

# Aerosol-cloud interactions and radiative feedbacks

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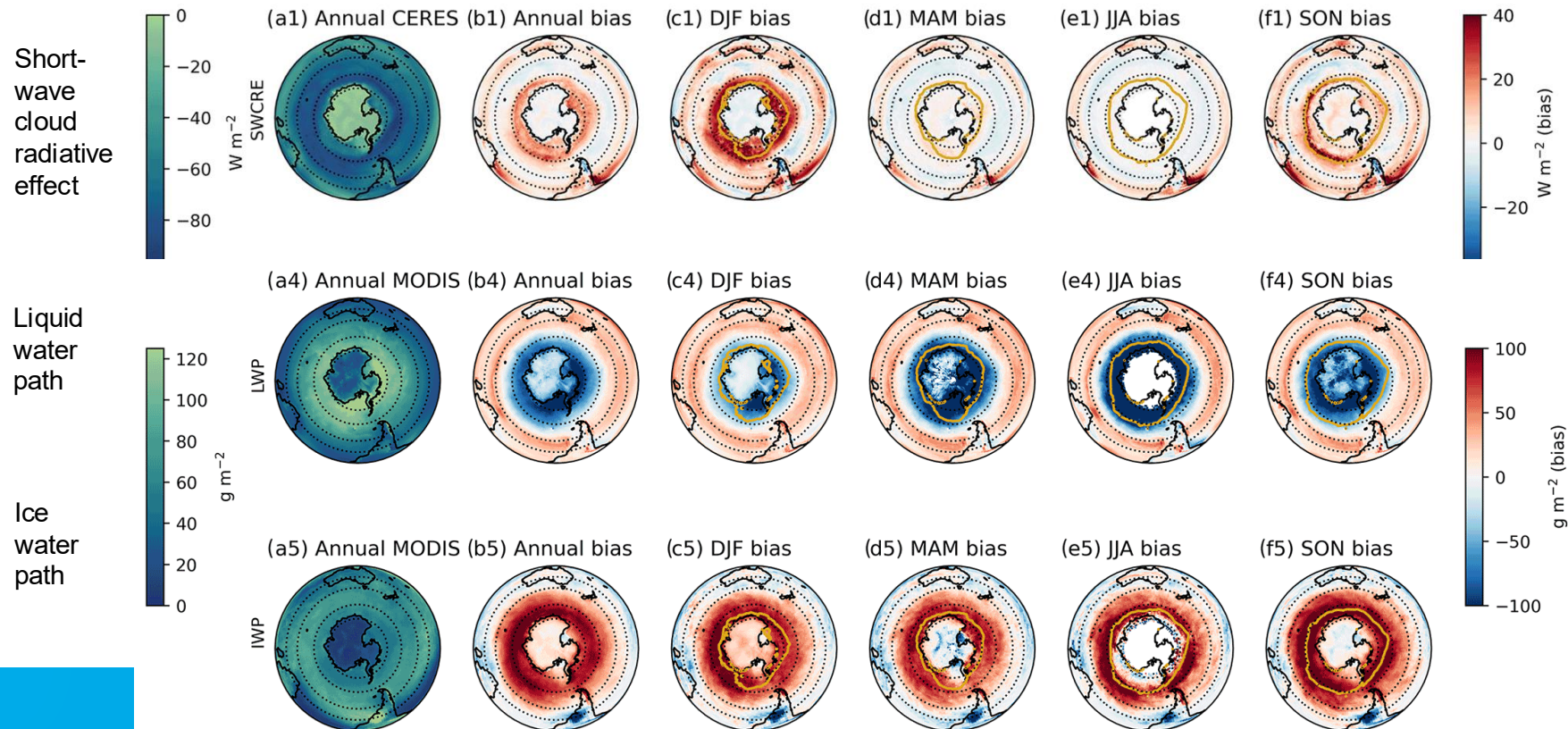


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# Why do we care about Aerosol-CLOUD interactions and radiative feedbacks?

- Significant variability in climate predictions originates from the simulated cloud cover over the Southern Ocean.
- Clouds have a marked impact on the energy balance.



ACCESS-AM2 radiation and cloud biases against CERES and MODIS

- SW radiative forcing up to 20  $W/m^2$
- Liquid water path bias up to -100  $g/m^2$  (Low bias)
- Ice water path bias up to +100  $g/m^2$  (High bias)

Fiddes et al., 2022, ACP



# Why do we care about Aerosol-CLOUD interactions and radiative feedbacks?

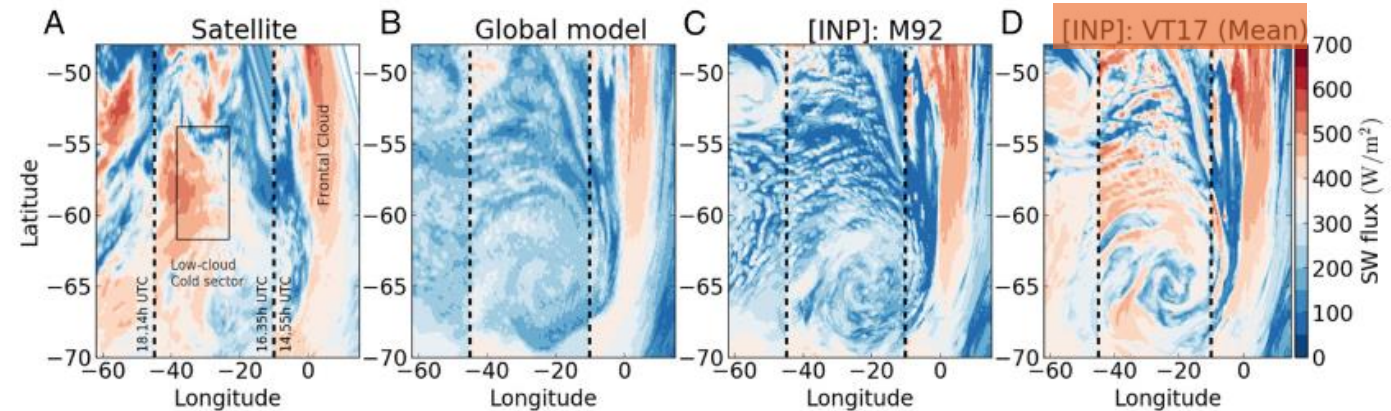
## Consequences in climate modeling:

- resultant biases in sea surface temperature (SST), up to 3 K too warm in the subtropics,
- lead directly to incorrect simulations of sea-ice extent,
- the position of the tropopause jet,
- and storm track locations
- as well as generating substantial bias in the top-of-atmosphere reflected shortwave radiation.



# Why do we care about AEROSOL-cloud interactions and radiative feedbacks?

- Aerosols determine the liquid and ice phase of clouds (to large extent) through **cloud condensation nuclei (CCN)** and **ice nucleating particles (INP)**
- Our knowledge on the sources, processes and abundances of CCN and INP are extremely poor



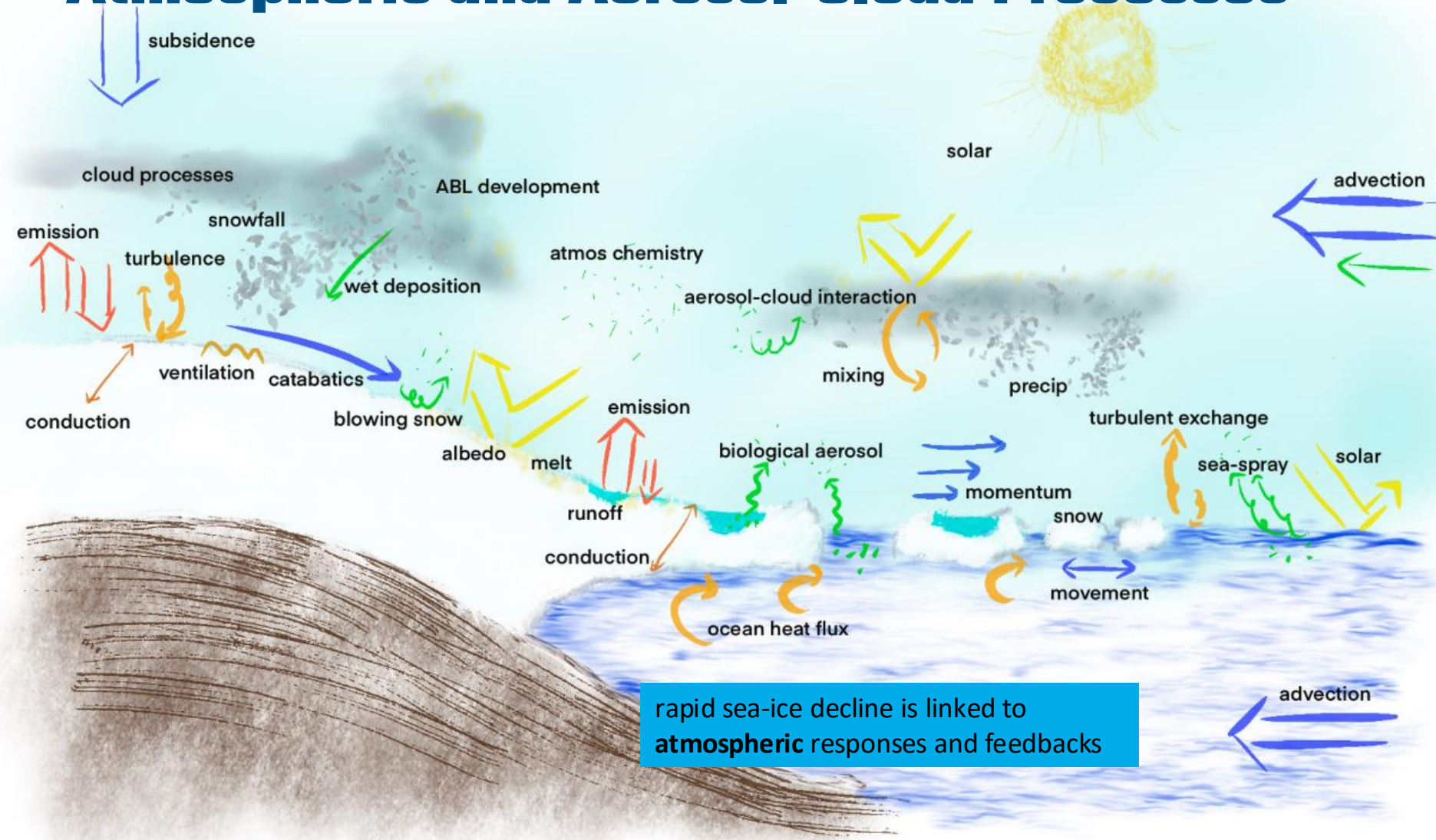
Vergara-Temprado et al., 2018, PNAS

- **This inhibits us to improve cloud radiative property representation in models**
- **Other factors like the ocean, sea ice decline and land ice need to be taken into account**

# Atmospheric and Aerosol-Cloud Processes



Surface mass balance and melt are a function of **atmospheric** responses and feedbacks



rapid sea-ice decline is linked to **atmospheric** responses and feedbacks

accumulation, thermal structure, winds, stratification, aerosol growth, ice advection, ice flow

Ice Sheet

Ice Shelves

Sea Ice + Snow

Open Ocean

Courtesy of Matt Shupe



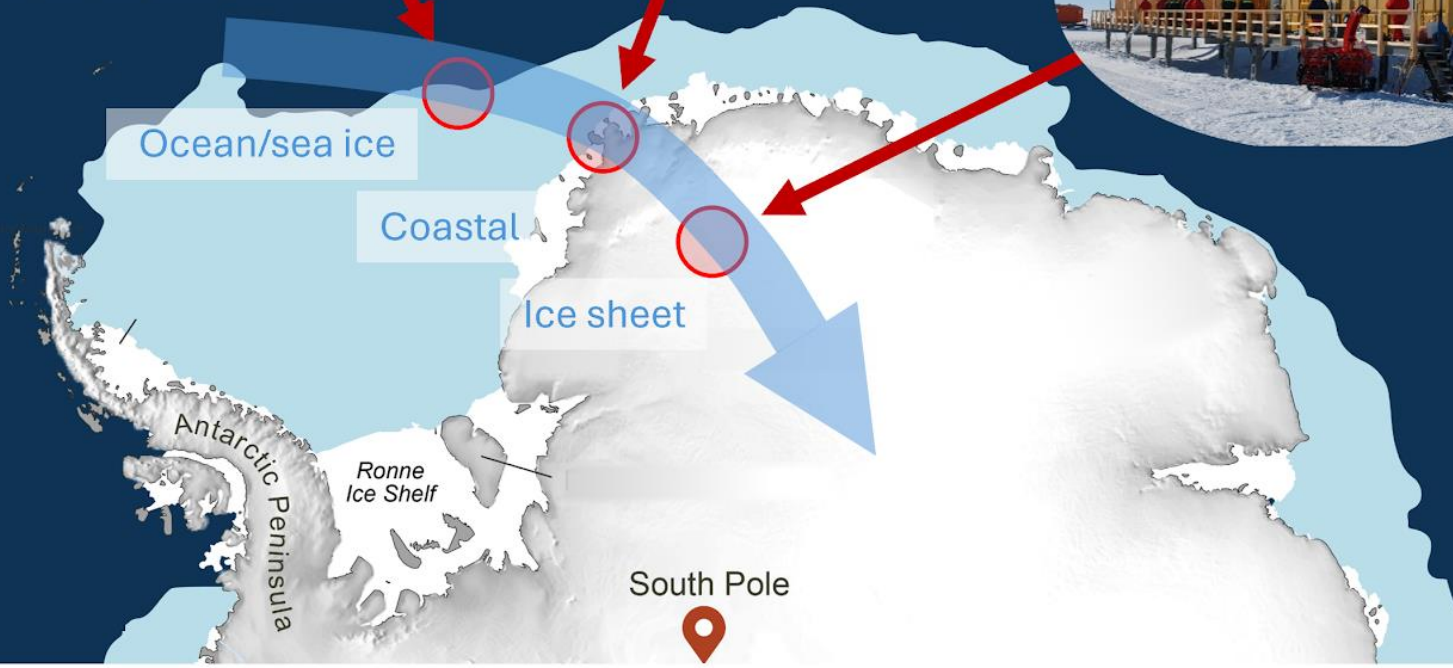
## Overarching Objective

- The **atmosphere** of the Southern Ocean / Antarctic region is closely **coupled** to the **ocean, sea ice, land surfaces and ice sheets** via a wide range of coupling processes.  
→ **many of these processes are only poorly understood**
- The **observational strategy** for the atmospheric component will be designed such that these **processes and their role** for Southern Ocean / Antarctic **climate change** will be understood better.  
→ **This shall lead to a better representation of these processes in climate models.**

# Implementation



Air mass transformation





## Next Steps

- A white paper draft for this theme is in preparation including
  - Overarching research questions
  - Specific research questions
  - Envisaged work program on the various platforms
- To build an international community for this theme, we need to know about your interest so we can gather.
  - Sign up on the Antarctica InSync website!
  - Join your national InSync team
- Beyond InSync join international IPY5 planning efforts

**Thank you**

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# Specific research questions - preliminary



1. What is the partitioning of types and sources of atmospheric aerosols in the SOA region?
2. How do variations in aerosol properties impact the phase partitioning and persistence of SOA clouds?
3. How do aerosol and cloud processes depend on the atmospheric circulation regime in the SOA?
4. How do atmosphere-surface exchanges of heat and moisture/mass differ between the sea ice and ice sheet regions of the SOA as a function of circulation regime?
5. How do boundary layer fluxes of heat and momentum depend on the SOA surface types and meteorological conditions?
6. How do superstable atmospheric boundary layer stratifications form, how do they influence exchange processes between surface and atmosphere?
7. Which processes contribute to sources and sinks of greenhouse gases?
8. What is the role of atmospheric chemistry from the boundary layer to the stratosphere in ongoing climatic changes?
9. How is the current atmospheric composition represented in snow and ice samples, and how are ongoing changes documented in the climate archive?
10. Which dedicated additional measurements have the potential to fill observational gaps with significant improvements of parameterisations for climate models?



# Overarching science questions - preliminary

1. What is the role of atmospheric processes for the observed turnaround in overall and regional trends in sea ice extent?
2. What are the driving mechanisms for the observed series of heat waves and temperature records on the ice sheet? Do these establish new climate trends in the SOA region, including on the central Antarctic plateau?
3. What is the contribution of changing cloud processes and aerosol/cloud coupling for climate change in the SOA region as compared to other mechanisms?
4. What is the contribution of atmospheric circulation changes for climate change in the SOA region, including trends of the occurrence frequency of atmospheric rivers, as compared to other mechanisms?
5. How does the atmospheric boundary layer influence the exchange between surface and atmosphere and is modified by exchange processes?