PACES

air Pollution in the Arctic:
Climate Environment and Societies

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Terry D. Lynch, NOAA Aircraft Operations Center

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air Pollution in the Arctic: Climate Environment and Societies

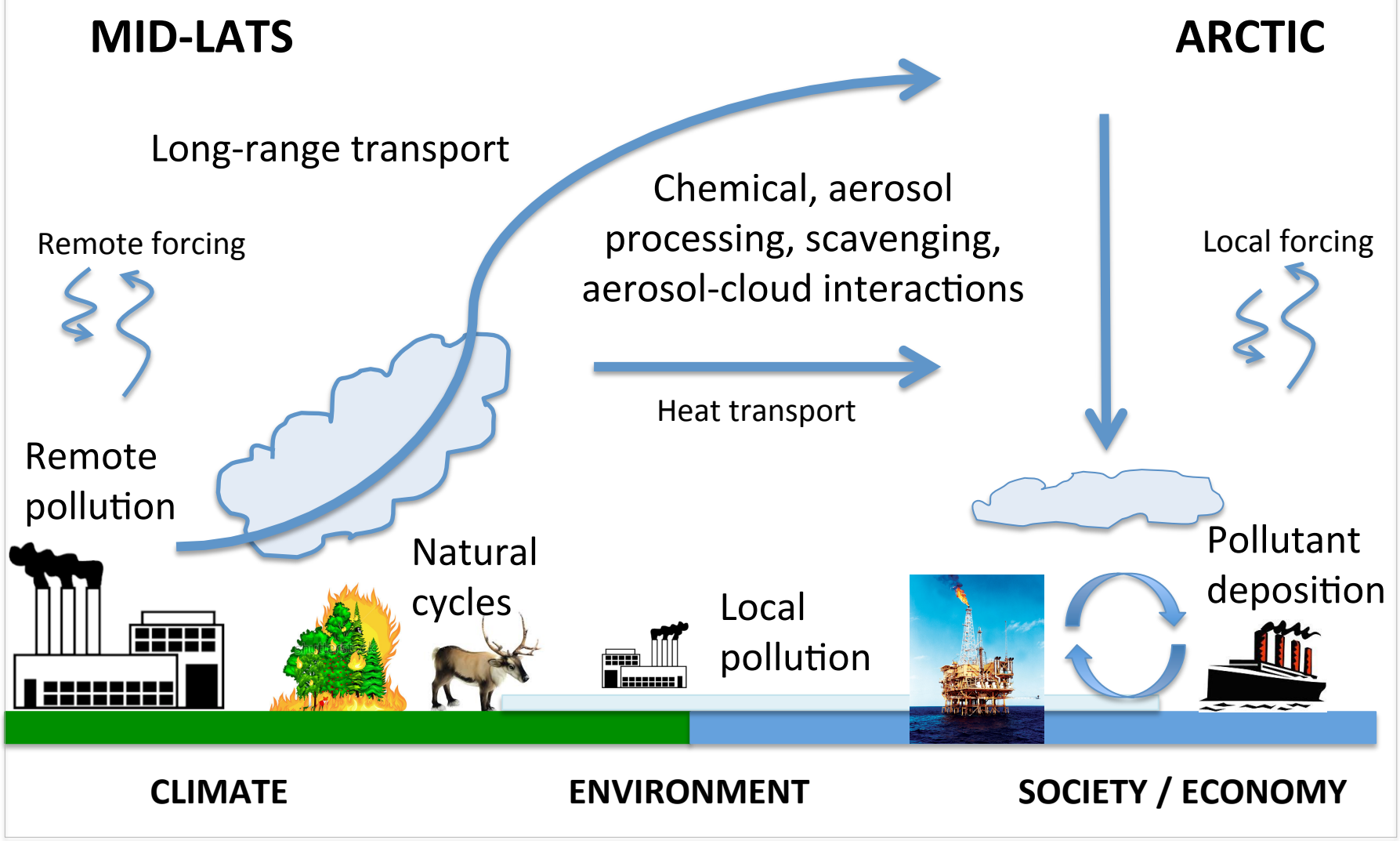
- **International initiative** co-sponsored by International Global Atmospheric Chemistry (IGAC)-Future Earth & International Arctic Science Committee (IASC) Atmosphere WG (since 2015)
- **Science focus:** remote and local sources of Arctic air pollution and interactions with climate, ecosystems and societies *(Arnold et al., 2016, Elementa)*
- **Aims:** coordinate and foster research efforts on Arctic air pollution → **improve underpinning science** → for assessments, policymakers, stakeholders
- **Engaging** with other international initiatives: AMAP, HTAP, MOSAiC, YOPP, CATCH, PEEX, IASOA, …)

See http://www.igacproject.org/PACES

Co-chairs: Kathy Law (LATMOS/CNRS, France),
Steve Arnold (U. Leeds/UK), Chuck Brock (NOAA/USA)

Photo credit: Terry D. Lynch, NOAA Aircraft Operations Center

PACES SCIENCE



See also Arnold et al., Elementa (2016)

PACES Activities

1. *Improving predictive capabilities (WG1)* *(contact charles.a.brock@noaa.gov)*
Planning semi-Lagrangian study of pollutant transport from Asia to the Arctic **(IMPAACT)** to reduce model uncertainties (processing, wet scavenging, aerosol-clouds)

- *Informal meetings/discussions with NOAA, NCAR, NASA, other interested groups (Japan, Germany, France, UK, Russia, Canada, …)*

2. *Arctic air pollution and societies (WG2)* *(contact julia.schmale@psi.ch)*
Improve quantification of Arctic air pollution sources and impacts on societies (AQ) and ecosystems (e.g. pollutant deposition) → inter-disciplinary sub-group

- *Workshops (Fairbanks 2016, Prague 2017) → Field experiment to investigate local pollution processing and quantify emissions, community based observations, assessment of societal impacts (under discussion)*

3. *Activities contributing to PACES science objectives* *(contact kathy.law@latmos.ipsl.fr)*

- *PACES related airborne campaigns (PARCS, YAK, PAMARCMIP, ATOM, MOSAiC, …), ground-based activities (IASOA, NDACC, GAW, ..), satellite data analysis*
- *PACES related model evaluations such as AMAP SLCFs, HTAP2, IPCC*

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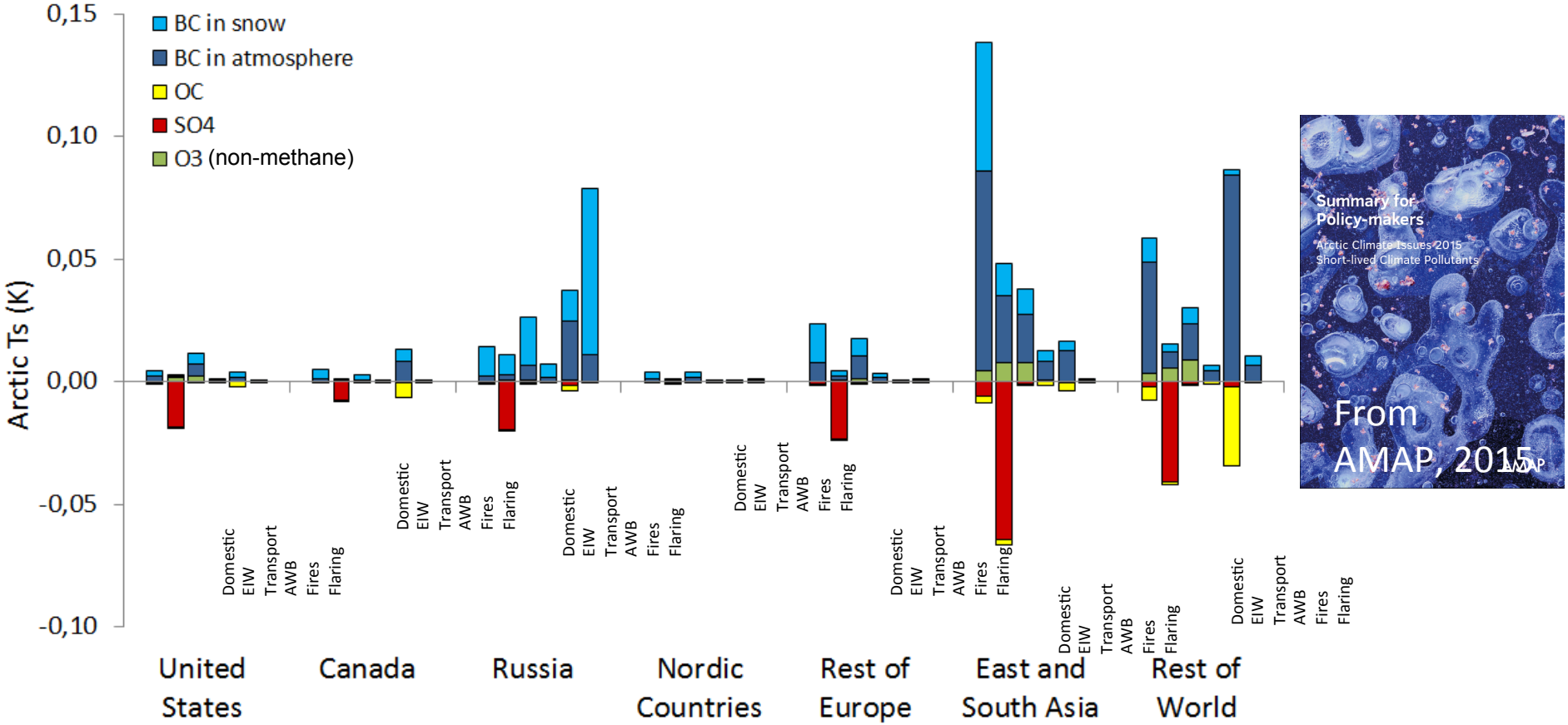
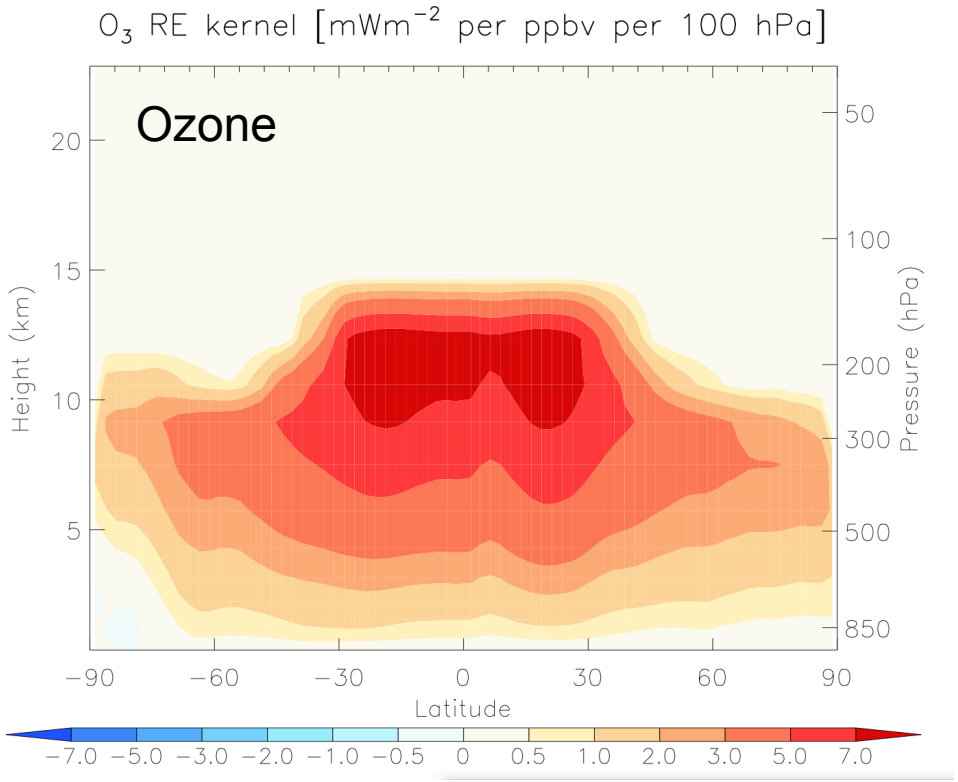
Short-lived climate pollutants (aerosols, ozone) - multi-model surface Arctic temperature response for different sectors & source regions



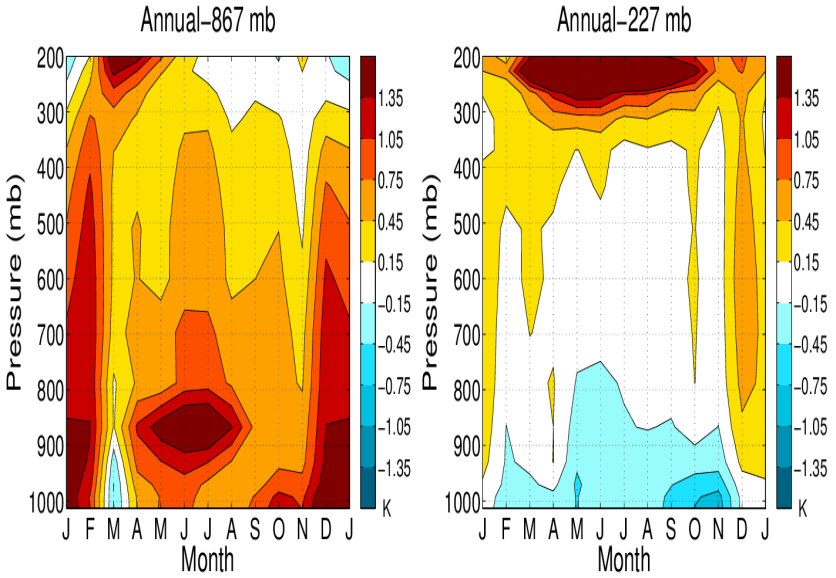
- **Largest contributions to Arctic warming from East+South Asian domestic emissions, Russian fires and flaring emissions**, and ROW domestic/ fire emissions *(just direct forcing effects, present-day, no aerosol-cloud effects)*
- **Targeted SLCP emission mitigation (methane, BC) could reduce Arctic warming by 0.5°C by 2050** *(in addition to CO2 mitigation to keep to 2°C increase by 2050)*

For climate forcing, the vertical profile matters!



Ozone radiative effect per ppbv increase (Rap et al., GRL, 2015).

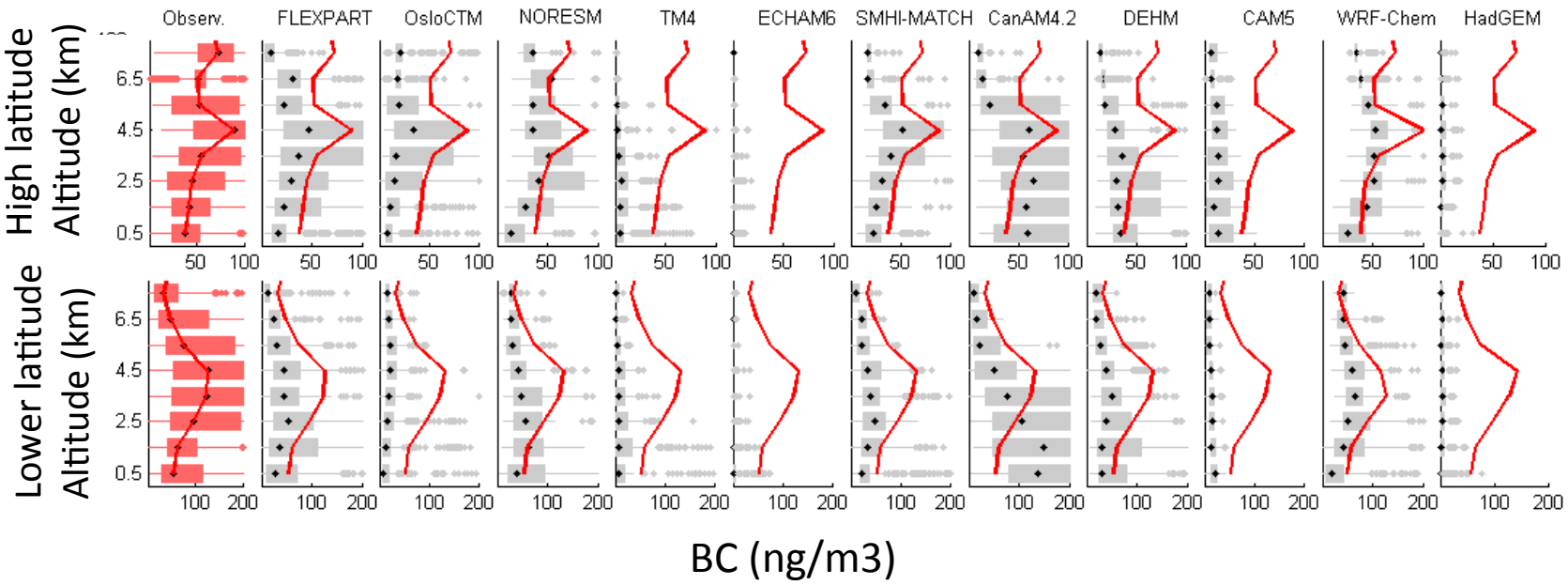
Black carbon aerosol



Arctic equilibrium temperature response to uniform layers of BC in the Arctic atmosphere located at different altitudes.

(Flanner, 2013)

AMAP (2015): multi-model evaluation of atmospheric BC against aircraft data (ARCTAS/ARCPAC) in spring 2008

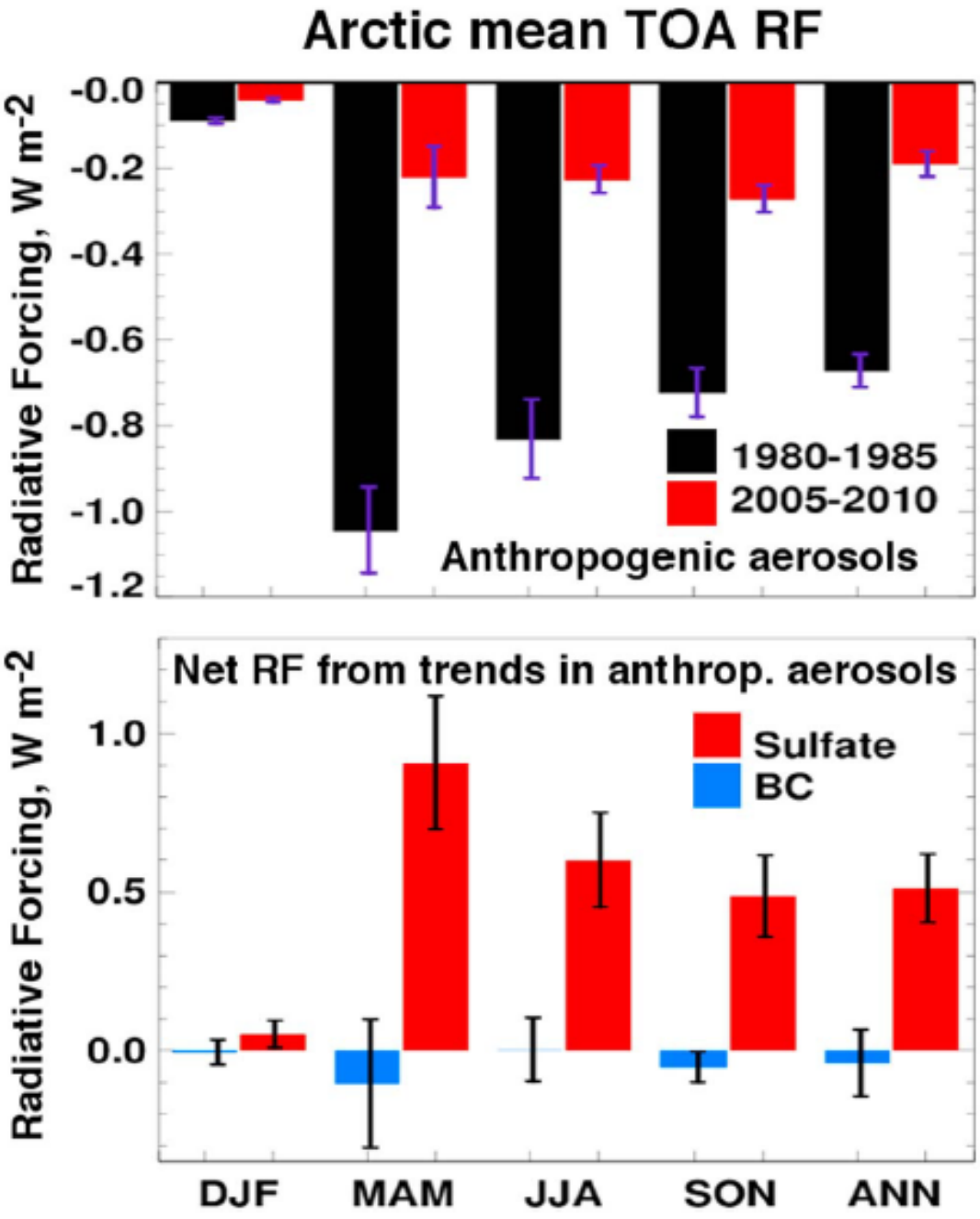


- Nearly all models **underestimate measured values throughout the depth of the troposphere (in spring)** (even if some models improved)

- **Models underestimate sulphate (SO4) at all altitudes** + only few models capture observed surface BC:SO4 correlations (positive) (**air masses have mixed origins**)

- **Significant uncertainties** in model treatments of processes such as **wet deposition and aerosol-indirect effects** (not included in the AMAP results)

Eckhardt et al. (2015); AMAP (2015) – models run with EU ECLIPSE emissions



Past trends in mid-latitude emissions

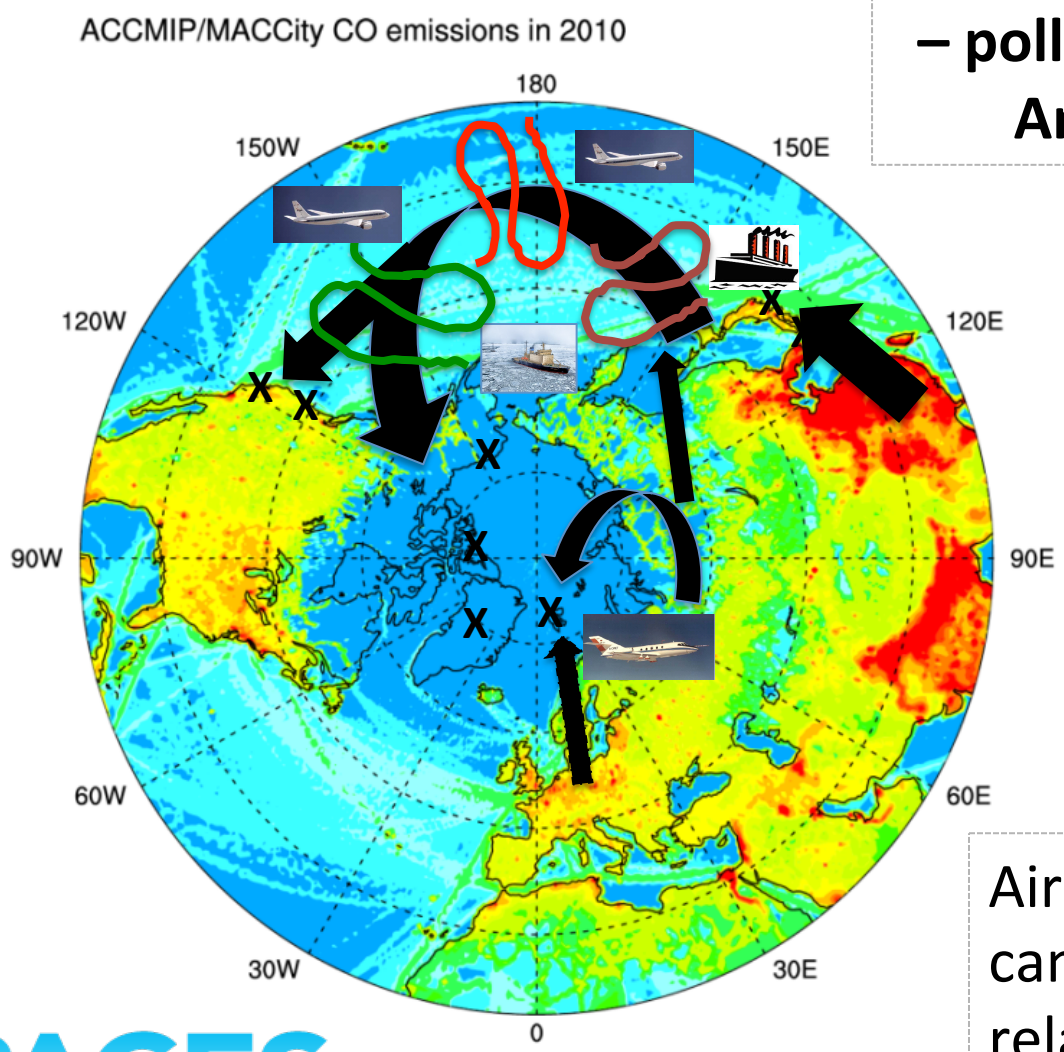
Reductions in direct Arctic Top of the Atmosphere (TOA) Radiative Forcing due to decreasing SO2 emissions

→ lower sulphate → less cooling
→ Arctic surface temperature warming (*estimated 0.27K +/-0.04K – one quarter observed warming*)

Not accounting for black carbon deposition on snow/ice → albedo or indirect aerosol-cloud effects
(used GEOS-CHEM global model)

From Breider et al. (2017)

PACES: Pollution Transport to the Arctic (WG1)



IMPAACT: Lagrangian Experiment – pollution transport from Asia to Arctic & N. America (2020/21)

Aim to improve predictive capability: scavenging, chemical/aerosol processing, aerosol-cloud interactions → underpinning science for new assessments (e.g. AMAP, HTAP)

Airborne/ground-based campaigns linked to PACES-related initiatives (2018-2020) (e.g. MOSAiC, YOPP, YAK)

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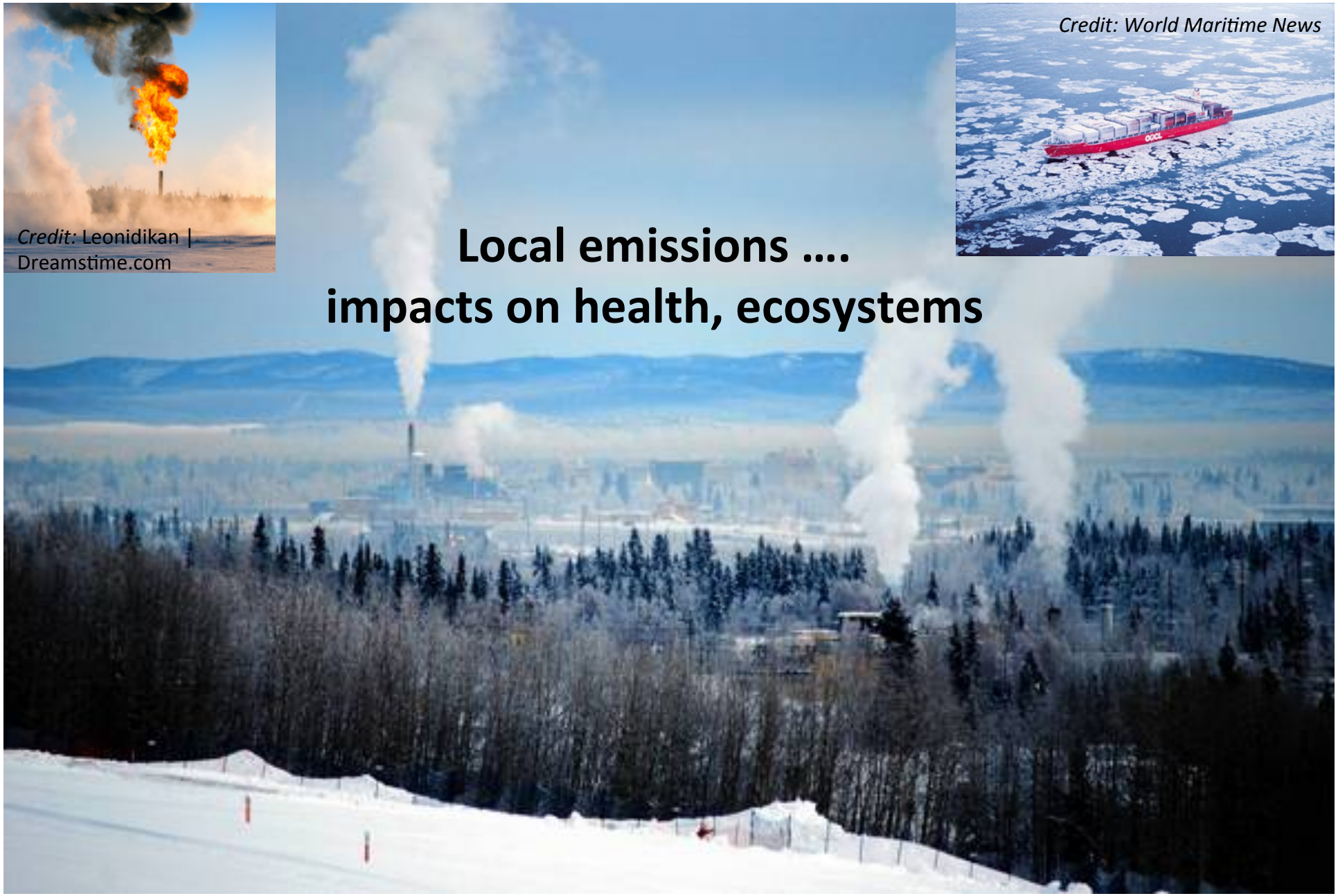
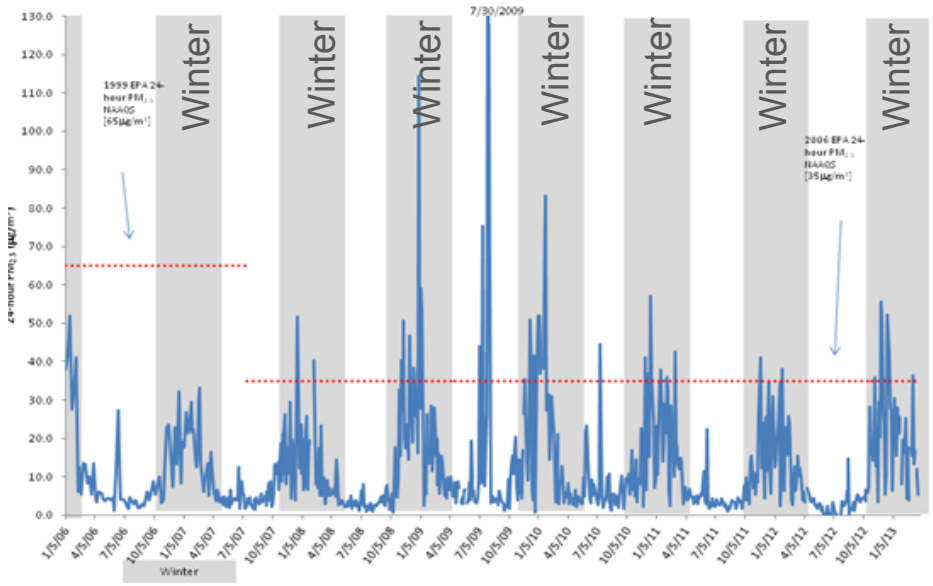
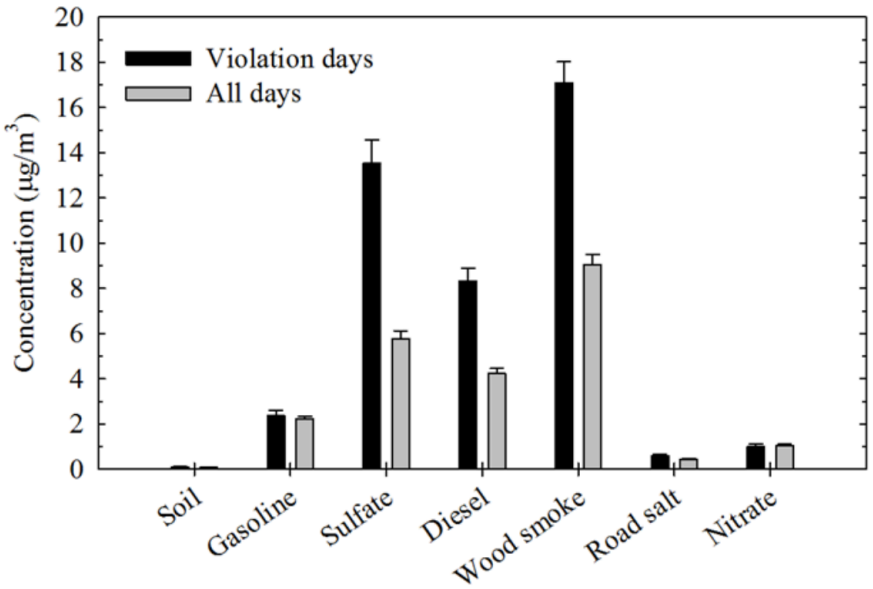


« A cloud of haze and smoke over Fairbanks, Alaska, feeds growing concerns over air pollution. » (Kim Murphy, Los Angeles Times, 2013)

Local Pollution: Fairbanks, Alaska

24hr average PM2.5 data (Fairbanks)





Wang and Hopke, (2014)

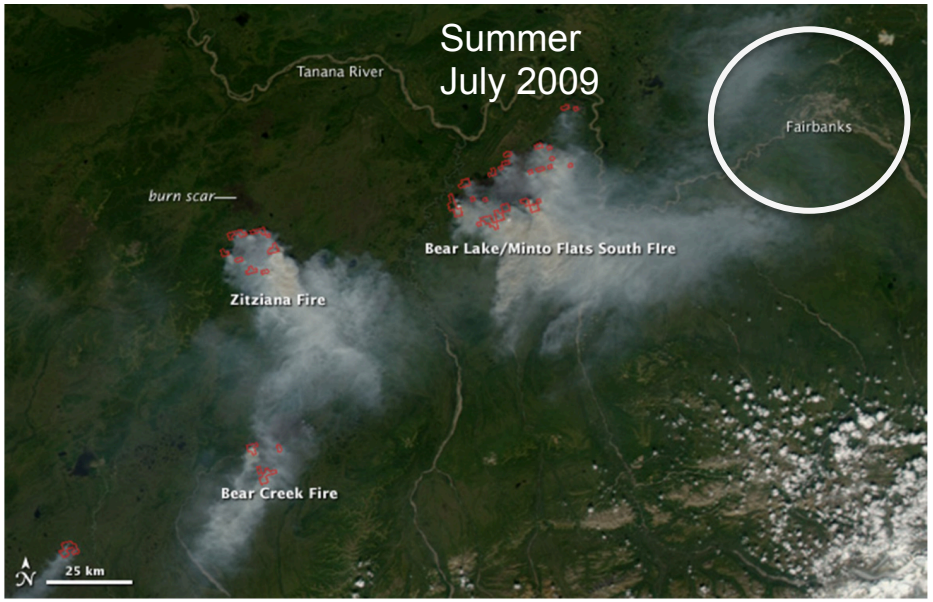


Fig. S1. This image from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite shows several lightning-triggered fires (outlined in red) southwest of Fairbanks, Alaska, on July 7

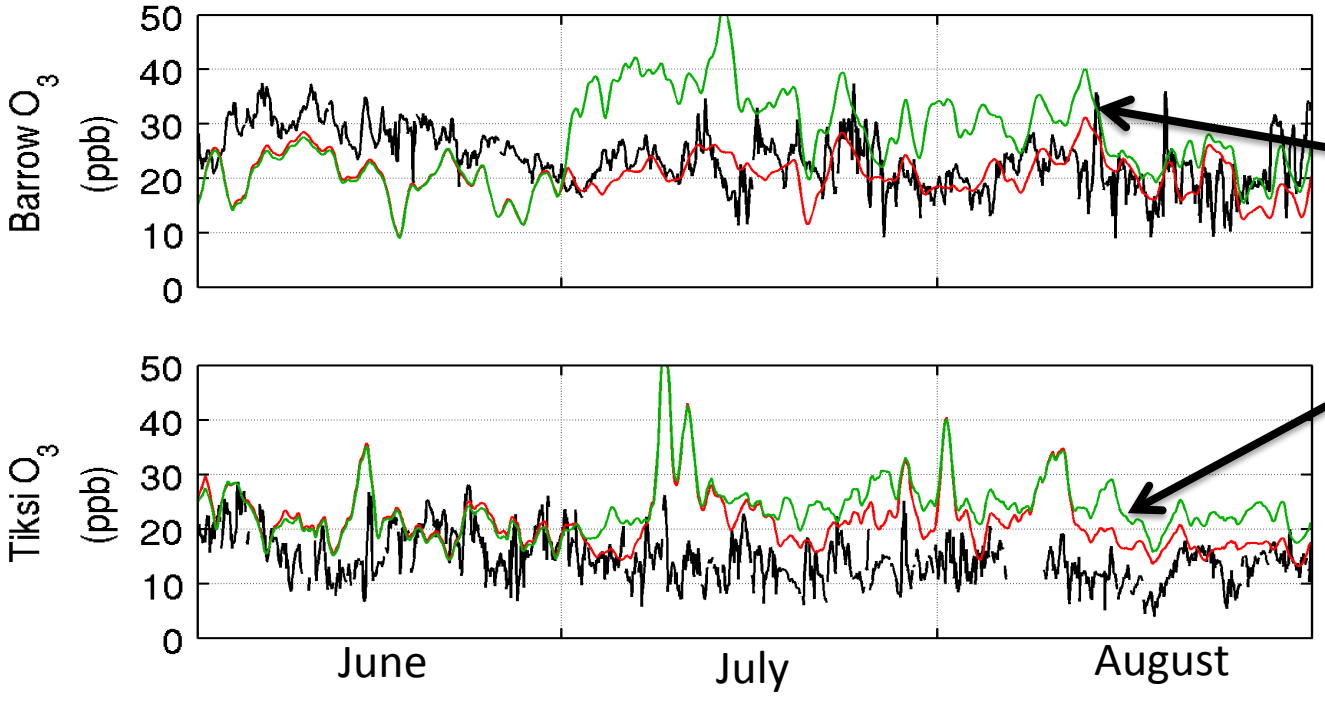
Winter: cold conditions → increased **wood burning** *(dominant on AQS violation days)*, fuel oil, coal, generators, **vehicle emissions**.

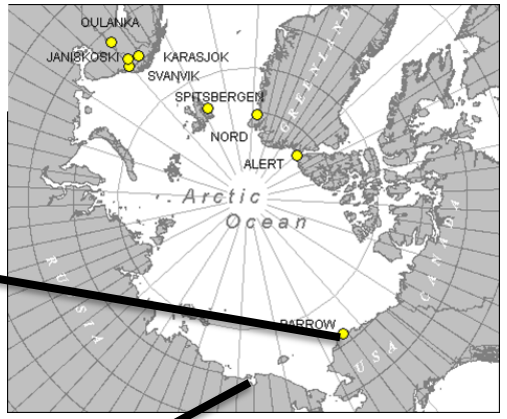
Summer: Forest fires

Local pollutant emissions, processing and impacts not well quantified under Arctic conditions

Summer surface ozone from Arctic shipping: present-day (2012) and future (2050)

Potential impacts on Arctic local/regional air quality (human health), ecosystems





→ Requires monitoring at surface sites

Observed surface ozone – black

WRF-Chem Modeled ozone (2050) – green

WRF-Chem Modeled ozone (2012) – red

Mode simulations from Marelle, L. et al., 2017 (in prep.)

Law et al., 2017
(Ambio, in press, EU ACCESS Special Issue)

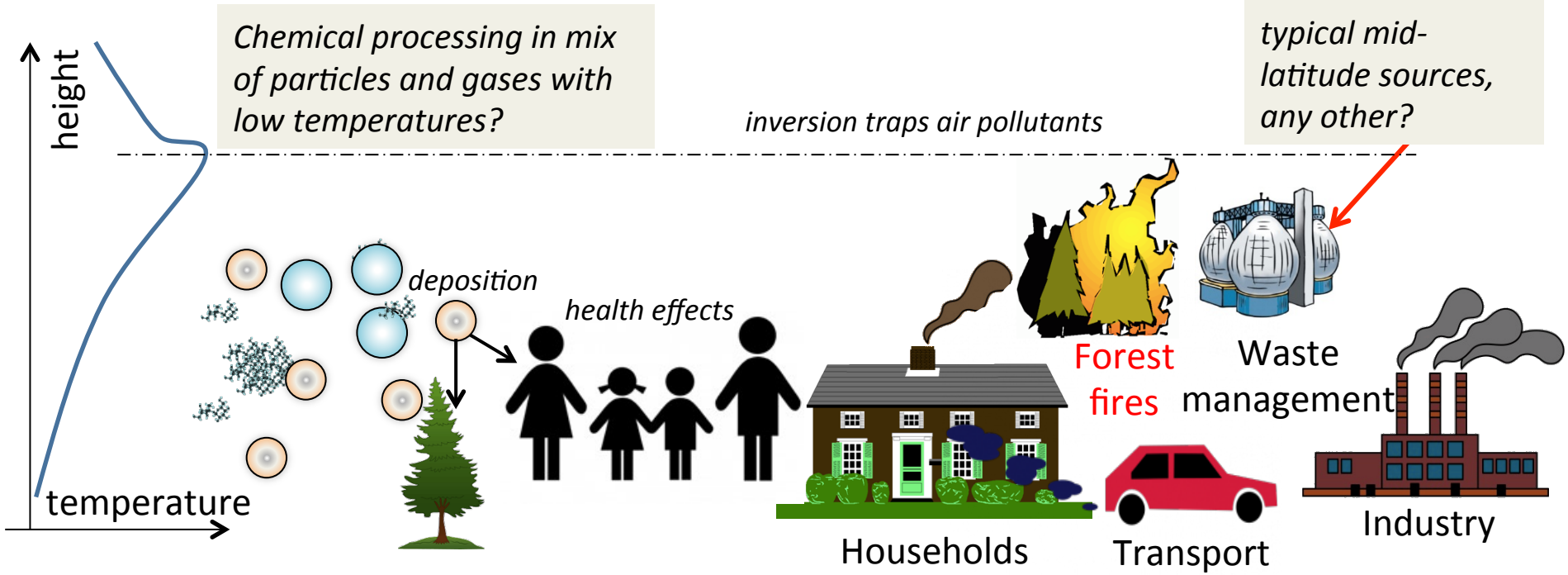
PACES: Arctic Air Pollution and Societies (WG2)

- Dialogues involving natural, social scientists, economists, revealed uncertainties about local Arctic air pollution sources and their impacts → inter-disciplinary approach in a multi-scale framework *(in collab. with existing initiatives)*

- Investigate Arctic urban air pollution (sources, atmospheric processing, impacts on public health and ecosystems) through

➢ A scientific measurement campaign in combination with

➢ Co-production of science+traditional knowledge - community based observations



PACES Timeline

Spring 2017
- **Developing PACES Implementation Plan**
- Presentations at IASC, CATCH, AMAP, HTAP meetings

April-May 2017
- Continue developing WG activities, writing white papers, submitting cross-cutting proposal to IASC (WG2)

June 2017
- **Second PACES Open Science Workshop – 27-29 June, Victoria, Canada** → science + WG discussions + new plans/ideas

2017-2018
- Planning for field experiment(s) + pre-campaign modeling. Coordinate national activities and preparation of proposals
- Proposed assessment of Arctic air pollution and impacts on societies
- Linking to observational/modeling activities related to PACES goals

2019-2020
- **Field experiment on local Arctic pollution – under discussion**

2020-2021
- **PACES large-scale field campaign(s) (IMPAACT, …)**

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