The Importance of Asia as a Source of Black Carbon to the Arctic

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NETCARE

Black carbon ⇨ **Arctic Warming**

Where does Arctic BC come from?

Which is the largest source?

Europe?

Stohl, 2006
Huang et al., 2010
Sharma et al., 2013

Asia?

Wang et al., 2014
Sand et al., 2015; 2016
Ikeda et al., 2017

Difference?

increase in Asian emissions?
decrease in European emissions?

New observations in the Arctic

- **New aircraft measurements**:

  NETCARE 2015, PAMARCMiP 2009 and 2011

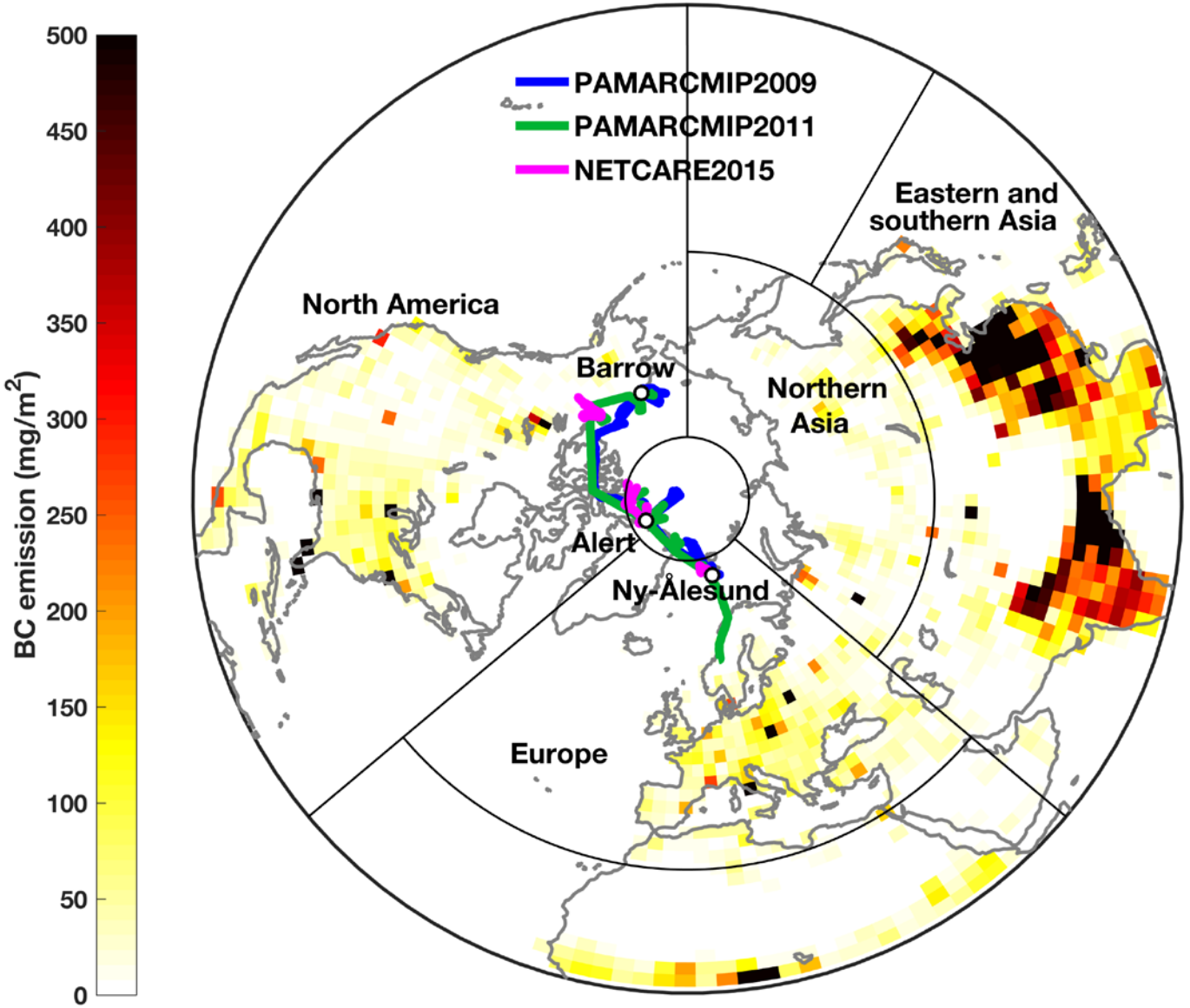
  * All in spring *Similar routes
  *All used SP2 (single particle soot photometer)
  *Vertical profiles near Alert, Barrow and Ny-Ålesund

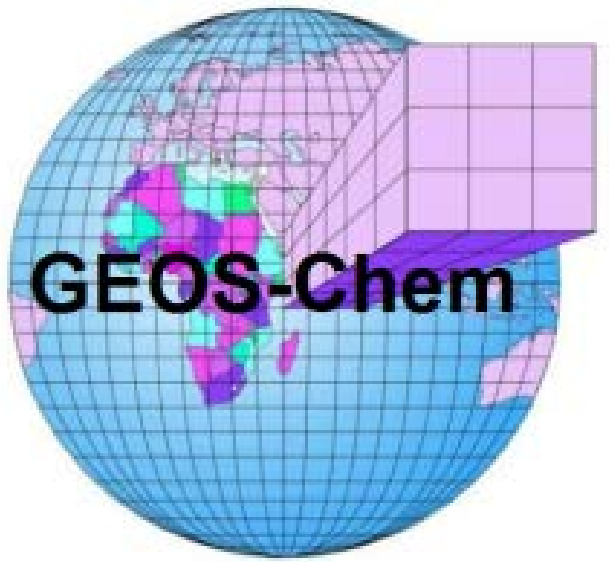
- **New surface measurements at Alert (82°N)**:

  SP2 and thermal method (Sharma et al., 2017)

- Interpret with the GEOS-Chem model to assess the regional contribution to Arctic BC

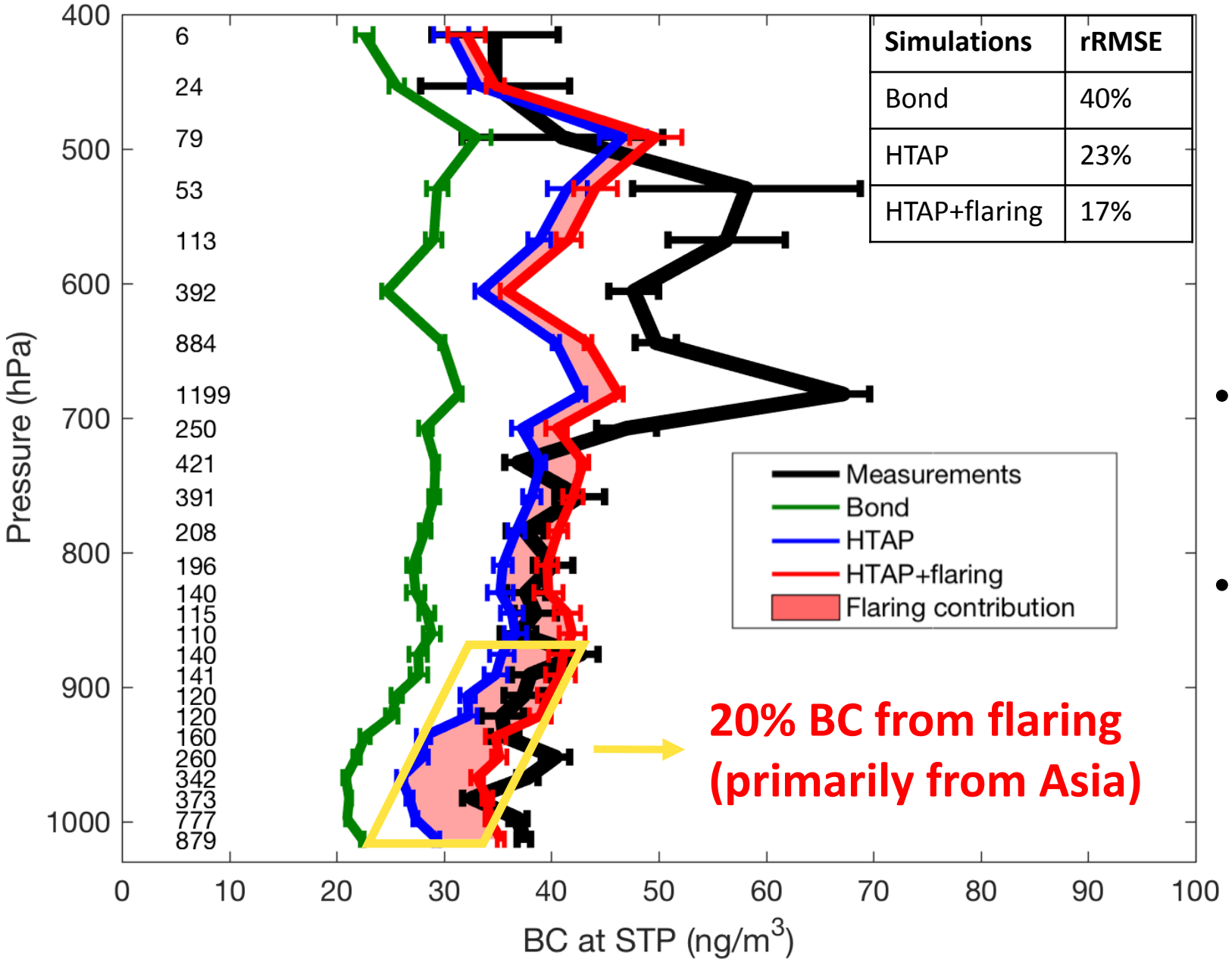
Emission inventories to represent the shift in Asian and European emissions





- HTAP anthropogenic emissions
- ECLIPSE gas flaring emissions
  (Stohl et al., 2013; Sand et al., 2016)
- GFED4 fire emissions

Arctic BC vertical profile for spring

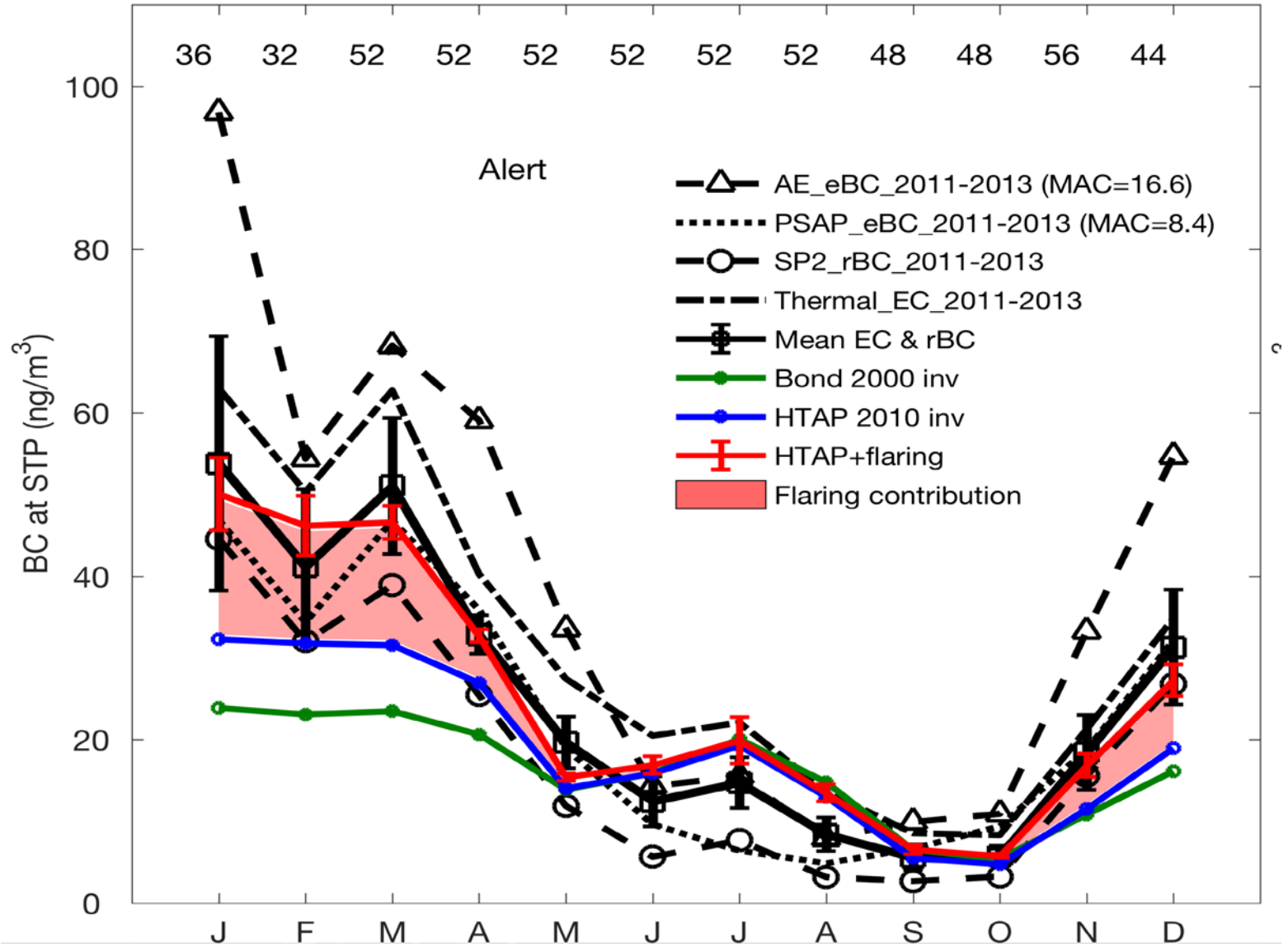


Simulations	rRMSE
Bond	40%
HTAP	23%
HTAP+flaring	17%

Constraining simulated vertical profiles by aircraft measurements

- The HTAP+flaring - best consistency with airborne measurements
- Underestimation in the middle troposphere likely due to plumes

Constraining simulated surface BC by observations

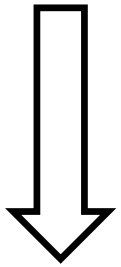


Diverse measurements at Alert (Sharma et al., 2017):

- Aethalometer > Thermal > PSAP > SP2
- Optical methods biased by a factor of 2
- Best estimate = mean EC and rBC

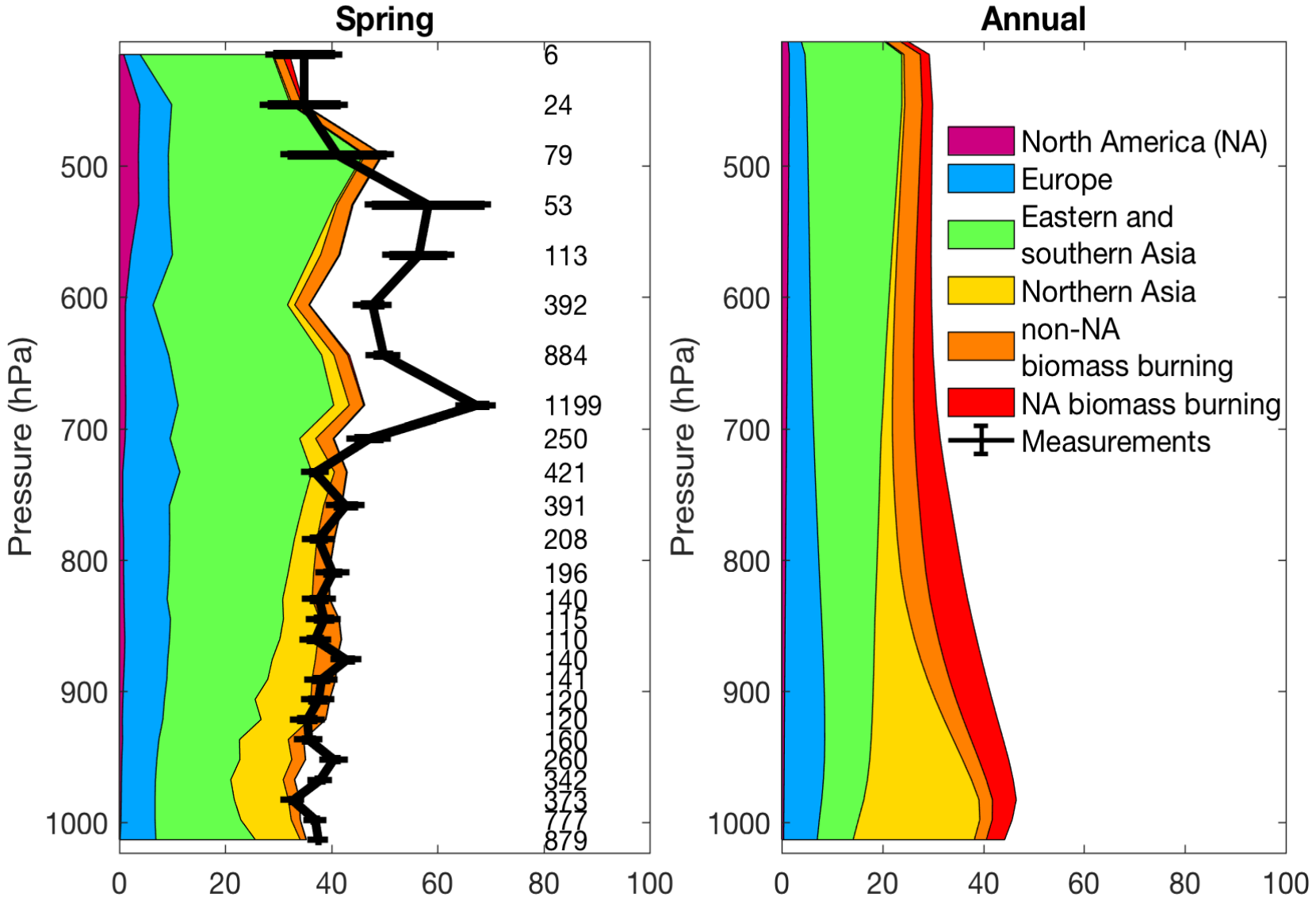
HTAP+flaring simulation: best consistency with surface measurements

HTAP+flaring exhibits good consistency with measurements



Interpreting geographic sources of Arctic BC with HTAP+flaring

Eastern and southern Asia – largest anthropogenic source in the mid-troposphere



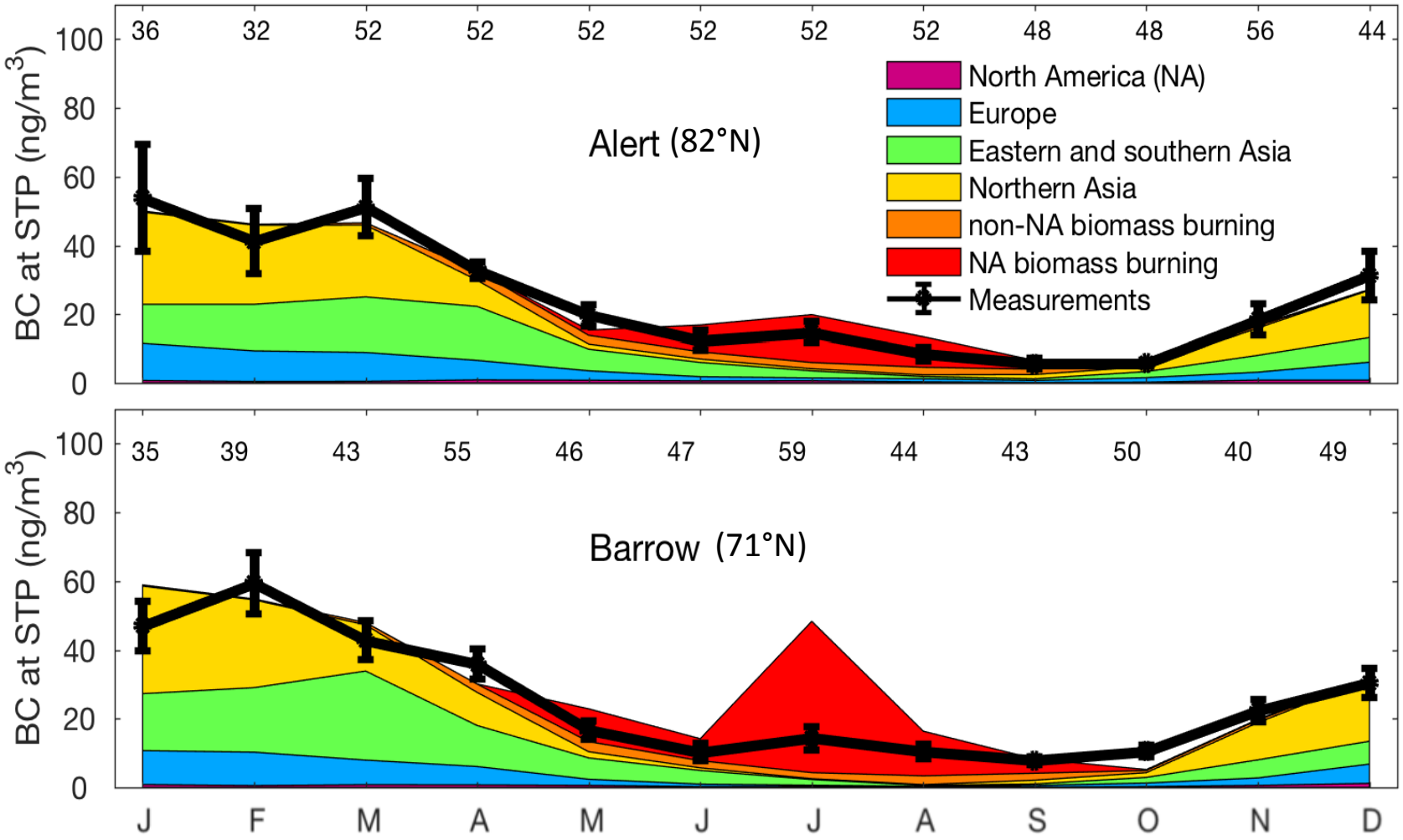
Spring

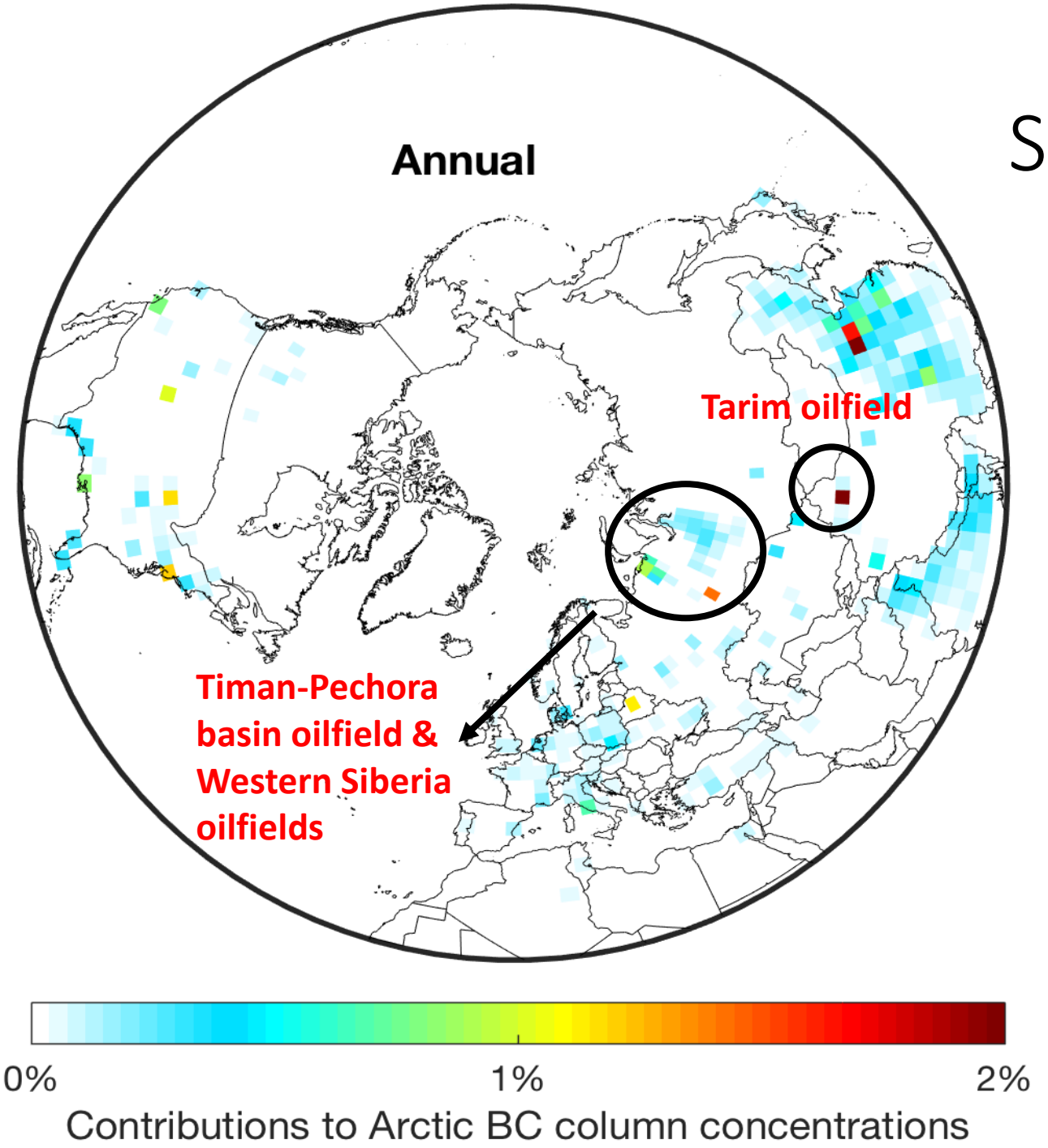
- Eastern Asia dominates: 56%, aloft > the surface
- Northern Asia: 4-fold decrease from the surface to 700hPa

Annual

- Eastern Asia: 37%; Biomass burning: 25%
- Northern Asia: 43% > 900hPa

Northern Asia – largest anthropogenic source of surface BC in the Arctic





Sensitivity of Arctic (>66.5°N) BC column concentrations to local emissions

Spatial

- **Eastern China** and **western Siberia** have the largest impact to Arctic BC loadings
- **Oilfields close to the Arctic** have striking impact on the Arctic

Summary

- The HTAP+flaring exhibited consistency with measurements
- **Asia** was the largest source of both tropospheric and ground-level BC in the Arctic. Eastern and southern Asia dominated the middle troposphere. Northern Asia dominated near the surface.
- **Tarim oilfield in China** and **oilfields in western Siberia** had a striking impact on Arctic BC loadings.