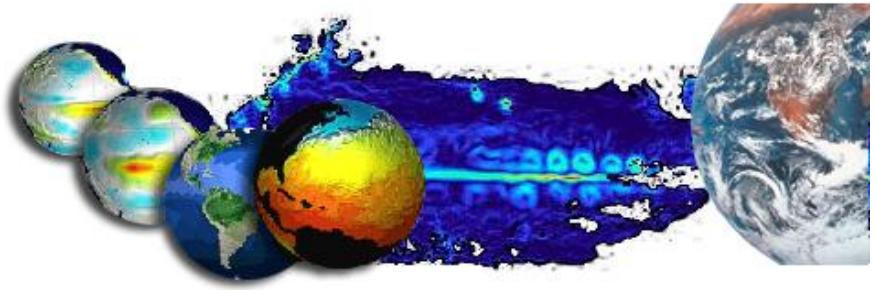
Examining the aerosol semi-direct effect at Barrow, AK

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AOES

How is the weather at Barrow modified by the the semi-direct effect?

The semi-direct effect occurs when an aerosol layer consisting of sunlight-absorbing particles such as BC warm the atmosphere – can affect the cloud distribution and vertical temperature and stability profiles.

Not much is known about how Arctic regions such as Barrow are affected by the semi-direct effect on polluted days (Arctic haze).

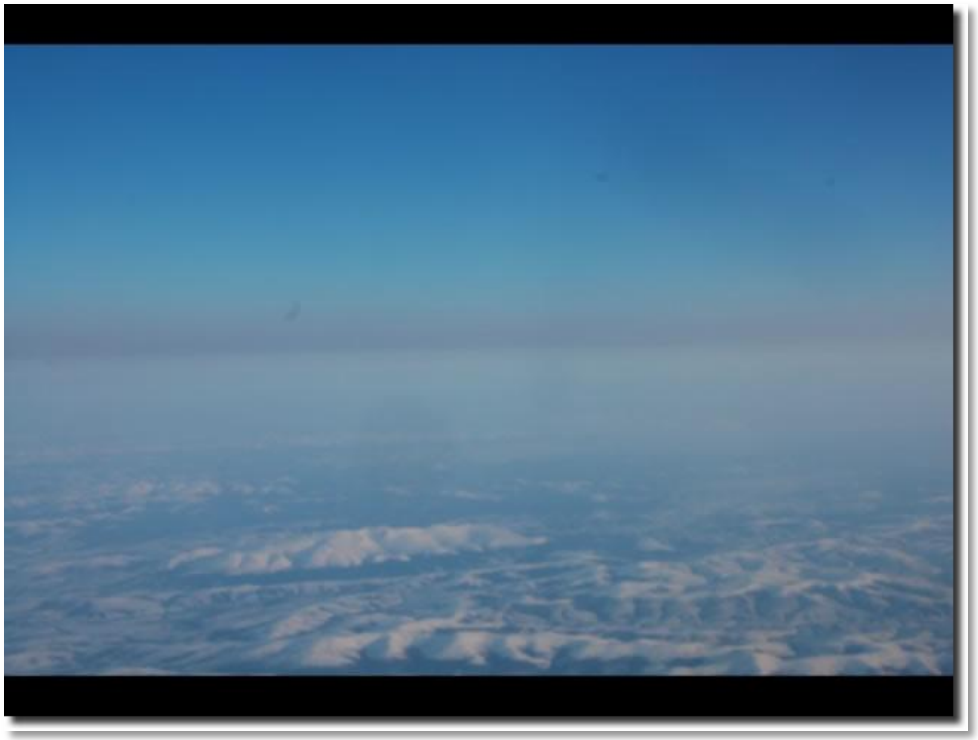


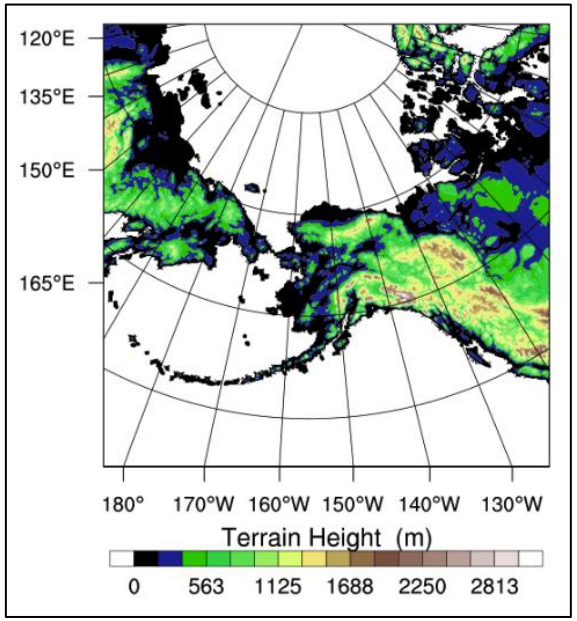
Photo from NOAA WP-3D aircraft during April, 2008 ARCPAC field experiment

About the Arctic Haze layer

- Stratified layers of air pollution in Arctic regions
- Maximum concentration at Barrow, AK is late winter / early spring.
- Originates in Siberia and Eastern Europe, pollutants from biomass burning and anthropogenic sources
- Contains black carbon (BC) which is efficient at absorbing sunlight

We investigate semi-direct effects with a mesoscale meteorological model

- Use WRF/Chem model to examine a polluted event on 18-21 April, 2008 at Barrow, and compare results with corresponding run that has no aerosol feedbacks to radiation scheme



WRF/Chem model domain

- Initialize WRF/Chem with reanalysis chemistry and aerosol fields from MOZART-4 global chemistry model

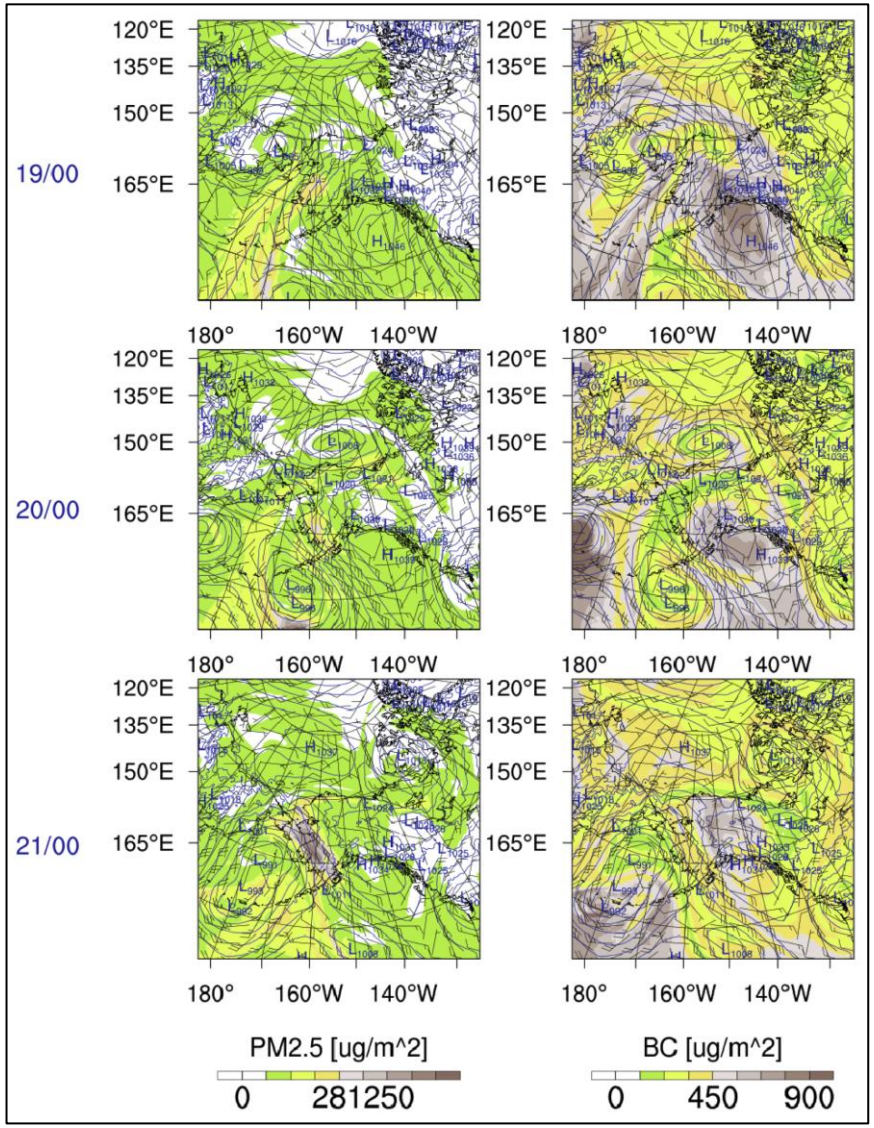
Setup-of experiments and goals:

Four simulations:

Simulation	Details	Notes
WRF	No aerosol radiative effects	Clean case, baseline run
CHEM	Initialized from MOZART-4	“real world” case initialized from reanalysis fields
CHEM2	Same as CHEM but with BC concentration doubled	Examine sensitivity of atmosphere to BC
CHEM0	Same as CHEM but with BC concentration zeroed-out	Is semi-direct effect apparent without BC?

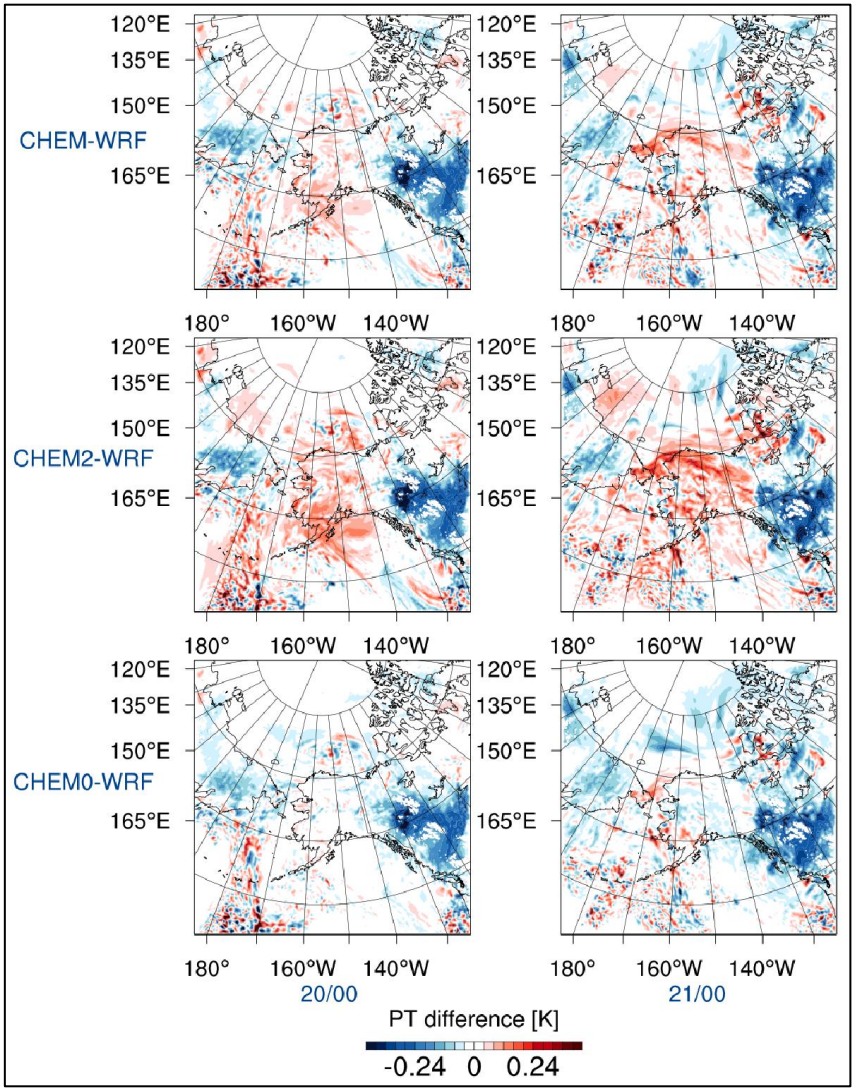
- Examine changes in vertical stability and cloud cover between WRF/Chem and baseline WRF simulations (i.e. CHEM-WRF)
- Sensitivity of semi-direct effect to changes in the BC concentration

Results: PM2.5 and BC fields



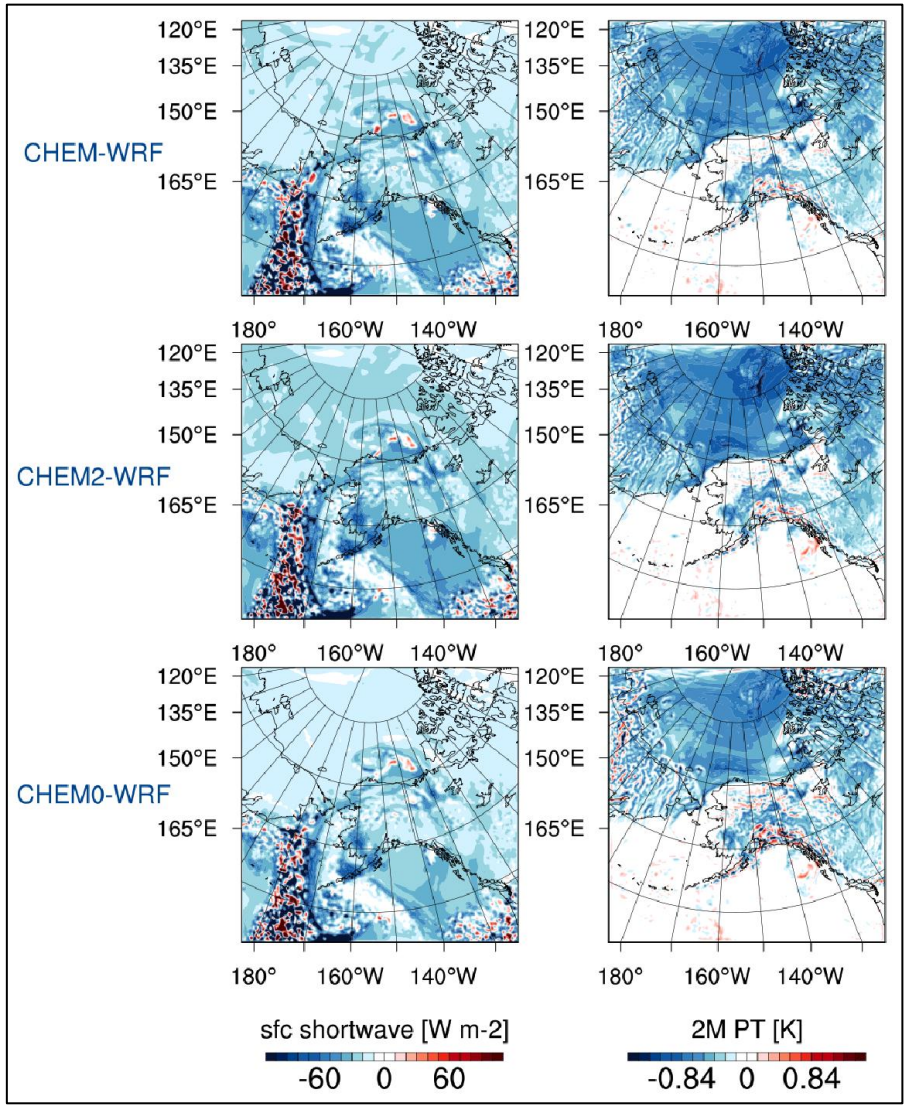
- Results show column-integrated BC and PM2.5 fields being advected around model domain
- Region of BC is concentrated over Alaska 20-21 April.

Results: 850 mB PT fields



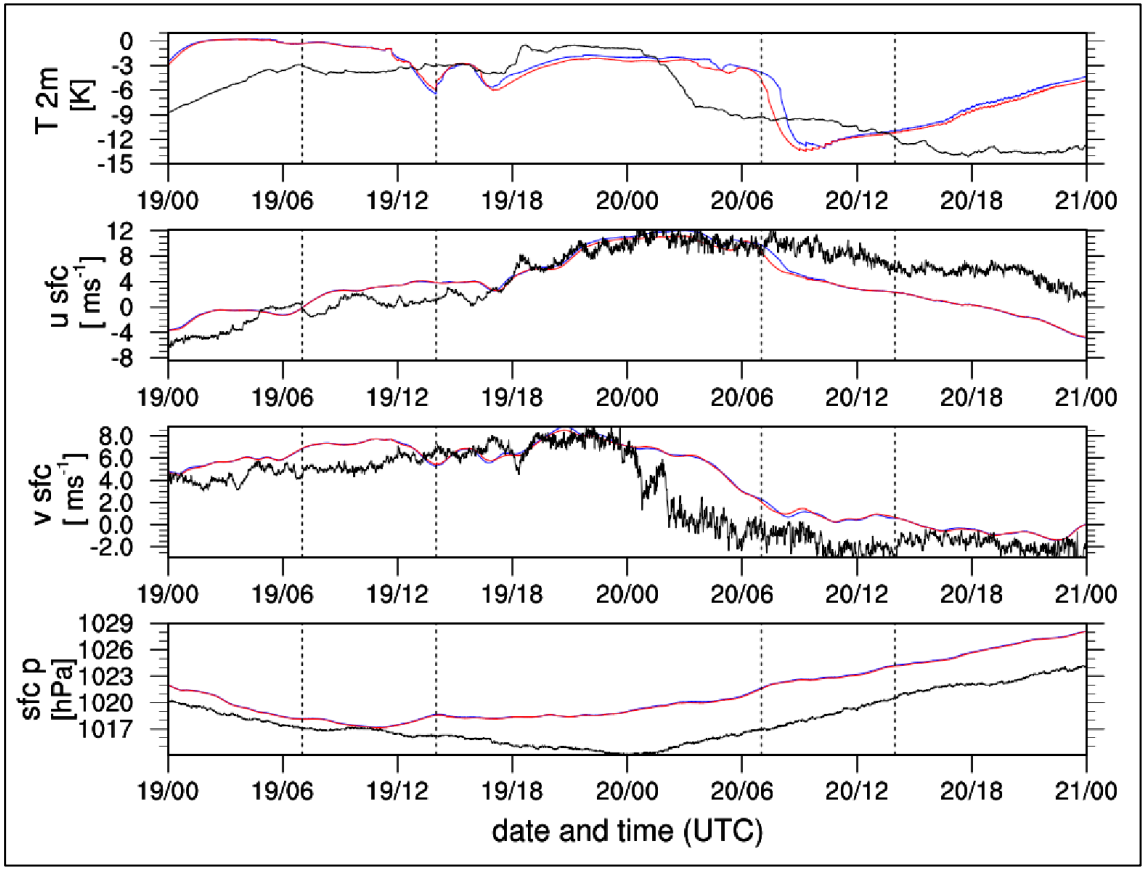
- CHEM2-WRF shows most significant warming at 850 mB
- Lack of warming for CHEM0-WRF shows how sensitive atmosphere is to BC.

Results: surface cooling



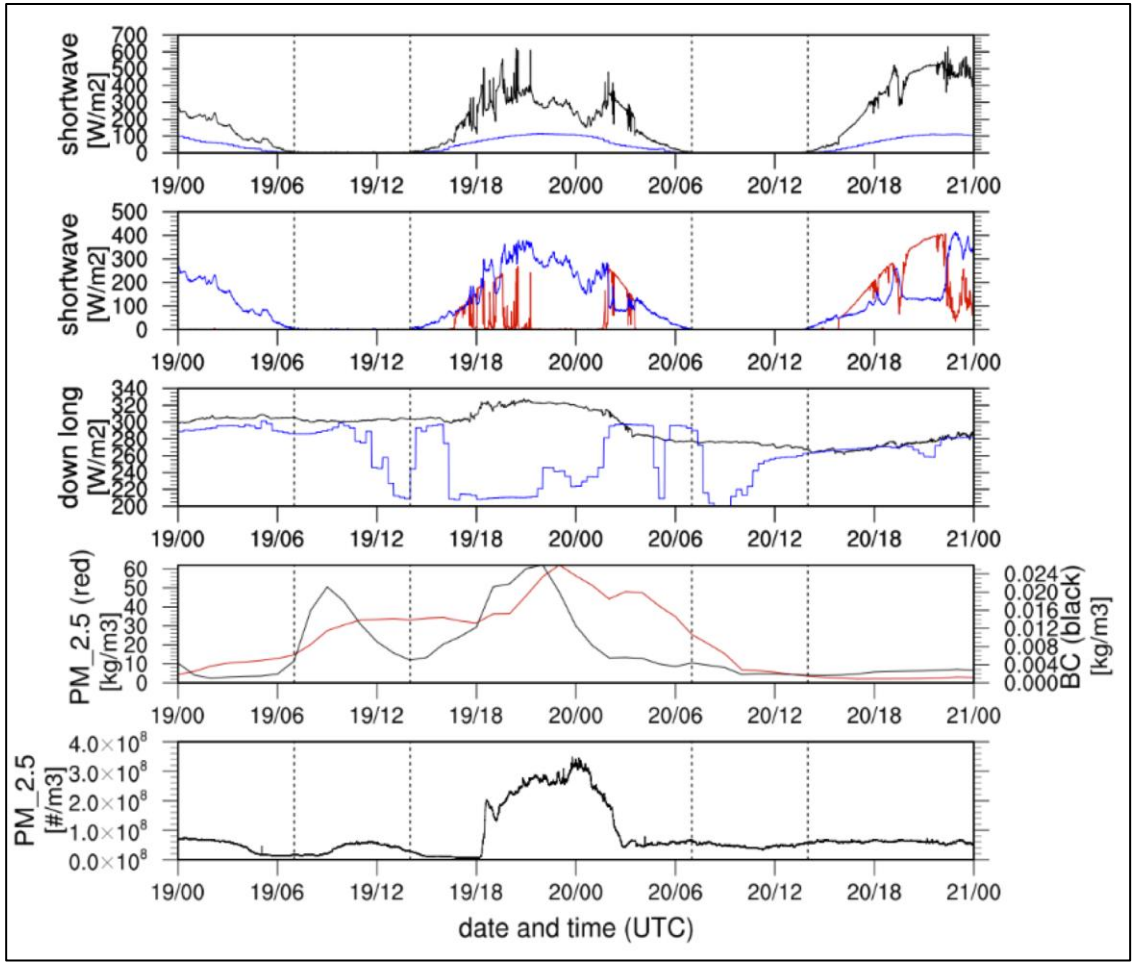
- All 3 cases show reduced solar radiation at ground level and lower temps (direct aerosol effect)
- Temp reduction is greatest over high albedo regions such as frozen Arctic and snow-covered regions.

Barrow: comparison with ARM measurements



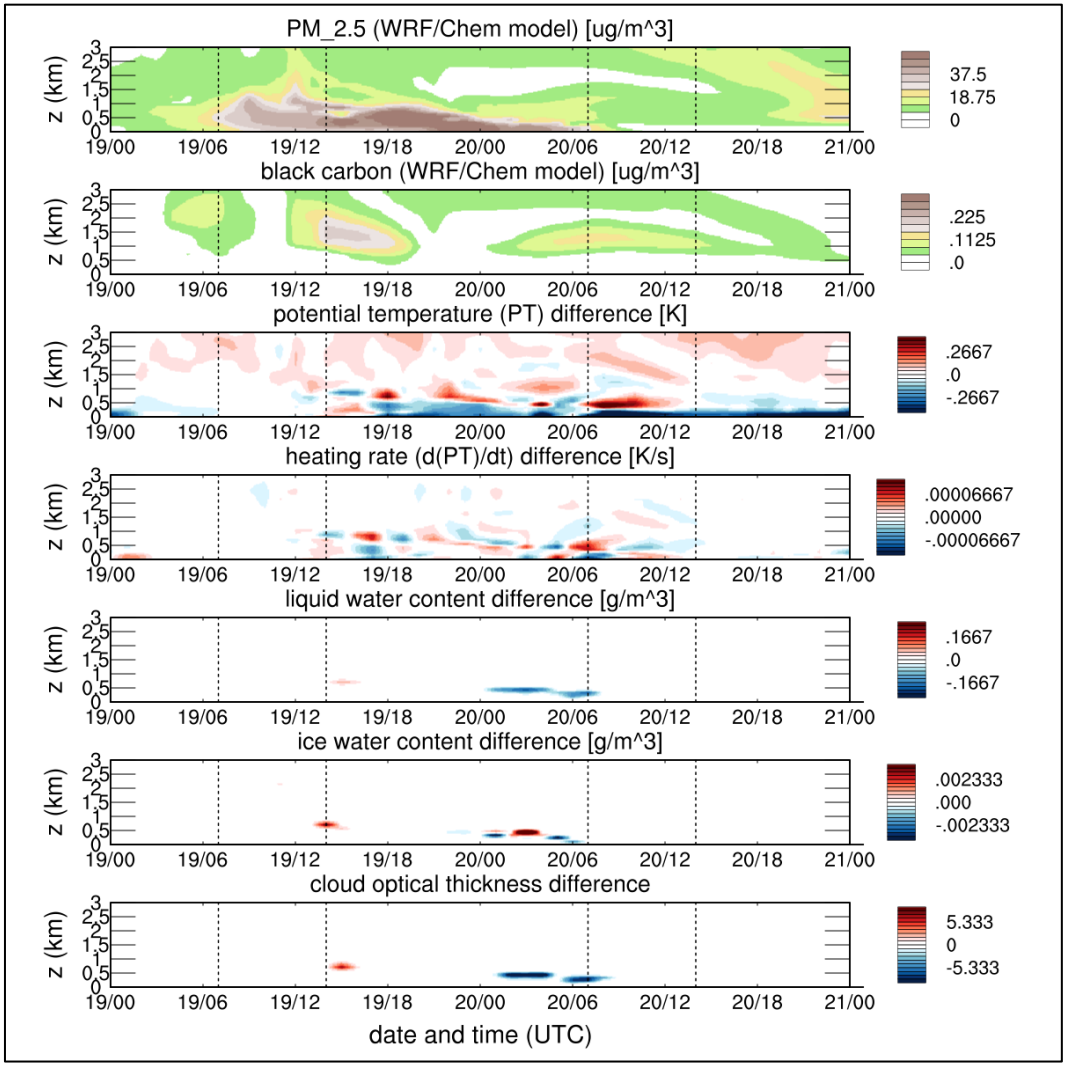
- Generally good agreement with obs.

ISDAC observations



- ISDAC observations show little direct sunlight before 20/15 UTC
- Arctic haze present 20/00 UTC
- Longwave radiaton observations more steady than model, affected by arctic haze

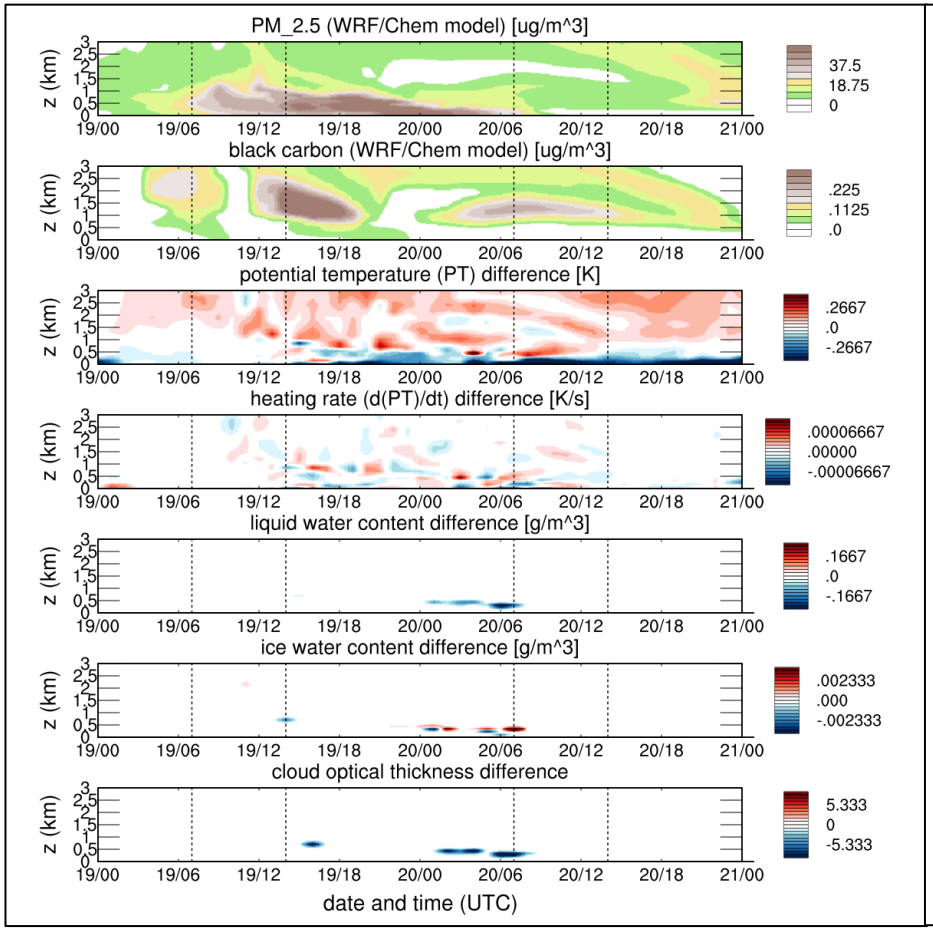
Barrow: meteogram CHEM-WRF



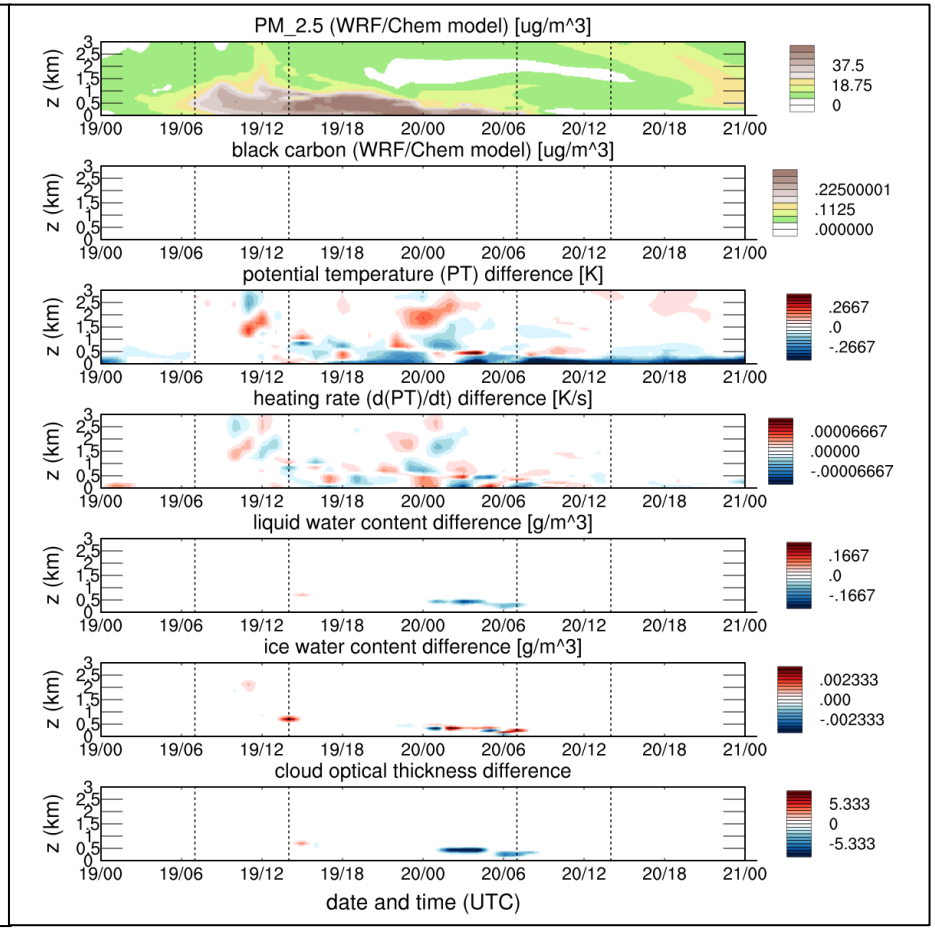
- Warming occurs in free atmosphere, particularly where BC is present
- Some drying of the atmosphere is evident on the 20th.

Barrow: meteograms

CHEM2-WRF

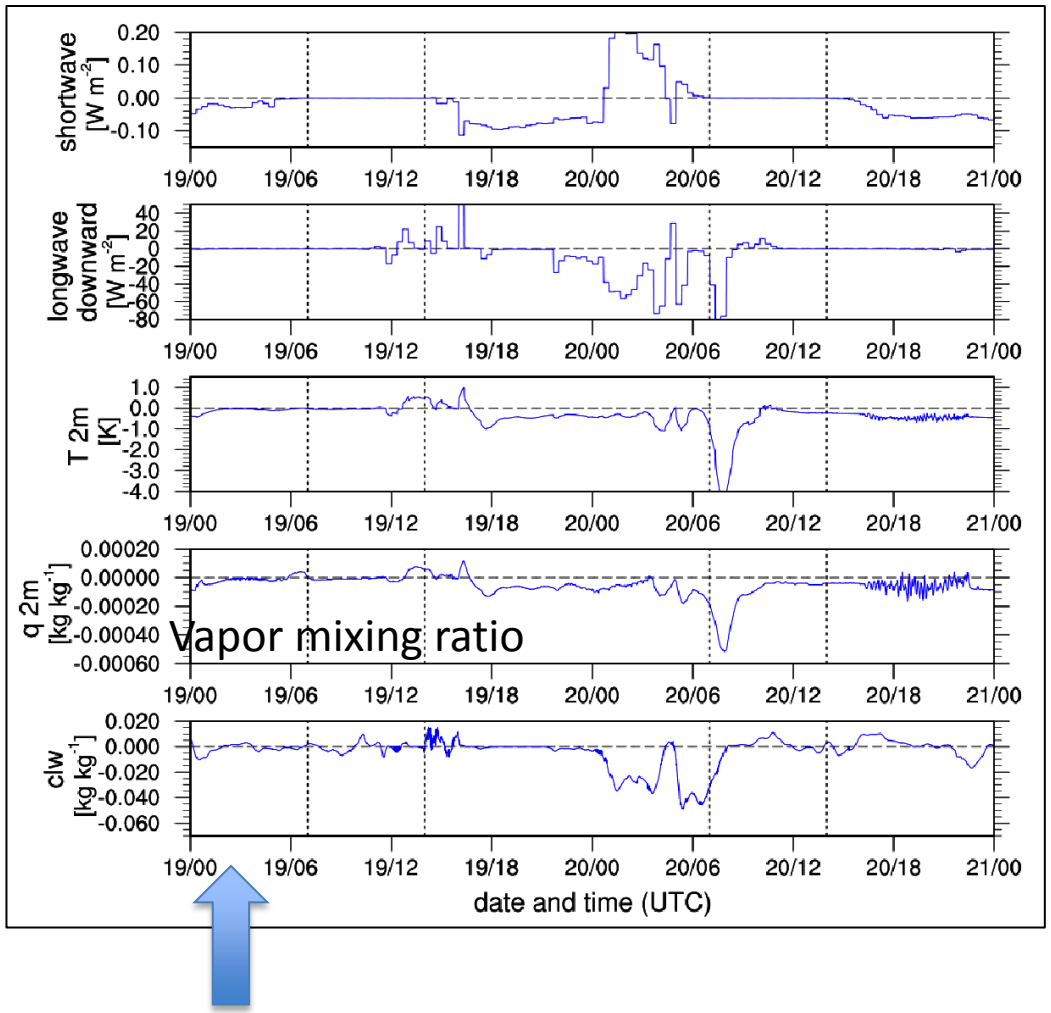


CHEM0-WRF



- Warming and drying are more evident in CHEM2-WRF than in CHEM0-WRF

Barrow: timeseries CHEM-WRF



- Reduction of SW radiation
- temp follows long-wave variations, particularly at night
- Redistribution and daytime reduction in water and cloud-column integrated variables.

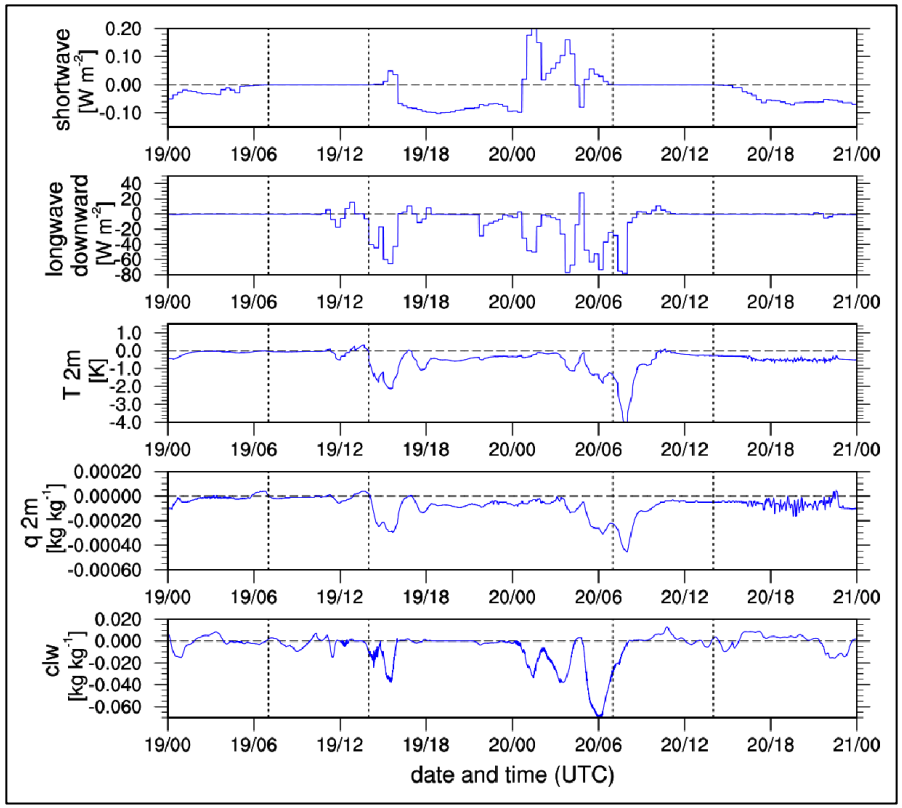
Total column-integrated water vapor and cloud variables

In summary…

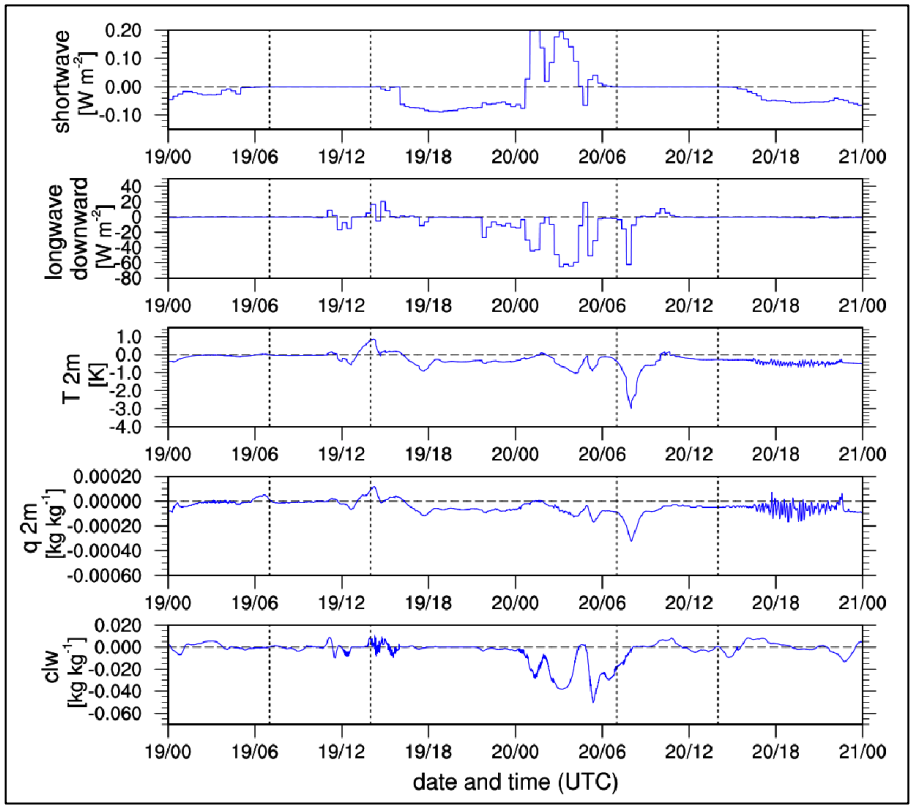
- Semi-direct and direct effects at Barrow lead to greater stability, higher temps in lower troposphere, and reduced clouds and moisture
- Consequently, the reduction in clouds and moisture alters the radiation balance and weather and climate at Barrow.
- Semi-direct effects need to be investigated further to be properly represented in global weather and climate models

Barrow: timeseries

CHEM2-WRF



CHEM0-WRF



- Reduction in 2m vapor mixing ratio and column-integrated water and cloud variables more evident in CHEM2-WRF than in CHEM0-WRF