

Analysis of the atmospheric circulation simulated by GCMs over Greenland



A. Belleflamme, X. Fettweis, M. Erpicum

MeteoClim - PhD Symposium - RMI

5/11/2010

Context

- Projected warming is the most important in polar regions
 - Greenland ice sheet melt projections based on
 - ♦ GCM simulations
 - ♦ RCM simulations (forced by GCMs)
 - ♦ Other downscaling methods (forced by GCMs)
 - GCM simulations : large uncertainties especially for surface variables (temperature, precipitation ...)
- ⇒ Importance of evaluating and comparing GCM simulations

GCM-based atmospheric circulation

- Used as forcing for downscaling methods
 - ♦ Biases of the GCM-based circulation not corrected
- ~ Independent from surface and local features
- Large-scale variations (atmospheric circulation)
 - ⇒ Supposed to be better simulated by GCMs
- Essential predictor variable for ground variables
 - ♦ Correlation geopotential height - temperature
 - ⇒ Greenland ice sheet melt

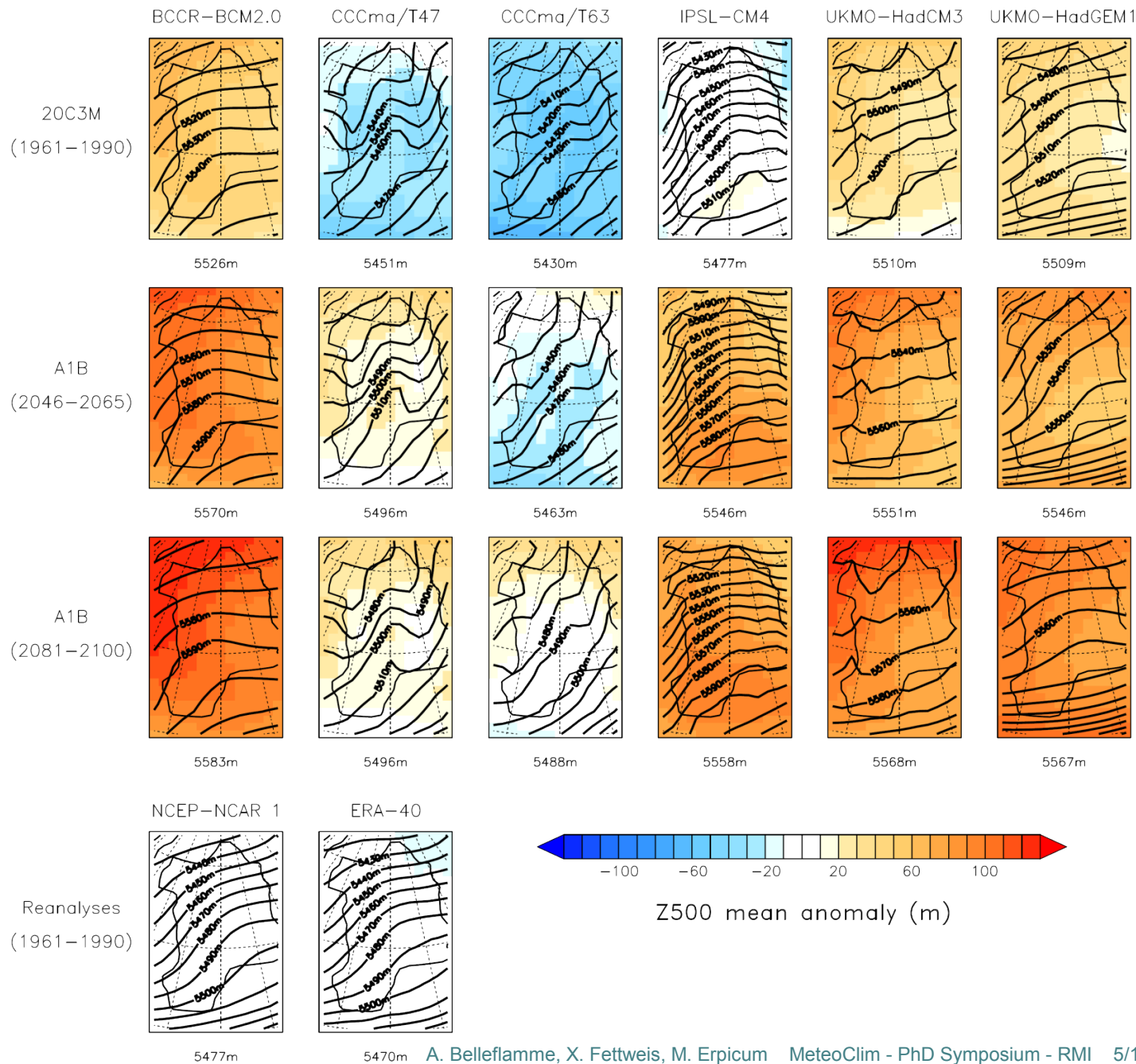
General Circulation Models

- Data for only 6 GCMs available
 - ♦ BCCR-BCM2.0 (No)
 - ♦ CCCma-CGCM3.1/T47 (Ca)
 - ♦ CCCma-CGCM3.1/T63 (Ca)
 - ♦ IPSL-CM4_v1 (F)
 - ♦ UKMO-HadCM3 (UK)
 - ♦ UKMO-HadGEM1 (UK)
- Compared to 2 reanalysis datasets
 - ♦ NCEP-NCAR 1 (USA)
 - ♦ ERA-40 ECMWF (Europe)
- Periods
 - ♦ 1961-1990 20C3M
 - ♦ 2046-2065 and 2081-2100 A1B

Circulation type classification

- Daily 500 hPa geopotential height for summer (JJA)
- Correlation-based method
- Number of classes fixed by the user (8 classes)
- Combined classification GCM + NCEP-NCAR 1
 - ♦ Comparison → frequency distribution
- Allows a precise analysis of each circulation type
- Classification issued from COST733 action

Mean geopotential height

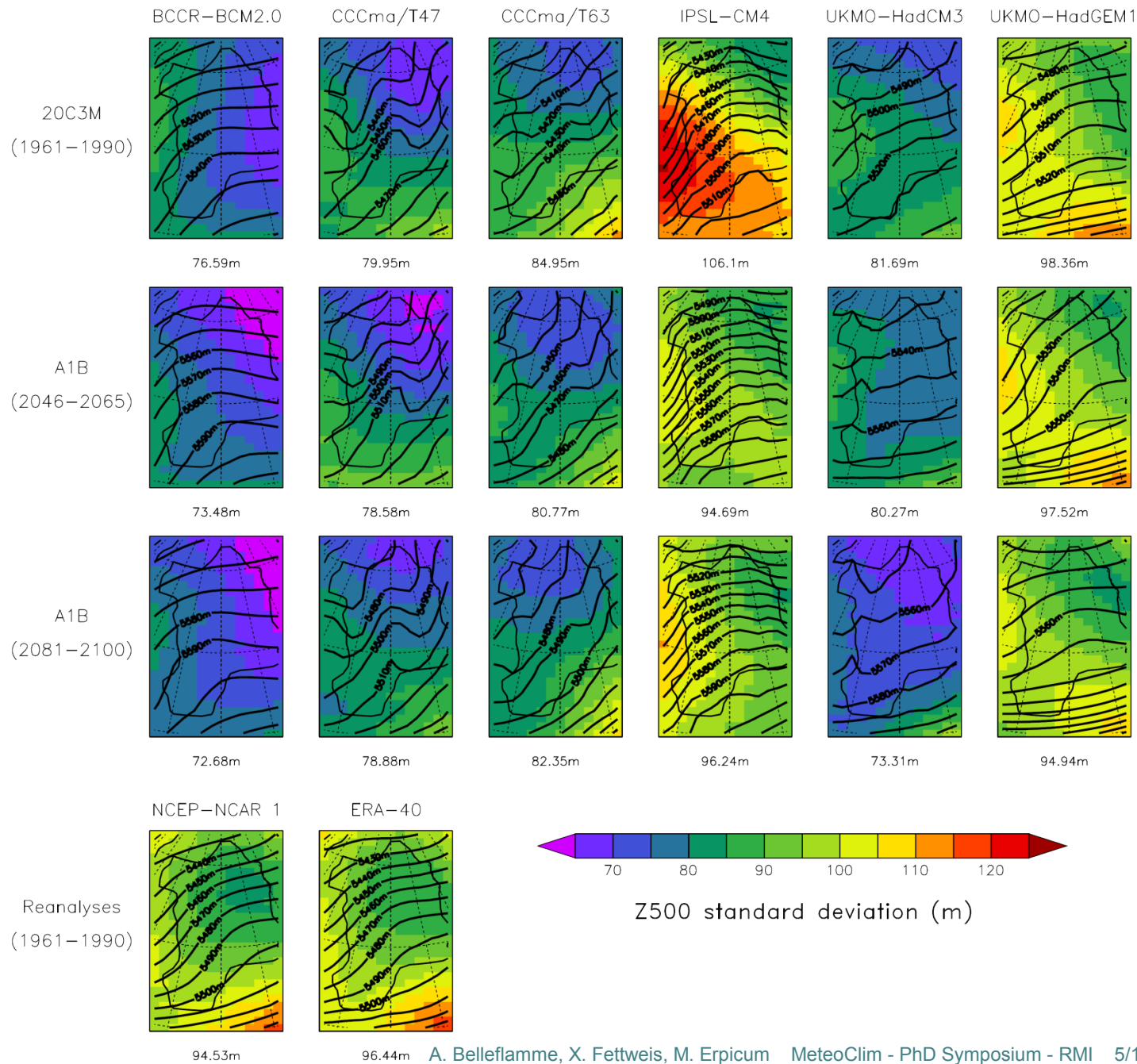


Lines
mean geopotential height

Colours
model anomaly ÷
NCEP-NCAR 1

- Biases in the mean geopotential height
- Conserved for future periods
- Increase of the mean geopotential height

Mean standard deviation

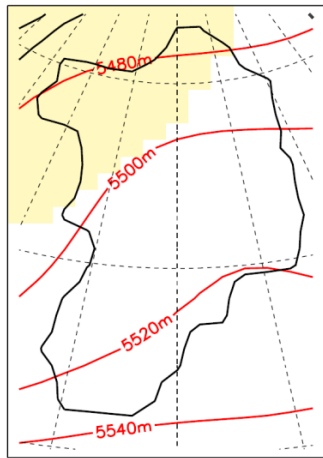


Lines
mean geopotential height

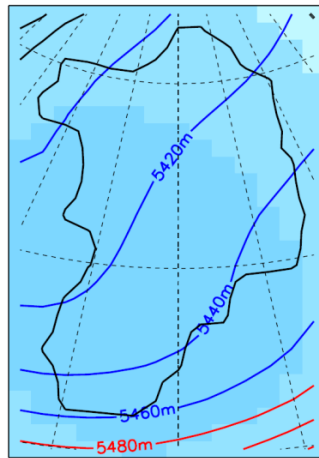
Colours
mean standard deviation

- Underestimation of the variability
- Remains constant for future periods

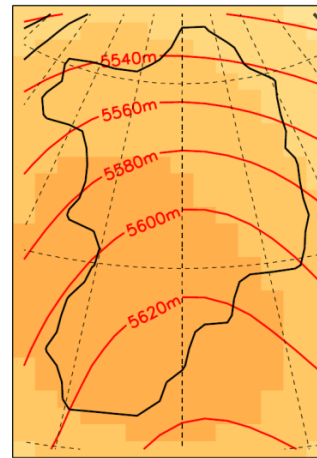
Results for current climate



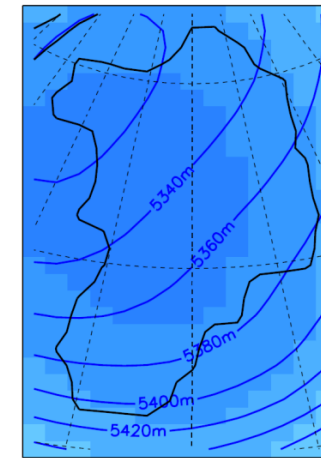
Class n°1 (30.7%)



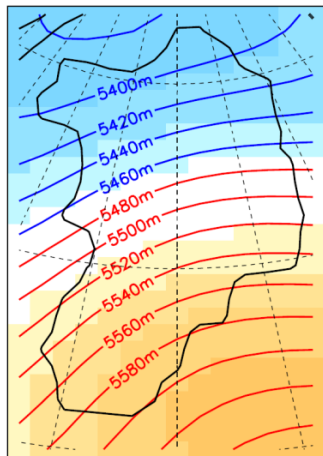
Class n°2 (26%)



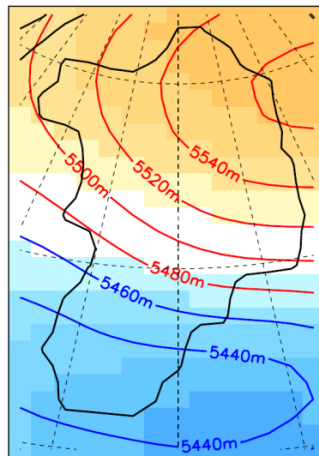
Class n°3 (19.8%)



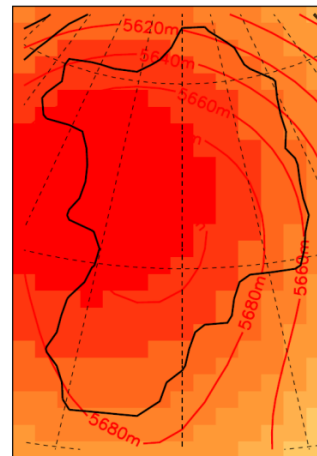
Class n°4 (8.8%)



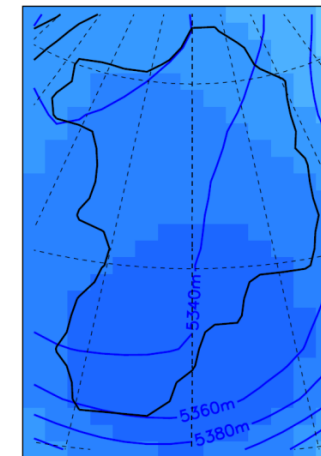
Class n°5 (7.2%)



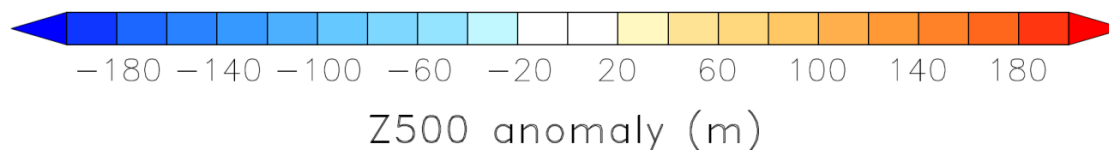
Class n°6 (3.4%)



Class n°7 (2.9%)



Class n°8 (0.7%)



NCEP-NCAR 1
1961-1990

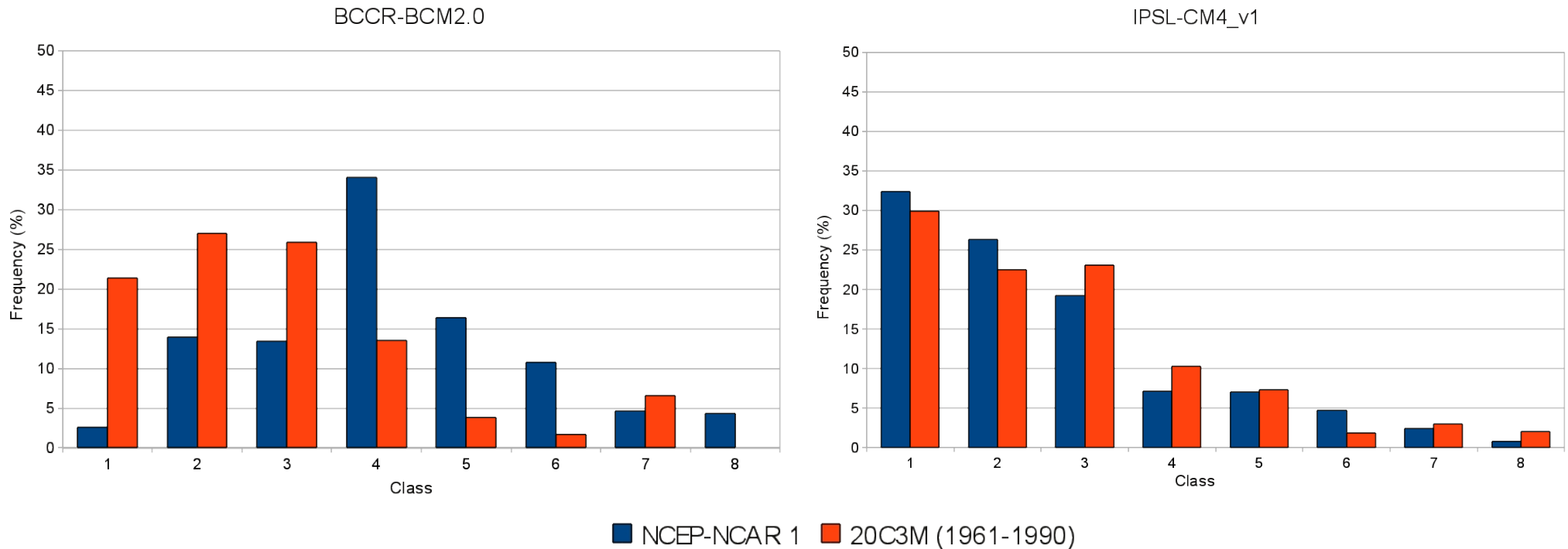
UKMO-HadGEM1
1961-1990 20C3M

Lines
reference situation

Colours
class anomaly ÷
seasonal mean

- Same types as for NCEP-NCAR 1 alone

Frequency distribution for current climate

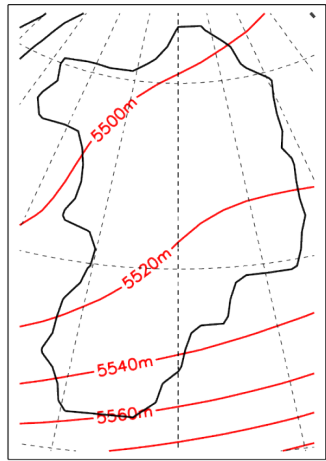


- Important differences from one GCM to another

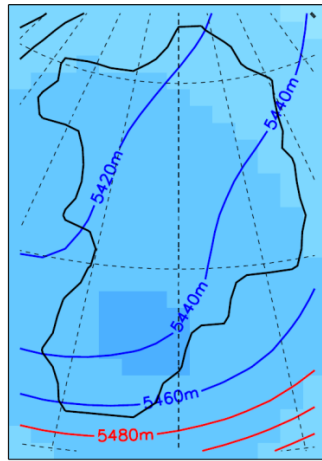
😊 IPSL-CM4_v1 : very close to reanalysis

😞 BCCR-BCM2.0 : some classes contain essentially situations from one dataset

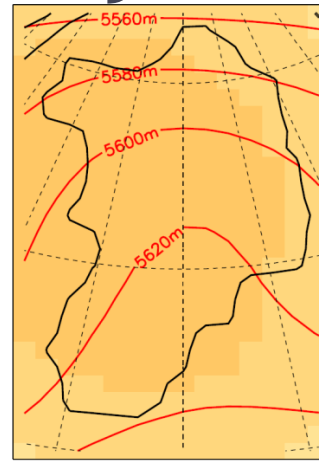
Results for future projections



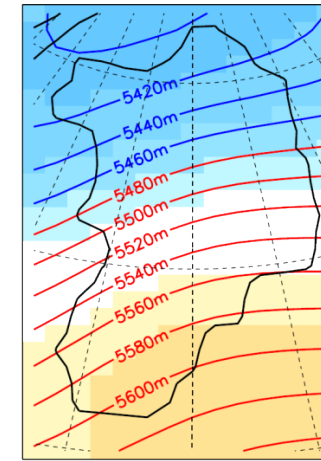
Class n°1 (29.5%)



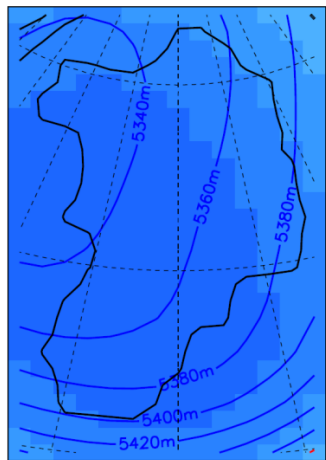
Class n°2 (21.2%)



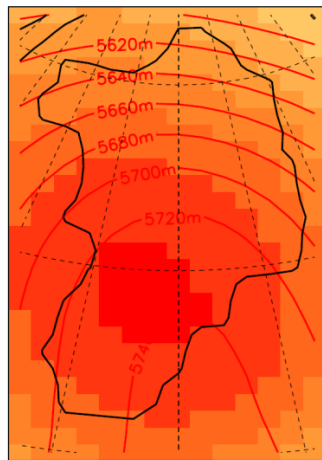
Class n°3 (25.9%)



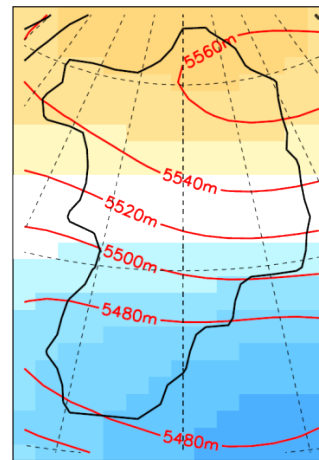
Class n°4 (7.8%)



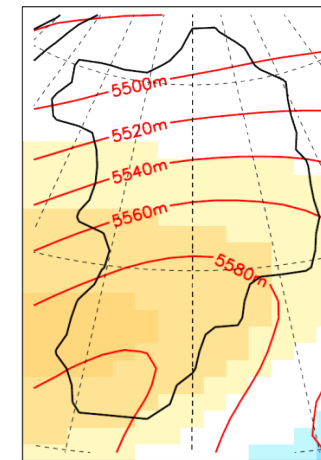
Class n°5 (5.7%)



Class n°6 (5.2%)



Class n°7 (3.9%)



Class n°8 (0.4%)

NCEP-NCAR 1
1971-1990

UKMO-HadGEM1
1971-1990 20C3M
2046-2065 A1B
2081-2100 A1B

Lines
reference situation

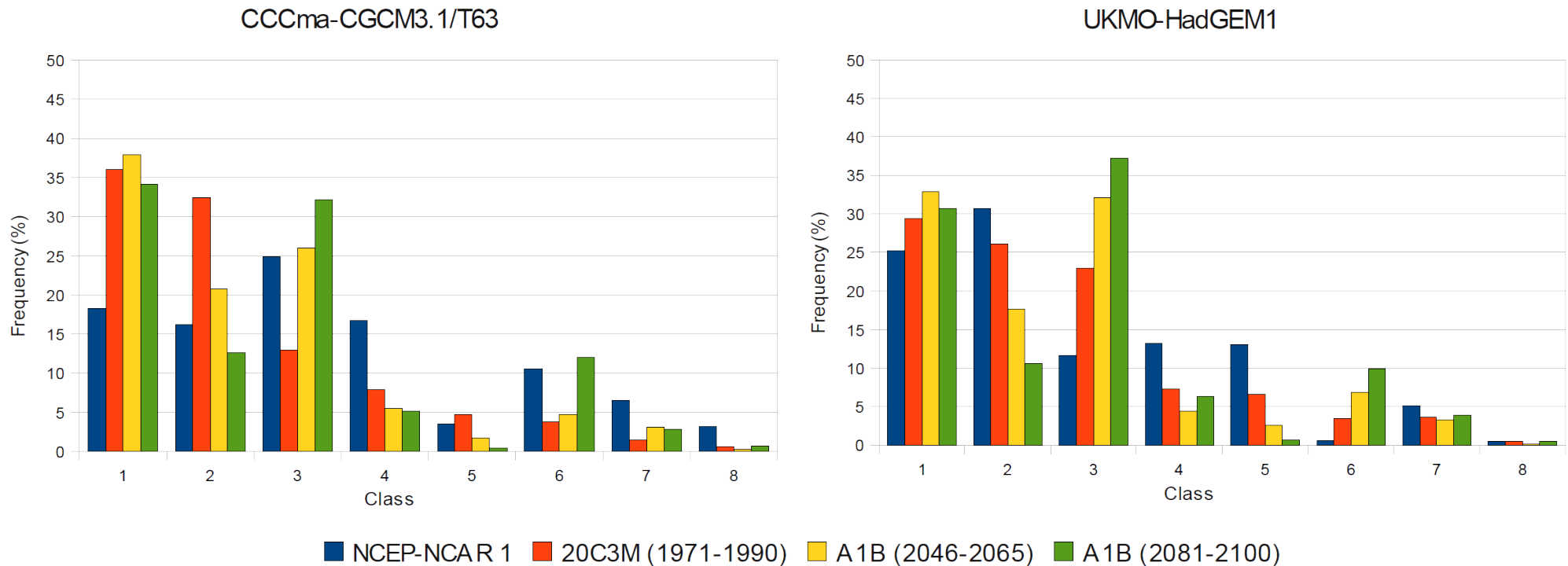
Colours
class anomaly ÷
seasonal mean

- No new types detected



Z500 anomaly (m)

Frequency distribution for future projections



- Different behaviour of the circulation types for the future periods
 - ♦ Significant increase / decrease
 - ♦ Relatively constant
- Differences $20C3M - NCEP-NCAR\ 1 \approx 20C3M - A1B\ (2046-2065)$

Conclusion

- Circulation type classification : useful for studying GCM-based circulation
- Current climate simulations
 - ♦ Main types individualised
 - ♦ Differences in frequency distribution
 - Due to systematic biases and variability underestimation

⇒ Most GCMs not able to well simulate the current climate circulations
- Future projections
 - ♦ No new types
 - ♦ Increase of geopotential height similar for all GCMs
 - ♦ Reliability of future projections knowing current climate uncertainties ?
- Mean melting rate per type → projected melting rate of the Greenland ice sheet for each GCM



Thanks for your attention