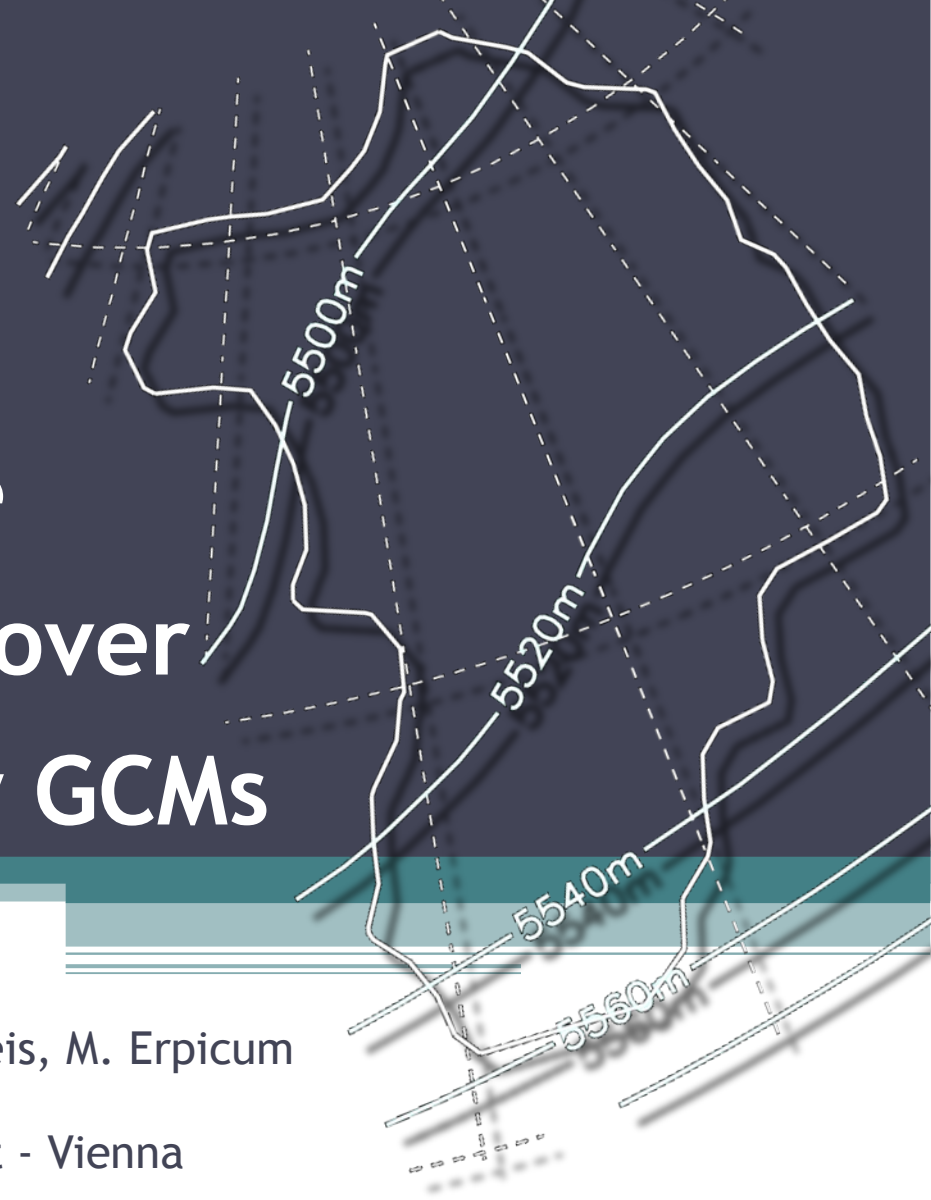


# Using a circulation type classification to analyse the general circulation over Greenland simulated by GCMs



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COST 733 Final Event - Vienna

22-24/11/2010

**COST 733**

Harmonisation and applications of weather type Classifications for European Regions



# 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 (similar to Lunds method)
  - ◆ Number of classes fixed by the user (8 classes)
  - ◆ Leader algorithm with varying threshold to minimise intra-class variability and built the requested number of classes
- Allows a precise analysis of each circulation type

# Combined classification

- Automated classification
  - ⇒ No influence on the types created
  - ⇒ How to compare the types between them ?
  
- Combined classification → reanalysis + GCM
  - ◆ Allows a comparison between the datasets based on the frequency distribution
  - ◆ Current climate (two 30-year periods)
    - ◆ 1961-1990 NCEP-NCAR 1
    - ◆ 1961-1990 GCM - 20C3M
  - ◆ Future projections (four 20-year periods)
    - ◆ 1971-1990 NCEP-NCAR 1
    - ◆ 1971-1990 GCM - 20C3M
    - ◆ 2046-2065 GCM - A1B
    - ◆ 2081-2100 GCM - A1B

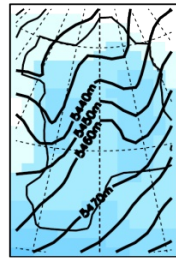
# Mean geopotential height

BCCR-BCM2.0    CCCma/T47    CCCma/T63    IPSL-CM4    UKMO-HadCM3    UKMO-HadGEM1

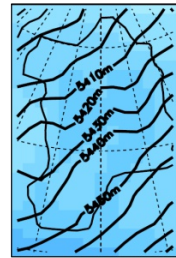
20C3M  
(1961-1990)



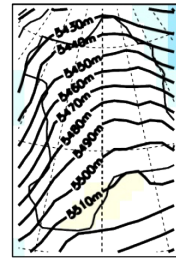
5526m



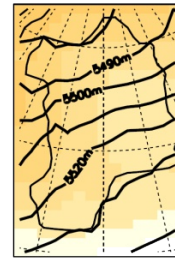
5451m



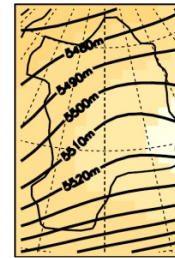
5430m



5477m



5510m

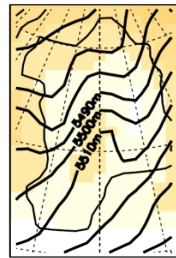


5509m

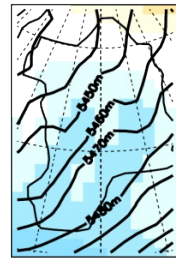
A1B  
(2046-2065)



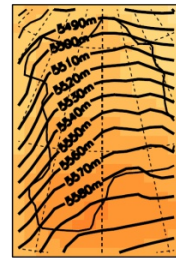
5570m



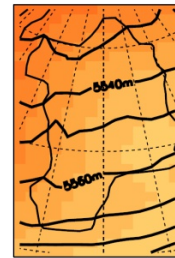
5496m



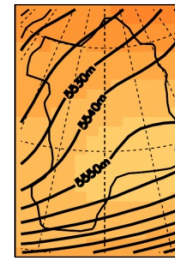
5463m



5546m

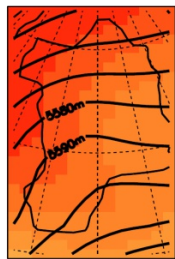


5551m

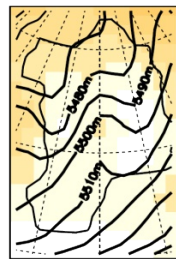


5546m

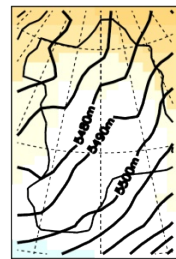
A1B  
(2081-2100)



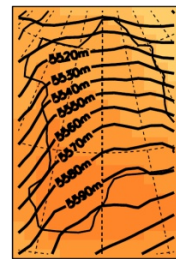
5583m



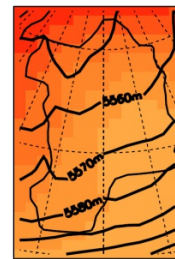
5496m



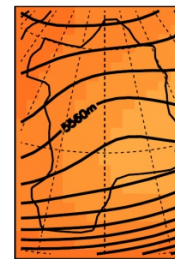
5488m



5558m

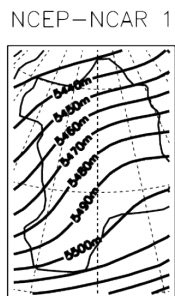


5568m

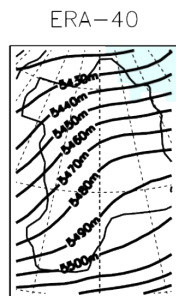


5567m

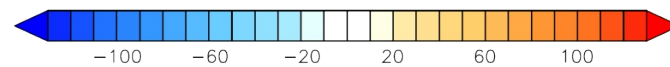
Reanalyses  
(1961-1990)



5477m



5470m



Z500 mean anomaly (m)

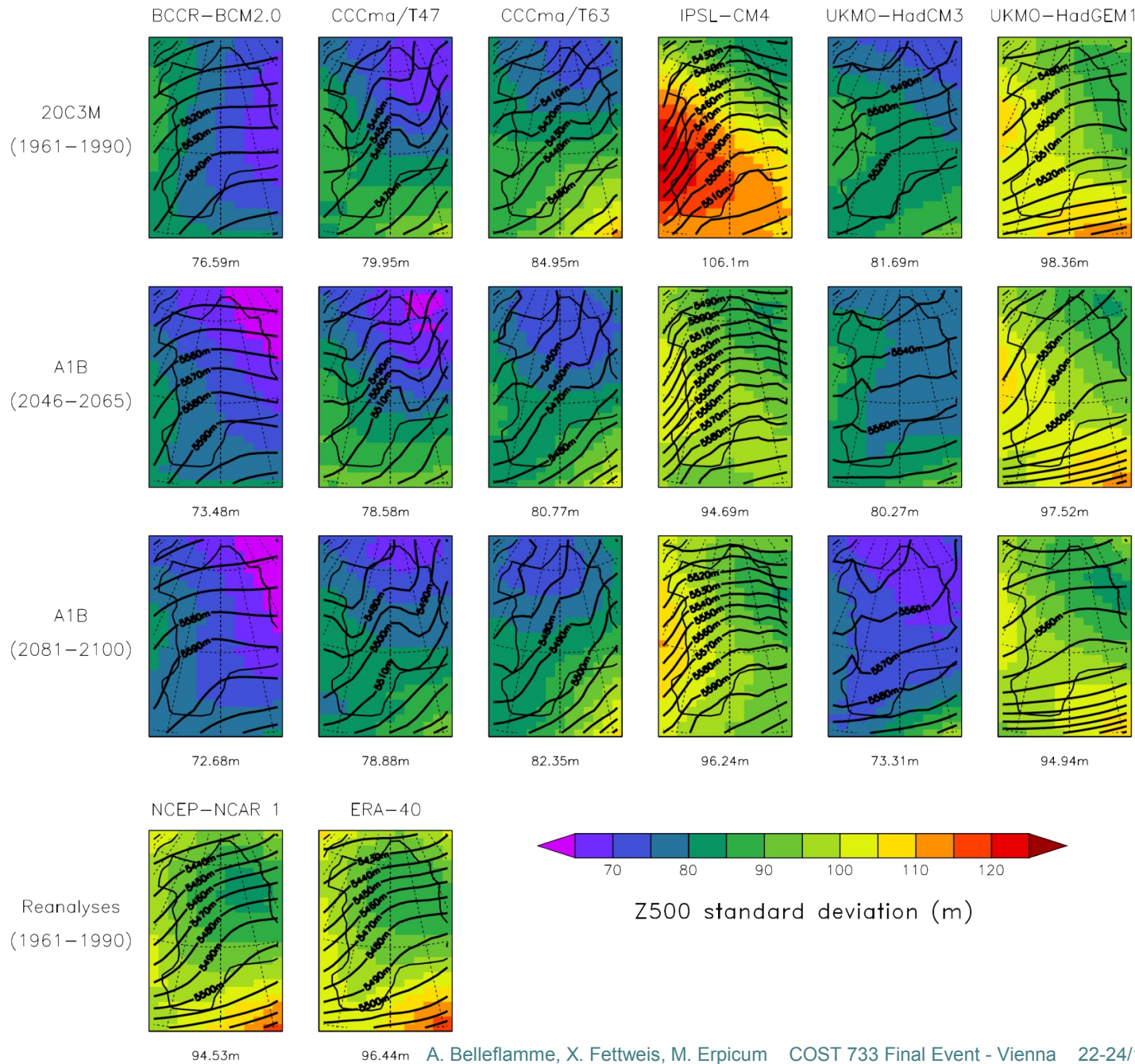
Lines  
mean geopotential height

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



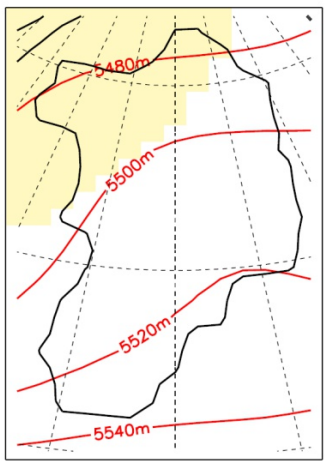
Lines  
mean geopotential height

Colours  
mean standard deviation

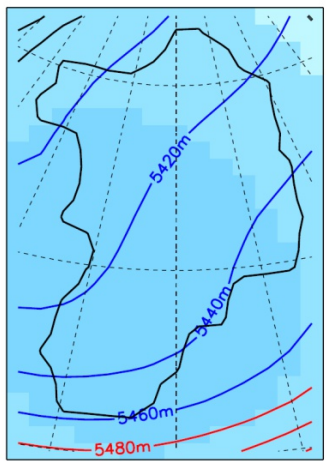
- Underestimation of the variability
- Remains constant for future periods



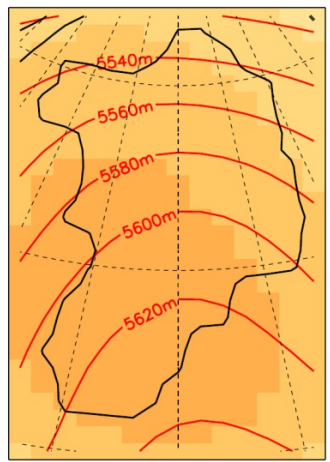
# Results for current climate



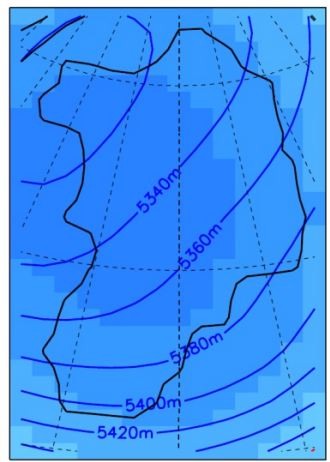
Class n°1 (30.7%)



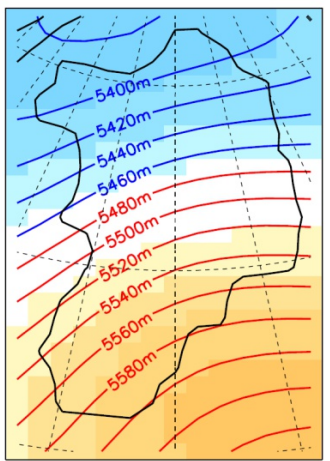
Class n°2 (26%)



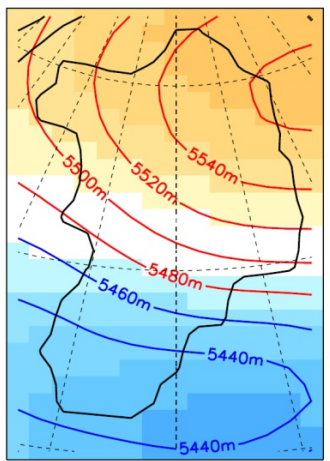
Class n°3 (19.8%)



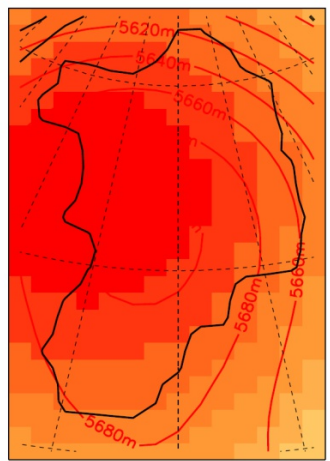
Class n°4 (8.8%)



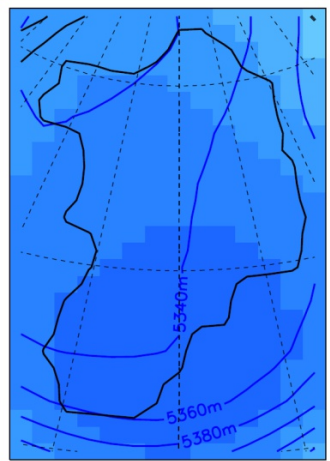
Class n°5 (7.2%)



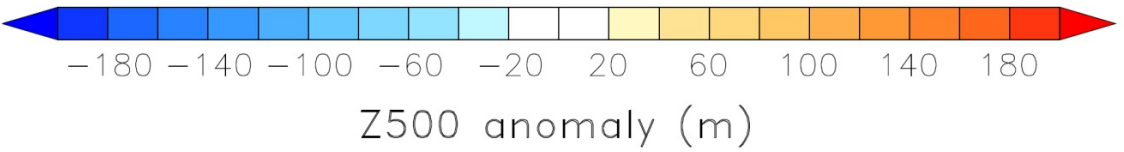
Class n°6 (3.4%)



Class n°7 (2.9%)



Class n°8 (0.7%)



NCEP-NCAR 1  
1961-1990

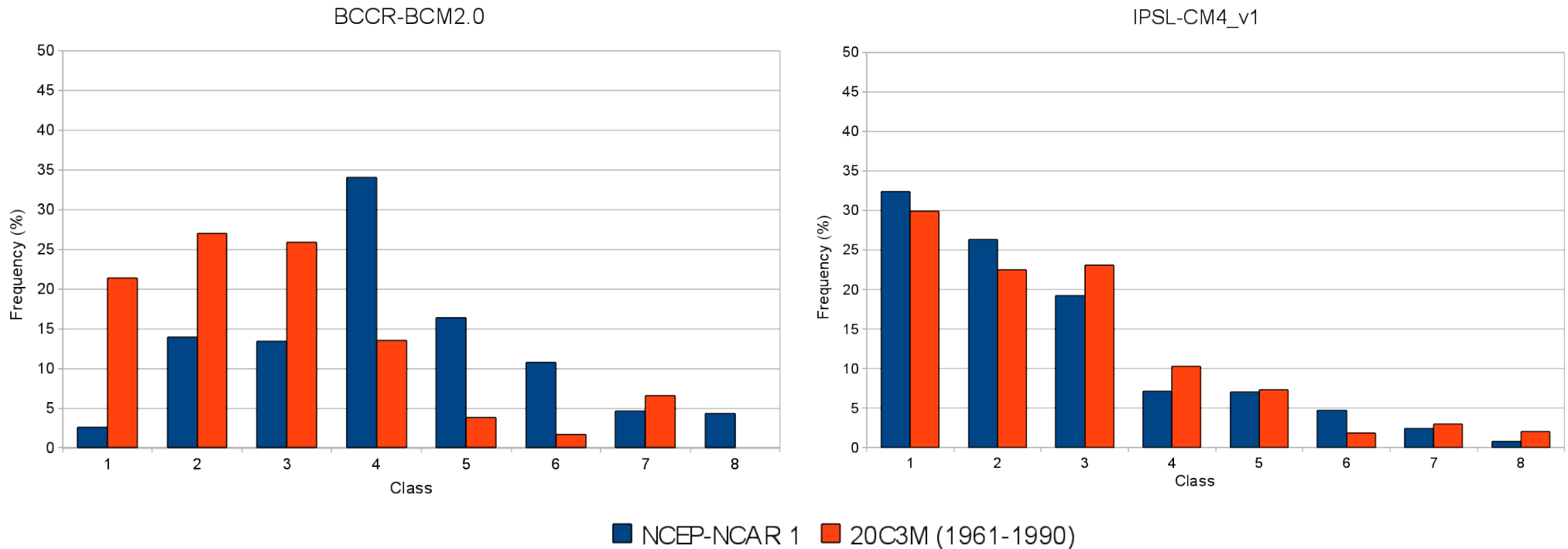
UKMO-HadGEM1  
1961-1990 20C3M

Lines  
reference situation

Colours  
class anomaly ÷  
seasonal mean

- Same types as for NCEP-NCAR 1 alone

# Frequency distribution for current climate

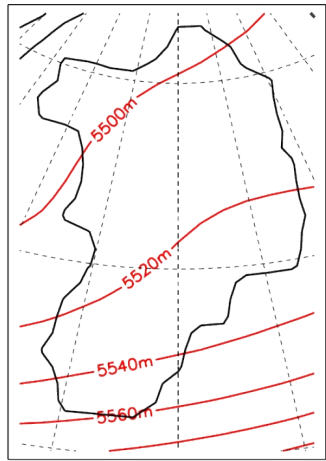


- Important differences from one GCM to another

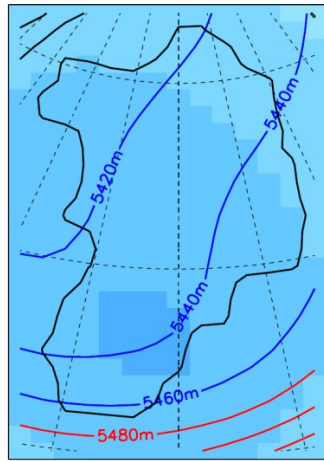
😊 IPSL-CM4\_v1 : very close to reanalysis

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

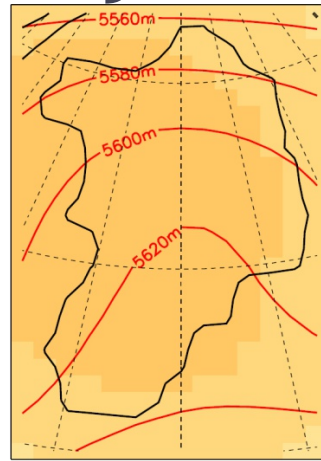
# Results for future projections



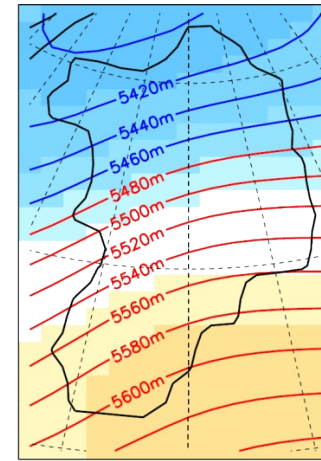
Class n°1 (29.5%)



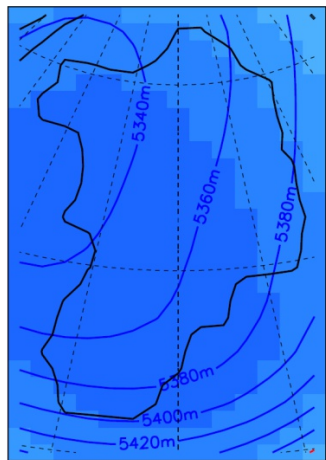
Class n°2 (21.2%)



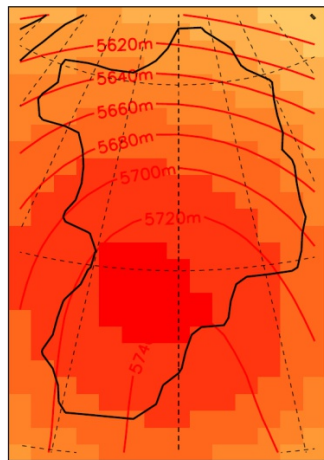
Class n°3 (25.9%)



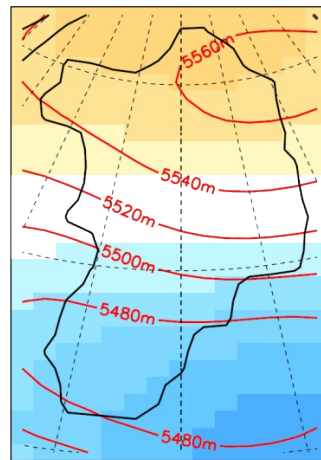
Class n°4 (7.8%)



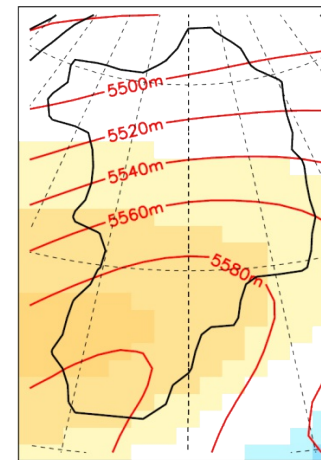
Class n°5 (5.7%)



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

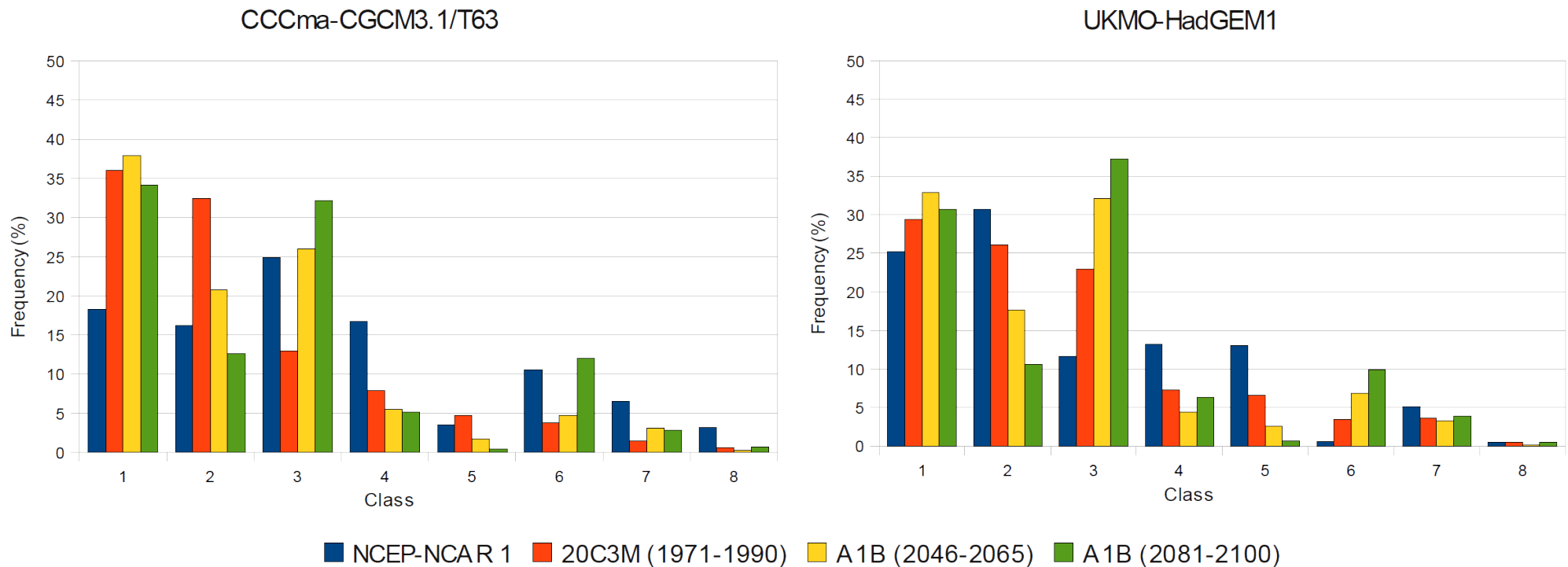
Colours  
class anomaly ÷  
seasonal mean

- 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

 COST 733

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