



結合區域模式與再分析資料探討全球暖化下極區
夏季氣候變化與大氣回饋機制

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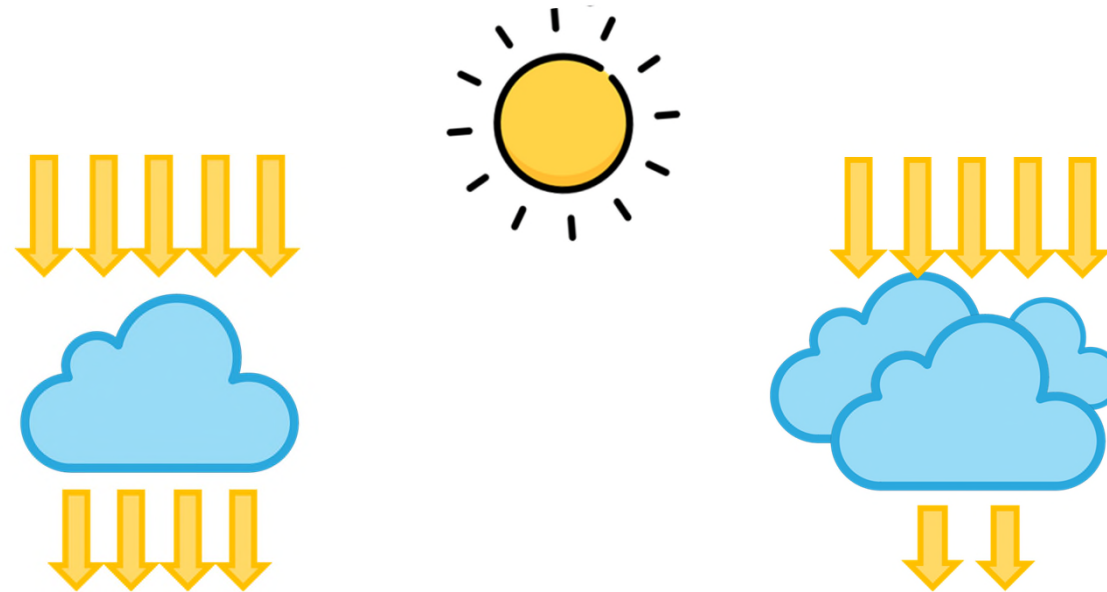
Outline

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- 01 Introduction
- 02 Data and method
- 03 Results
- 04 Summary

Introduction

- In recent decades, **temperatures in the Arctic have increased dramatically** because of growing concentrations of greenhouse gases and complex feedback processes. (Hartmann et al. 2013)
- **Clouds are crucial that impact radiative balance and temperatures** at the surface and at the top of the atmosphere. (Taylor et al. 2015 ; Wyser et al. 2005)



Therefore, this study tried to use WRF model to understand **how global warming impact the Arctic atmosphere** .

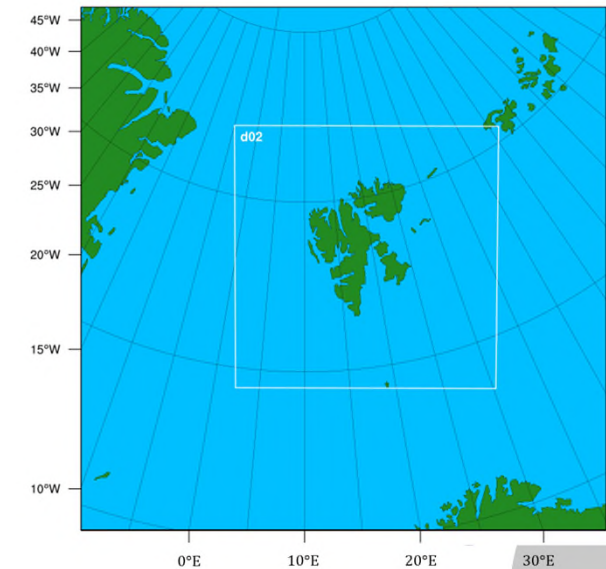
Data and method

- WRF model configuration

Configuration	
WRF version	WRF 4.4
Resolution	9 km / 3km
Simulation Period	2013/08/01 - 2013/08/30 2023/08/01 - 2023/08/30
Simulation Strategy	Simulate 36 hrs and spin up 12 hrs every single day
Vertical levels	136 levs to top 10 hpa
Input data	ERA5
Microphysical scheme	Thompson-Eidhammer Aerosol-Aware
PBL scheme	MYNN Level 2.5 EDMF
Long-wave radiation scheme	RRTMG longwave scheme
Short-wave radiation scheme	RRTMG shortwave scheme
Land surface model	Noah-MP land surface model
Surface layer scheme	revised MM5 surface layer physics parameterization



Domain setting

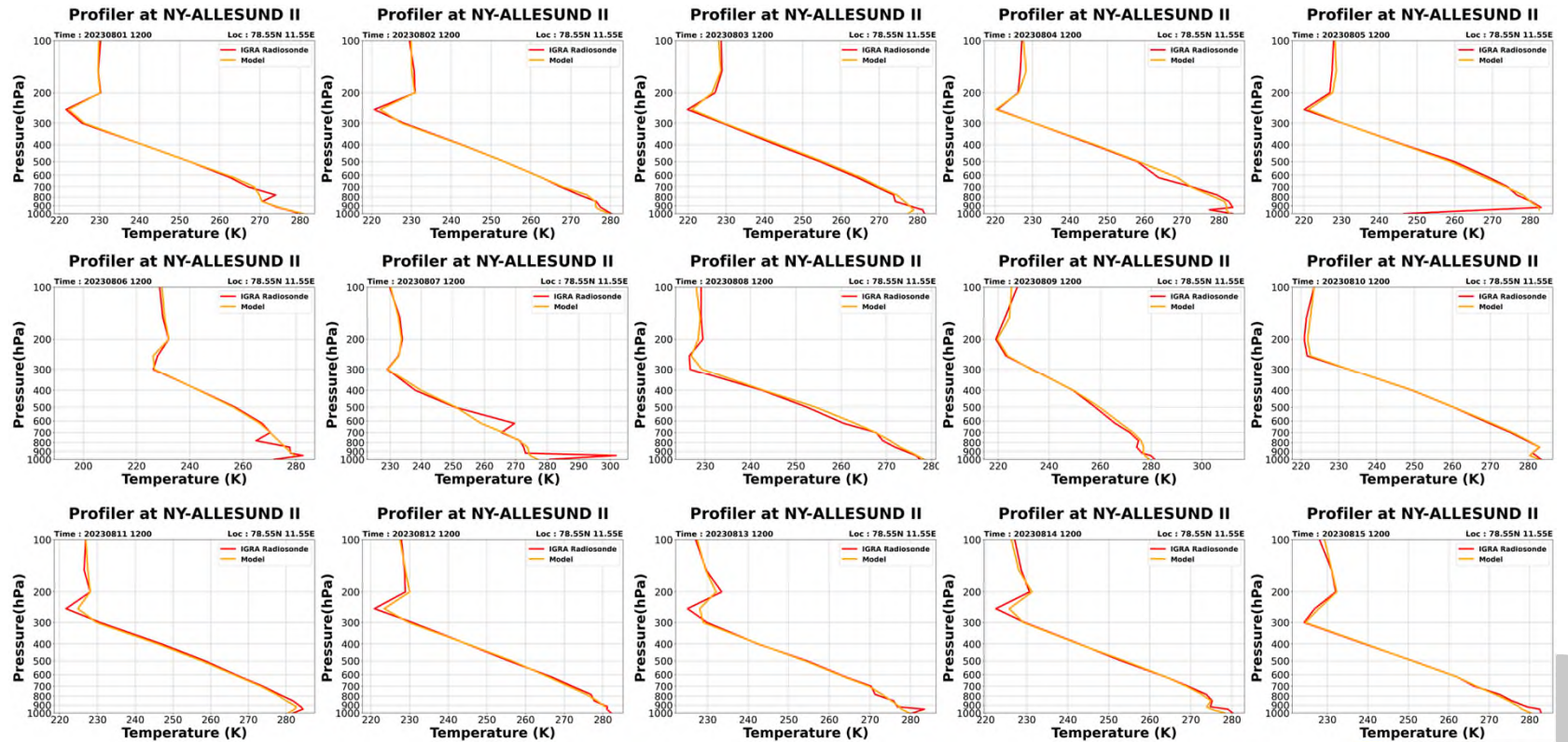


- Sounding data

Integrated Global Radiosonde Archive (IGRA) from NOAA

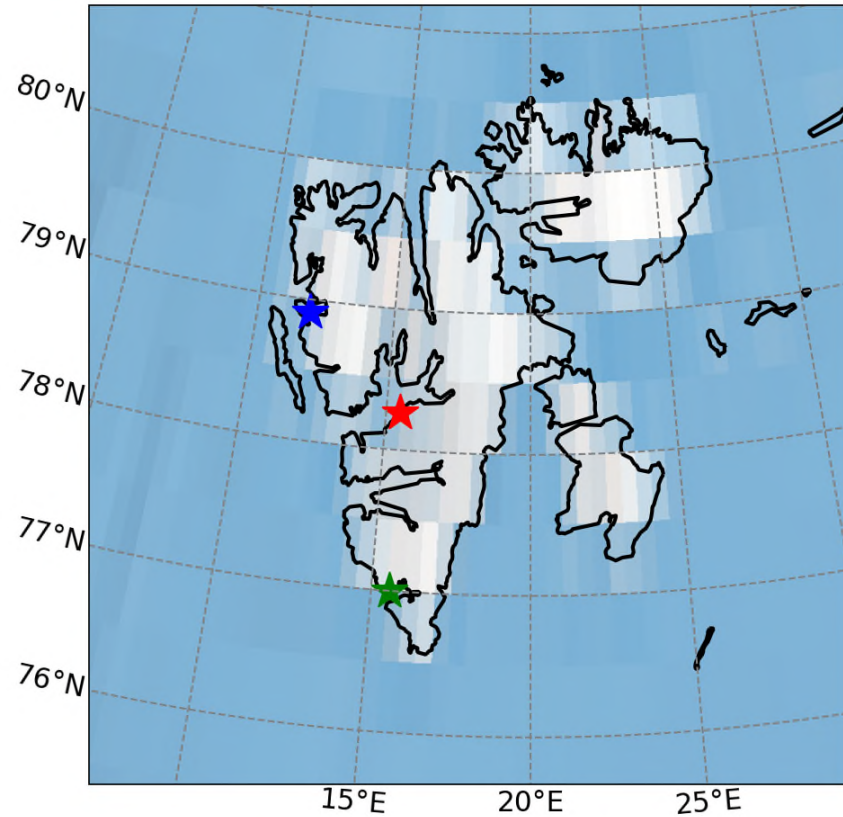
0801-0815

WRF ; IGRA



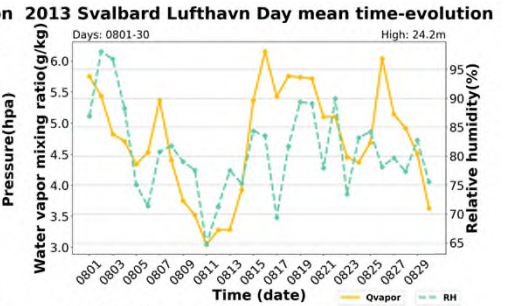
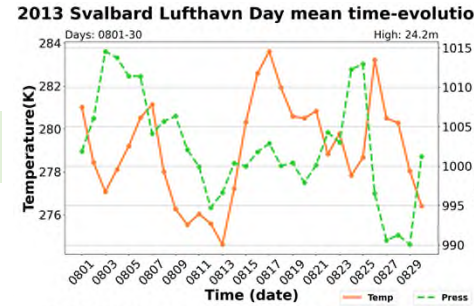
- Observation data of Stations

Ny-ålesund ; Svalbard Lufthavn ; Hornsund

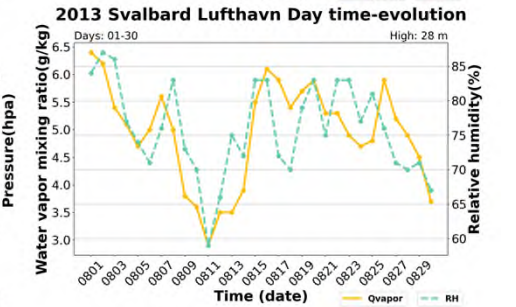
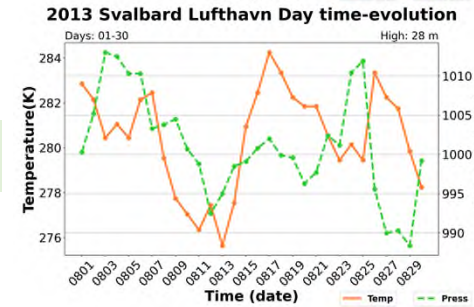


2013

Mol

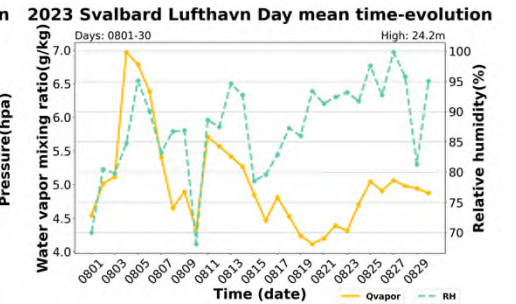
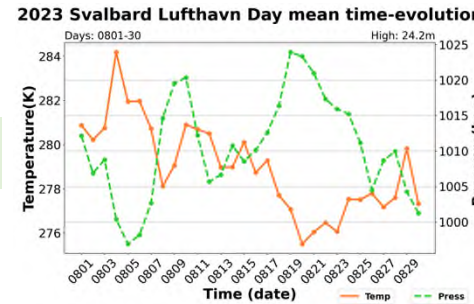


Obs

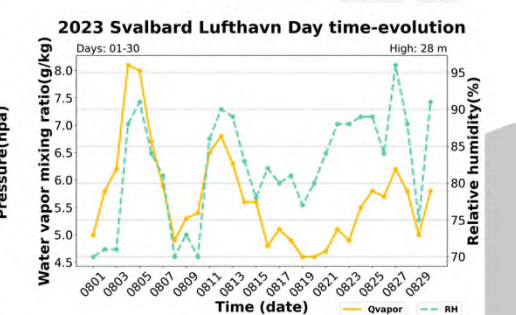
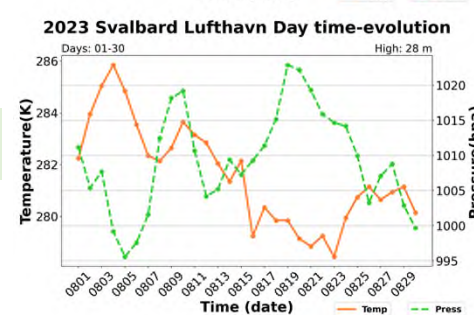


2023

Mol



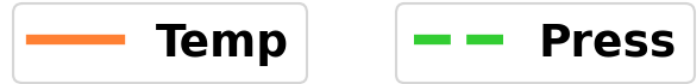
Obs



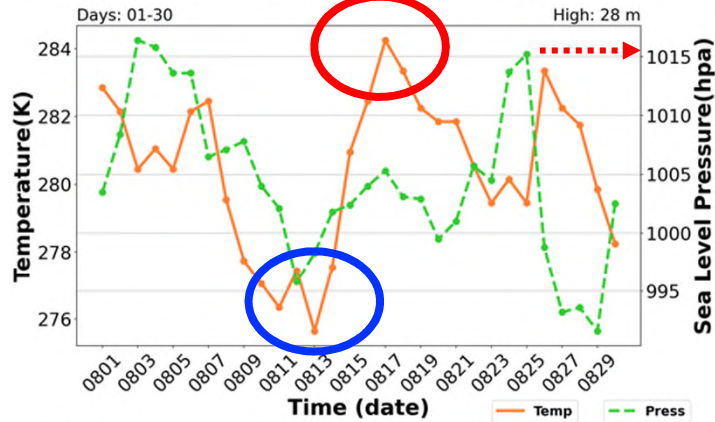
Result

Results

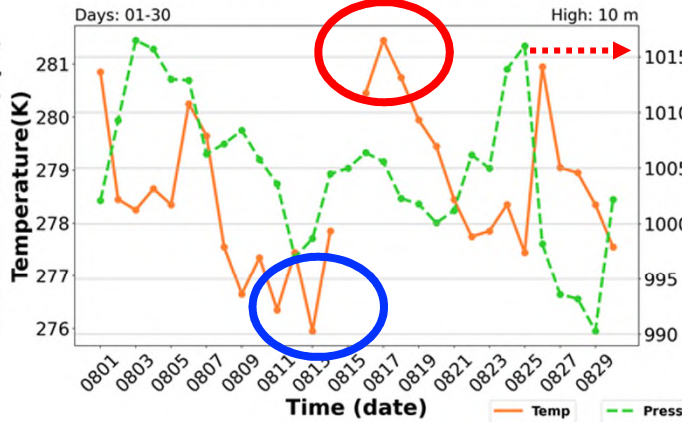
- 2013 2023 Station Observation – P and T



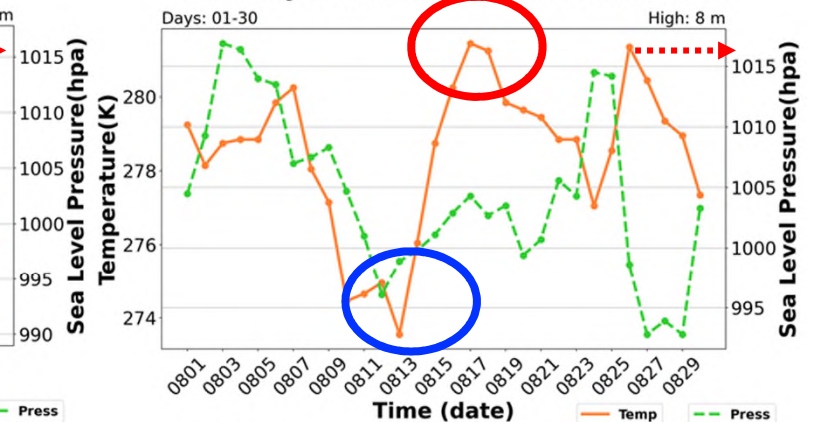
2013 Svalbard Lufthavn Day time-evolution



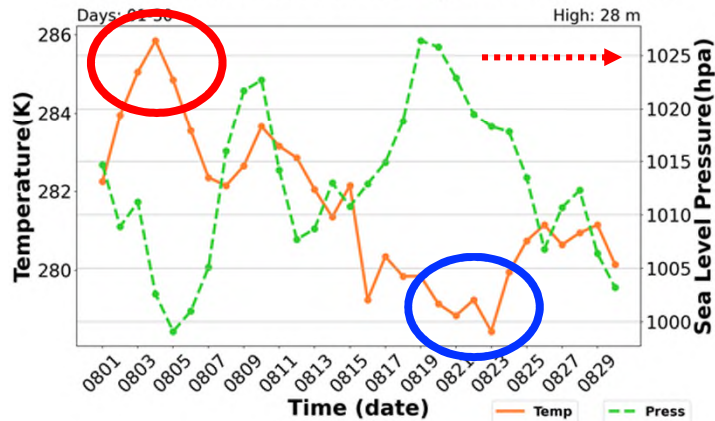
2013 Hornsund Day time-evolution



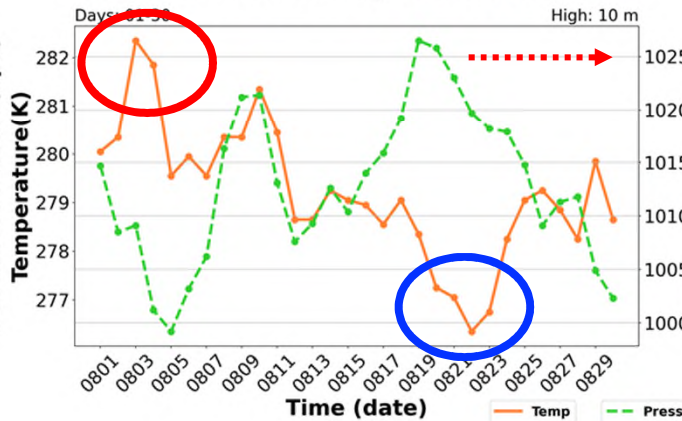
2013 Ny-ålesund Day time-evolution



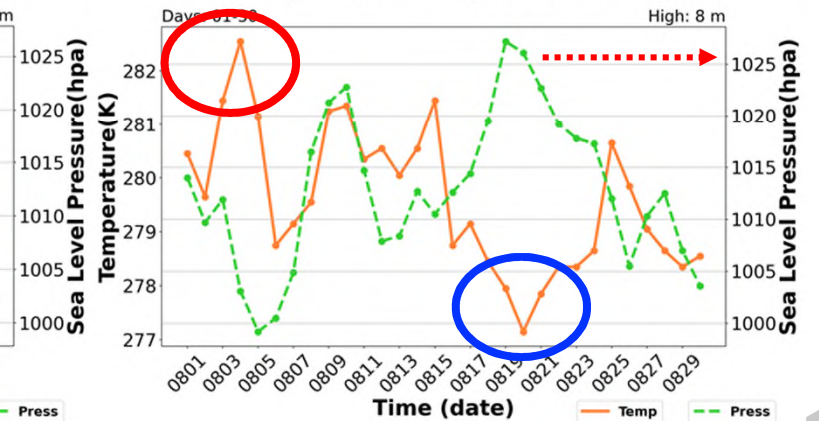
2023 Svalbard Lufthavn Day time-evolution



2023 Hornsund Day time-evolution

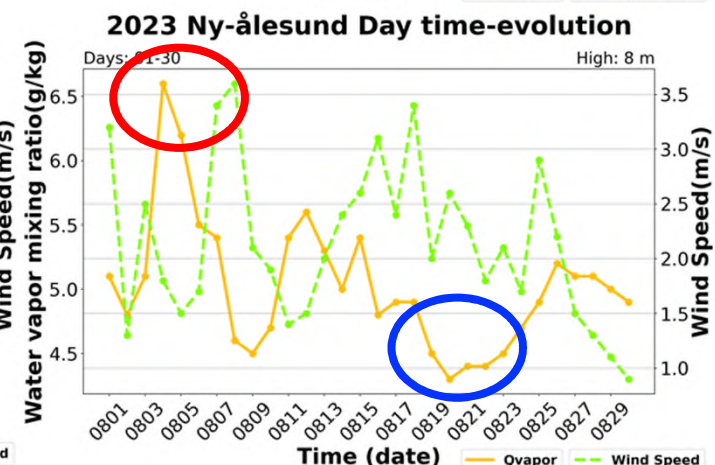
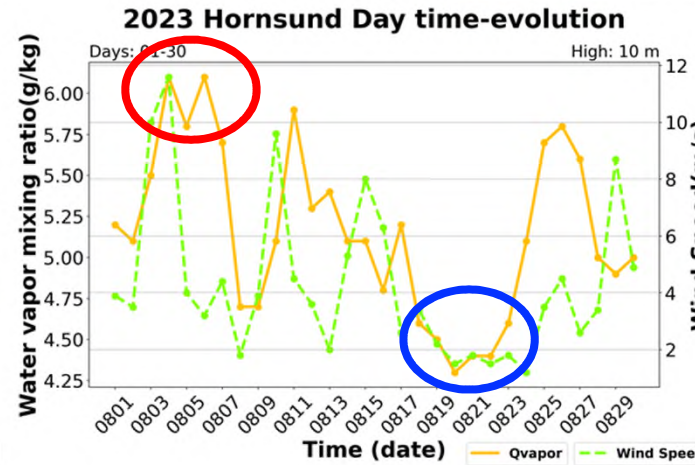
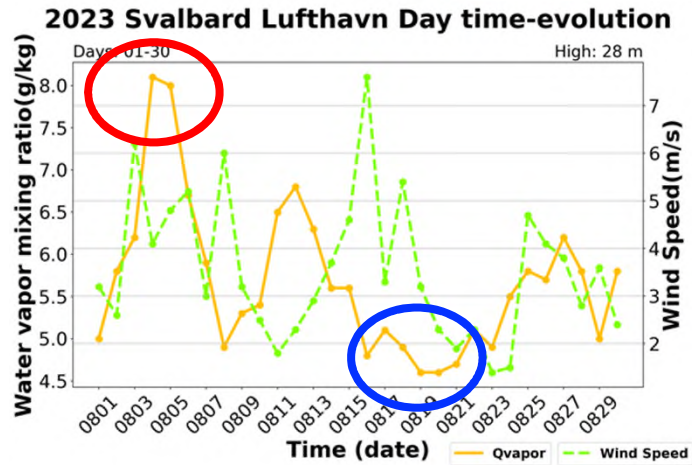
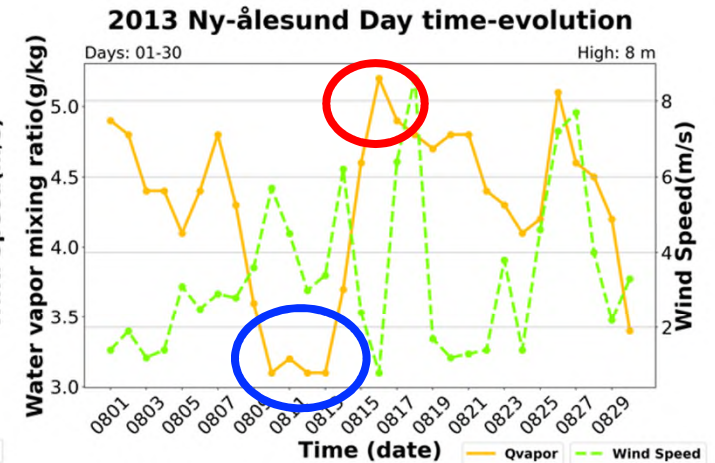
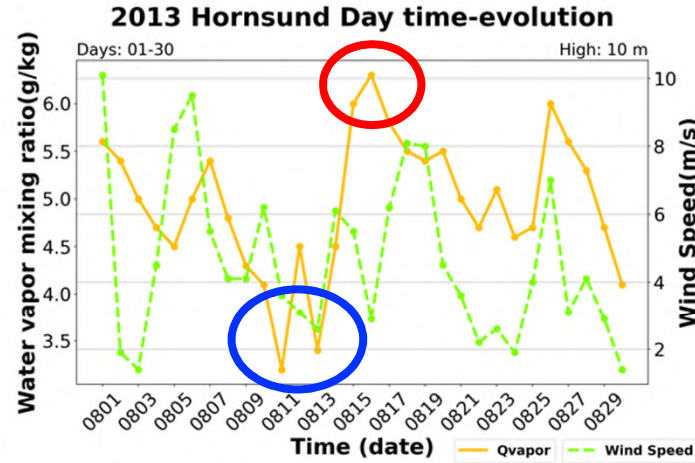
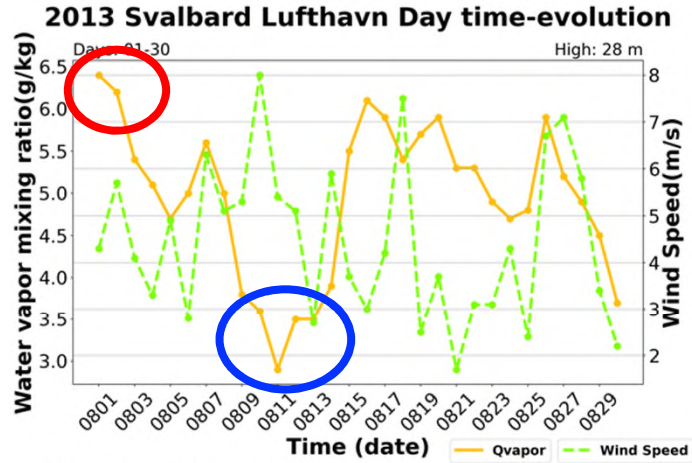


2023 Ny-ålesund Day time-evolution



Results

- 2013 2023 Station Observation – Qv and WS



Svalbard Lufthavn (Mean)	Station Obs (2013/2023)		WRF Model (2013/2023)		ERA5 (2013/2023)	
Temperature (K)	280.50	281.59	278.31	278.33	280.04	280.91
Sea Level Pressure (hPa)	1004.39	1012.92	1005.40	1013.60	1004.54	1012.93
Humidity g/kg	4.94	5.69	4.74	5.02	5.29	5.48
Wind Speed (m/s)	4.44	3.55	4.18	2.50	4.70	3.33
Accumulated Precipitation	1.97 mm	1.64 mm	2.13 mm	1.38 mm	2.52 <i>kg/m²</i>	1.97 <i>kg/m²</i>

Increase : Surface Temperature 、 Pressure 、 Humidity

Decrease : Wind Speed 、 Precipitation

Hornsund (Mean)	Station Obs (2013/2023)		WRF Model (2013/2023)		ERA5 (2013/2023)	
Temperature (K)	278.63	279.21	278.03	278.16	278.74	279.11
Sea Level Pressure (hPa)	1004.73	1012.95	1005.41	1012.55	1004.89	1013.15
Humidity (g/kg)	4.96	5.16	5.12	5.16	5.16	5.21
Wind Speed (m/s)	4.64	4.31	6.03	5.89	5.46	5.48
Accumulated Precipitation (mm)	2.54	1.89	6.97	3.38	4.93	2.96
					kg/m^2	kg/m^2

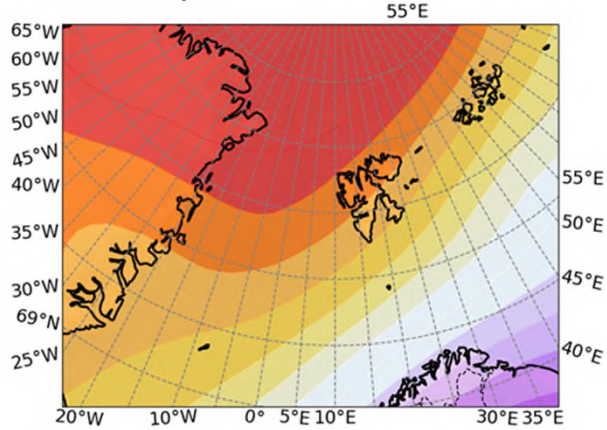
Ny-ålesund (Mean)	Station Obs (2013/2023)		WRF Model (2013/2023)		ERA5 (2013/2023)	
Temperature (K)	278.47	279.60	277.52	278.45	279.04	280.11
Sea Level Pressure (hPa)	1004.42	1012.86	1004.77	1012.95	1004.20	1012.85
Humidity (g/kg)	4.28	5.03	4.51	4.97	4.87	5.16
Wind Speed (m/s)	3.39	2.14	6.37	4.60	3.42	2.18
Accumulated Precipitation (mm)	3.34	1.96	3.09	1.97	3.06	1.70
					kg/m^2	kg/m^2

Increase : Surface Temperature 、 Pressure 、 Humidity

Decrease : Wind Speed 、 Precipitation

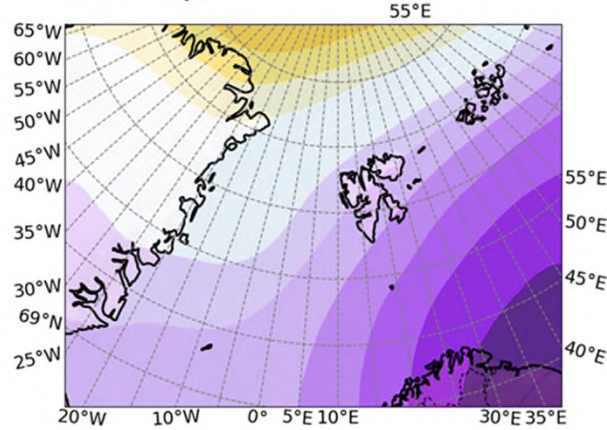
2013 ERA5_Geopotential

Plev : 500 hpa



2023 ERA5_Geopotential

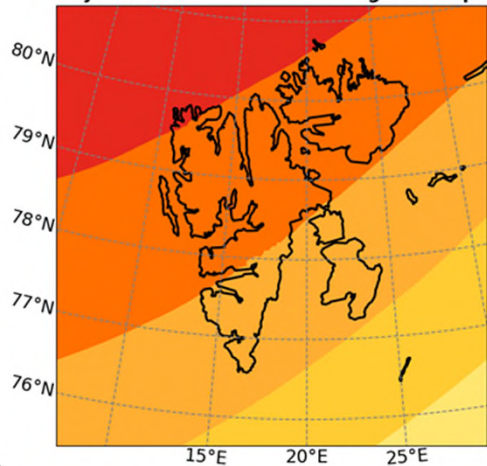
Plev : 500 hpa



2013 WRF

Days: 0801-30

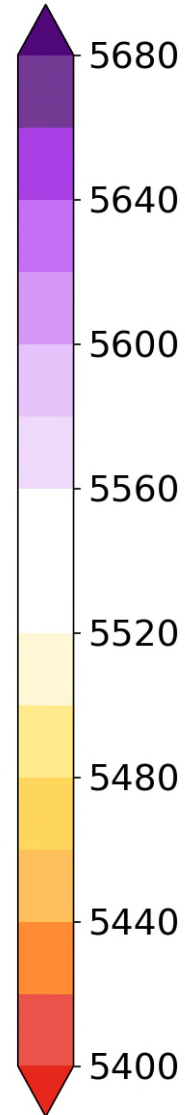
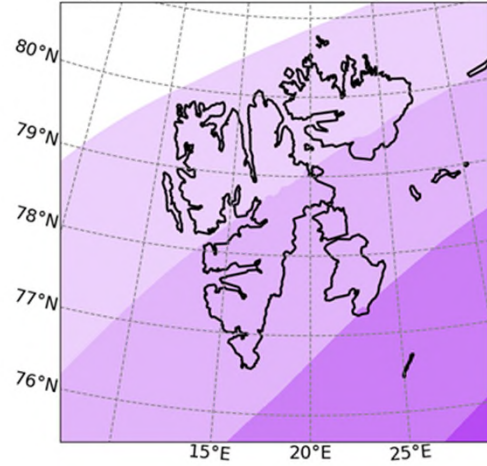
High: 500 hpa



2023 WRF

Days: 0801-30

High: 500 hpa

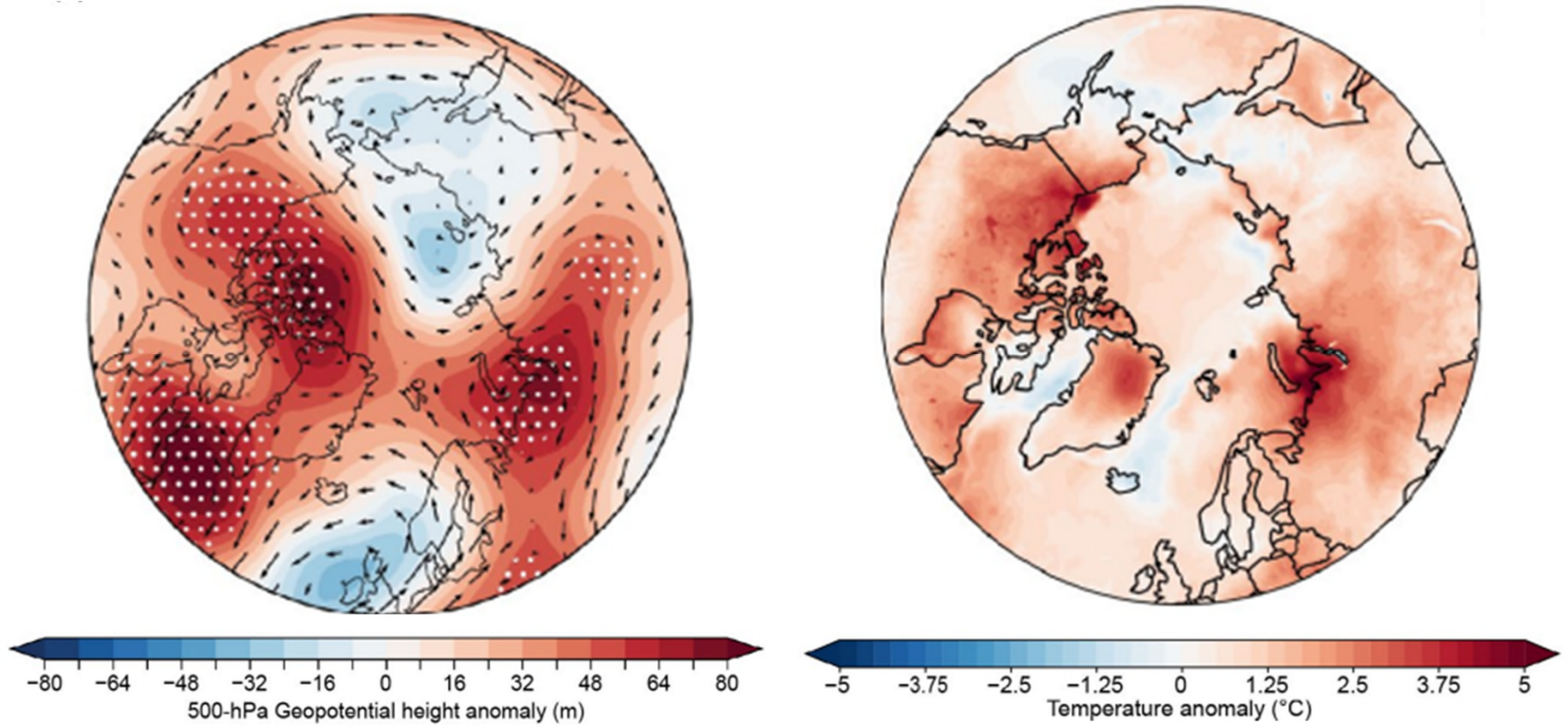


Summer

Geopotential height become higher across a broad region of the Arctic in 2023

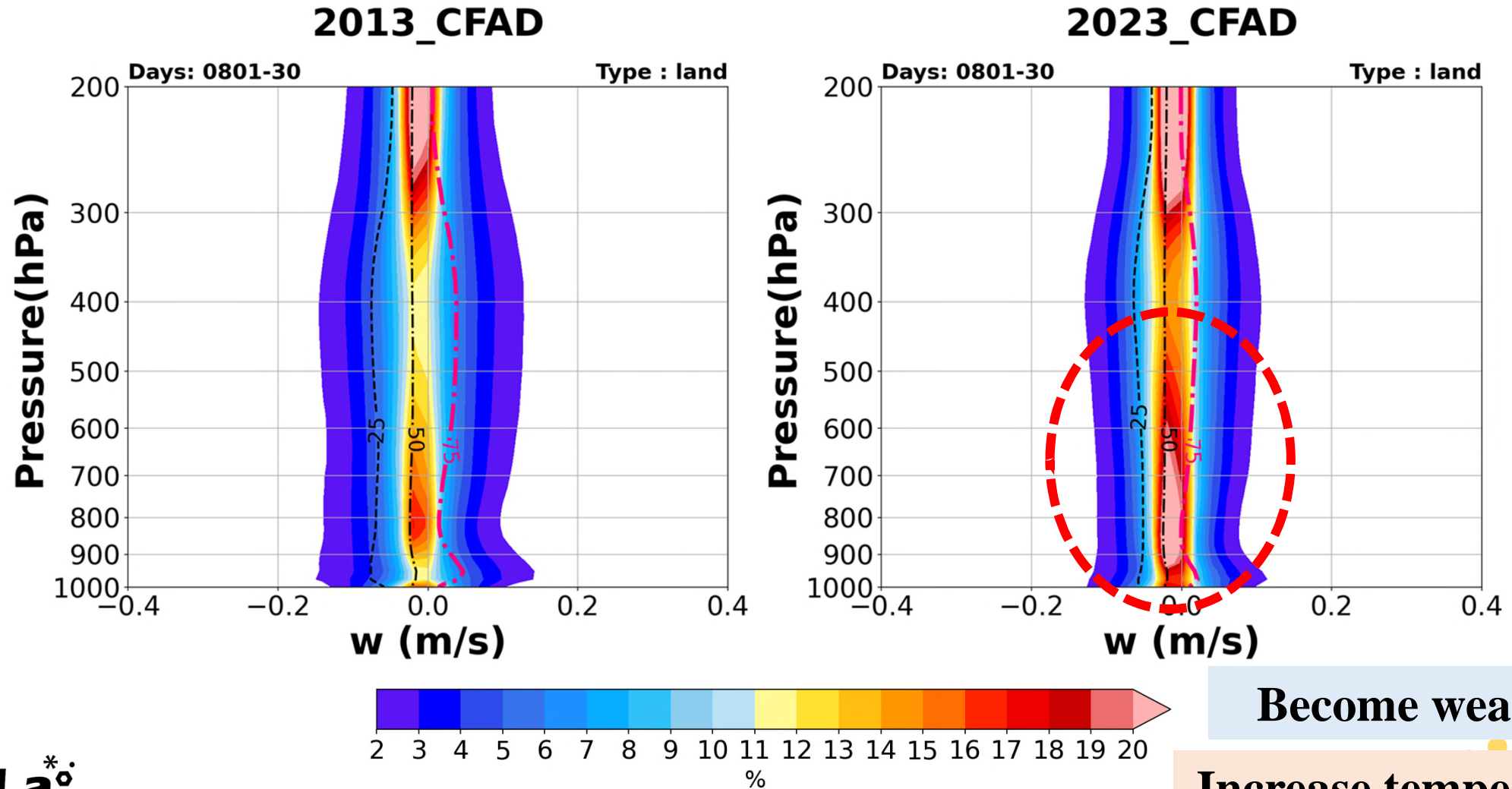
Increase Surface Pressure

- AMS 《State of the Climate in 2023: The Arctic 》
Summer 1991–2020



Arctic Amplification (Serreze and Barry 2011).

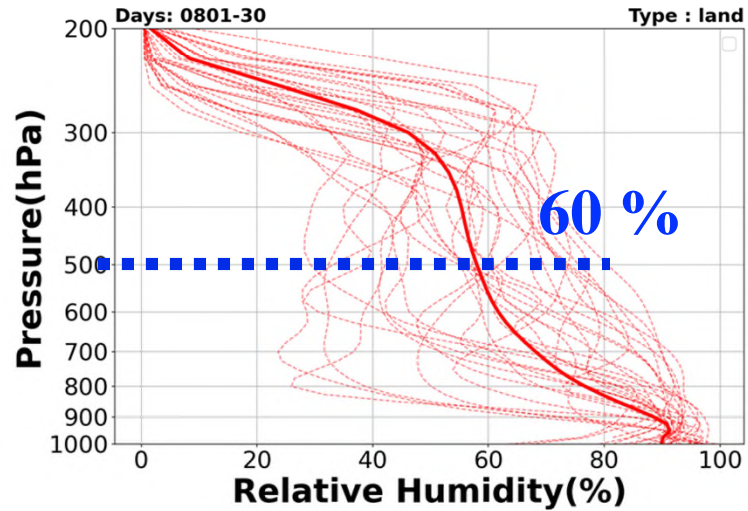
- CFAD of Vertical Wind



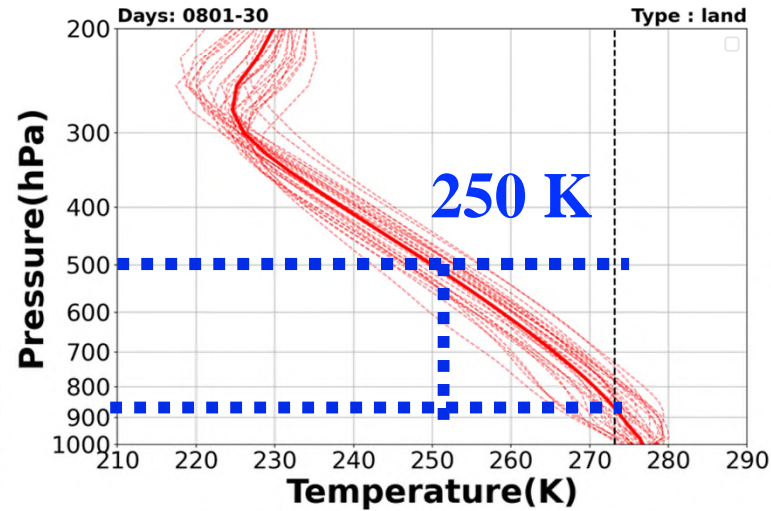
Become weaker

Increase temperature

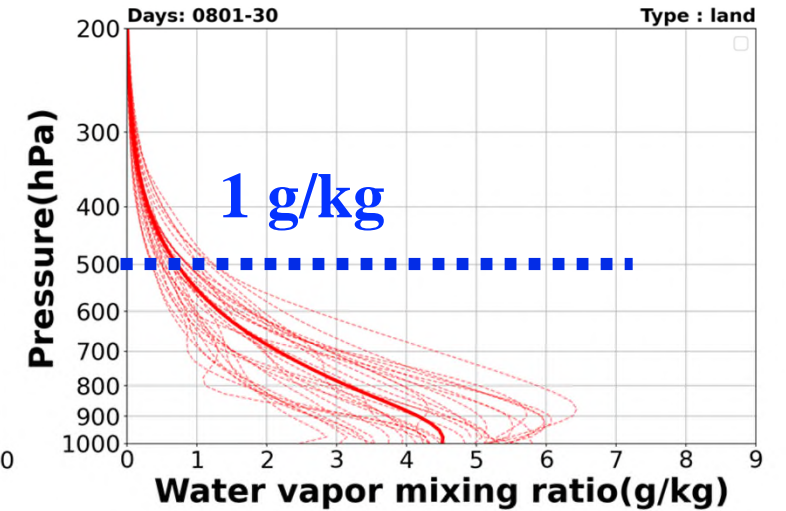
2013 Day Mean Profiler



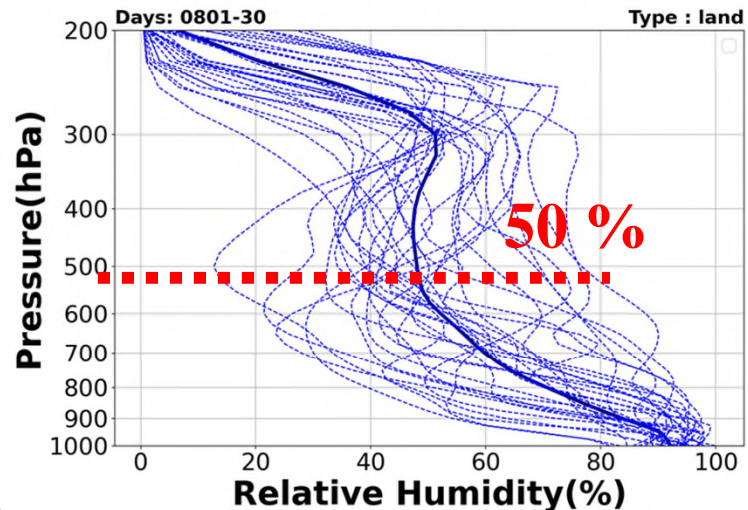
2013 Day Mean Profiler



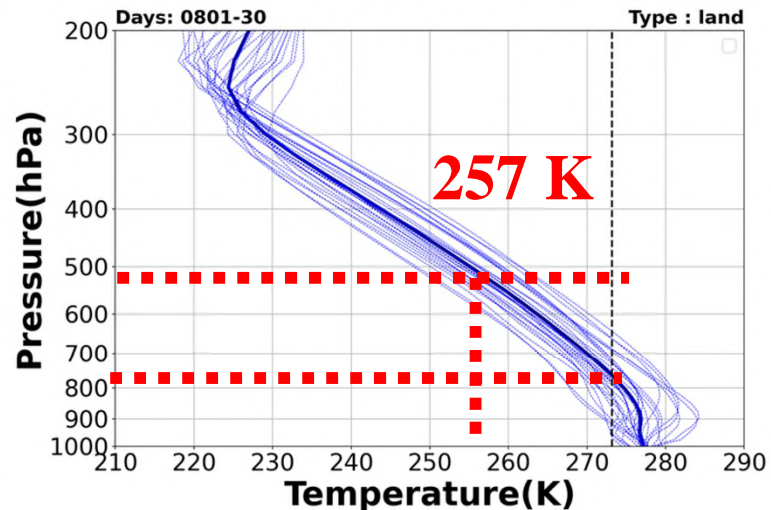
2013 Day Mean Profiler



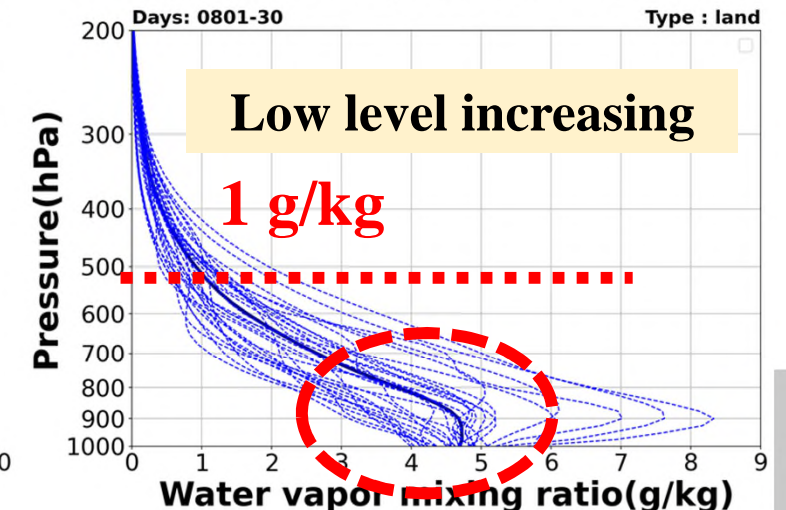
2023 Day Mean Profiler



2023 Day Mean Profiler



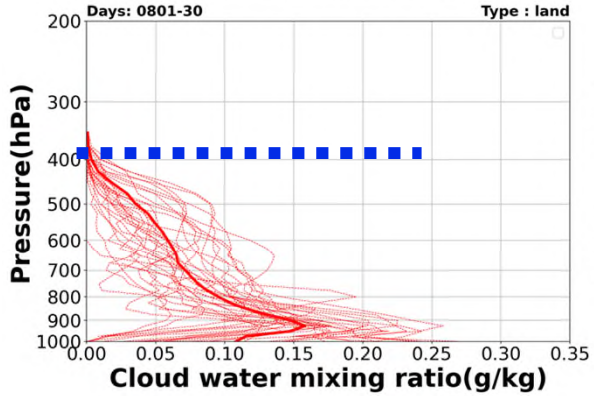
2023 Day Mean Profiler



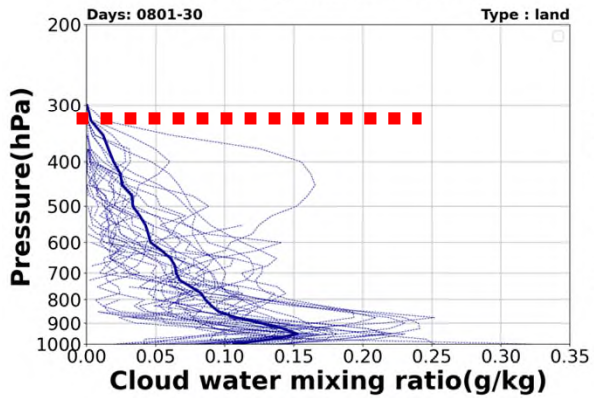
- Hydrometeors profilers

Cloud water

2013 Day Mean Profiler

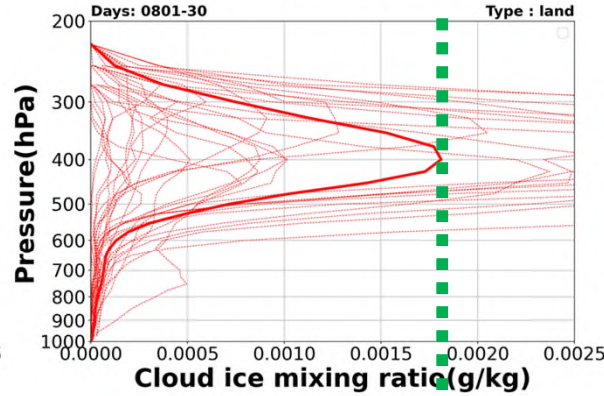


2023 Day Mean Profiler

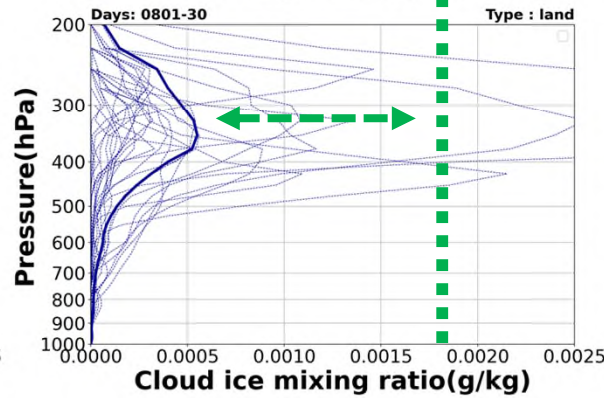


Cloud ice

2013 Day Mean Profiler



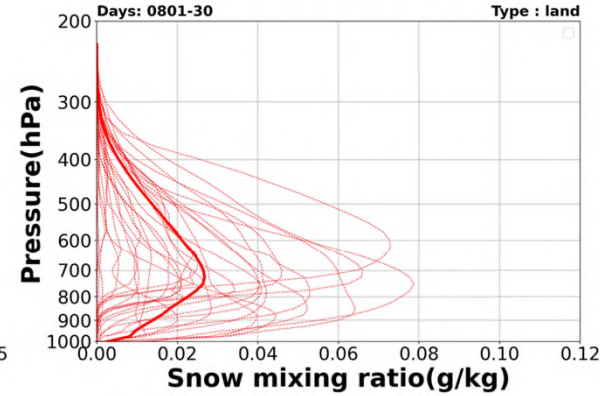
2023 Day Mean Profiler



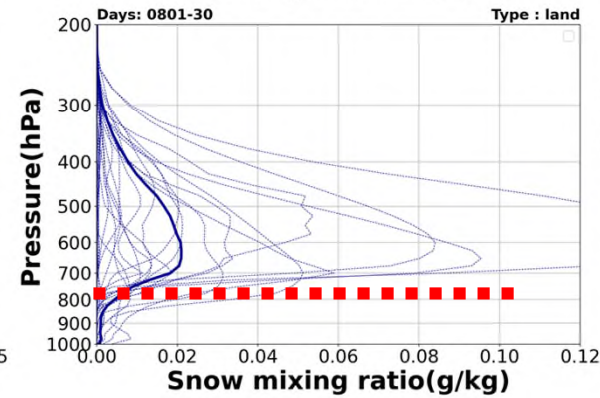
Decrease

Snow

2013 Day Mean Profiler

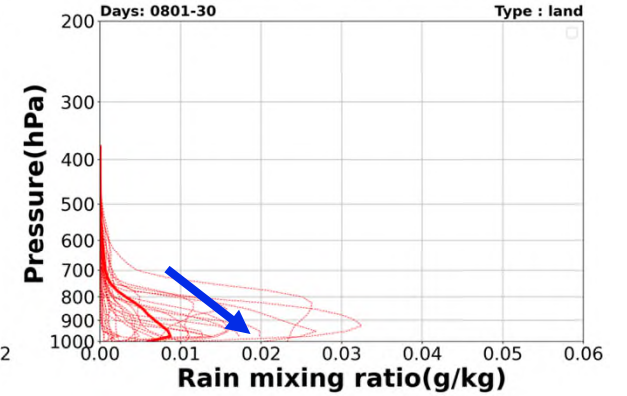


2023 Day Mean Profiler

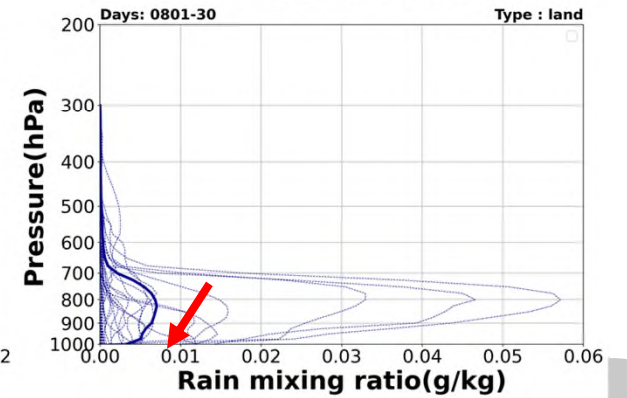


Rain

2013 Day Mean Profiler

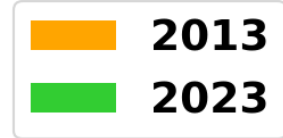


2023 Day Mean Profiler

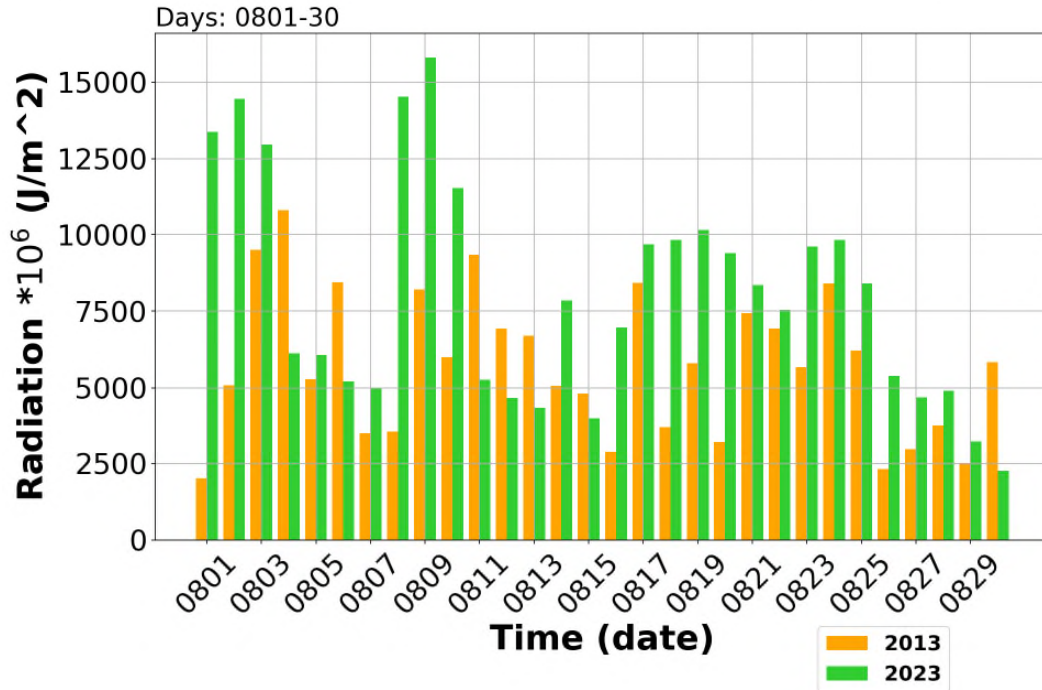


Reduce precipitation

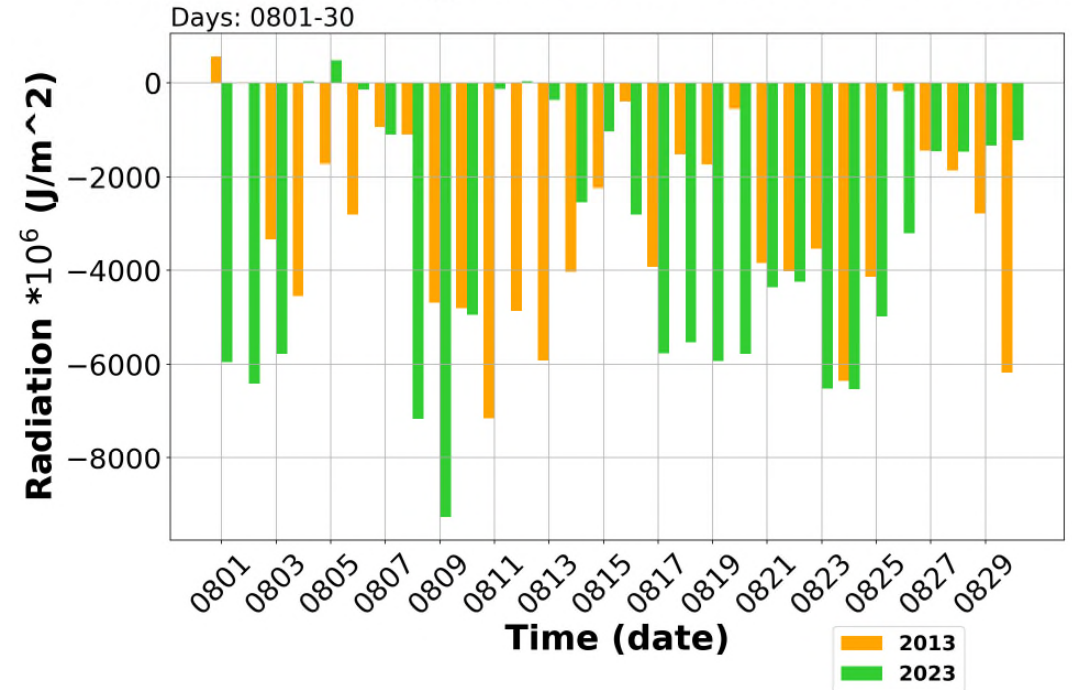
- Radiation



Land ERA5 Net short wave radiation flux Time-Evolution



Land ERA5 Net long-wave radiation flux Time-Evolution



Mean	2013	5712.72	-2998.81
	2023	8045.81	-3508.88

Radiation increase

Summary

- This research uses **WRF model** to **simulate the atmosphere environment** of Arctic region in 2013 and 2023 **to figure out the influence from the global warming.**
- Compared to the results in 2013, the year 2023 exhibited the following changes :
 1. Geopotential height indicated a **strengthening pattern**
 - **Surface pressure increased**, while near-surface wind speed and vertical motion weakened.
 - **Weakened updraft** prevented the lifting of low-level moisture
 2. **Warming in 700–500 hPa** led to a **decreased capacity for saturation**
 - **Condensation decreased** and induced net shortwave and longwave **radiation increased**
 - **Surface temperature increased** and **precipitation decreased.**

- Hartmann, J.; West, A.J.; Renforth, P.; Köhler, P.; De La Rocha, C.L.; Dürr, H.H.; Scheffran, J.; Wolf-Gladrow, D.A.; Wolf-Gladrow, D.A.(2013). Enhanced chemical weathering as a geoengineering strategy to reduce atmospheric carbon dioxide, supply nutrients, and mitigate ocean acidification. *Rev. Geophys.*, **51**, 113–149.
- Blunden, J. and T. Boyer, Eds., 2024: “State of the Climate in 2023”. *Bull. Amer. Meteor. Soc.*, **105** (8), Si–S483 <https://doi.org/10.1175/2024BAMSStateoftheClimate.1>.
- Serreze, M. C., and R. G. Barry, 2011: Processes and impacts of Arctic amplification: A research synthesis. *Global Planet. Change*, **77**, 85–96, <https://doi.org/10.1016/j.gloplacha.2011.03.004>.
- Wyser, K.; Jones, C.G. Modeled and observed clouds during Surface Heat Budget of the Arctic Ocean (SHEBA) (2005). *J. Geophys. Res. Space Phys.*, **110**.

Thanks for listening

- 1) Study structure and characters of Arctic boundary layer
- 2) Analysis the change of atmosphere in 2050 by TaiESM.
- 3) Simulate winter cases