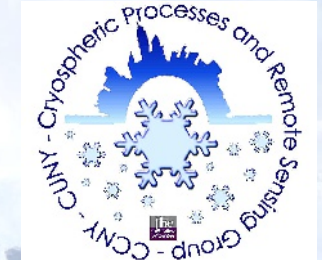




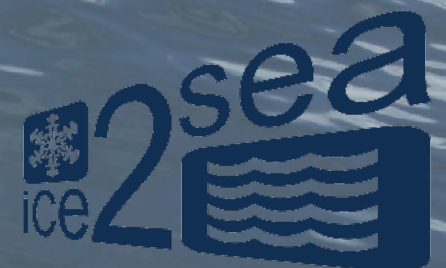
University of Liège
Laboratory of Climatology
<http://www.climato.be>

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How is the general circulation responsible of the record warm 2010 summer over the Greenland ice sheet?

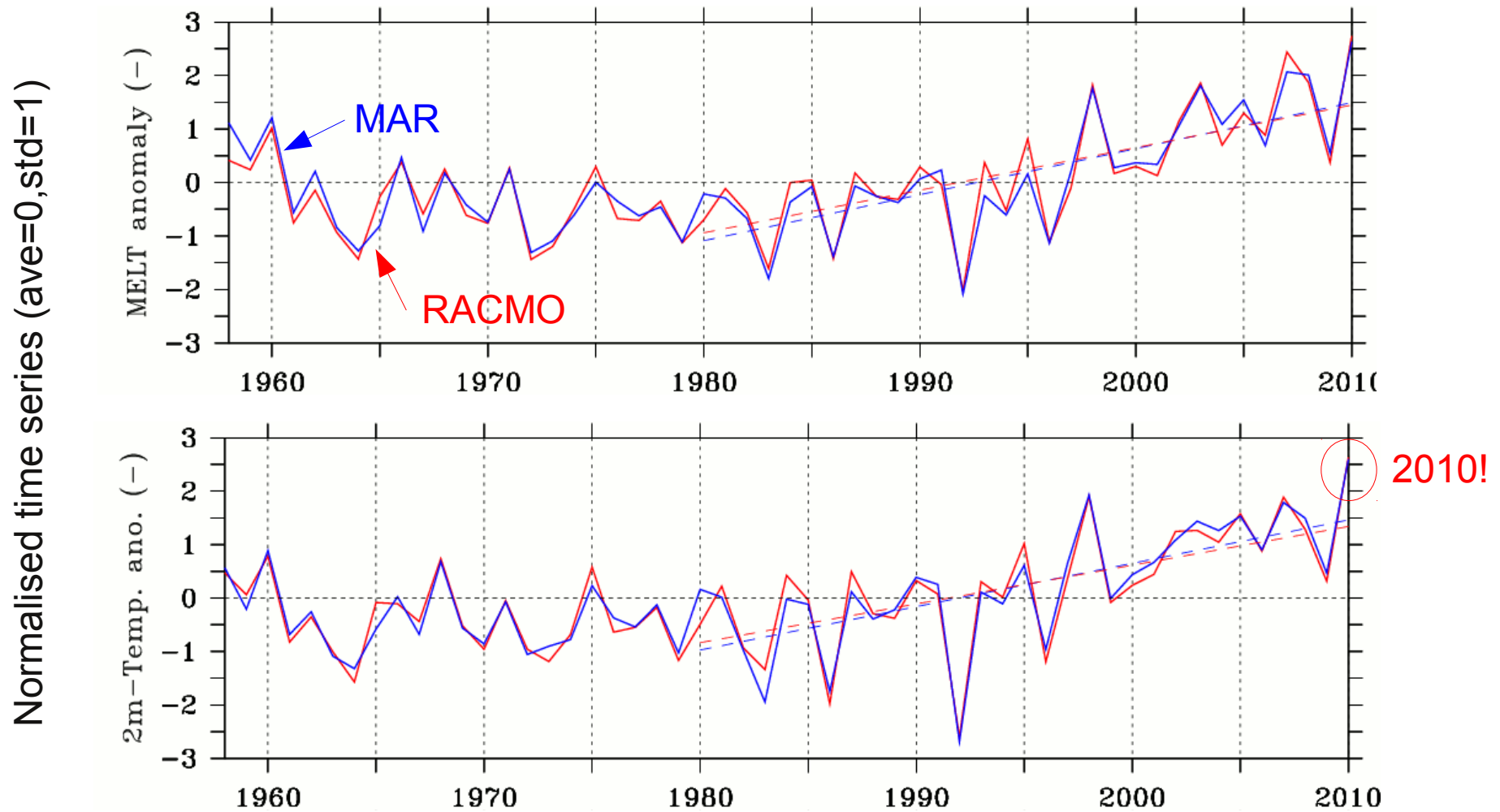
Xavier Fettweis (Ulg, Belgium)
M. van den Broeke, W. J. van de Berg (Utrecht, Netherlands)
M. Tedesco (New-York, USA)
A. Belleflamme, B. Franco, M. Erpicum (Ulg, Belgium)



1. Introduction (1/2)

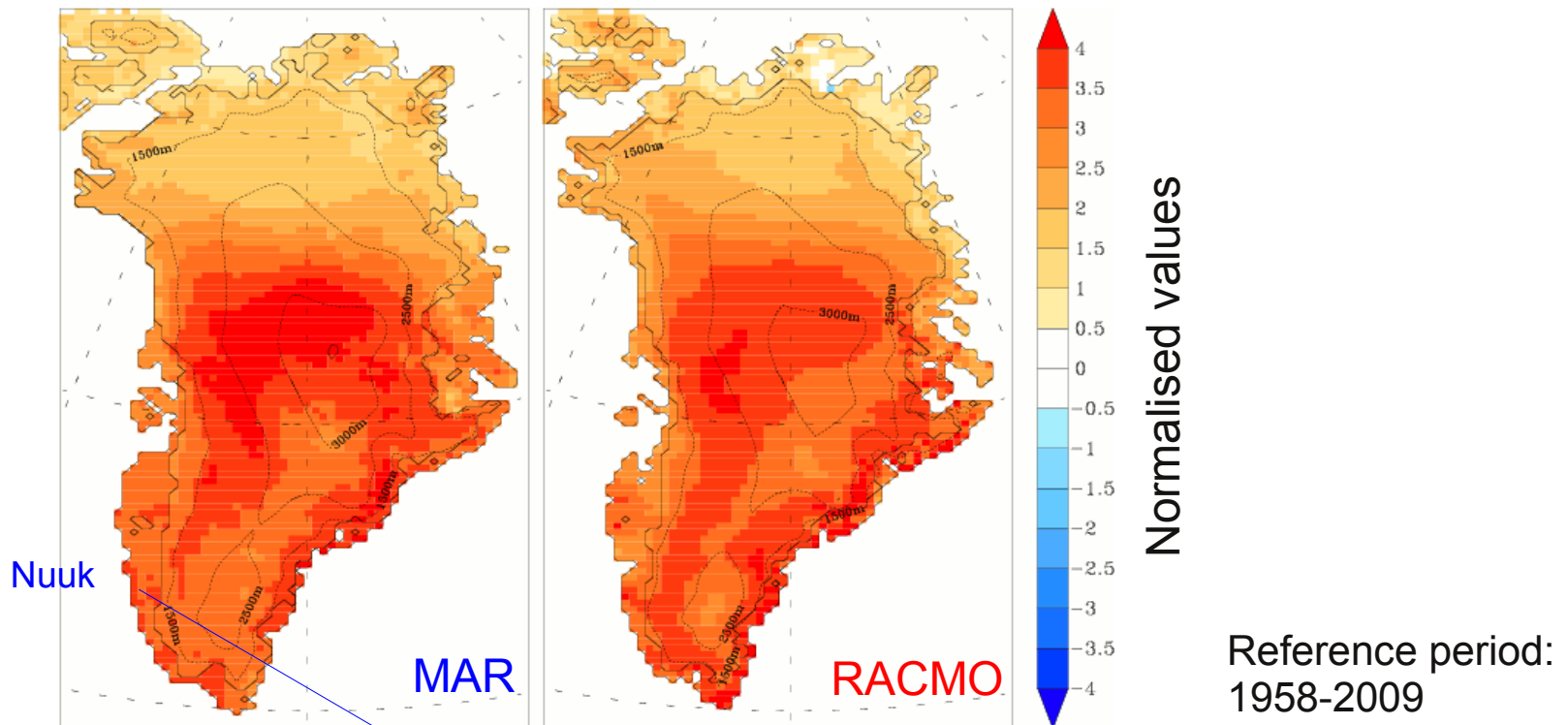
$\Delta \text{MELT} \sim \Delta \text{TT}$ taken over the mean melt area

Corr: 0.97

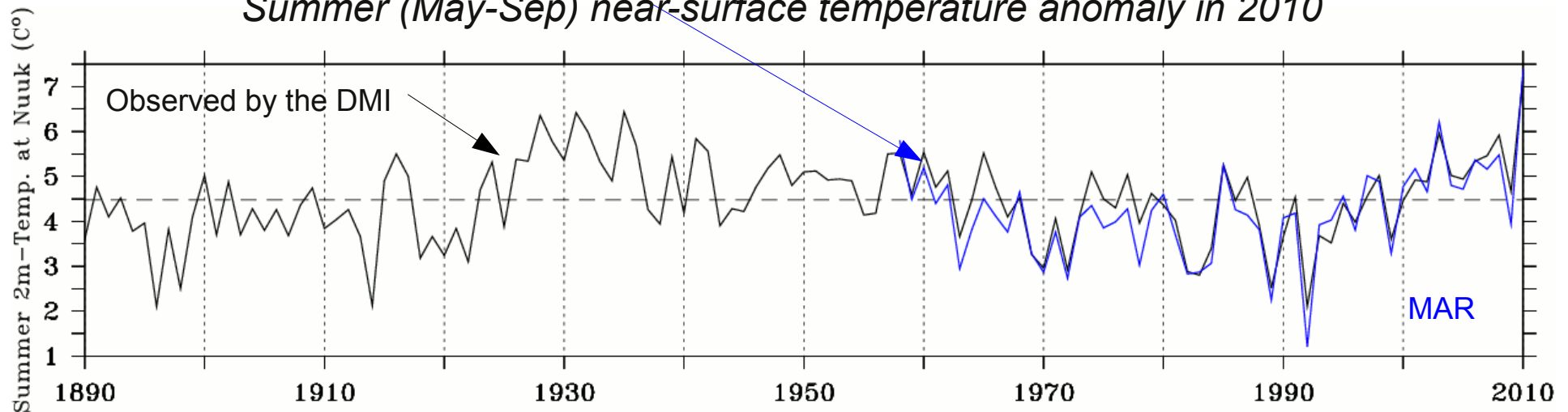


GrIS melt and near surface temperature anomalies simulated by MAR and by RACMO

1. Introduction (2/2)



Summer (May-Sep) near-surface temperature anomaly in 2010



2. Analogues using Z500 (1/4)

A similarity index is used for

classifying the Z500's in 8 classes with the help of a automatic circulation type classification.

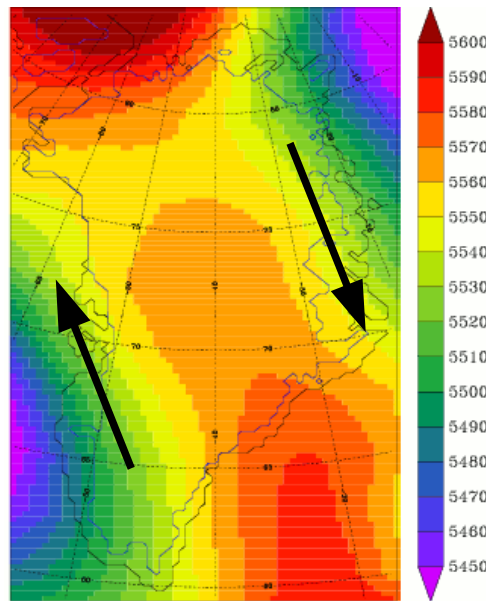
searching analogues Z500's in respect to a particular day.

$$i(Z500_{day1}, Z500_{day2}) = \begin{cases} 1 & \text{if } Z500_{day1} = Z500_{day2} \\ 0 & \text{if very different} \end{cases}$$

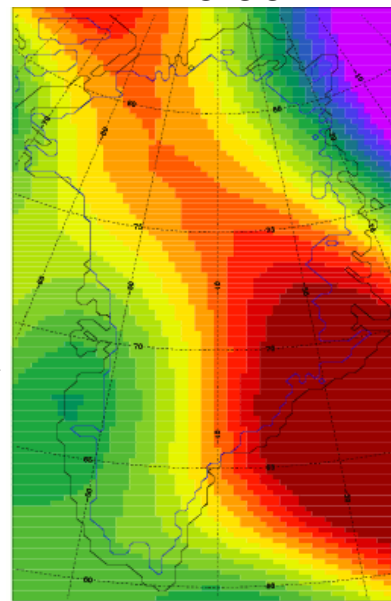


Hypothesis: similar Z500's induce similar near-surface temperature !

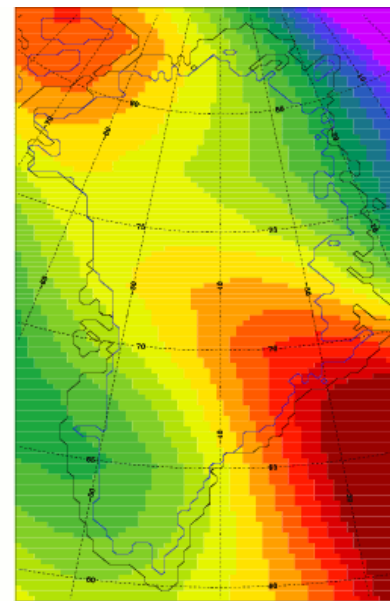
Geopotential height at 500hPa (m)



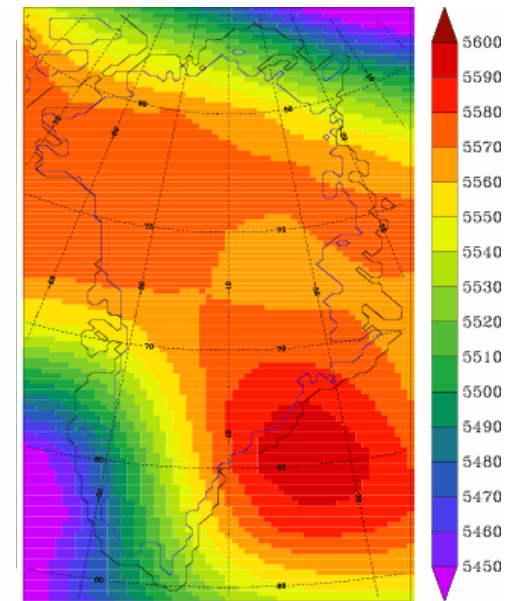
23-JUN-2010



19-JUN-1982



09-JUN-1984

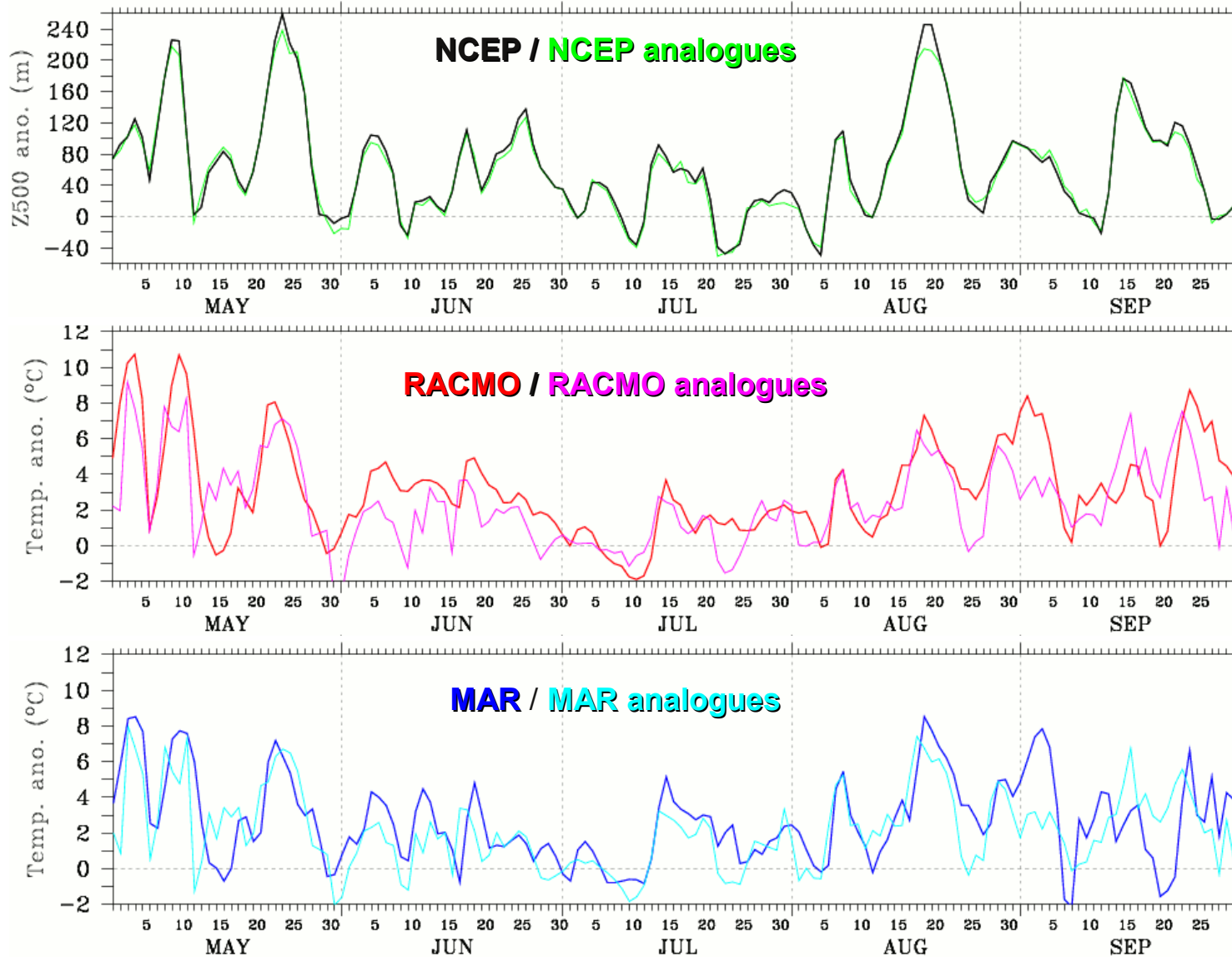


28-JUN-2001

Ref: Fettweis et al.: The 1958-2009 Greenland ice sheet surface melt and the mid-tropospheric atmospheric circulation, *Clim. Dynam.*, 2011.

2. Analogues using Z500 (2/4)

Daily anomalies in respect to the 1958-2009 period

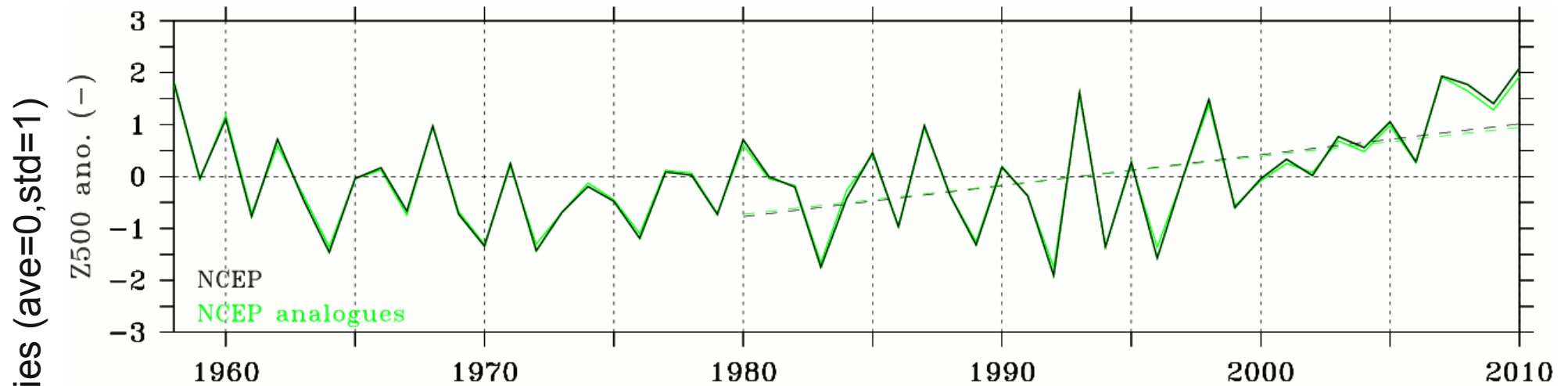


Days of Summer 2010

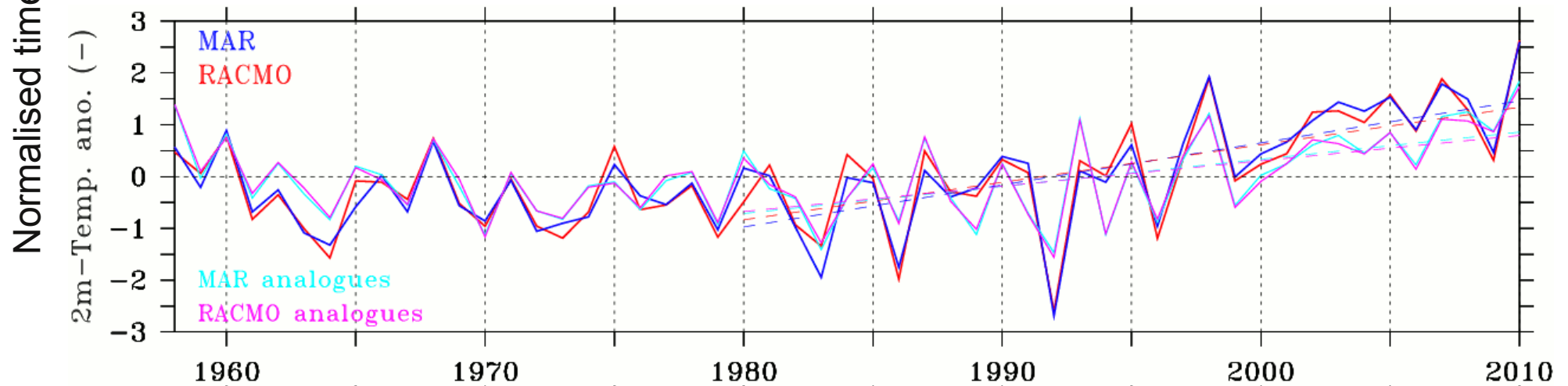


The similitude index is chosen here to have at least analogues in 10 summers!

2. Analogues using Z500 (3/4)



The analogues explain the whole Z500 variability.



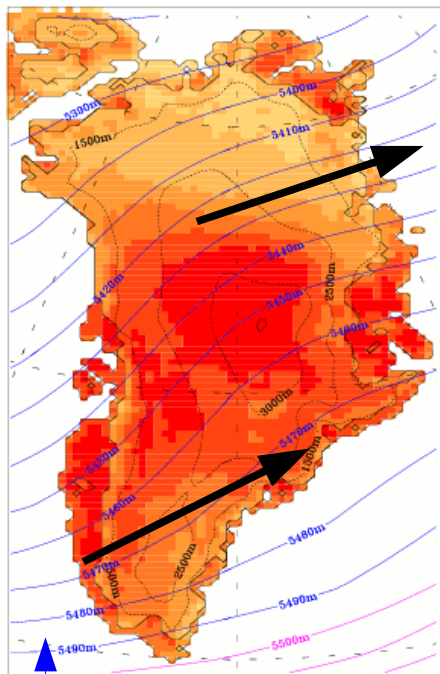
The analogues explain ~70% of the temp. increase since 1980. of the anomalies in 2010.

2. Analogues using Z500 (4/4)

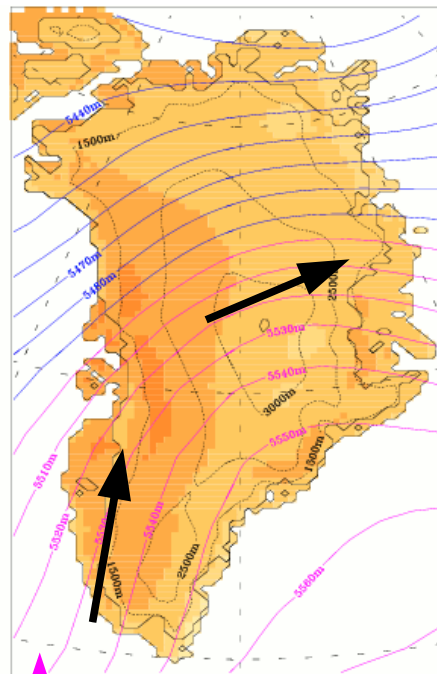
Part of the temperature anomalies explained by the general circulation

2010 summer (May-Sep) 3m Temperature anomaly simulated by MAR (°C)

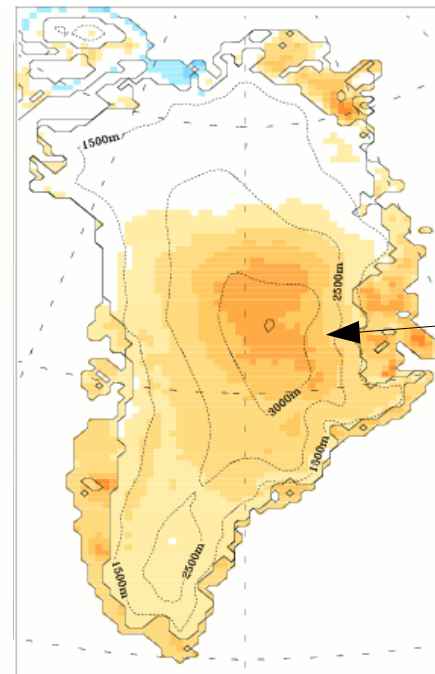
Incoming longwave anomaly (W/m²)



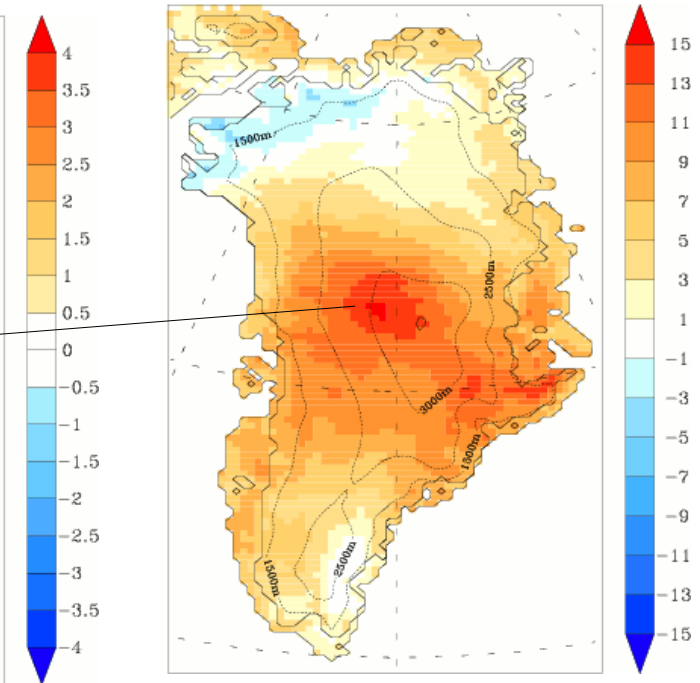
MAR anomaly



Analogues anomaly



MAR - Analogues



MAR - Analogues

Z500: mean summer circulation

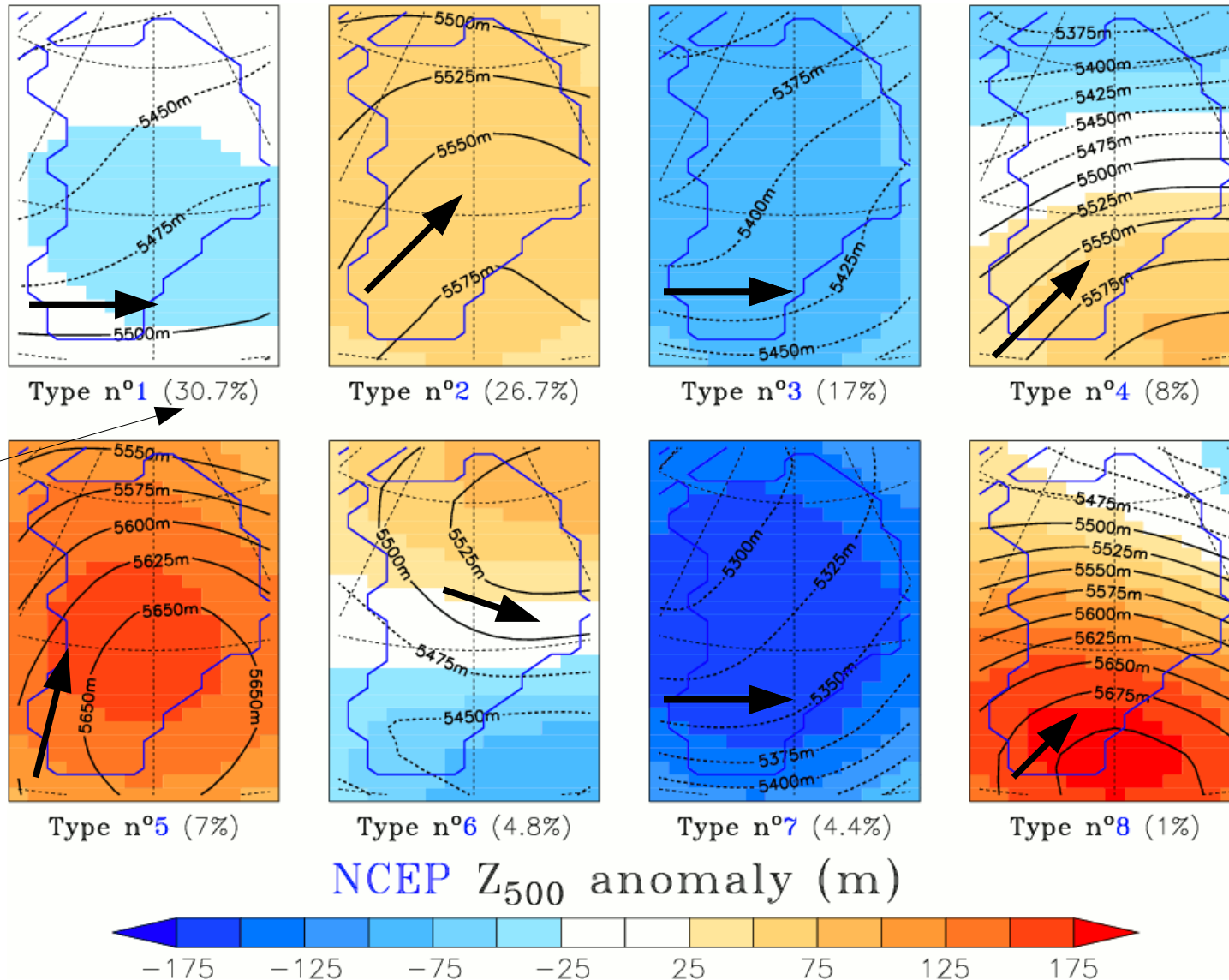
Z500: 2010 summer circulation



The temperature anomaly not due to the circulation is mainly explained by anomalies in longwave due to abnormal cloudiness.

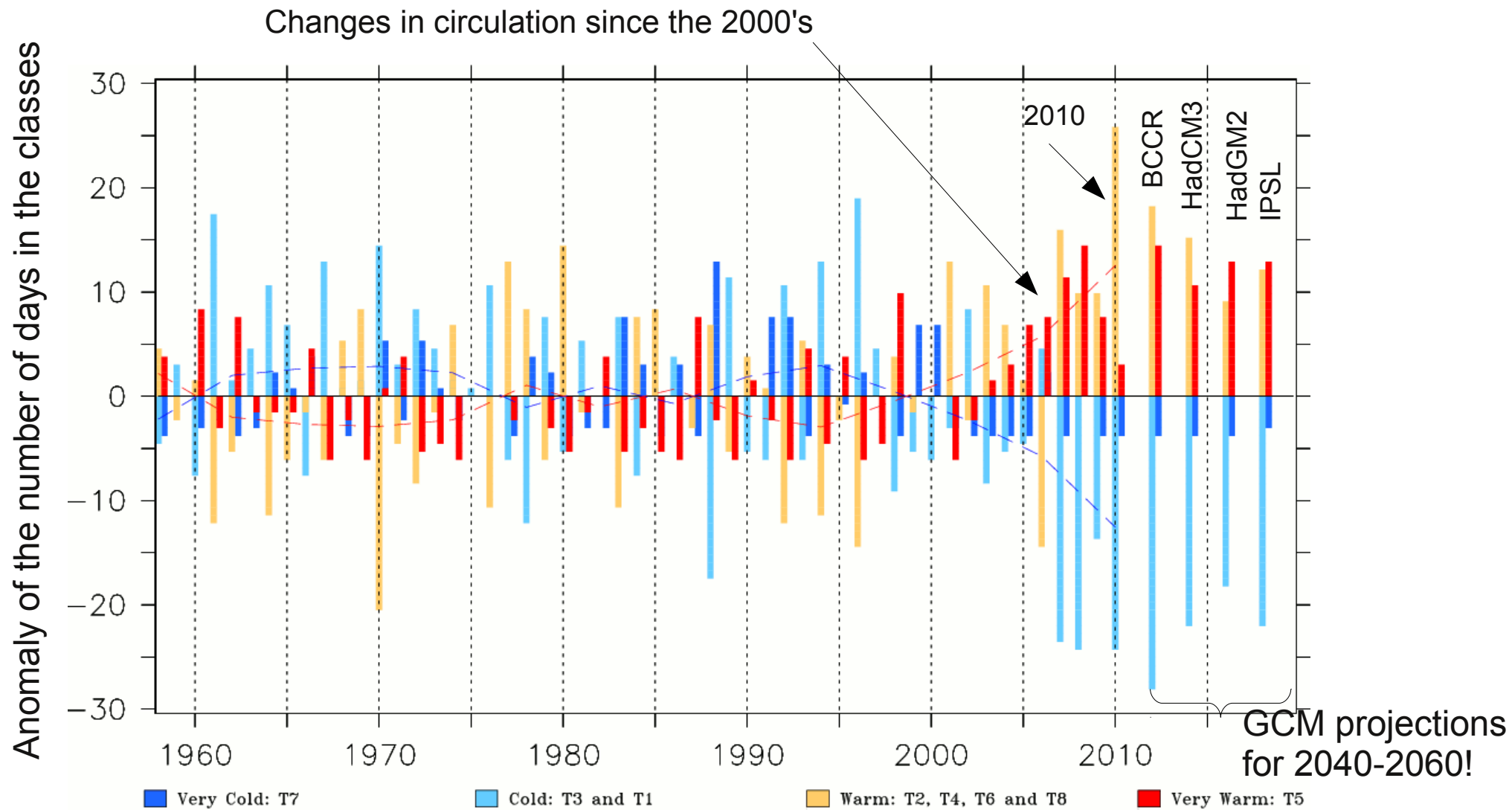
3. Circulation type classification (1/2)

Circulation type classification made on the JJA days over 1958-2010



Ref: Fettweis et al.: The 1958-2009 Greenland ice sheet surface melt and the mid-tropospheric atmospheric circulation, *Clim. Dynam.*, 2011.

3. Circulation type classification (2/2)



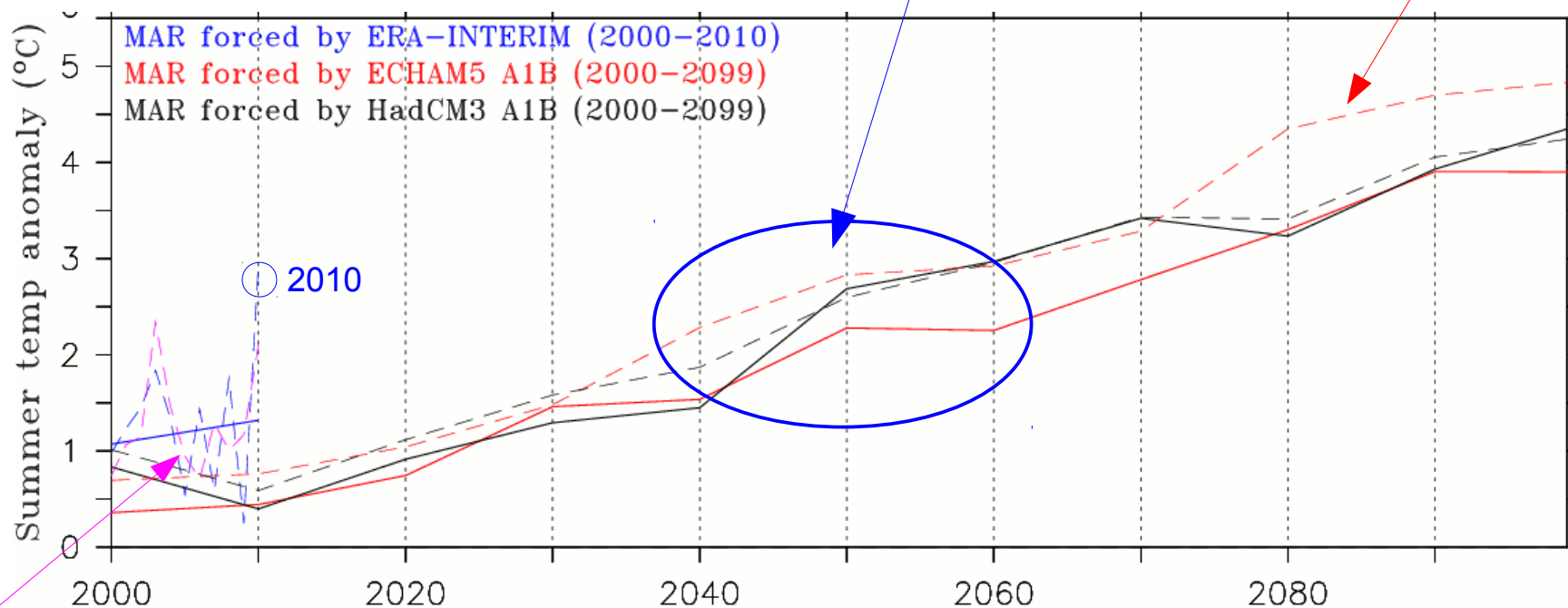
See: Poster **XL 71** of Belleflamme et al.

4. Future climate (1/1)



The GCMs project for 2040-2060 similar temp anomalies than 2003, 2007, 2010!

In dash, temperature anomaly from ECHAM5-A1B



Observed at Taasiliak (East Greenland)

Mean GrIS 3m-Temperature anomalies in respect to the period 1980-1999.

See: Poster **XL 68** of Fettweis et al.

5. Conclusion

- Summer 2010 was one of the warmest since 100 year over Greenland inducing very low SMB!
- The 2010 temp anomaly is mainly explained by anomalies in the general circulation (Z500) inducing a shift towards the north of the Azores anti-cyclone and then an increase of warm air advection.
- The circulation changes of the 2000's agree with future projections of GCMs and they are likely a consequence of the global warming.

Thanks !