12 classes)
  - Leader algorithm with varying threshold to minimise intra-class variability and build the requested number of classes

- Allows a precise analysis of each circulation type

  ⇒ Focus on the ability of the GCMs to reproduce the variability of the atmospheric circulation

- But: automated classification
  - No influence on the types created
  - How to compare the datasets?
Classification scheme

Automatic classification

NCEP-NCAR 1 reference classification (1961-1990)

Forced classification → imposed types

Comparison

GCM – 20C3M recent climate (1961-1990)

Evaluation

New types

GCM – A1B future projections (2046-2065 & 2081-2100)

Forced classification → imposed types

Automatic classification → unclassified days (2081-2100)
NCEP-NCAR 1 reference classification

- Lines: class mean situation
- Colours: class anomaly divided by seasonal mean

Class n°1 (8.8%)
Class n°2 (11%)
Class n°3 (15.8%)
Class n°4 (14.2%)
Class n°5 (11.6%)
Class n°6 (11.7%)
Class n°7 (11.5%)
Class n°8 (6.2%)
Class n°9 (4.9%)
Class n°10 (2.5%)
Class n°11 (0.6%)
Class n°12 (0.8%)

Z500 anomaly (m)
Seasonal mean geopotential height (JJA)

- Lines: seasonal mean situation
- Colours: anomaly \( \div \) NCEP-NCAR 1

Z500 mean anomaly (m)

- A1B (2046–2065)
- A1B (2081–2100)
- Reanalyses (1961–1990)

NCEP–NCAR 1
ERA–40
Seasonal standard deviation (JJA)

- **BCCR-BCM2.0**
  - 20C3M (1961–1990): 69.11 m
  - A1B (2046–2065): 70.45 m
  - A1B (2081–2100): 68.21 m

- **CCCma/T47**
  - 20C3M (1961–1990): 88.86 m
  - A1B (2046–2065): 92.85 m
  - A1B (2081–2100): 94.83 m

- **CCCma/T53**
  - 20C3M (1961–1990): 96.32 m
  - A1B (2046–2065): 97.53 m
  - A1B (2081–2100): 99.54 m

- **IPSL-CM4**
  - 20C3M (1961–1990): 76.93 m
  - A1B (2046–2065): 75.65 m
  - A1B (2081–2100): 79.27 m

- **UKMO-HadCM3**
  - 20C3M (1961–1990): 84.49 m
  - A1B (2046–2065): 89.53 m
  - A1B (2081–2100): 87.34 m

- **UKMO-HadGEM1**
  - 20C3M (1961–1990): 86.07 m
  - A1B (2046–2065): 82.15 m
  - A1B (2081–2100): 81.45 m

Reanalyses (1961–1990)
- **NCEP-NCAR 1**: 91.32 m
- **ERA-40**: 94.38 m

- **Z500 standard deviation (m)**
  - Lines: seasonal mean situation
  - Colours: standard deviation
Frequency distribution and evolution

Class 1

Class 2

Class 3

Class 4

Class 5

Class 6

Class 7

Class 8

Class 9

Class 10

Class 11

Class 12

- NCEP  - ECMWF  - BCCR  - CCCma47
- CCCma63  - HadCM3  - HadGEM1  - IPSL

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NCEP-NCAR 1 reference classification

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Class n°10 (2.5%)
Class n°11 (0.6%)
Class n°12 (0.8%)

Z500 anomaly (m)
Classification of class 12 – HadGEM1

- Lines: class mean situation
- Colours: class anomaly ± seasonal mean (NCEP-NCAR 1)

Emergence of two new types
- Similar to existing ones
- With much higher geopotential height
- Similar for all GCMs
Conclusion

- Circulation type classification useful to evaluate GCM-based circulation and particularly its variability

- GCMs have difficulties to simulate well current climate circulation over western Europe
  - biases in mean geopotential height
  - underestimation of its variability
  - Best matching GCMs: CCCma-CGCM3.1/T63, UKMO-HadGEM1, UKMO-HadCM3

- Future projections
  - General increase of the geopotential height
  - Emergence of two new types

- Projected change lower or of the same order than uncertainties for current climate!
Thank you for your attention.