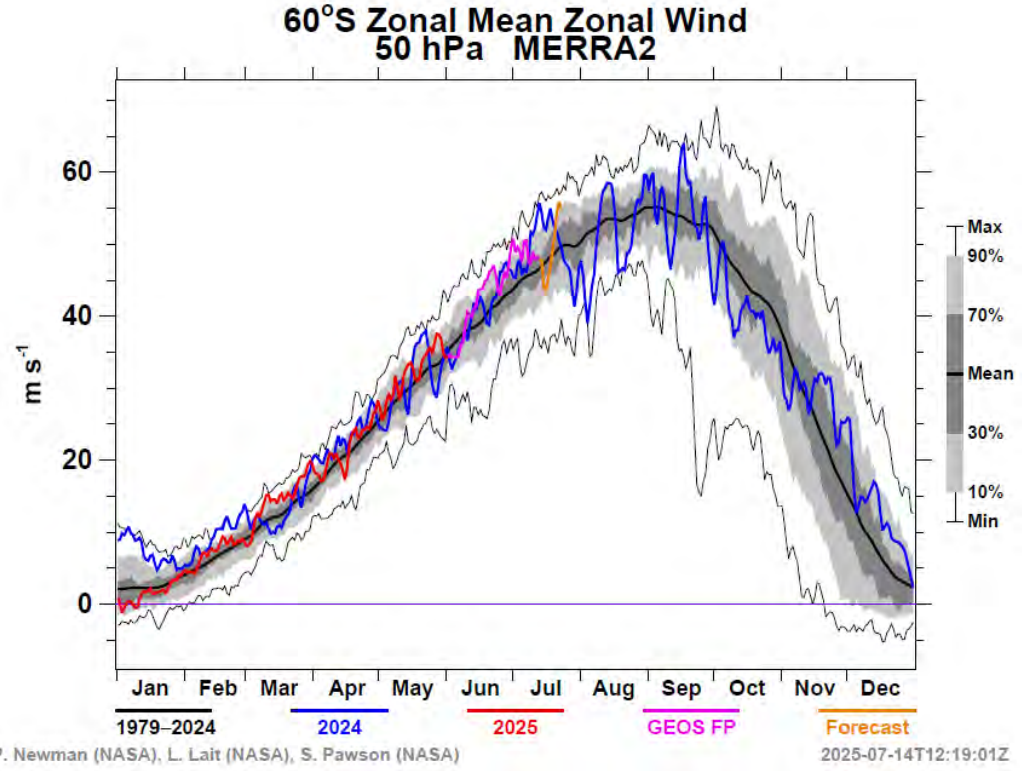

HELMHOLTZ GEOMAR

# Contributions of Various Climate Forcings to Historical Southern Hemisphere Stratospheric Vortex Strength and Lifetime

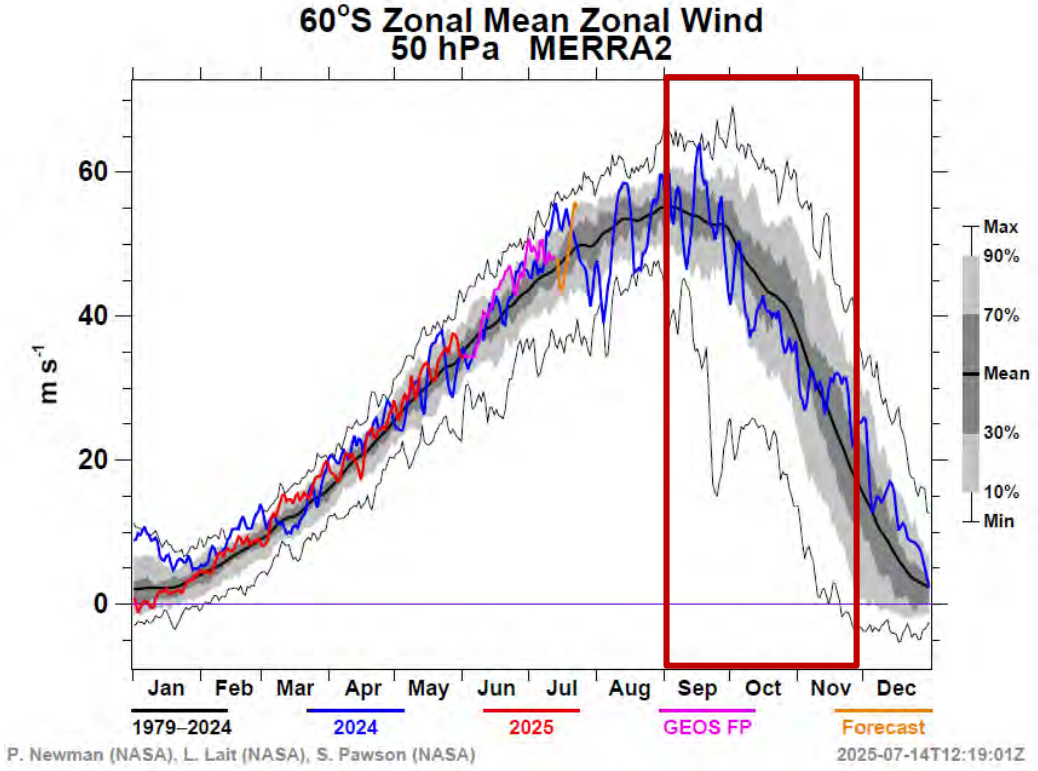
**Sabine Bischof**
Amy Butler, Julia Mindlin, Marisol Osman

# SH stratospheric polar vortex




https://ozonewatch.gsfc.nasa.gov/

# SH stratospheric polar vortex




1. SON mean state

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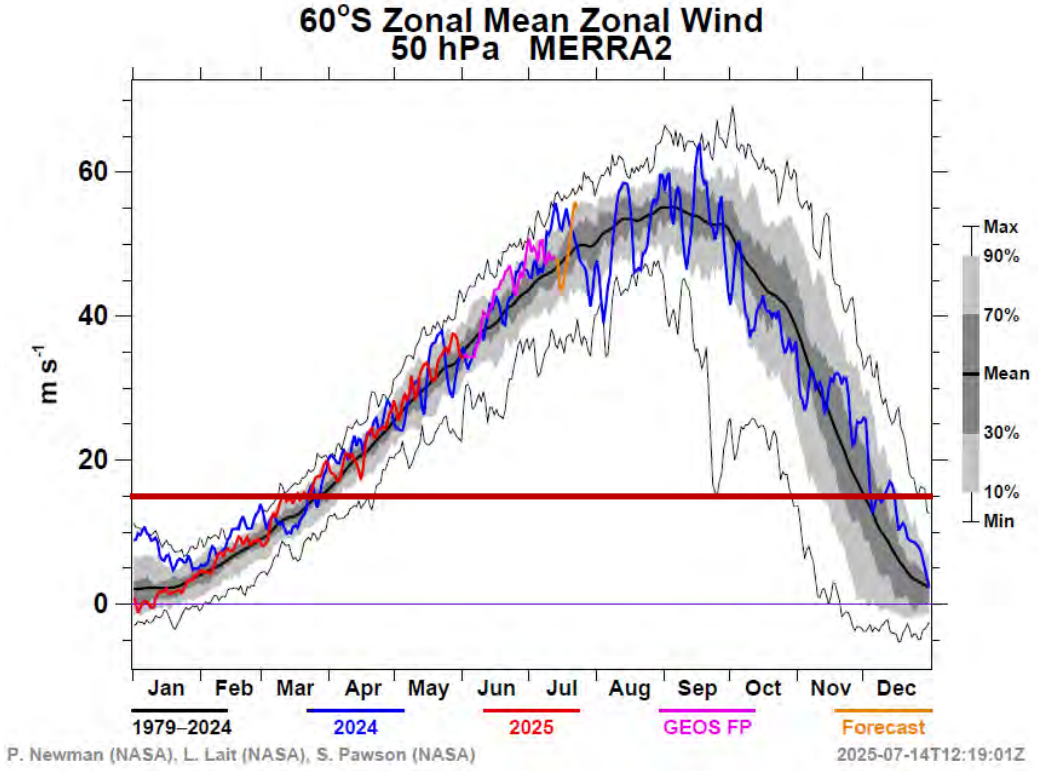
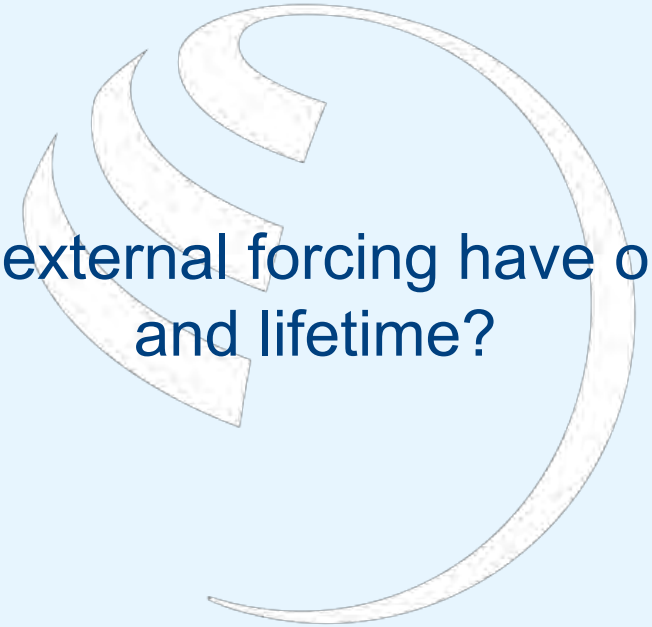
# SH stratospheric polar vortex




1. SON mean state
2. Transition from winter to summer circulation:

   ⇨ final warming date **SFW**

https://ozonewatch.gsfc.nasa.gov/



# What effect does external forcing have on vortex strength and lifetime?

# The LESFMIP data

| Model | historical | hist-GHG | hist-aer | hist-totalO3 |
|---|---|---|---|---|
| ACCESS-ESM1-5 | 40 | 10 | 10 | |
| CMCC-CM2-SR5 | 11 | 10 | 10 | |
| CNRM-CM6-1 | | 10 | 10 | |
| CanESM5 | 65 | 50 | 30 | 10 |
| GISS-E2-1-G | 89 | 45 | 45 | 5 |
| HadGEM3-CG31-LL | 55 | 55 | 55 | 50 |
| IPSL-CM6A-LR | 33 | 10 | 10 | |
| MIROC6 | 50 | 50 | 10 | 10 |
| MPI-ESM1-2-LR | 51 | 30 | 30 | 30 |
| NorESM2-LM | 44 | 23 | 23 | 20 |

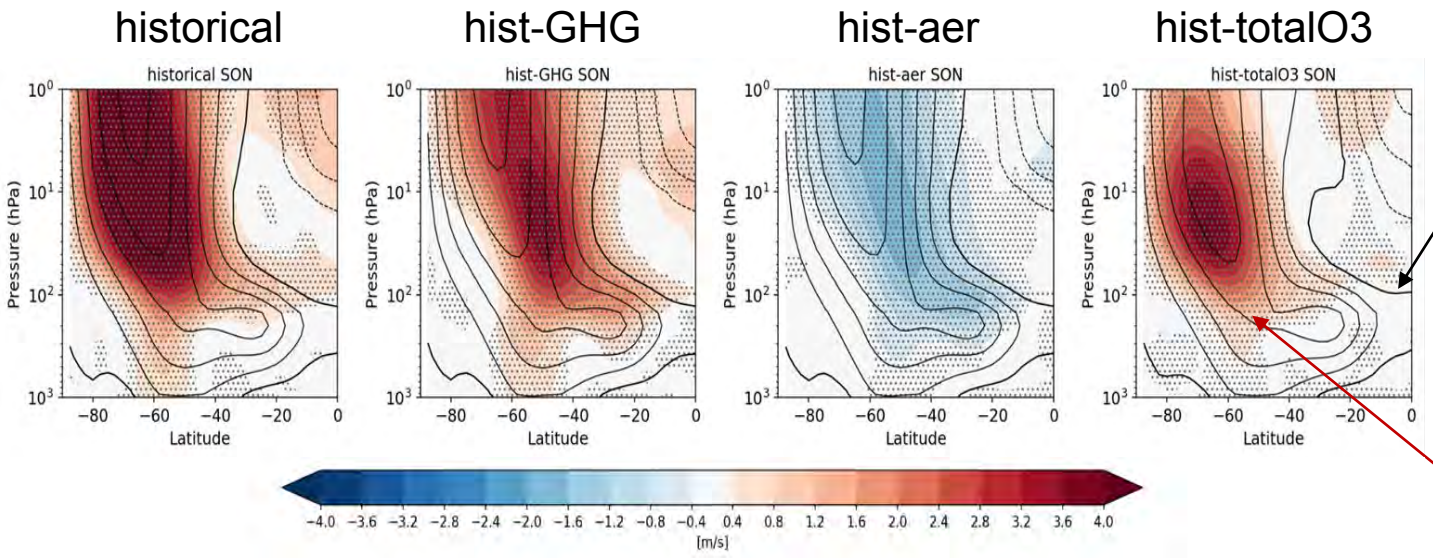
LESFMIP data (provided on JASMIN)

- mainly monthly data

I focus on

- historical
- hist-GHG → GHG
- hist-aer → Aerosol
- hist-totalO3 → Ozone

# SON – zonal mean zonal wind




Climatology 1850-1884

Difference: 1980-2014 vs. 1850-1884

- Strengthening of the vortex in historical simulation, which is due to GHG and Ozone forcing
- Aerosols have a negative effect on zonal wind strength

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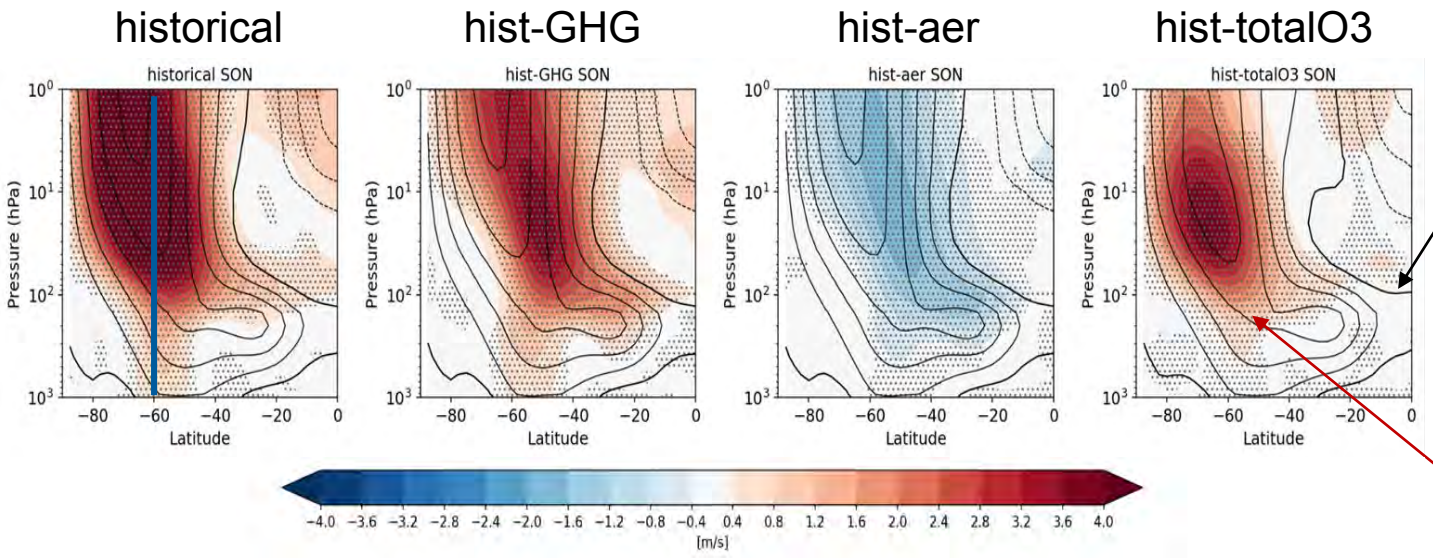


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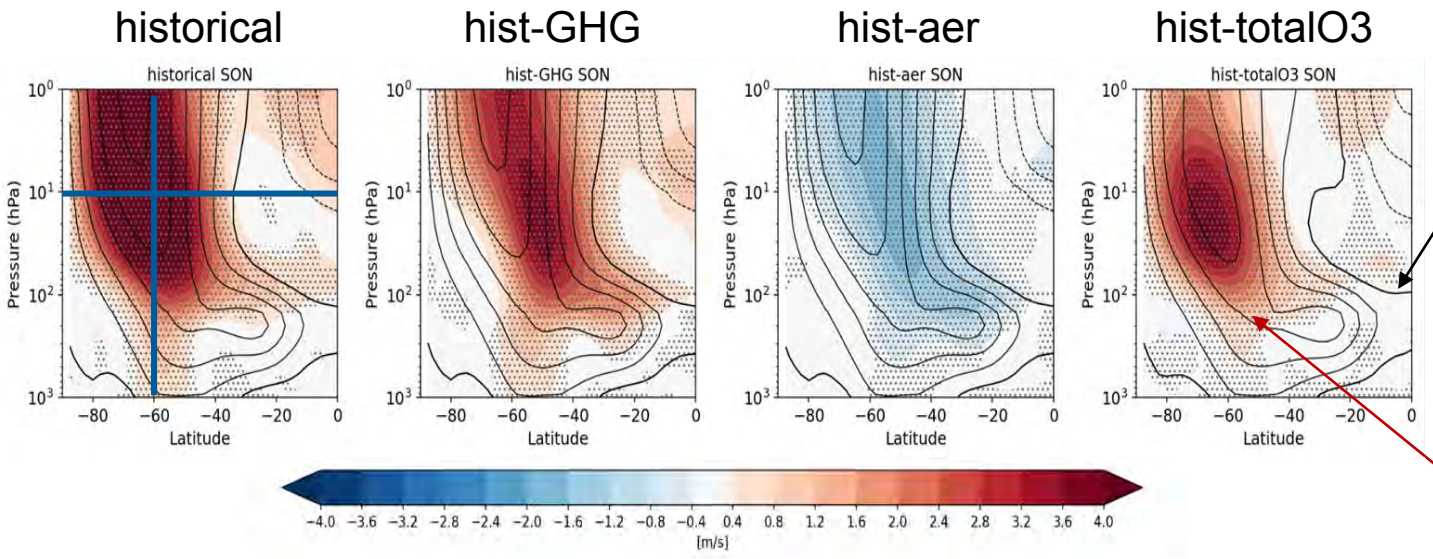


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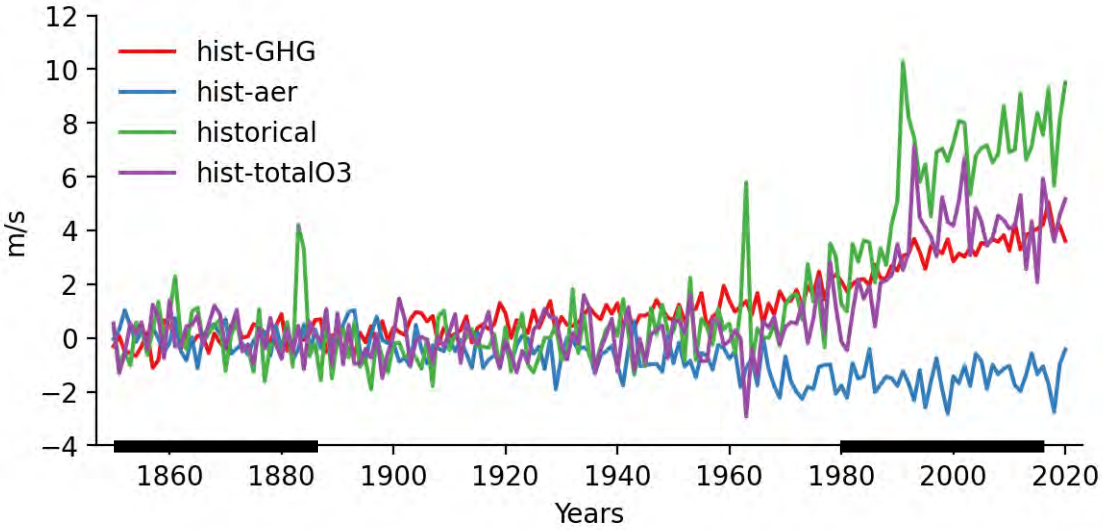
# SON – zonal mean zonal wind anomalies

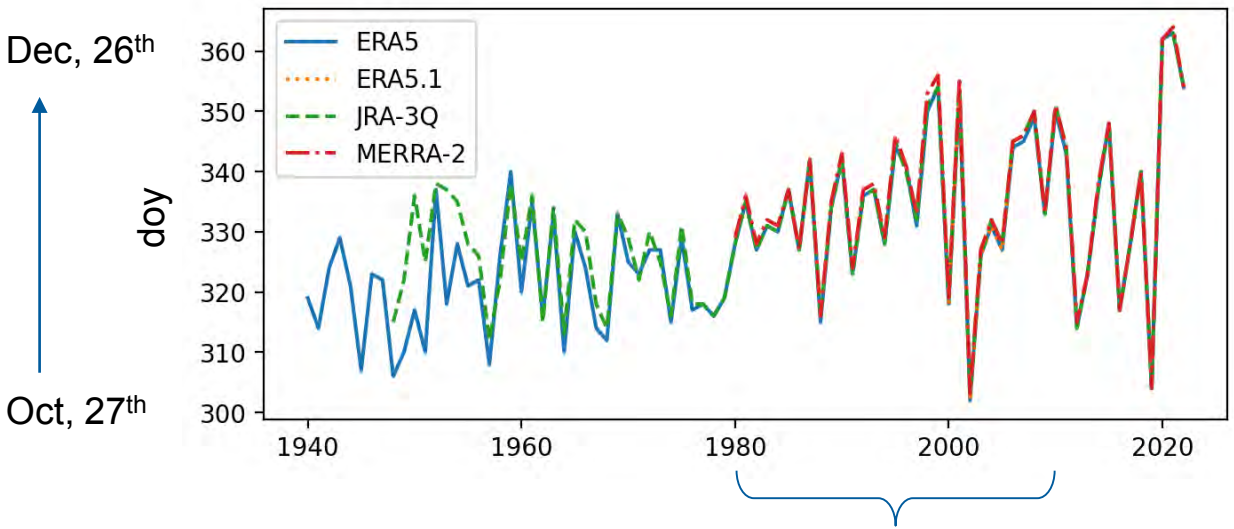
Anomalies relative to 1850-1884




- Strong volcanic signal in historical simulation
- Ozone and GHGs contribute to a strengthening of the vortex
- Aerosols counteract GHG and Ozone forcings

# SFW dates in the reanalysis

- SFW definition based on Hardimann et al. (2011) at 50 hPa , 60°S
- 15 m/s threshold as in Ceppi and Shepherd (2019)

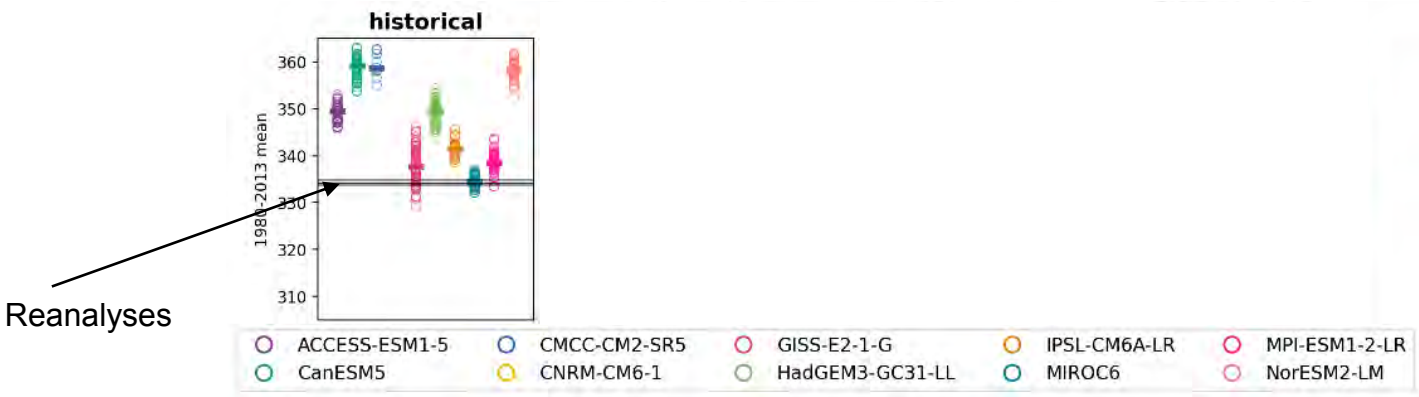



for 1980 to 2013:

| | |
|---|---|
| ERA5 | 334 |
| MERRA2 | 335 |
| JGR | 334 |

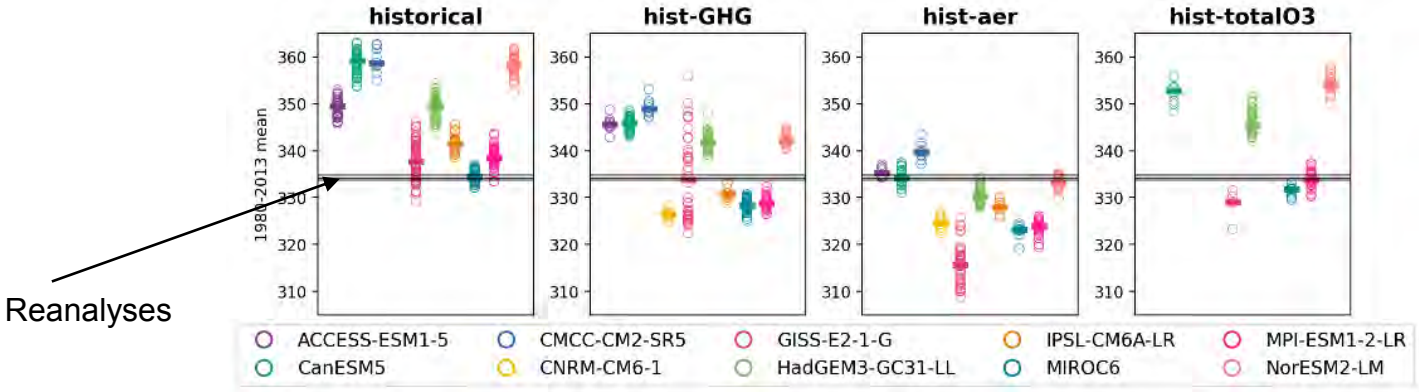
⇨ Nov 30th to Dec 1st

# SFW dates in the historical simulations




- too late SFWs for most models in historical experiment

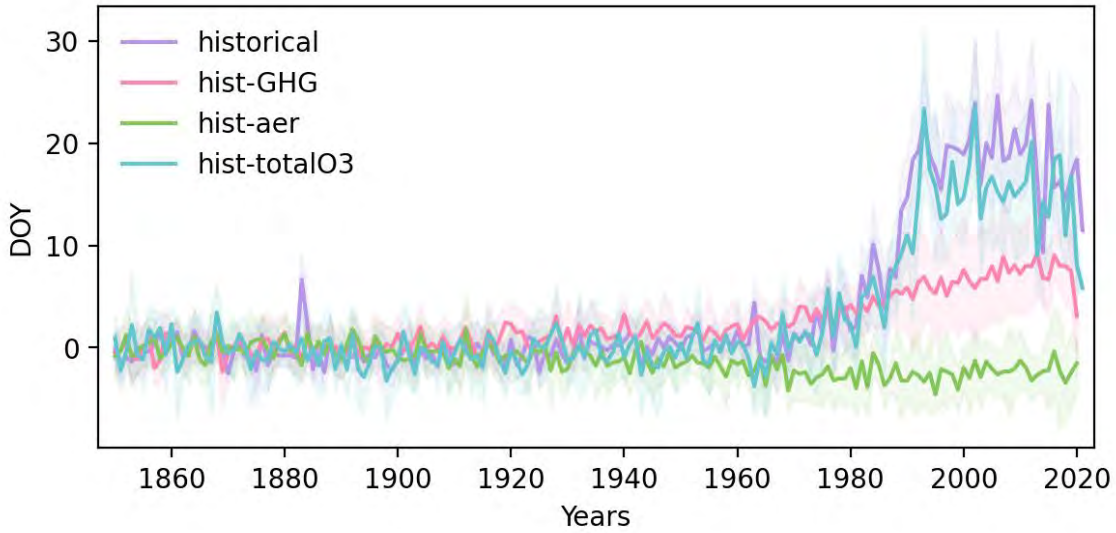
# SFW dates in the historical simulations




- too late SFWs for most models in historical experiment
- too early SFWs for most models in Aerosol experiment
- inconclusive for GHG and Ozone forcing

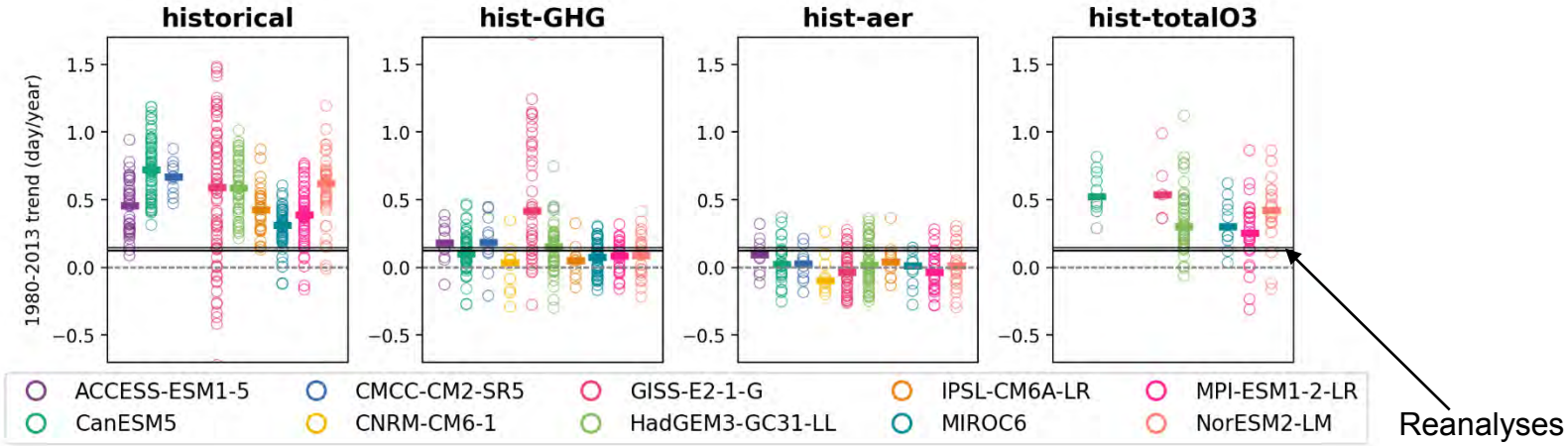
# SFW dates – ensemble means

Anomalies relative to 1850-1884




- Ozone forcing explains most of the difference
- GHGs also contribute to a delay of the vortex break down
- Aerosols counteract GHG and Ozone forcings

# SFW dates – trends: 1980-2013



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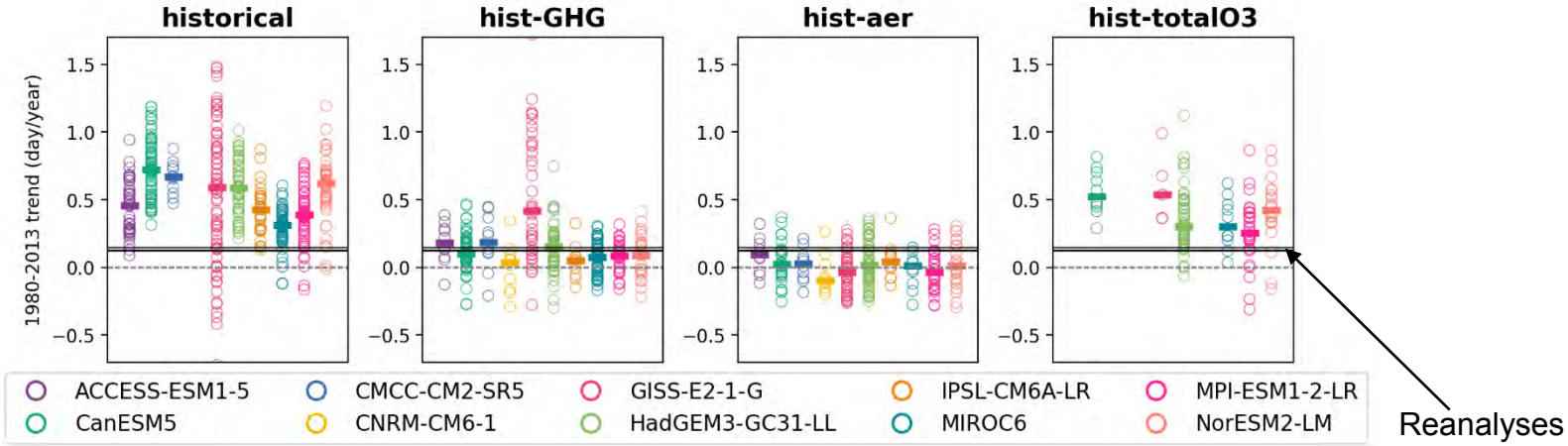


Trends in historical experiment too strong compared to reanalysis

… due to too strong response in ozone?

# Summary

Ozone and GHGs contribute to

- strengthening of the polar vortex in recent decades
- delay of the vortex breakdown

Aerosols tend to counteract Ozone and GHG forcing

Historical simulations are biased towards later SFW dates as compared to reanalyses

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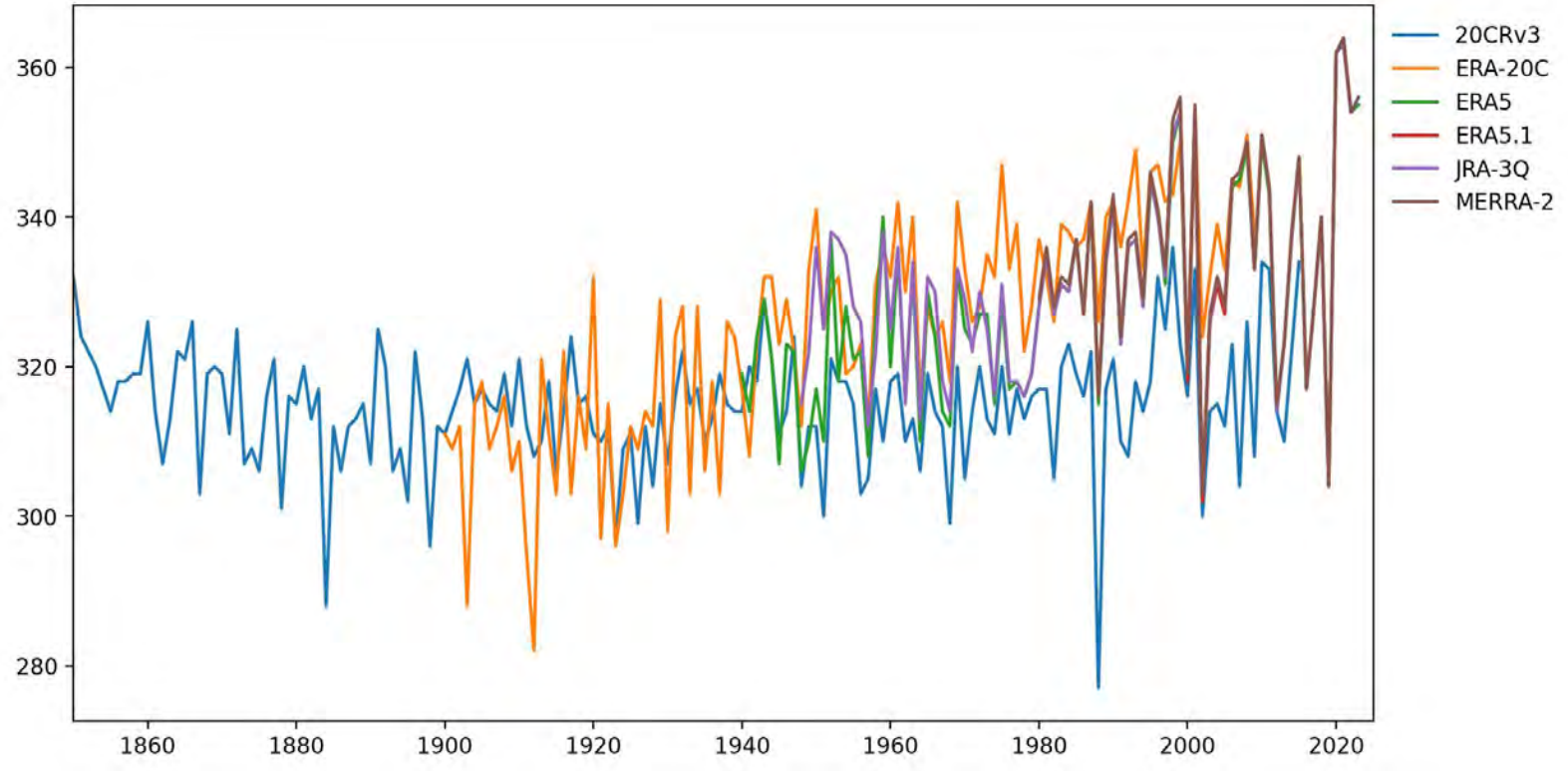
Thank You!

# Additional Slides

# Reanalysis


360
340
320
300
280
1860
1880
1900
1920
1940
1960
1980
2000
2020
20CRv3
ERA-20C
ERA5
ERA5.1
JRA-3Q
MERRA-2

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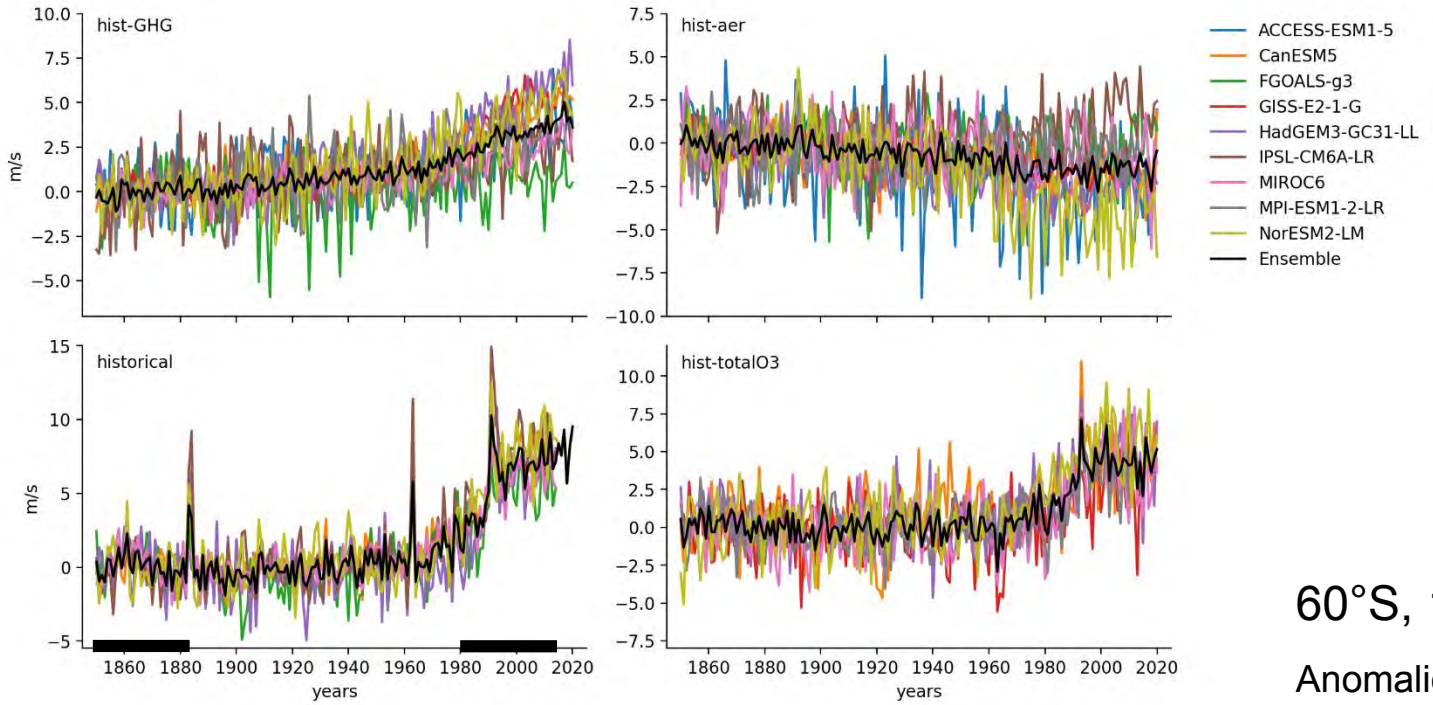
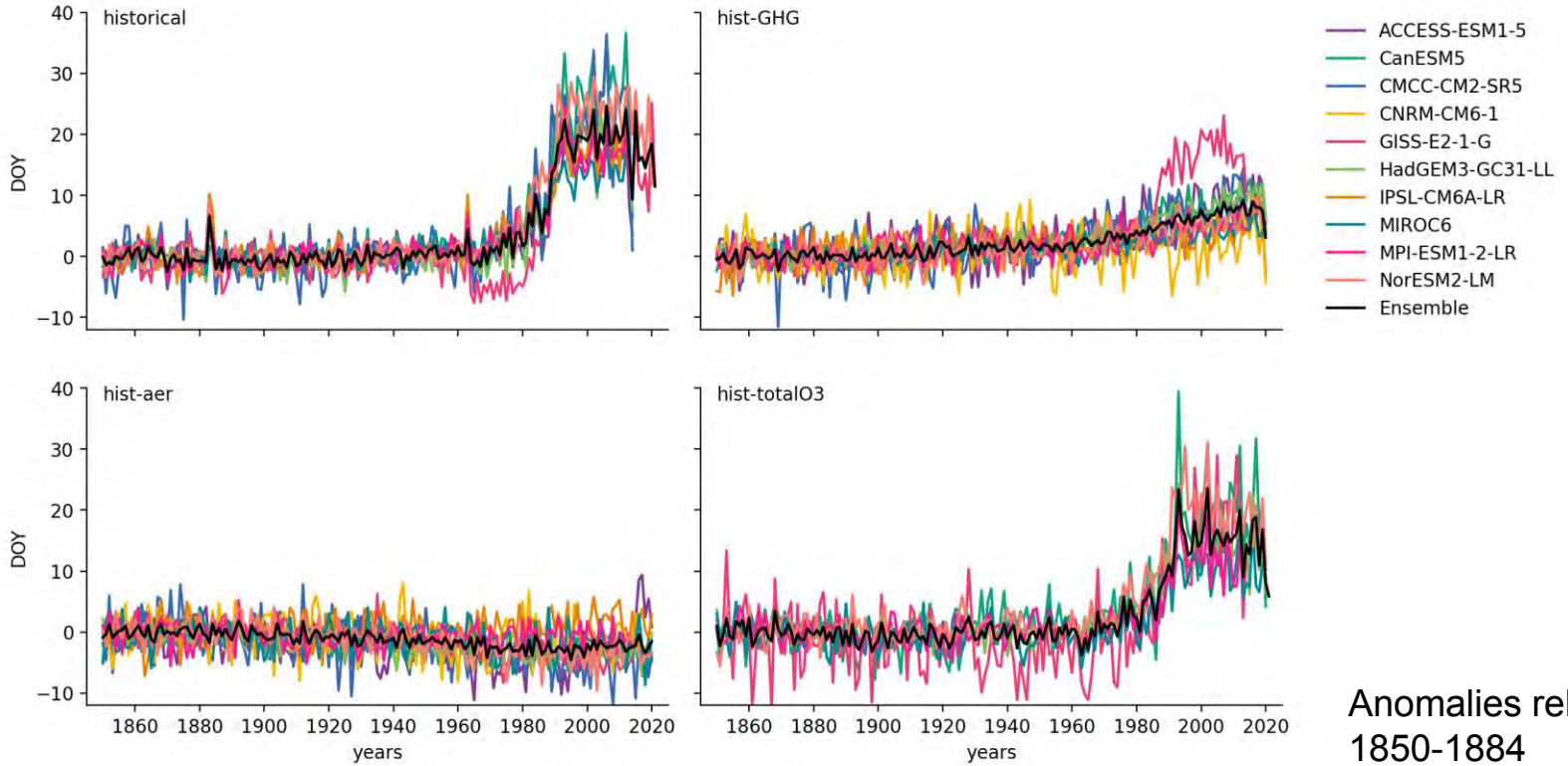



60°S, 10 hPa

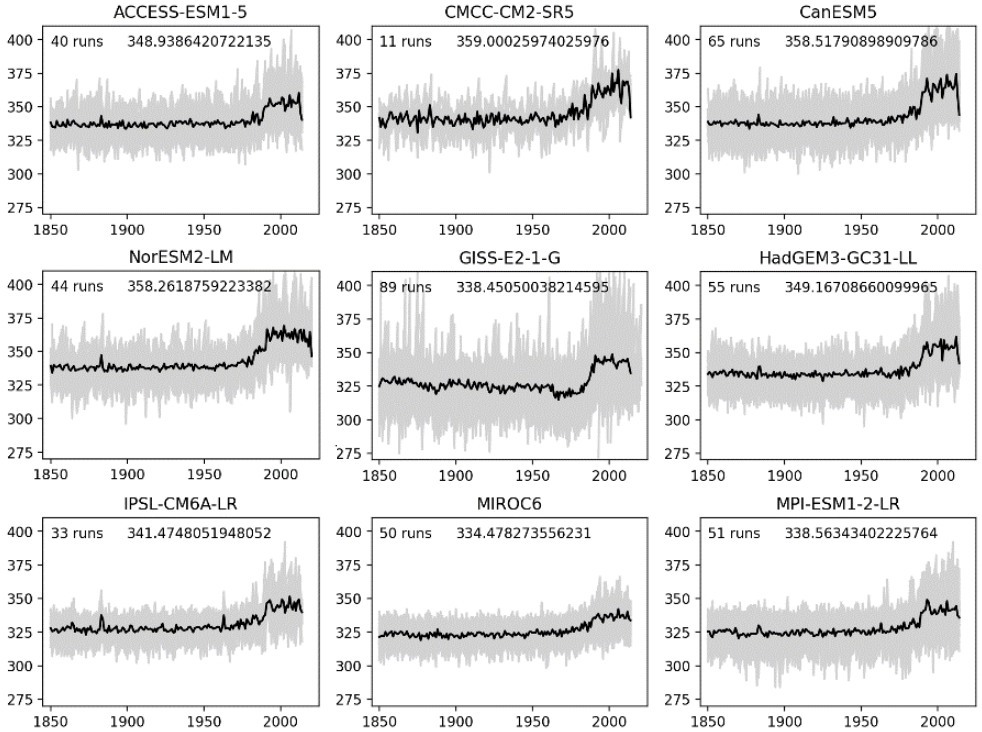
Anomalies relative to 1850-1884

# SFW dates for the different experiments




Anomalies relative to 1850-1884

# SFW dates in the historical simulations




SFW Definition (using monthly data)

- based on Hardimann et al. (2011)
- assuming the monthly values to be in the center of the month, interpolating to find threshold crossing
- 50 hPa , 60°S (commonly used to define strength of the SH strat. polar vortex)
- 15 m/s threshold as in Ceppi and Shepherd (2019)