Jet Propulsion Laboratory
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Intercomparison of SMAP, SMOS and Aquarius Sea Surface Salinity products in the Arctic Ocean

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Motivations: A need to study freshwater content and distribution changes in the Arctic Ocean

- Arctic Ocean freshwater content and distribution are changing:
  - hydrological forcing (increased river runoff) - *Peterson et al., 2002*
  - cryospheric forcing (melting sea ice) - *Vaughan et al., 2013*
  - atmospheric forcing (accelerated winds and increased precipitation) - *Bintanja and Andry, 2017; Giles et al, 2012; Proshutinsky et al., 2002; Morison et al., 2012*

    -> impacts on: North Atlantic and global oceanic circulation
    ocean heat content
    water and biogeochemistry cycles

- Recent development of sea surface salinity remote sensing (since 2010)

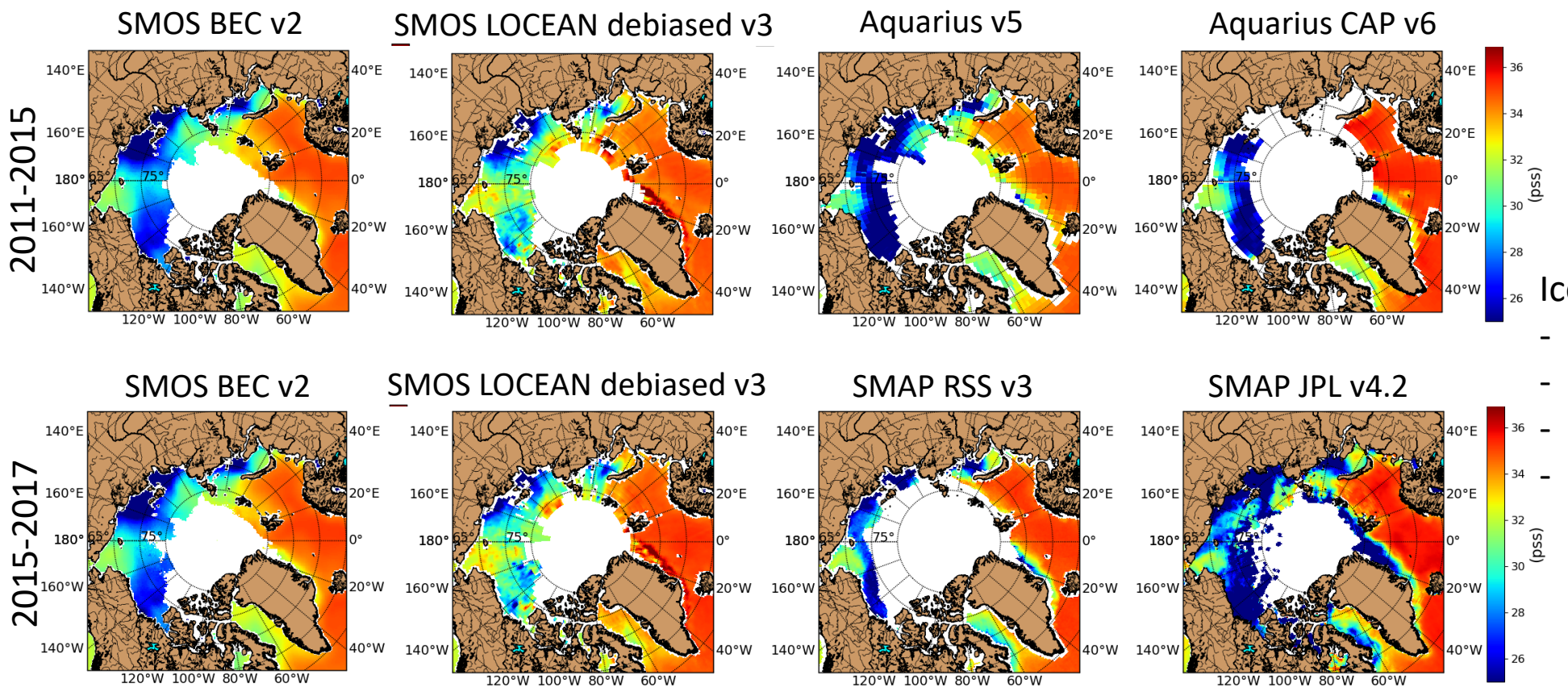
  -> large uncertainties are expected at high latitudes - *Swift and McIntosh, 1983*

  -> Arctic SSS signals are also large

Can satellite sea surface salinity be used to study freshwater content and distribution in the Arctic Ocean? - Need to assess S/N ratio

6 different SSS products in the Arctic Ocean in overall good agreement

Averages



Ice concentration thresholds:

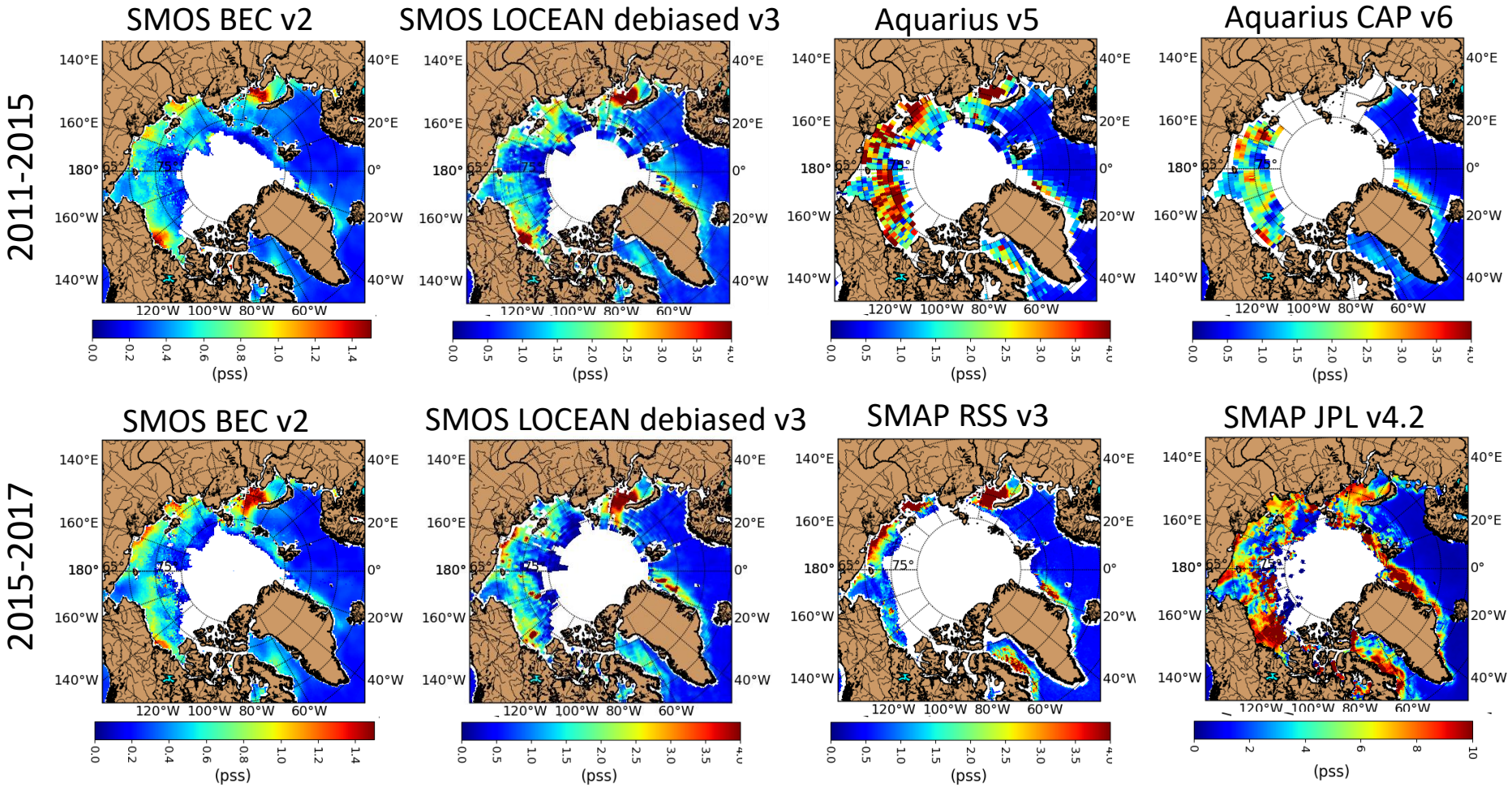
- Aquarius 0.1%
- Aquarius CAP v6 3%
- SMAP RSS 0.1%
- SMAP JPL 3%

- Overall good agreement
- RSS ice mask more aggressive
- JPL SMAP saltier in the North Atlantic Ocean
- SMOS LOCEAN saltier in fresh regions (Greenland, Baffin, Beaufort, Siberia)

6 SSS products with large local differences

Different amplitudes!!

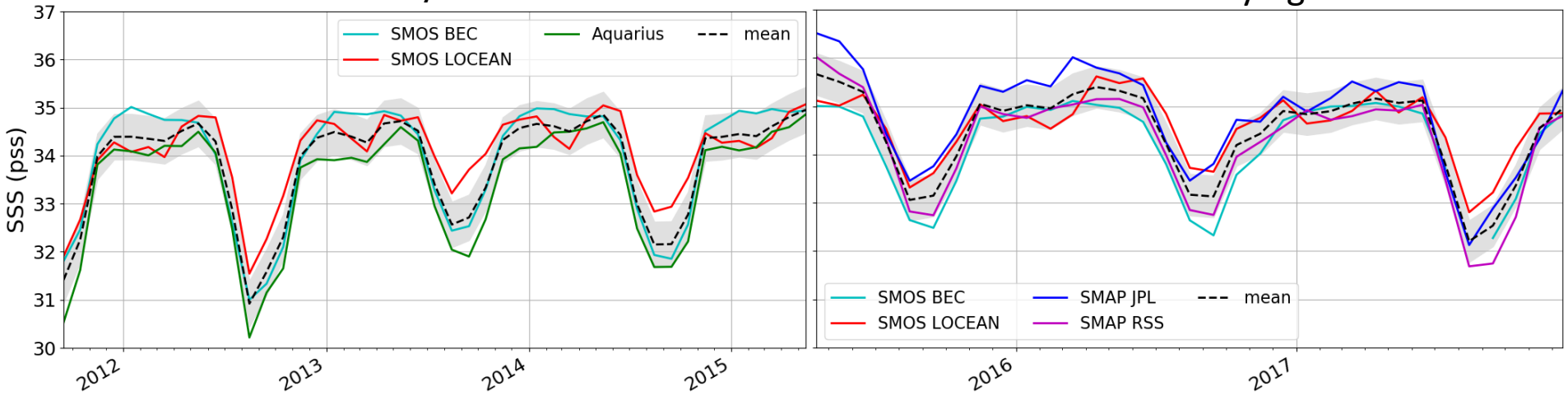
Standard Deviation



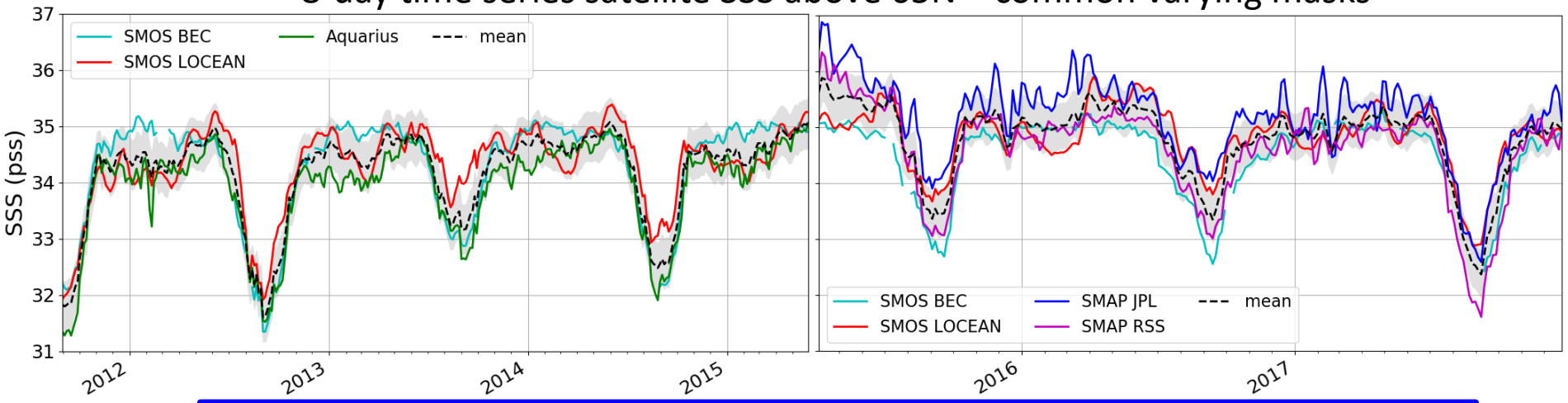
Similar regions of high SSS variability
But large difference in magnitude between SMAP, SMOS and Aquarius

Different SSS products in overall good agreement over the entire Arctic Ocean basin

Monthly time series satellite SSS above 65N – common varying masks



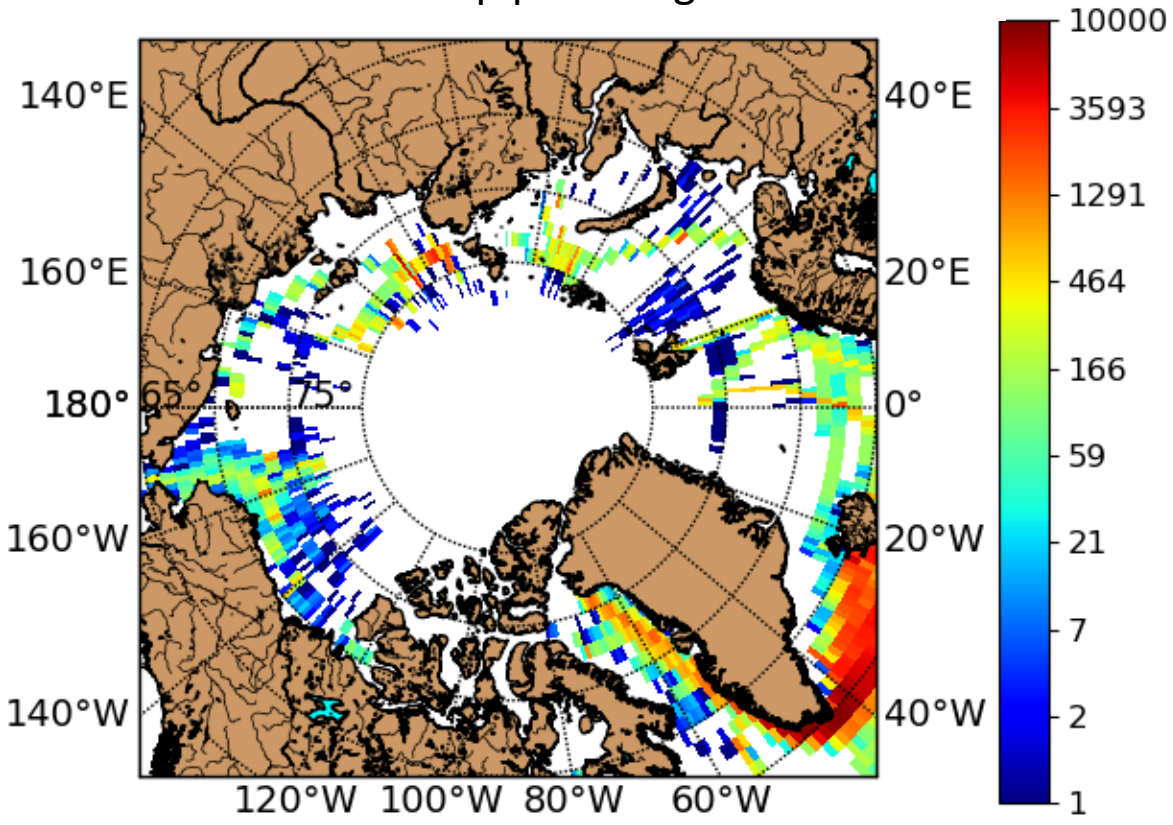
8-day time series satellite SSS above 65N – common varying masks



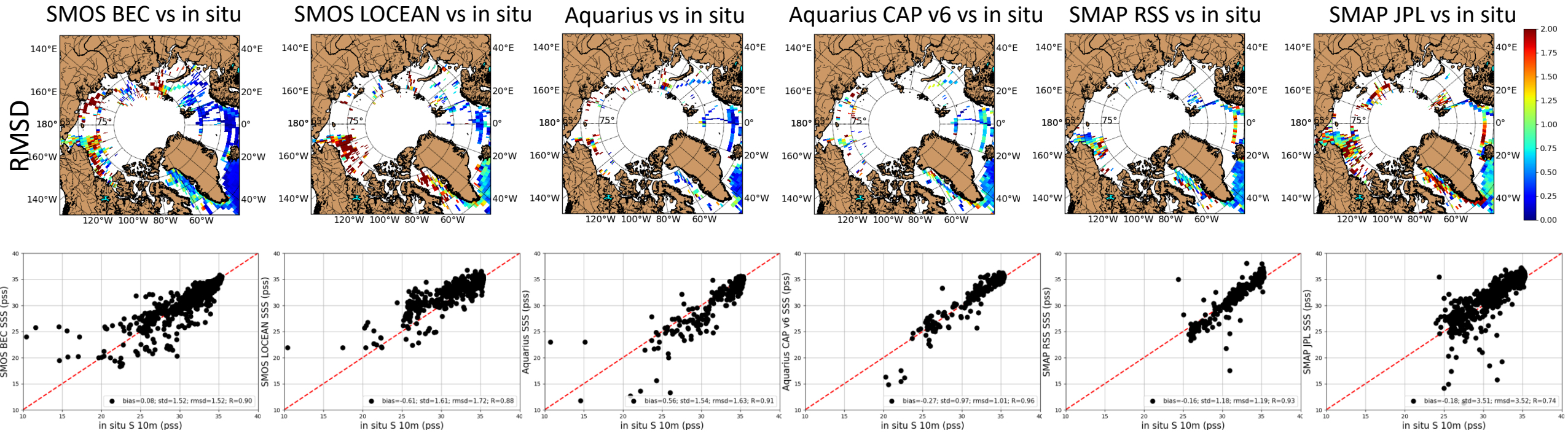
- Overall excellent agreement
- Spread among products (0.43/0.47 pss) smaller than seasonal variability (2-4 pss)

Limited in situ observations in the Arctic Ocean

Number of in situ observations collocated with satellite observations within the first 10m deep per 1 degree bin



Satellite-in situ comparisons



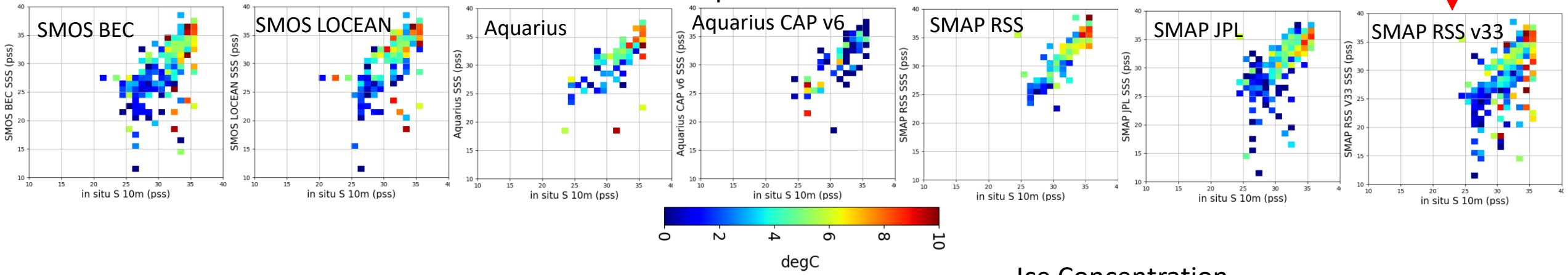
RMSD = 1.52 | RMSD = 1.72 | RMSD = 1.63 | RMSD = 1.01 | RMSD = 1.19 | RMSD = 3.52

- Good comparisons between satellite and in situ observations
- Effects of temperature and ice on salinity retrievals
- Important to note the differences in ice masks
- Important to understand satellite & in-situ sampling differences

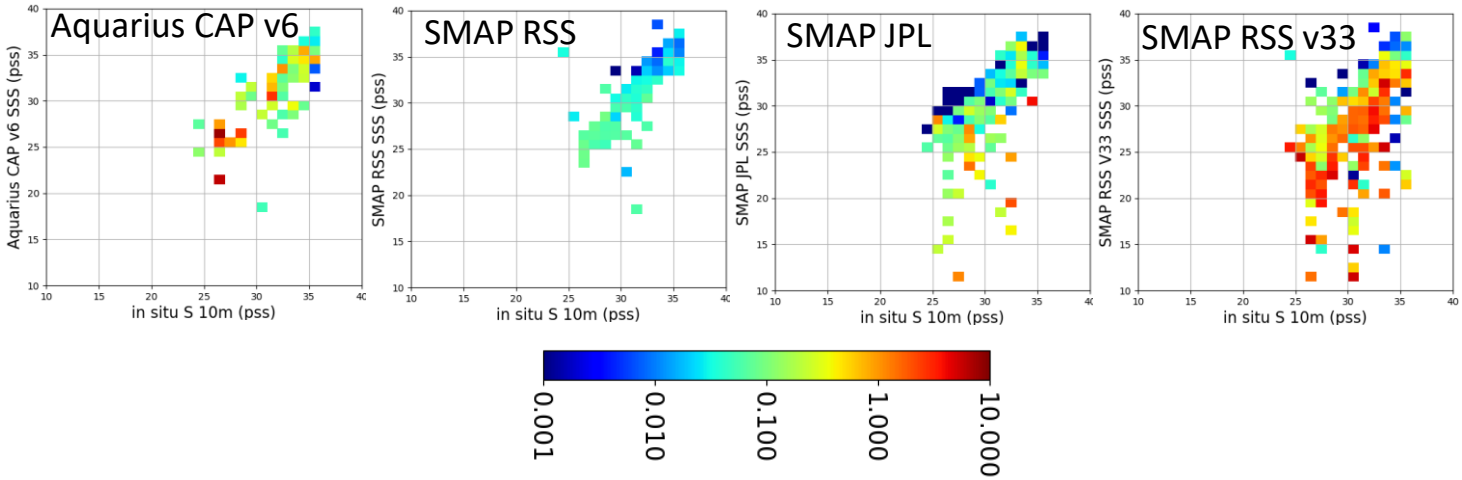
Satellite-in situ comparisons as a function of temperature and ice concentration

Another version of SMAP RSS (v33) with ice concentration threshold of 10%

Temperature



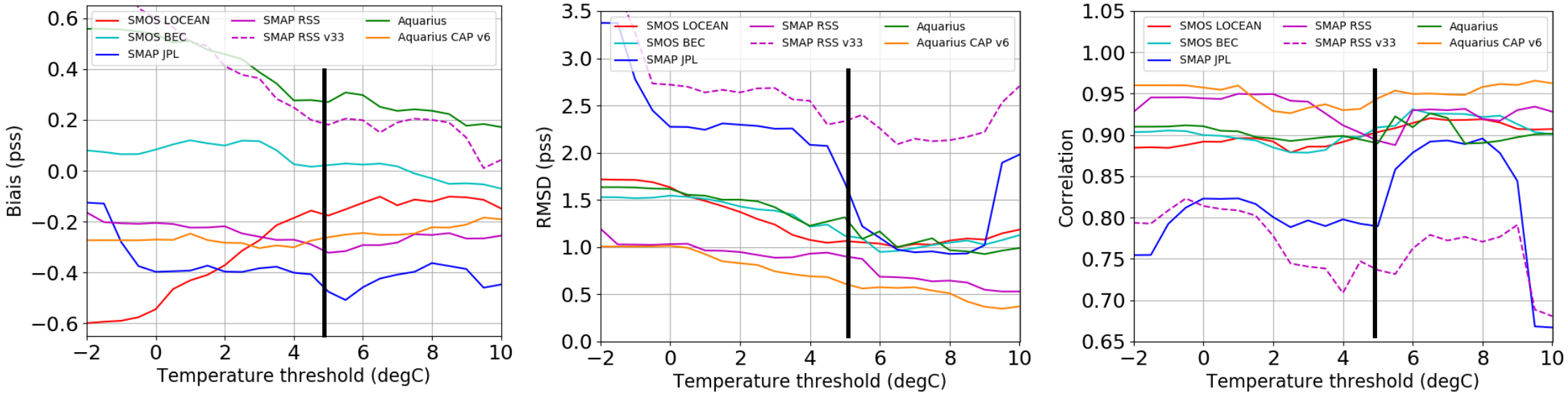
Ice Concentration



Effects of temperature : largest differences between satellite and in situ usually correspond to low temperature waters and higher sea ice concentration

Satellite-in situ comparisons – impact of temperature

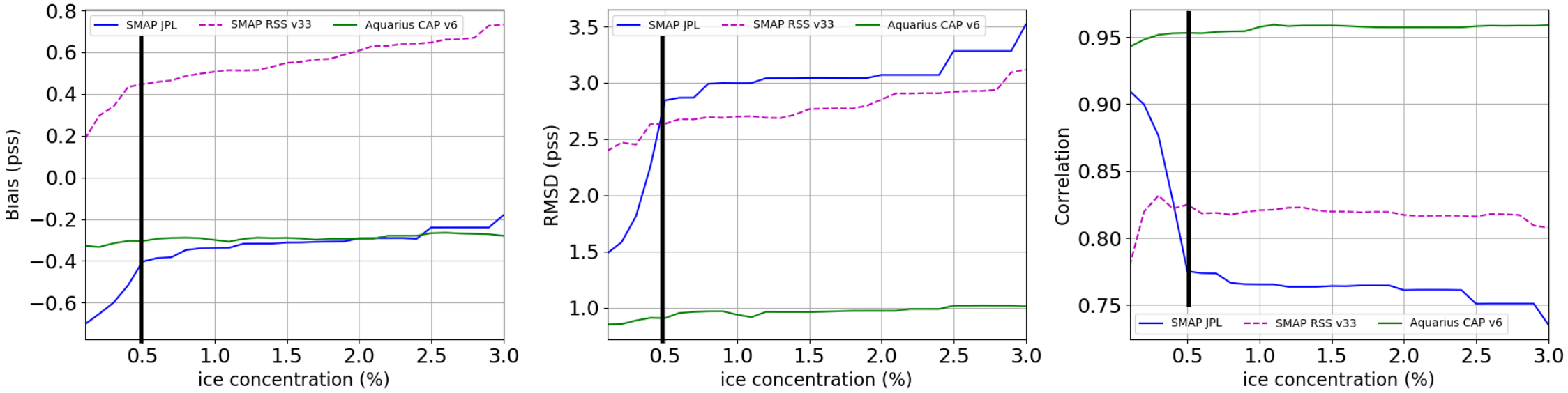
Another version of SMAP RSS (v33) with ice concentration threshold of 10%



RMSD significantly lower when considering only temperature lower than 5°C
(especially for products allowing retrievals closer to ice: SMAP JPL and SMAP RSS v33)

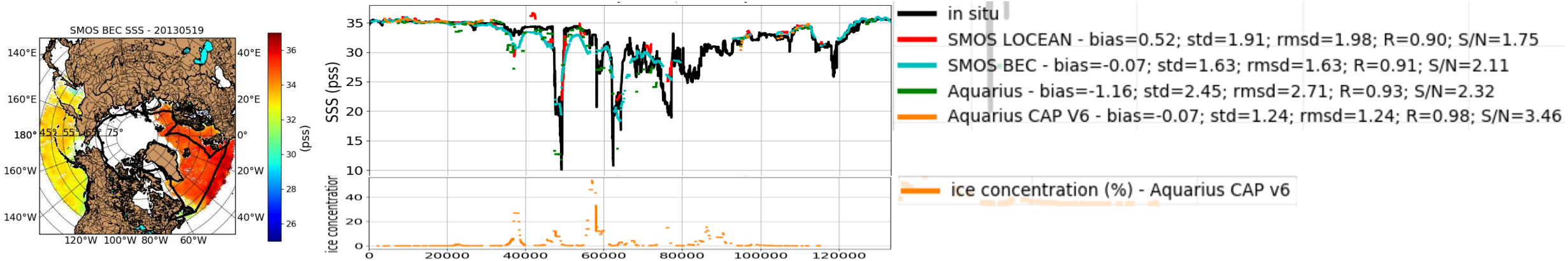
Satellite-in situ comparisons – impact of ice concentration

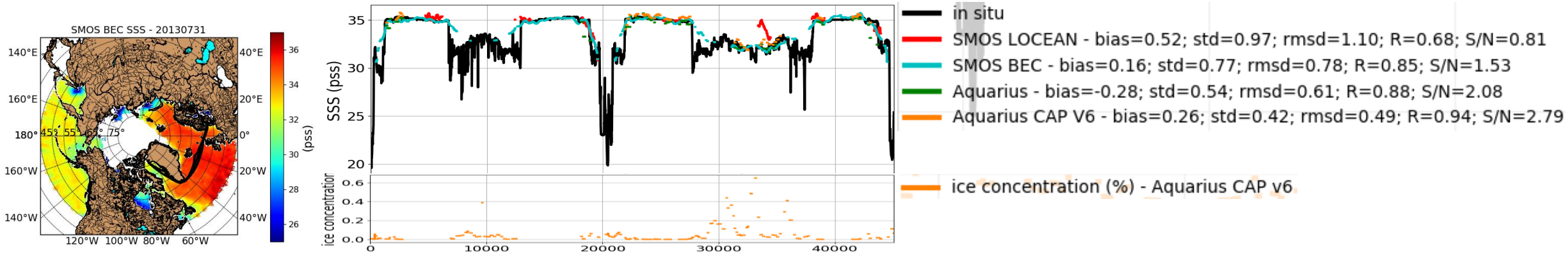
Another version of SMAP RSS (v33) with ice concentration threshold of 10%

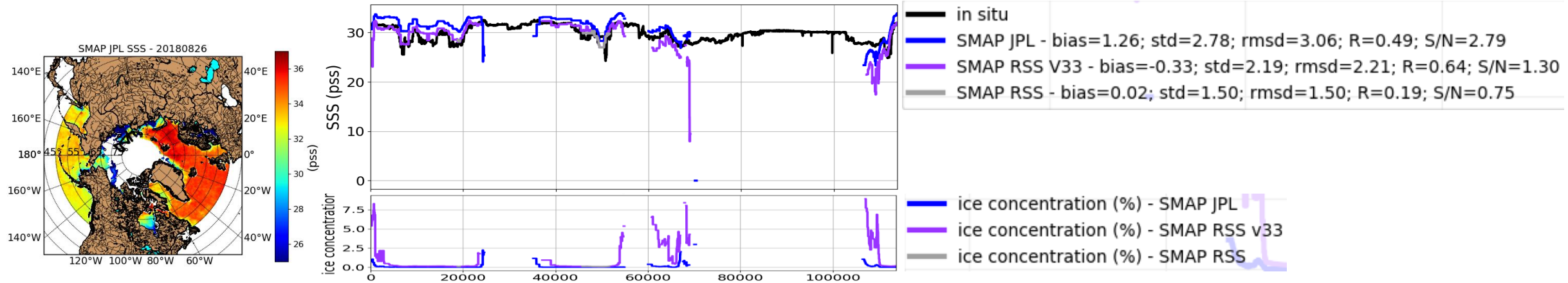


- RMSD decreases with sea ice concentration threshold
- RMSD significantly lower for a threshold of 0.5% (for products allowing retrievals closer to ice: SMAP JPL and SMAP RSS v33)

Satellite-in situ comparisons along TSG transects







Summary

- Excellent Pan-Arctic consistency between SMOS BEC, SMOS LOCEAN, Aquarius, Aquarius CAP, SMAP JPL and SMAP RSS products with Spread among products smaller than seasonal variability

- SMAP JPL is saltier and SMOS LOCEAN is saltier in fresh regions (Greenland, Baffin, Beaufort, Siberia)

- Major differences in ice masks among products

- Spatial patterns of spatial variability consistent among products but the magnitude of the variability are very different

- Satellite-in situ salinity comparisons:
  - in-situ observations are sparse in time and space in the Arctic Ocean region
  - Largest differences between satellite and in situ typically correspond to low temperature waters and higher sea ice concentration
  - RMSD significantly lower when considering a threshold of 5°C
  - RMSD significantly lower when considering a threshold of 0.5% for sea ice concentration