Polar Symposium: Climate

Nicole van Lipzig and Alexander Mangold

with contributions from: Stephane Vannitsem, David Docquier, Andy Delcloo, Quentin Laffineur, Michel Van Roozendael, Alexis Merlaud, Corinne Vigouroux, Simon Chabrillat,Christophe Walgraeve, Preben Van Overmeiren, Nadine Mattielli, Pierre Coheur, Cathy Clerbaux, Catherine Wespes, Xavier Fettweis, Stef Lhermitte, Gabrielle Delanoy

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Climate and Ice Sheets

The UCLA research team at work in August 2014. Photo: Mia Bennett.

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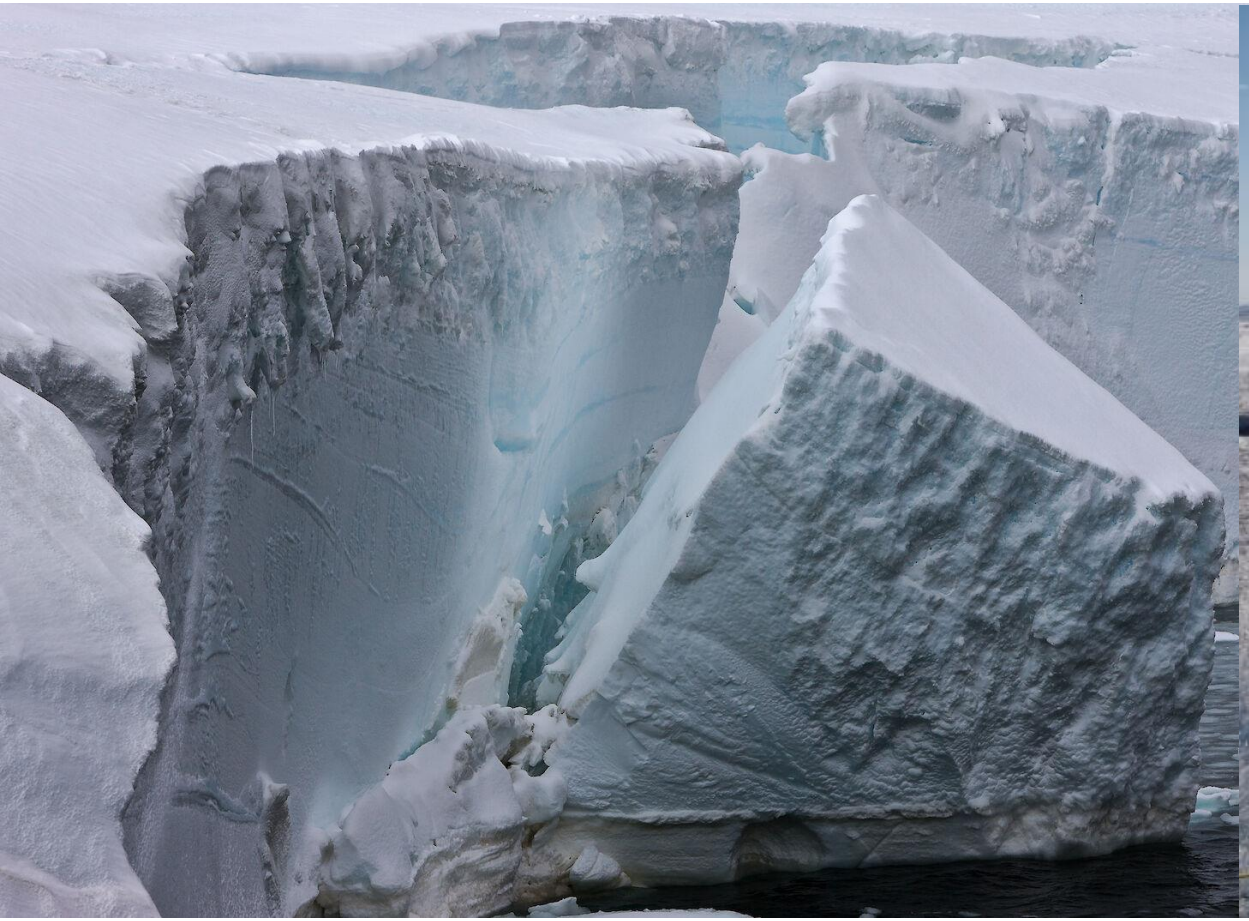
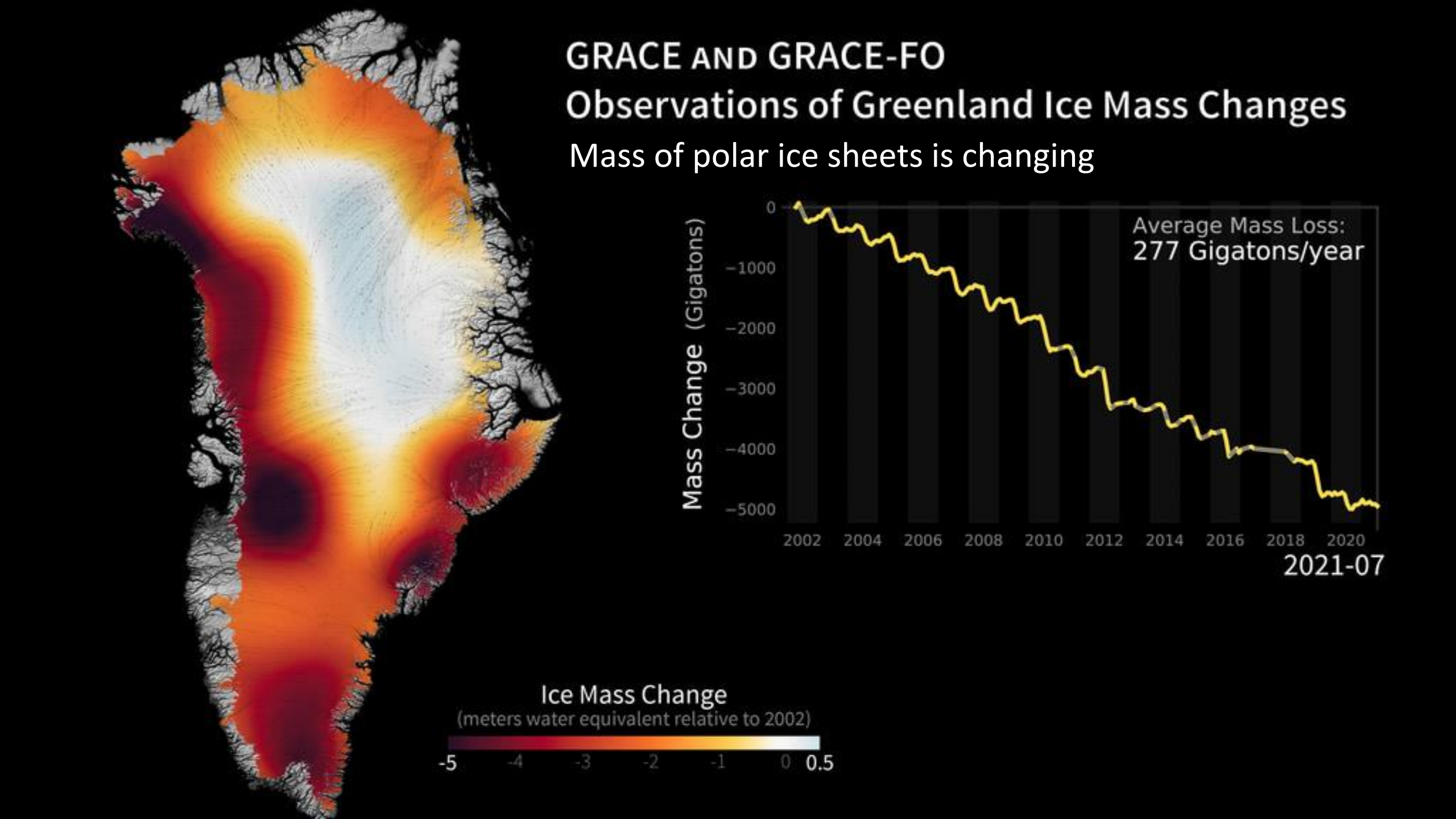
Ice sheet mass decrease causes sea level rise



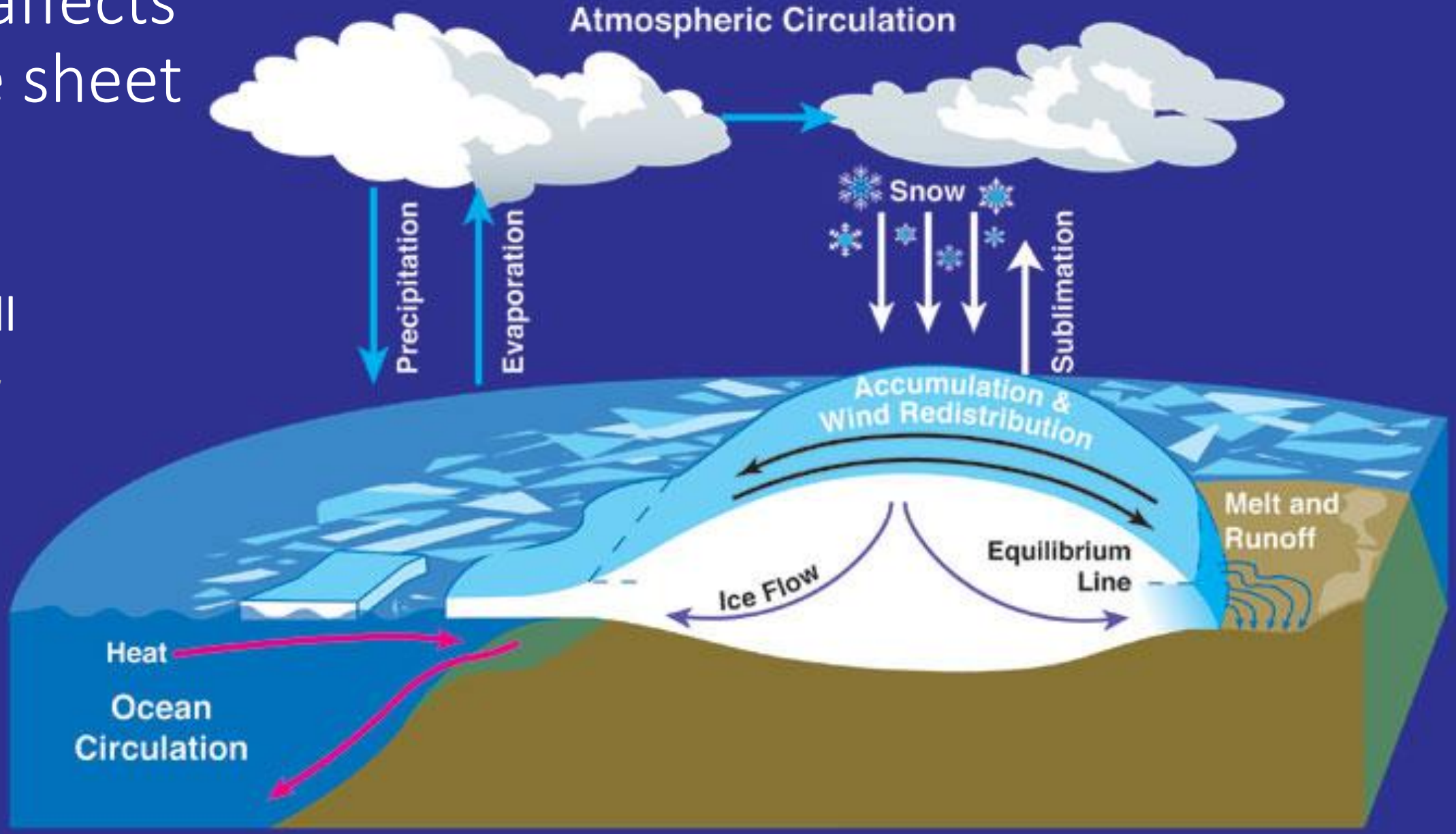
Ice calving from an ice cliff face in Antarctica. (Photo: Ian Phillips)

The UCLA research team at work in August 2014. (Photo: Mia Bennett)


GRACE AND GRACE-FO
Observations of Greenland Ice Mass Changes
Mass of polar ice sheets is changing
Mass Change (Gigatons)
0
−1000
−2000
−3000
−4000
−5000
Average Mass Loss:
277 Gigatons/year
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2021-07
Ice Mass Change
(meters water equivalent relative to 2002)
-5
-4
-3
-2
-1
0
0.5

What affects the ice sheet mass?

- Melt
- Snowfall
- Ice flow

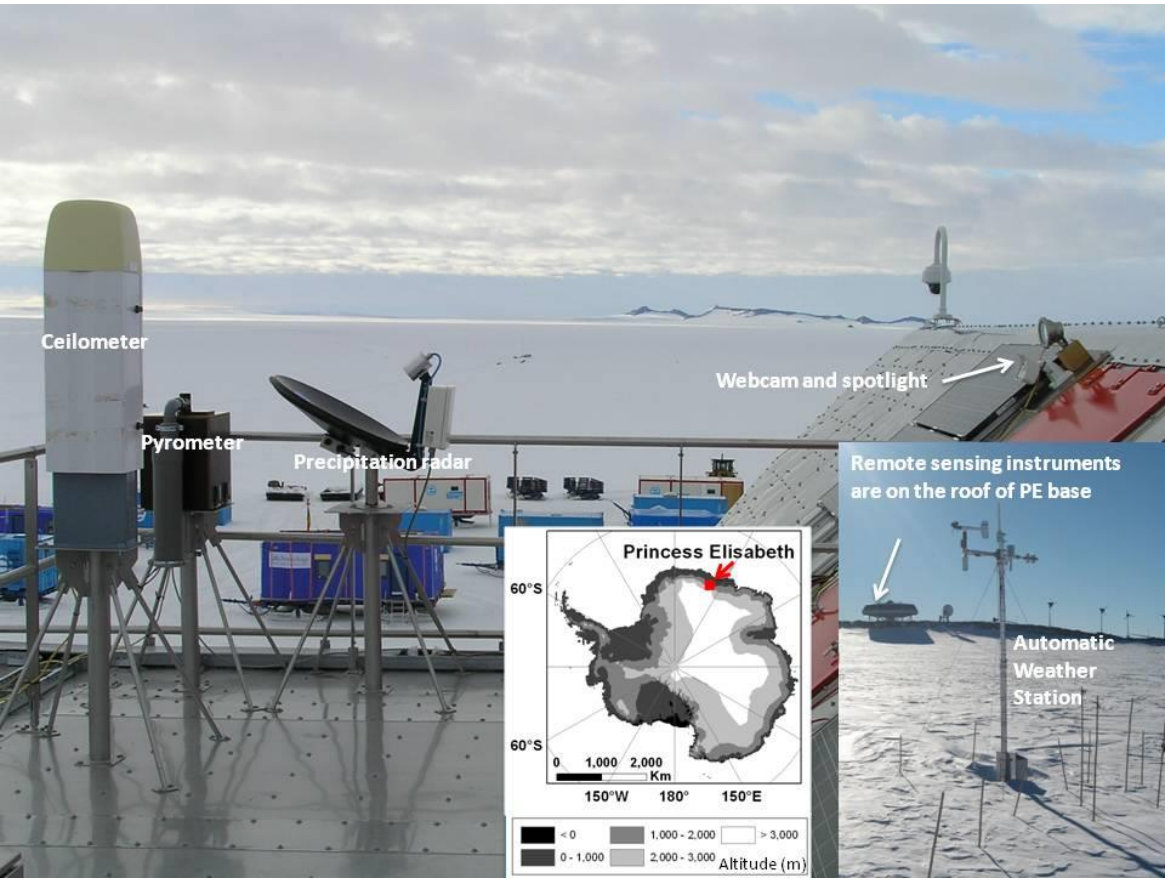


Observations

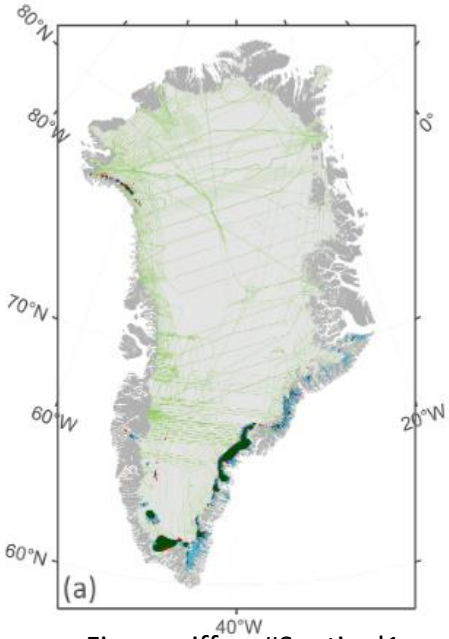
Ground-based remote sensing

In-situ observations

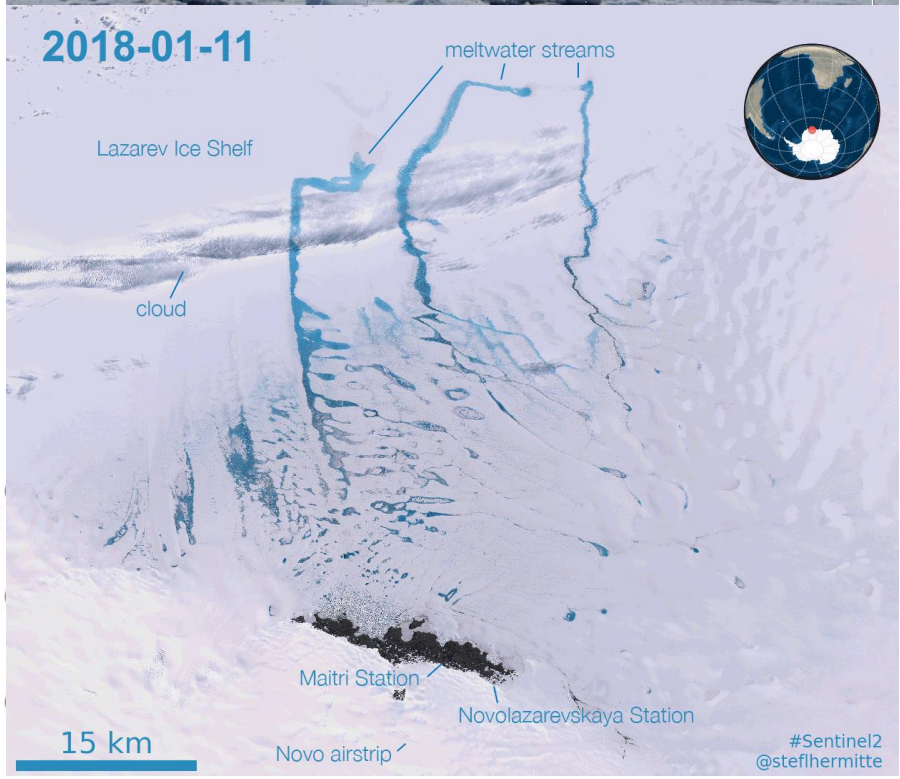
Satellite remote sensing



Observatory at the Princess Elisabeth Antarctica Gorodetskaya et al. (2015)



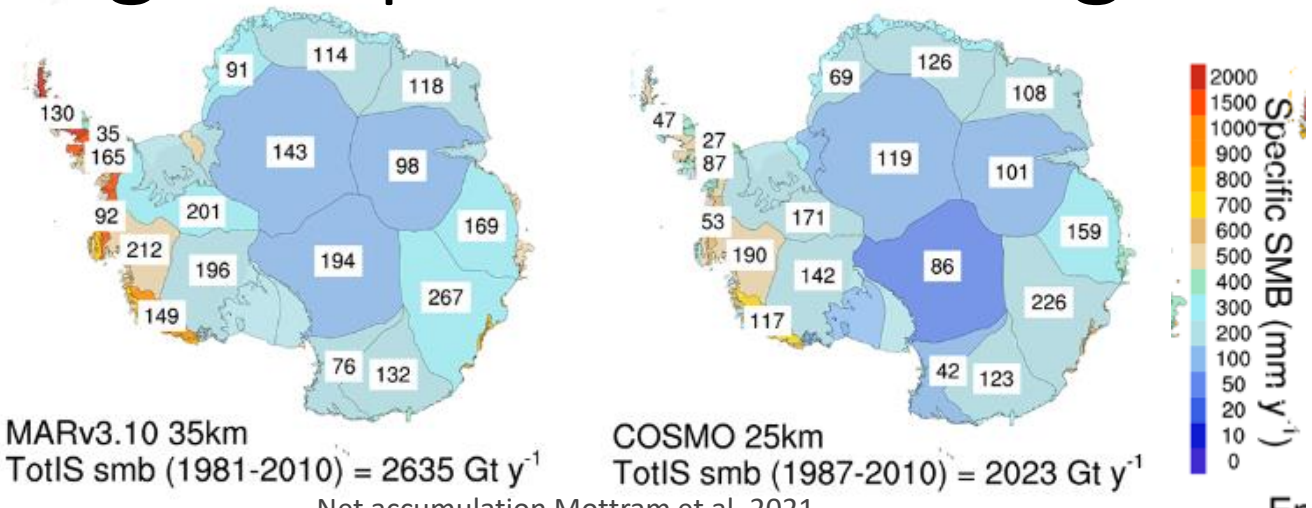
Firn aquiffers #Sentinel1 Brangers et al. (2020)



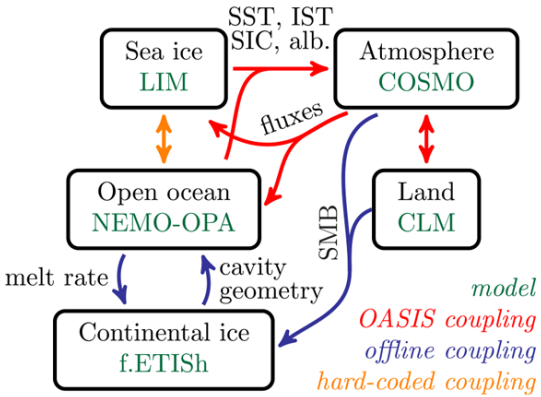
Ice shelf hydrology Antarctica #Sentinel2 @steflhermitte

Insight in future change requires modelling

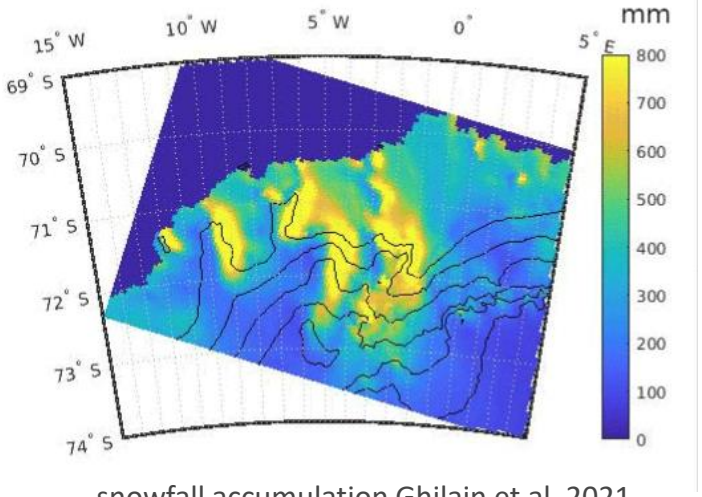
- regional climate modelling (bipolar) MAR, COSMO-CLM
- coupled regional climate model (bipolar)
- Statistical downscaling



Net accumulation Mottram et al. 2021



PARASO coupled regional climate model Pelletier et al., 2021

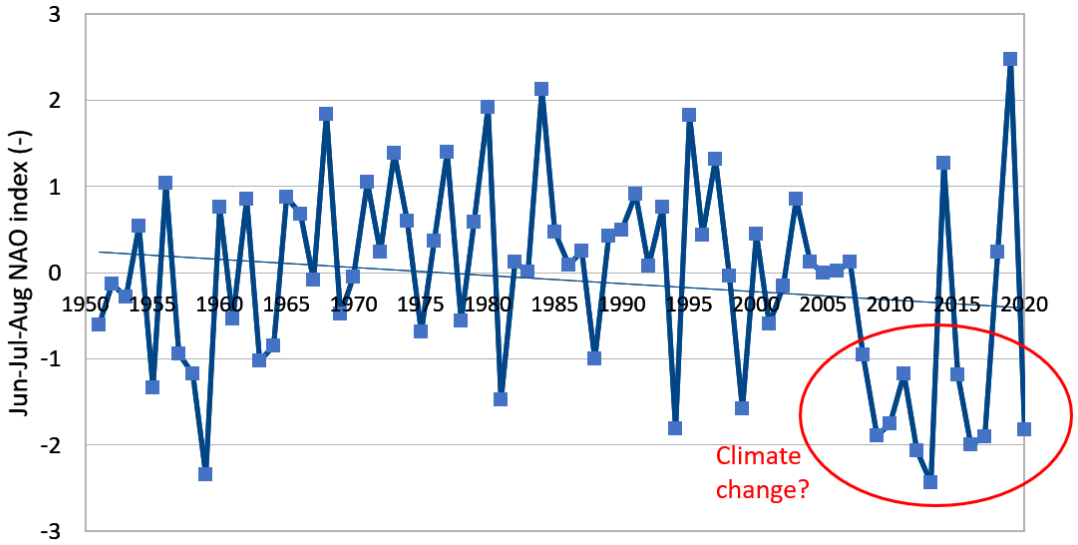


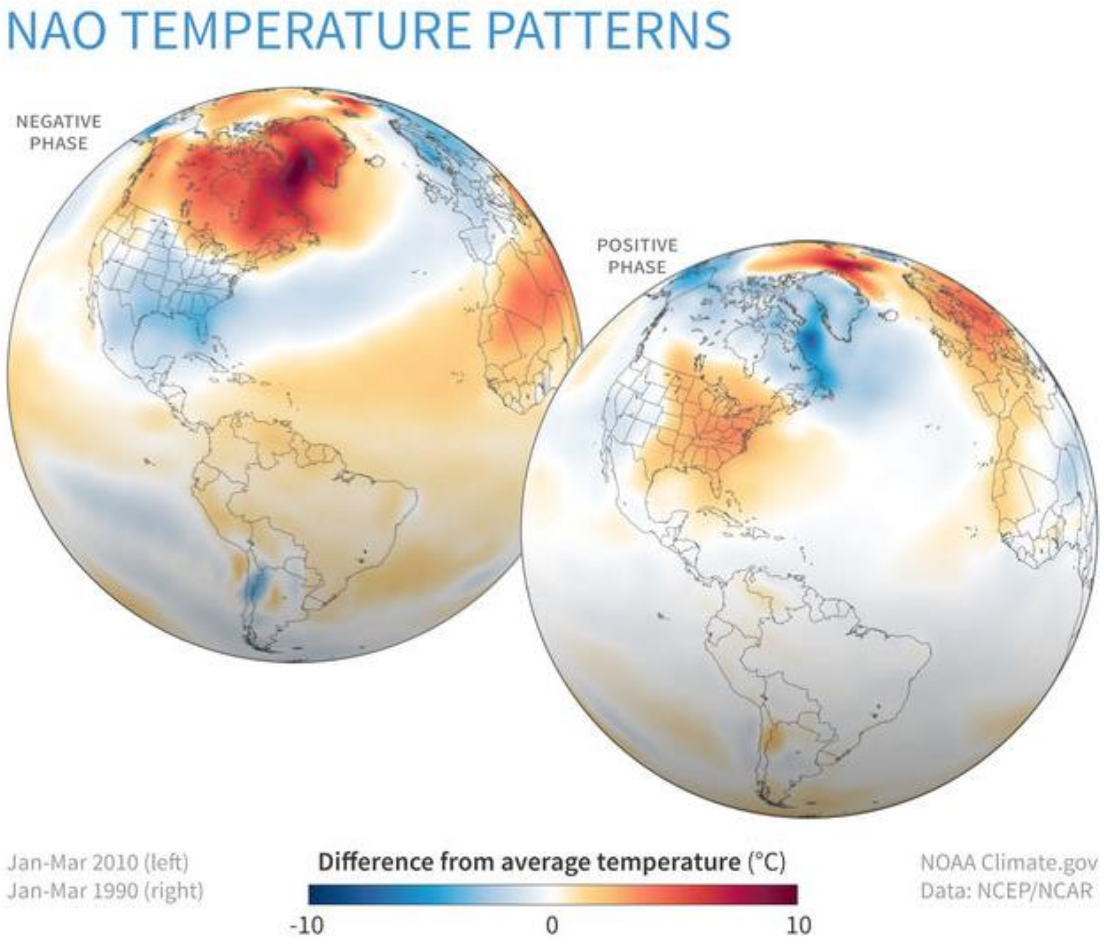
snowfall accumulation Ghilain et al. 2021

Models reveal causes of change

Influence of air temperature, sea-ice concentration and atmospheric circulation on surface mass balance

Recent changes in atmospheric flow patterns exacerbate Greenland melt (Delhasse et al. 2020)





Polar clouds and aerosols

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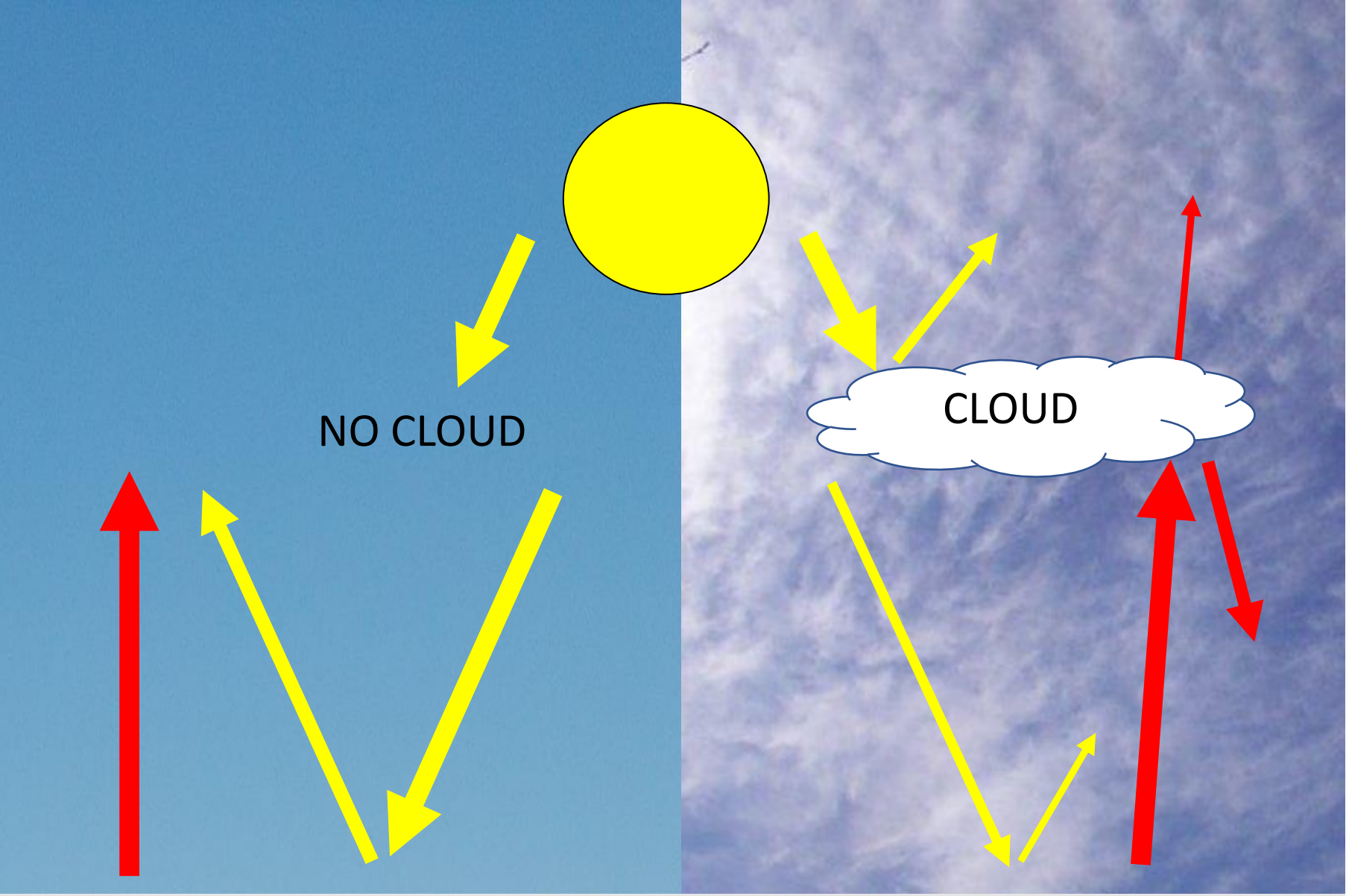
Clouds affect radiation



sun's radiation

thermal radiation

Aerosols affect radiation

sun's radiation

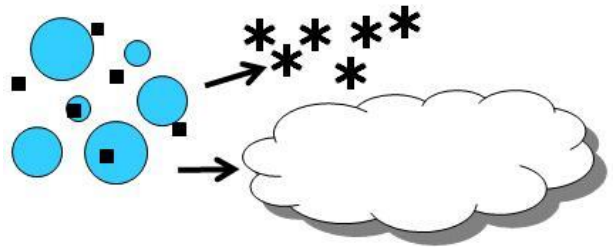
thermal radiation

Aerosols affect radiation

sun's radiation

thermal radiation

Aerosols (cloud condensation nuclei and ice nuclei) are agent
for cloud formation



NO AEROSOL

AEROSOL

particles suspended in the atmosphere

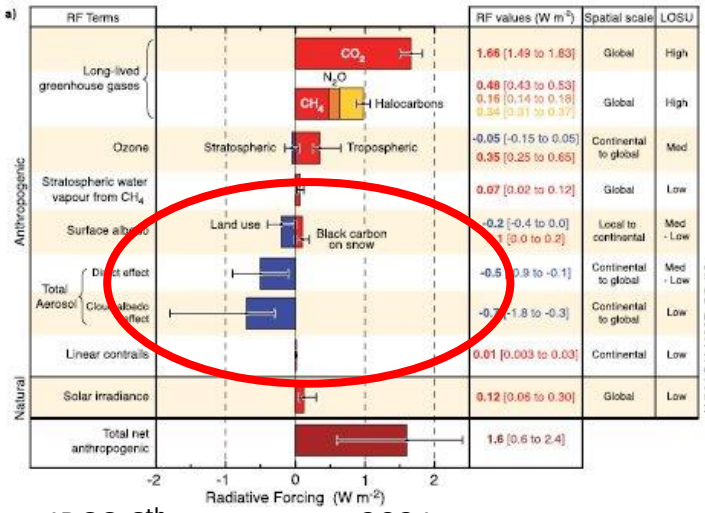
surface

Aerosols affect radiation

sun's radiation

thermal radiation

Driver of climate change

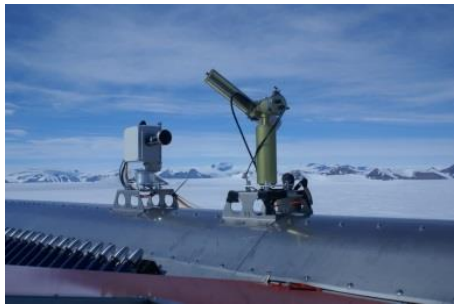


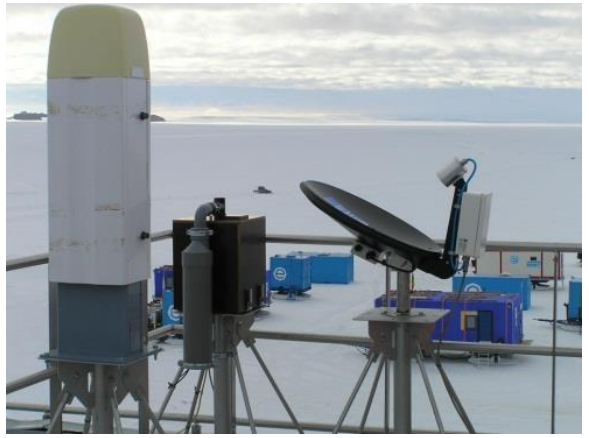
IPCC 6th assessment 2021

Observations

Aerosol – Cloud – Precipitation observatory at Princess Elisabeth Antarctica since 2010

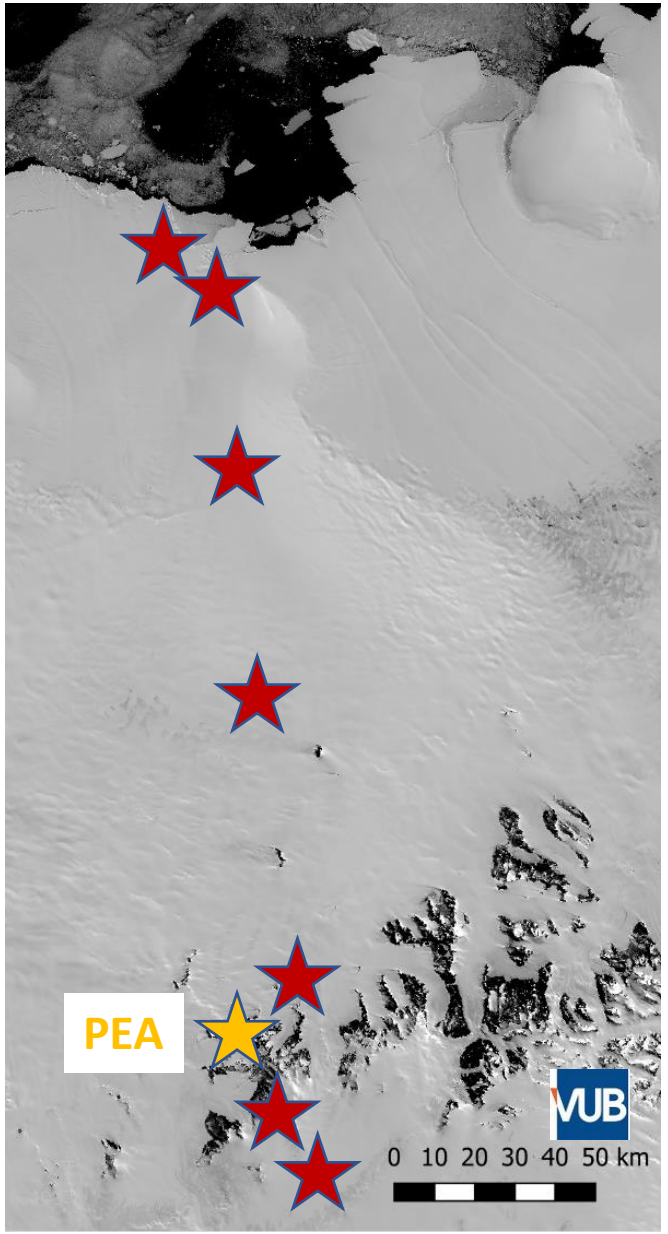
- cloud properties
- precipitation properties
- aerosol physical properties
- aerosol optical properties
- cloud condensation nuclei
- ice nuclei
- meteorology
- air mass origin



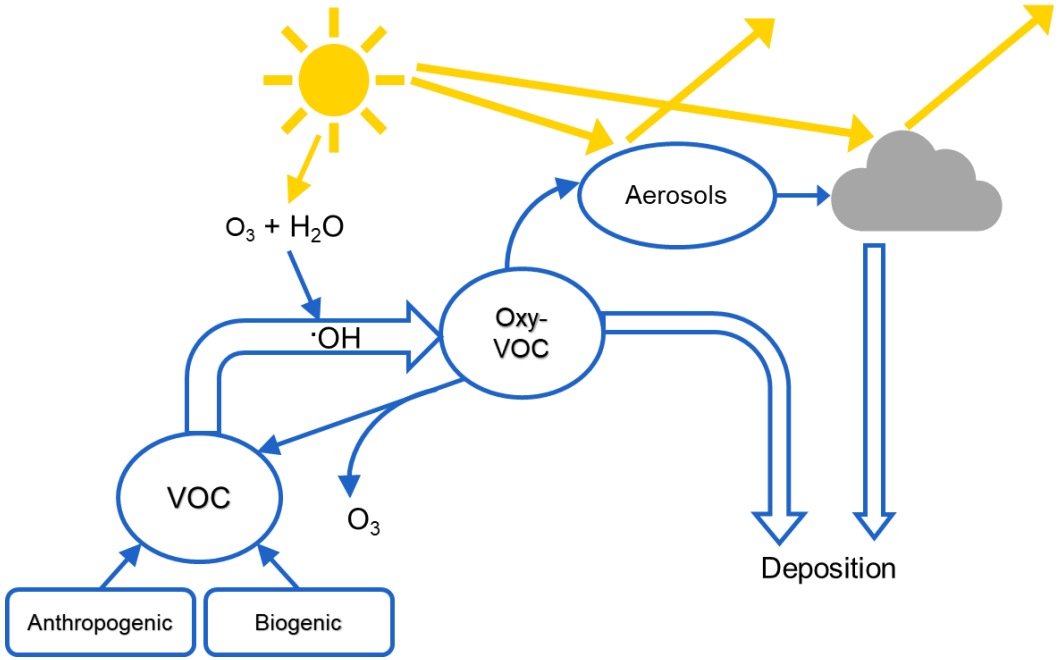


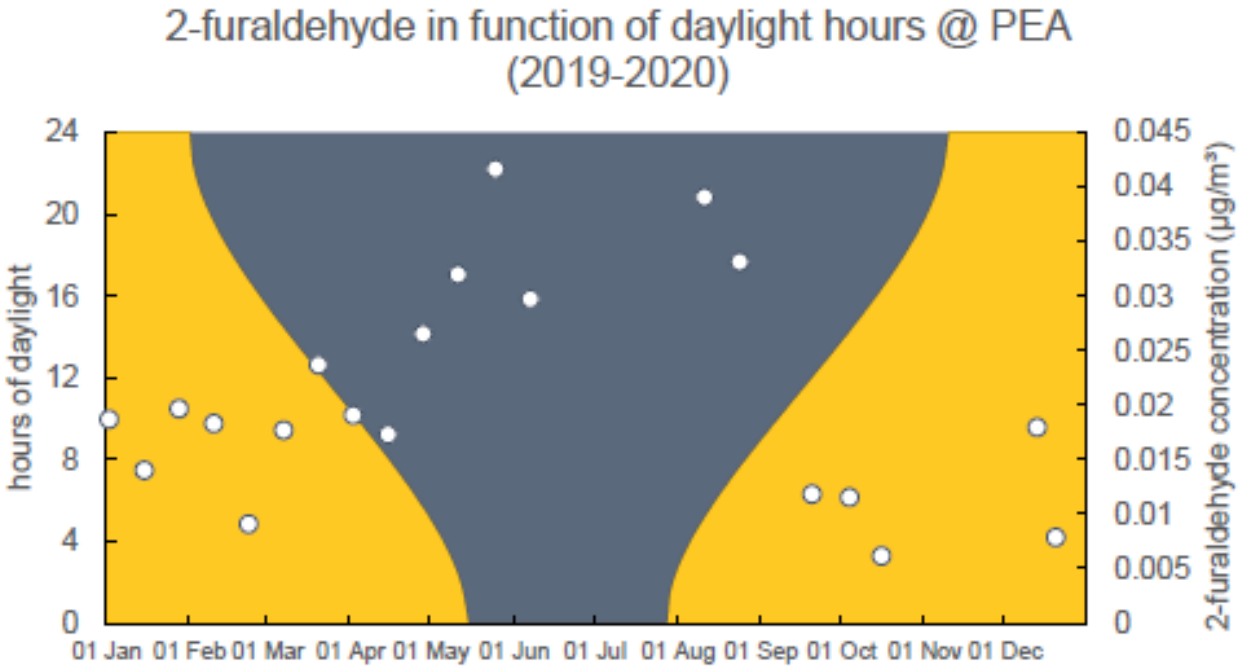
Observations

- Chemical characteristics of atmospheric particles and Volatile Organic compounds (VOCs)
- Since December 2017
- At Princess Elisabeth Antarctica and along transect
- Passive Sampling (red): Year-average
- Active Sampling (orange): seasonality; power required



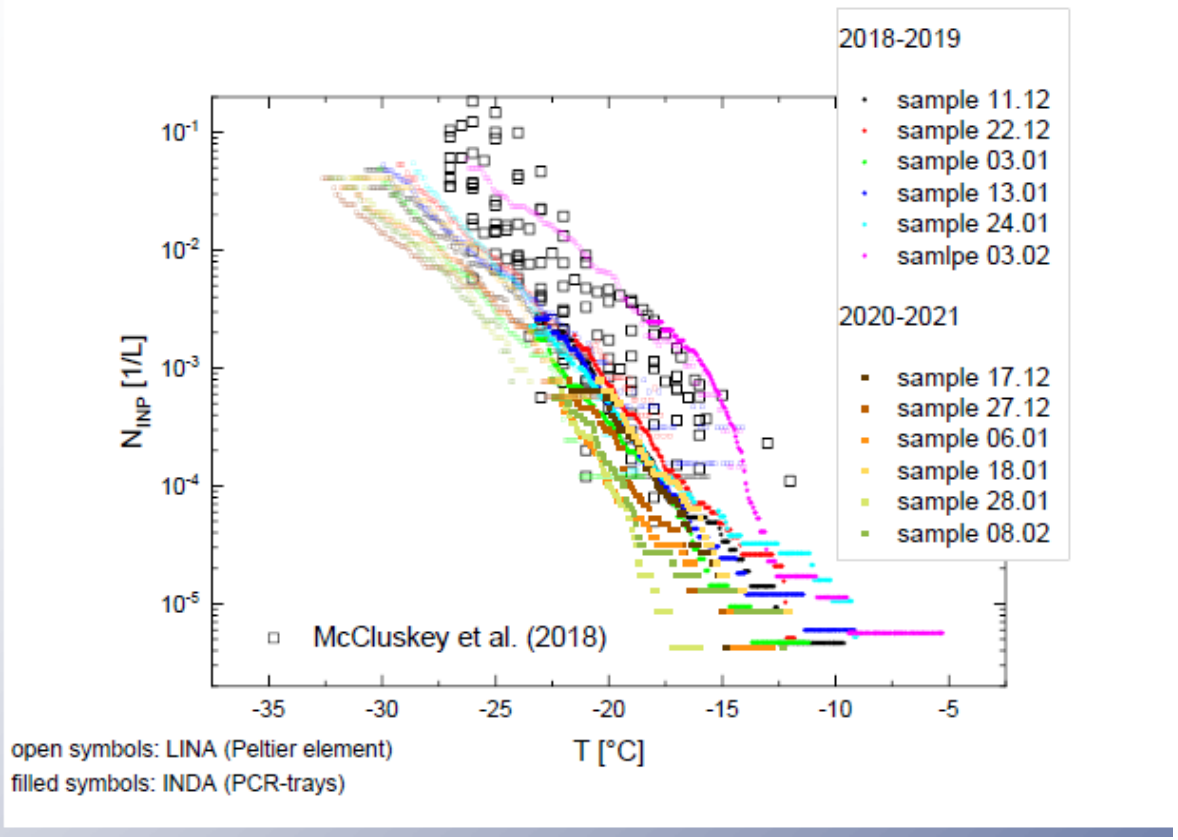
Volatile Organic Compounds can be precursors for new particle formation



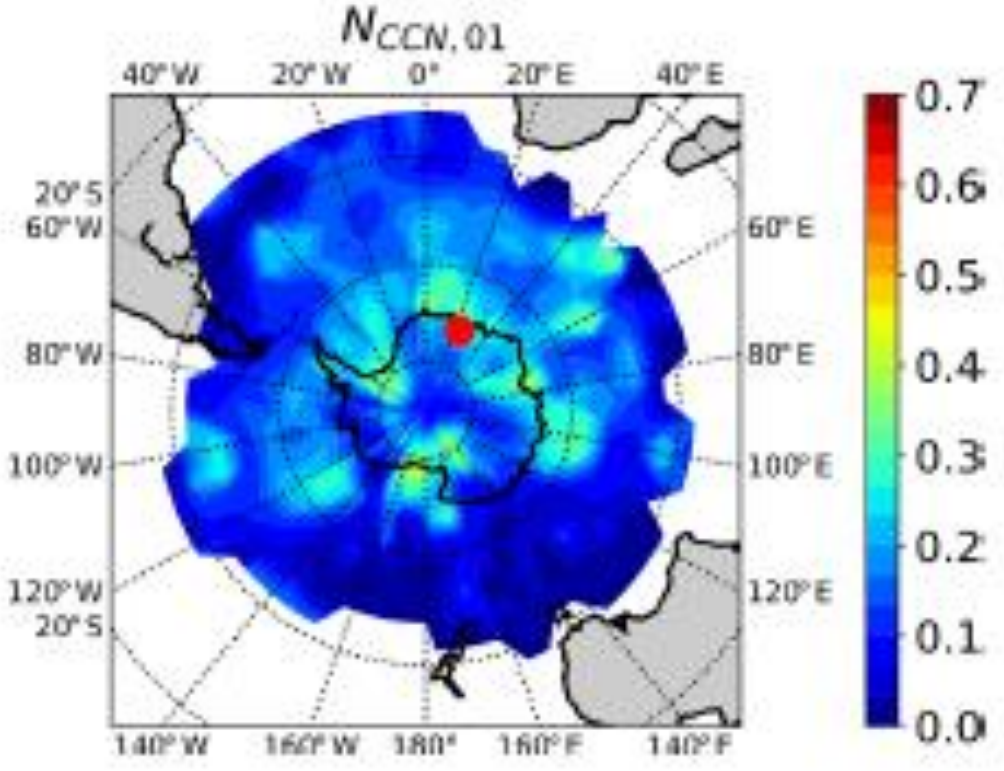


Sunlight is needed for these chemical reactions

Very low Antarctic ice nuclei concentrations

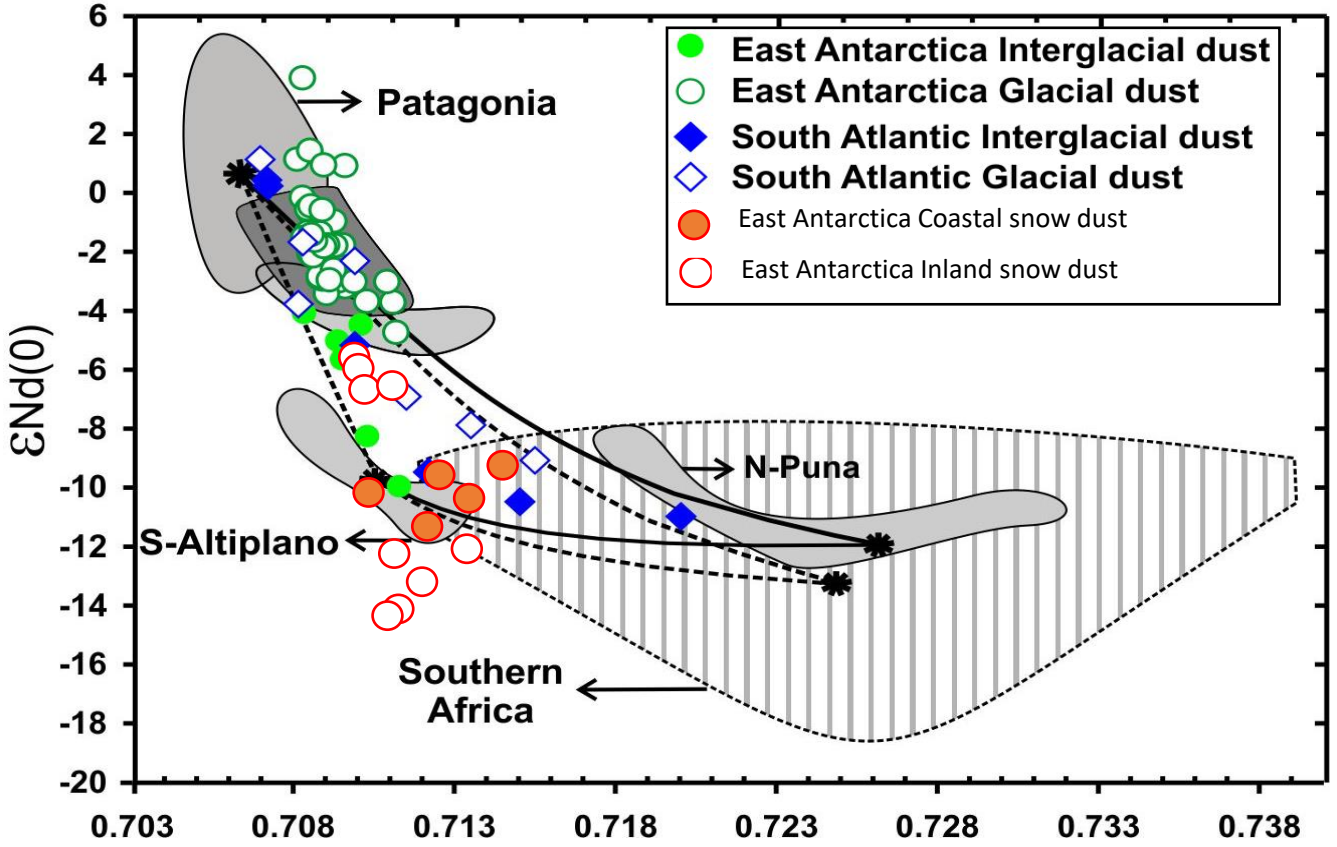


measured at PEA Wexet al., 2022



Potential air mass origins for cloud concentration nuclei Herenz et al. 2019

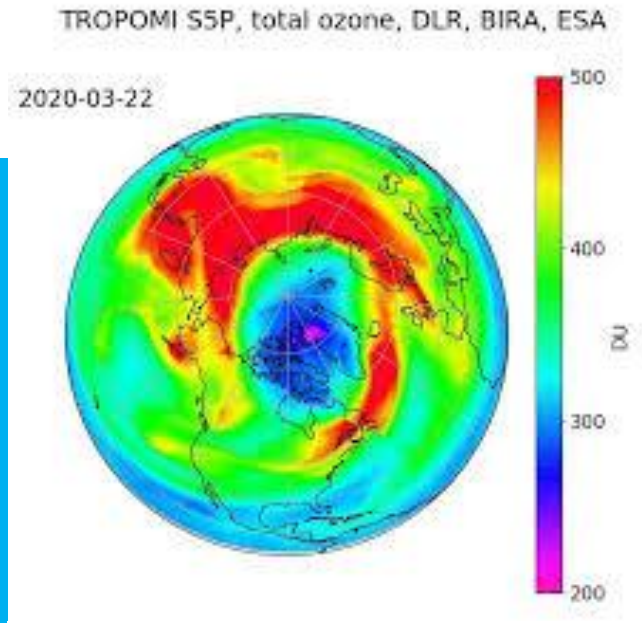
Dust origin might have changed

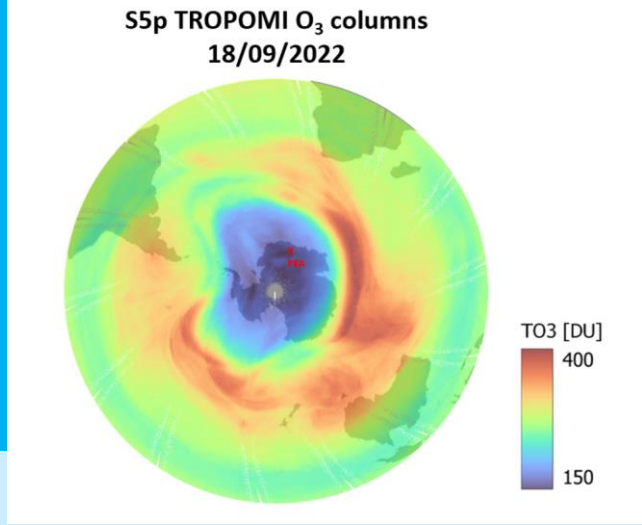


- isotopic analyses in recent surface snow samples
- change potential dust origin – compared to glacial and interglacial periods
- shift to Southern Africa

Gili et al., 2022

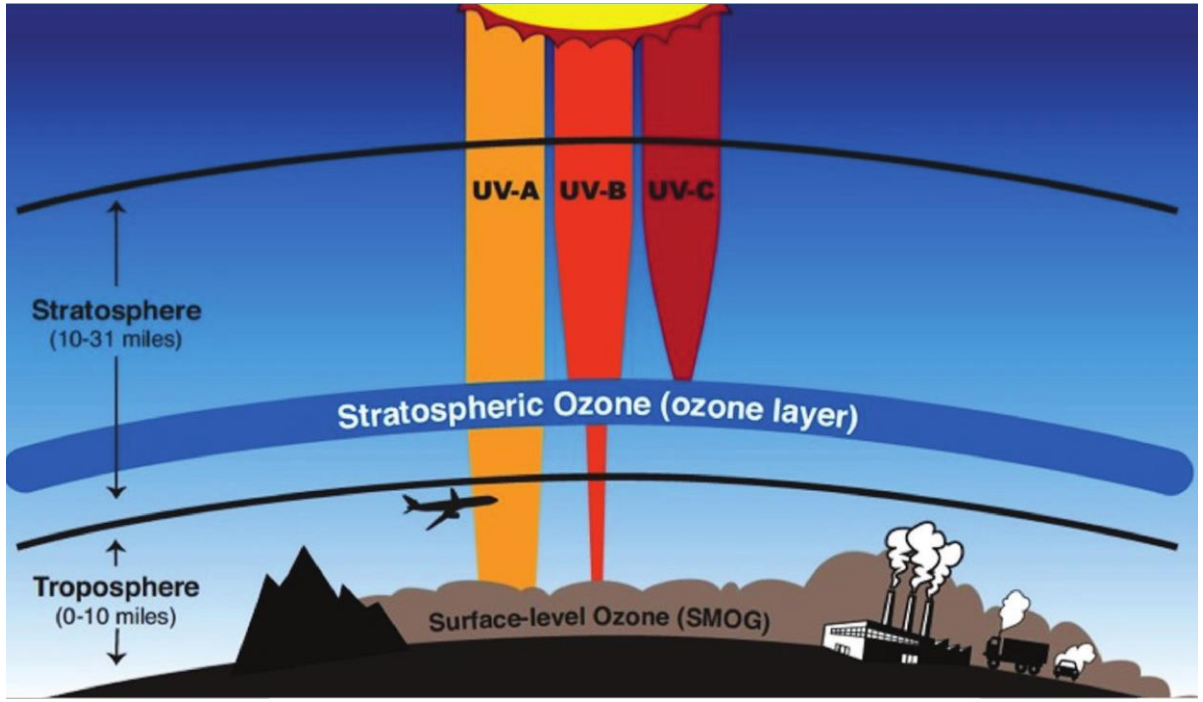
Arctic and Antarctic ozone hole

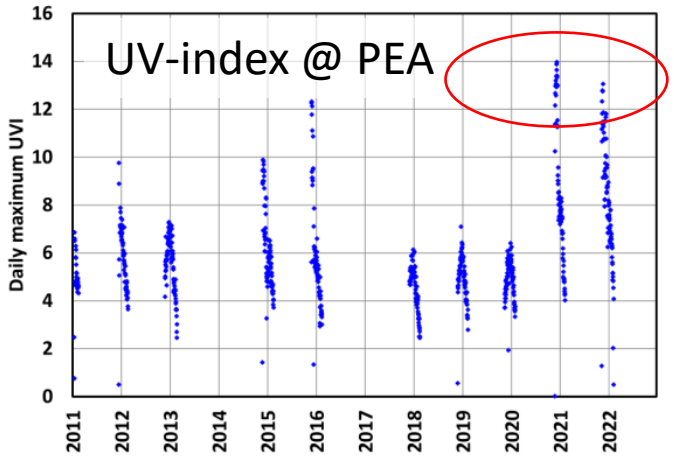


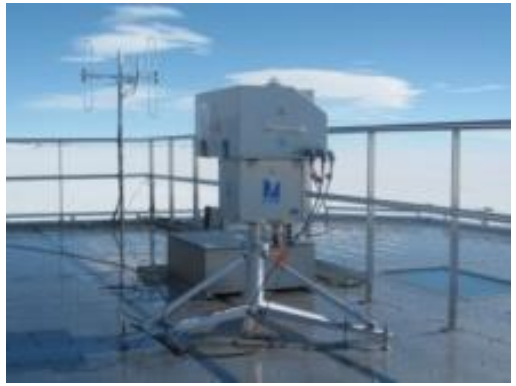


Stratospheric ozone protects

- against "hard" UV which would otherwise damage human health
- depleted by human-made products
- banned by Montreal protocol in 1987

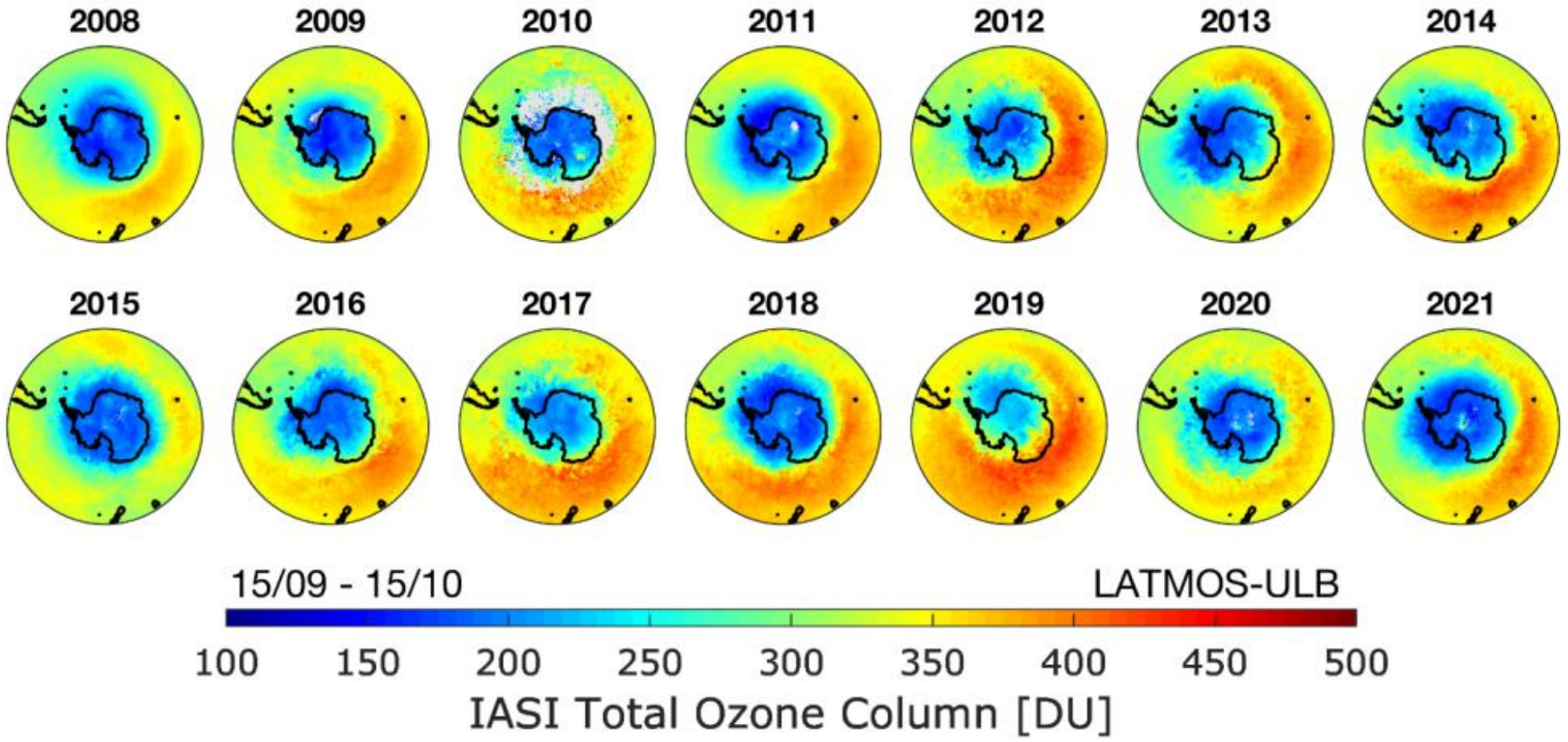






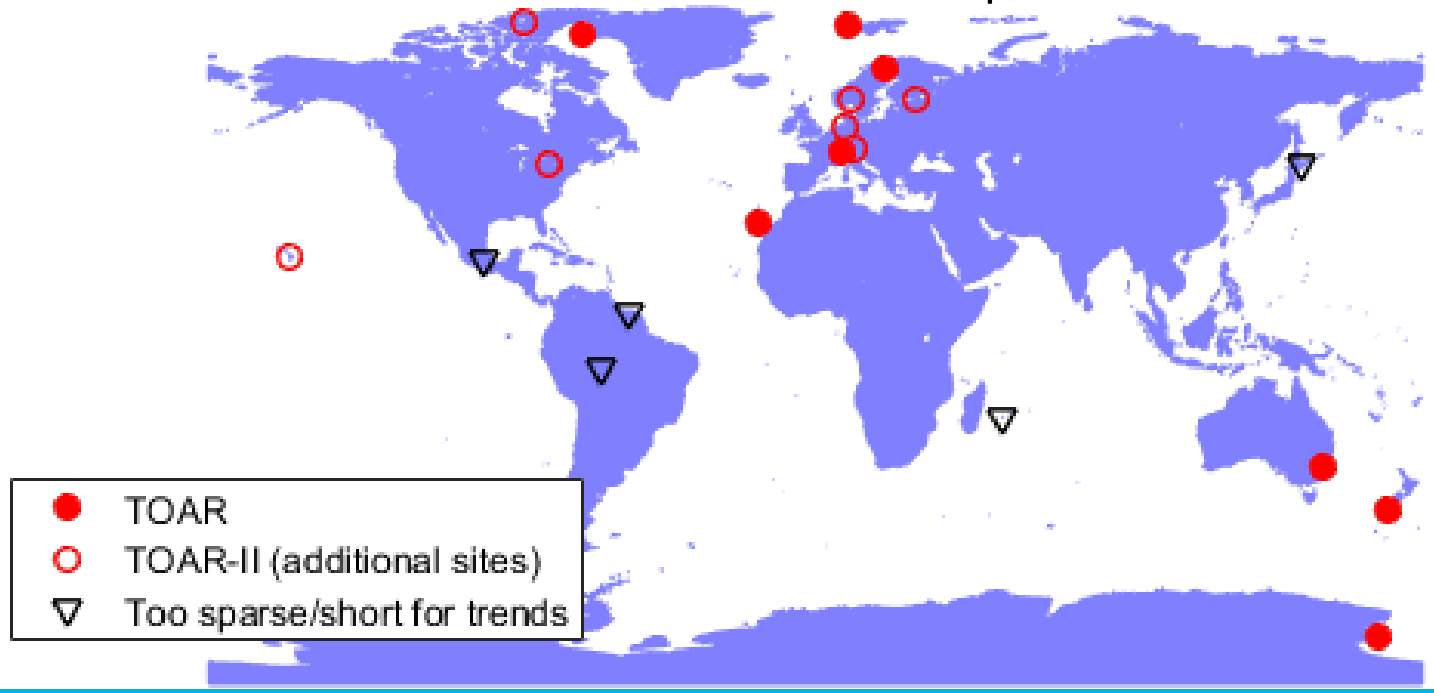
Recovery still not clearly detectable

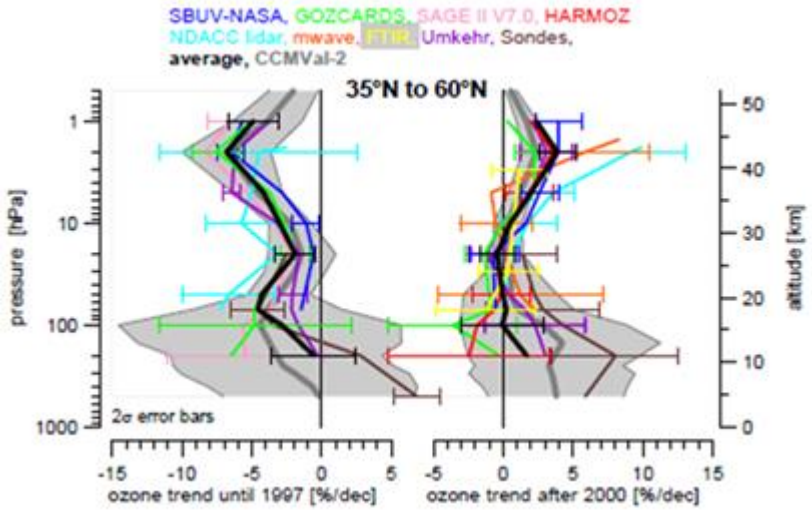
Monitoring polar ozone with IASI instrument onboard of EUMETSAT METOP satellites



Ground-based remote-sensing

- Long-term Fourier transform Infrared (FTIR) measurements (from the mid-90s for the oldest): total, tropospheric and stratospheric ozone
- Network for the Detection of Atmospheric Change; about 24 stations; 6 stations above 60°N; 1 in Antarctica
- Contribution to WMO ozone assessment reports

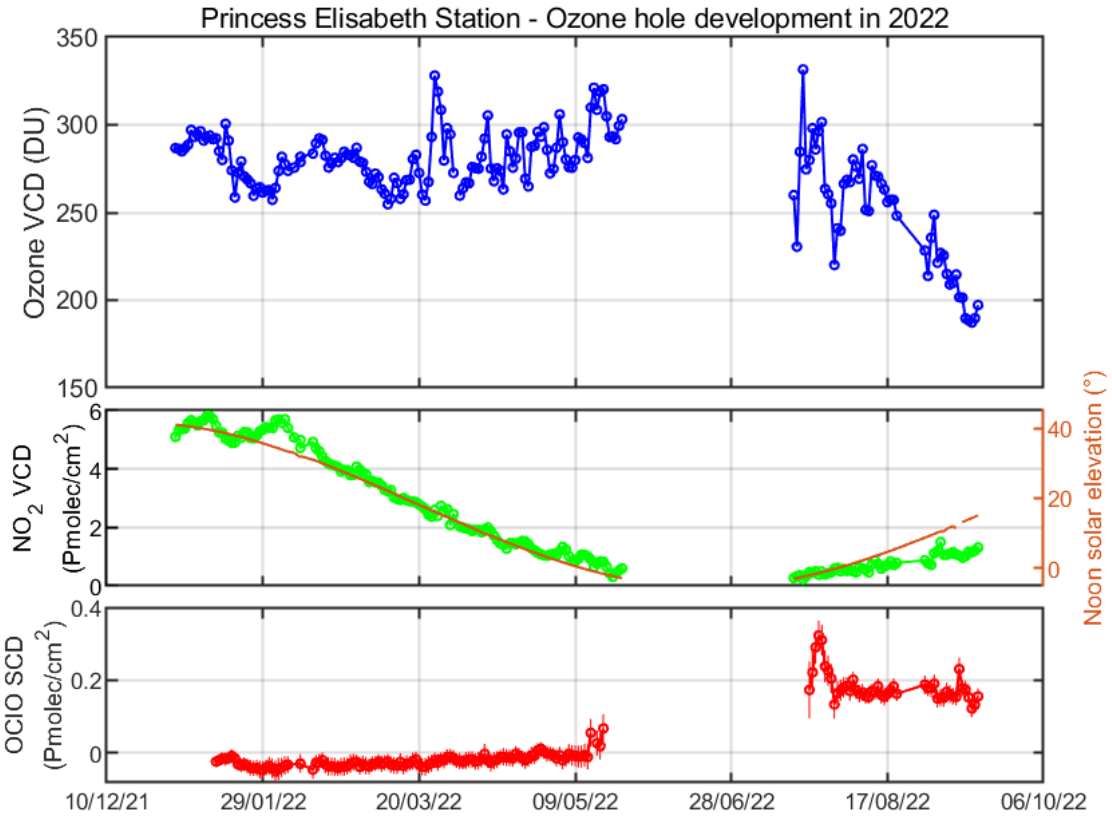


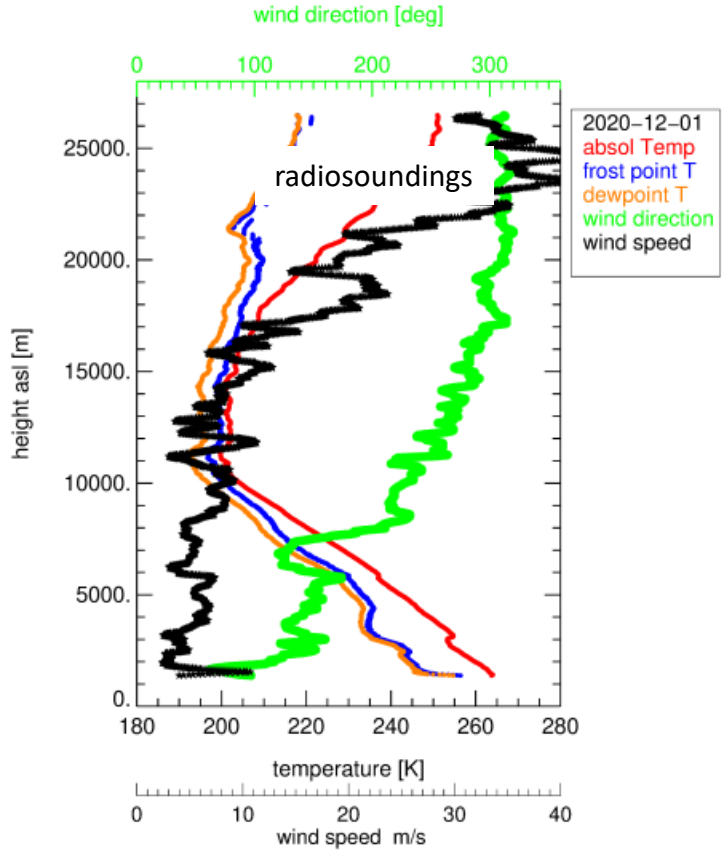


WMO 2014

Ground-based remote-sensing

Observations of stratospheric chemistry at PEA from MAXDOAS instrument





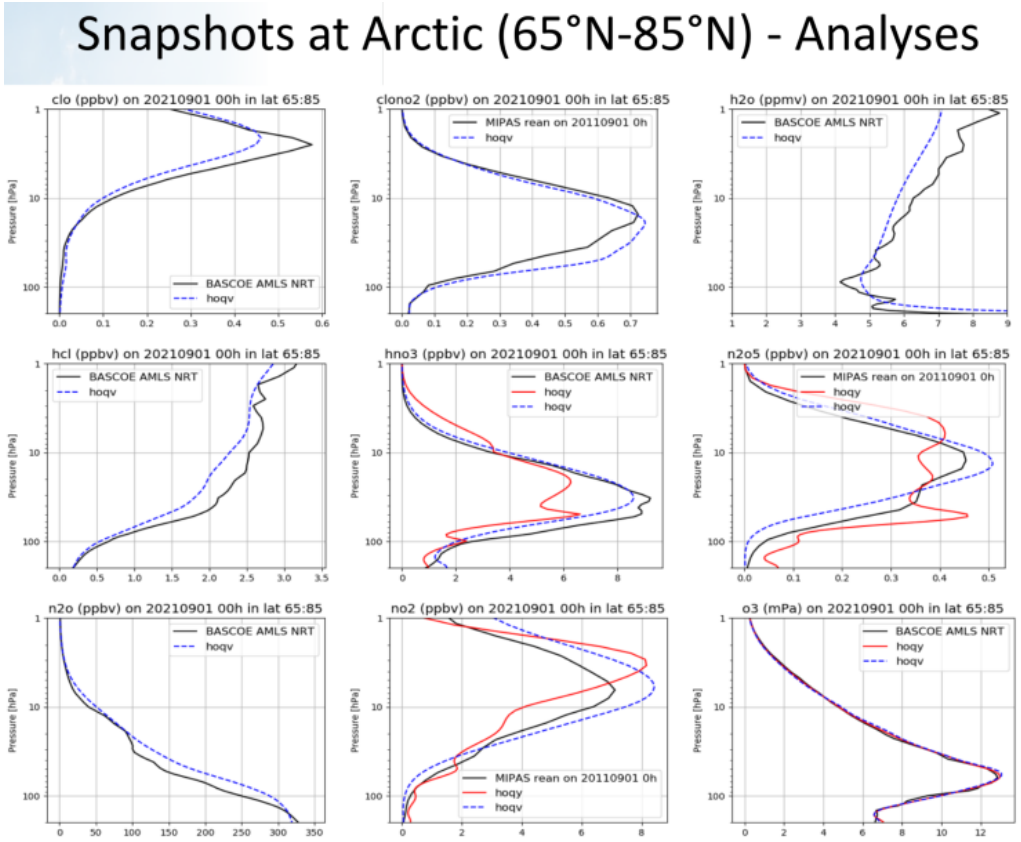
vertical profiles of meteorological parameters needed for retrieval algorithms

Modelling of stratospheric composition

Copernicus Atmosphere Monitoring Service (CAMS) provides near real-time data for air quality and the ozone layer, both globally and with a focus on Europe.

Next upgrade of the system:

- add stratochemistry module BASCOE
- improved ozone forecasts



BIRA reanalysis of MLS
CAMS-op
Future CAMS with BASCOE module

Thanks to BELSPO, IPF, other funding schemes, universities and federal institutes

BELSPO projects

- Hydrant
- Belatmos
- Aerocloud
- Chase
- Climb
- Mass2Ant