satellite observations of tropospheric BrO over salt lakes and northern high latitudes

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BrO in the atmosphere – why do we care?

In the stratosphere:

- catalytically destroys O_3 with significantly higher efficiency than ClO (starts with $Br_2 + h\nu \rightarrow 2Br$) …
- *"BrO is to ClO what CH_4 is to CO_2 – there is a lot less of it, but it is a lot more potent on a per-molecule basis"*

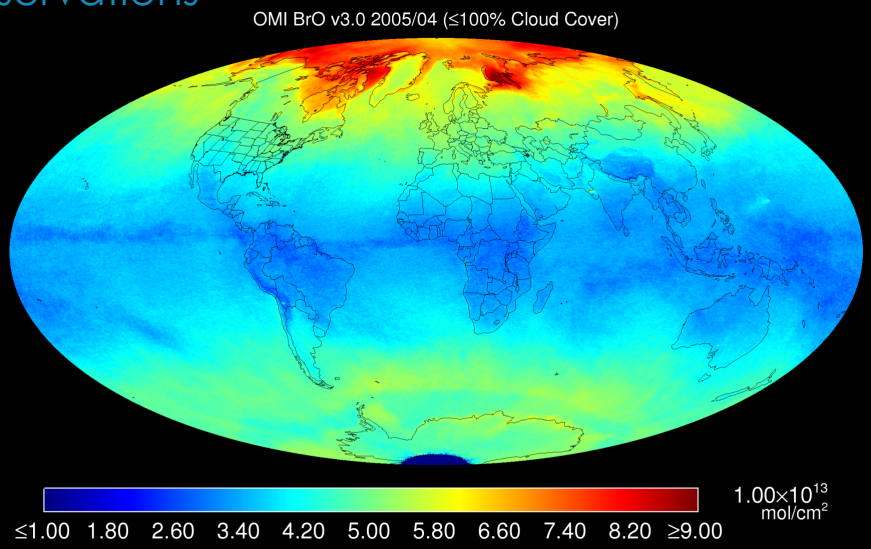
In the troposphere:

- main sources of bromine in the troposphere: bromocarbons (CH_3Br, CH_2Br_2, $CHBr_3$) and release mechanisms from sea salt
- associated with nearly-complete ozone depletion events observed in polar regions
- environmental impact: BrO oxidizes gaseous mercury to reactive mercury, which leads to mercury deposition (main process in the Arctic)
- changes the NO_x(NO + NO_2) and HO_x(OH + HO_2) balance towards OH, with the potential to increase CH_4 oxidation

BrO in the atmosphere

what we know from surface and balloon observations

- observations of BrO in volcanic plumes, over salt lakes, and in the polar regions
- confirmation of enhanced BrO during tropospheric ozone depletion events in the Arctic and Antarctic
- possible tropospheric loading of ~0.5-1.2×10^{13} mol/cm^2 (1-2 ppt)



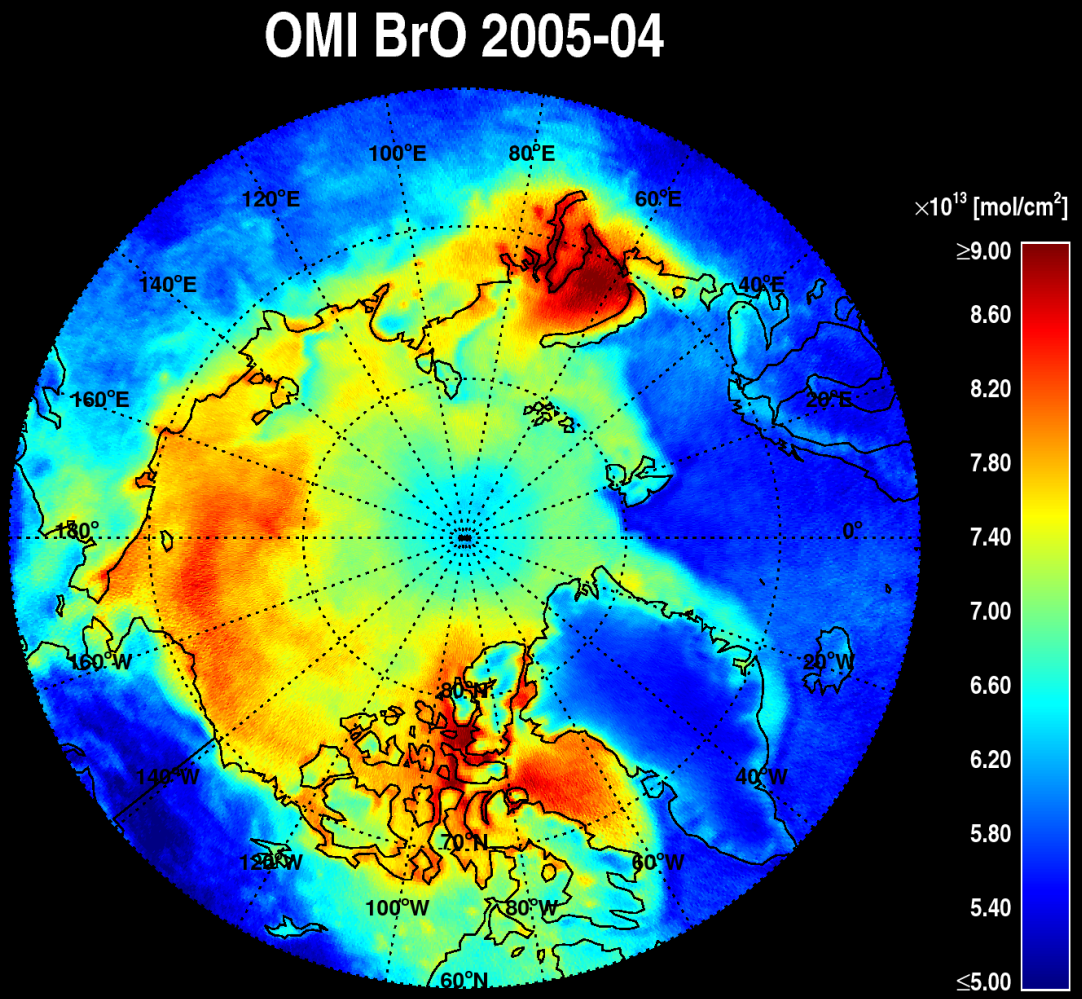
what we know from satellite observations

- global BrO total columns have a longitudinally uniform distribution
- latitudinal variation between ~3×10^{13} mol/cm^2 (tropics) and ~5×10^{13} mol/cm^2 (high latitudes)
- tropospheric hotspots are observed at high latitudes in polar springtime over fresh sea ice and during snow-blowing events (Choi et al., 2017) – "bromine explosions"
- BrO was detected in the plume of the Kasatochi eruption in August 2008
- Salawich et al., (2010) showed that low tropopause events can lead to "hot spots" that may be erroneously interpreted as being of tropospheric origin

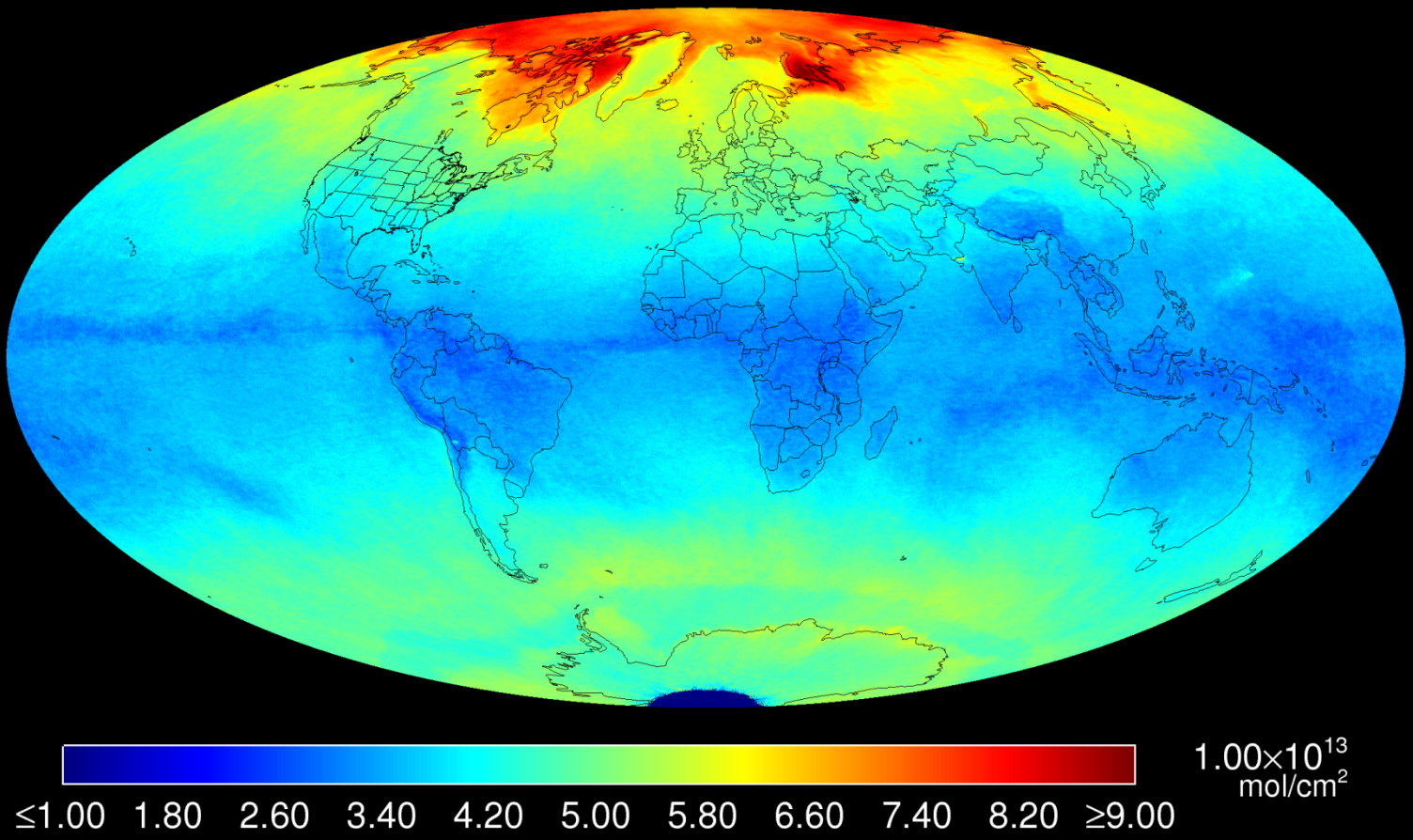
BrO at high northern latitudes

surprisingly detailed features in Arctic coastal areas:

OMI BrO shows high sensitivity to tropospheric/ boundary layer events of (polar) BrO.

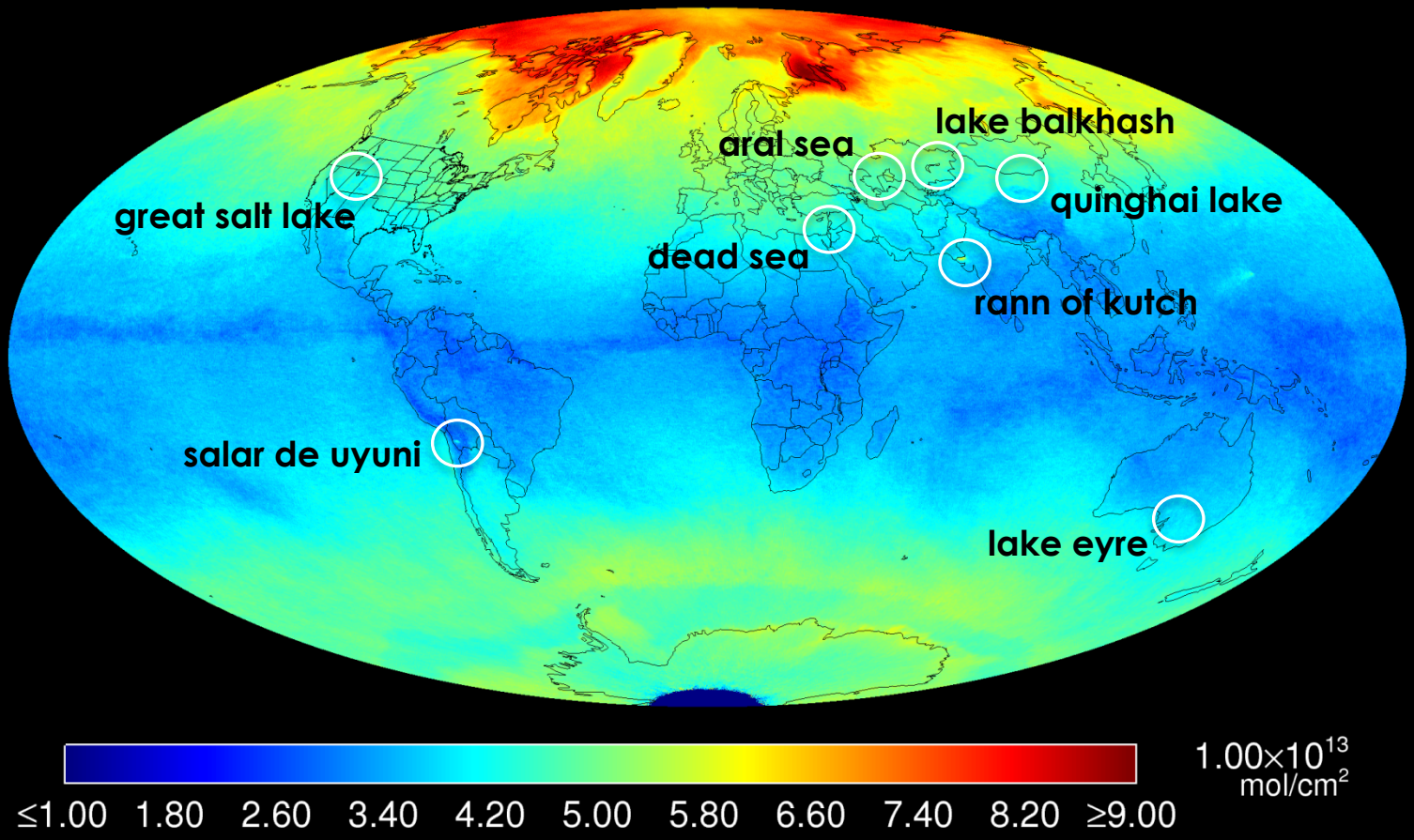


a global view: OMI BrO April 2005 monthly average



longitudinally homogenous, strong latitudinal gradient

moving on to salt lakes



small tropospheric BrO signatures – how to extract the signal

steps in identifying small tropospheric BrO signatures in OMI data:

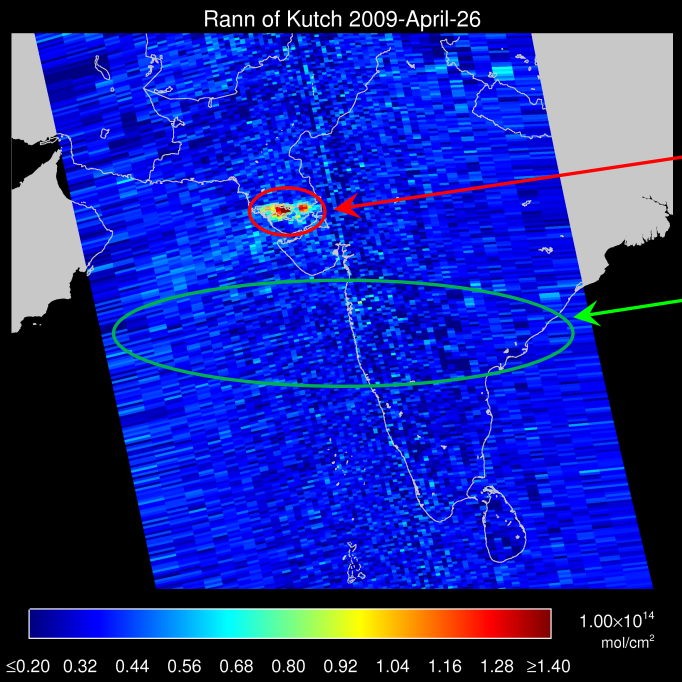
(1) define the target region of activity: salt lake, volcanic plume, *etc*.

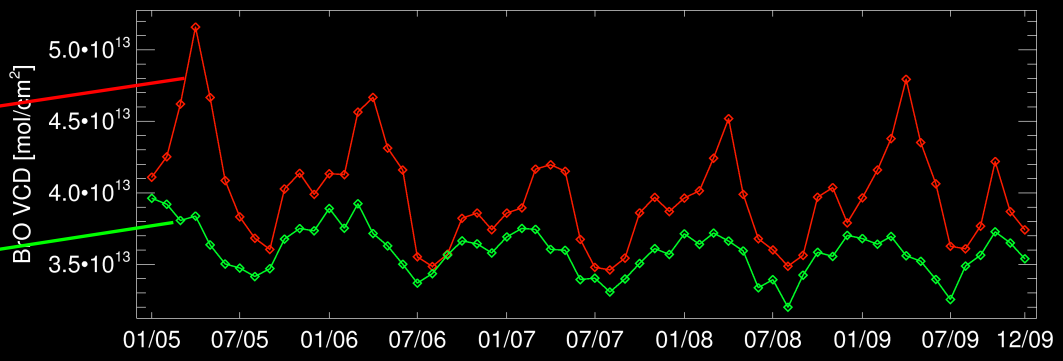
(2) identify signals originating from the target and from the surrounding area

(3) subtract the averages of the two regions

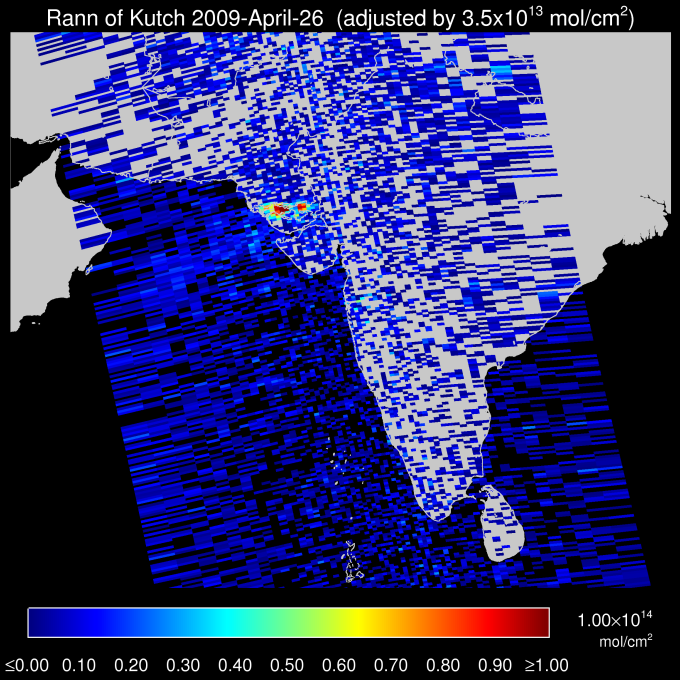
example: The Great Rann of Kutch (India)

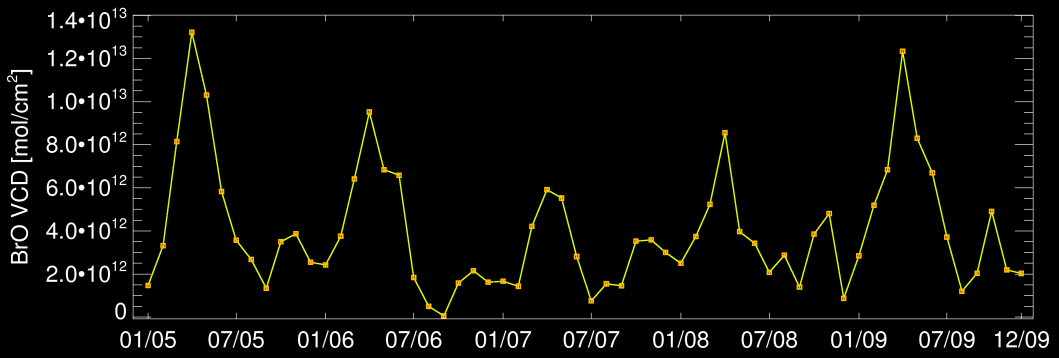
BrO from salt lakes – the Rann of Kutch, India

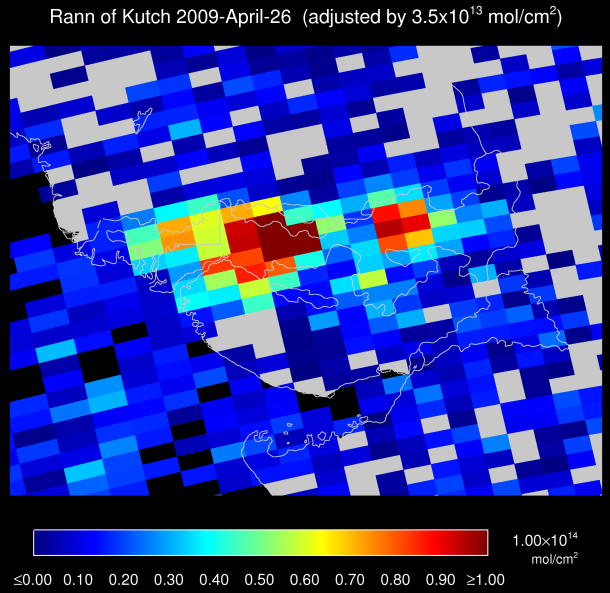




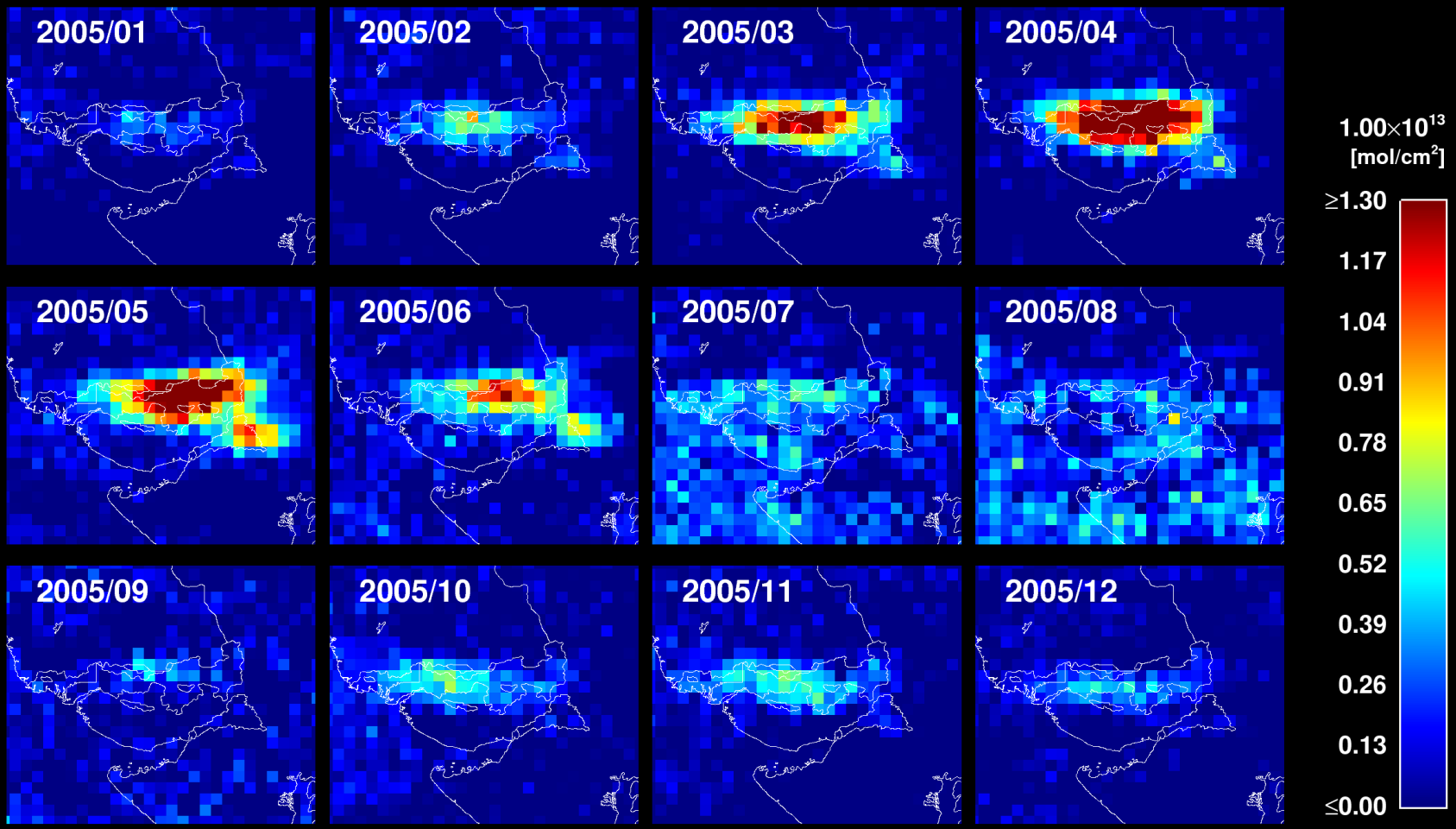
BrO from salt lakes – the Rann of Kutch, India



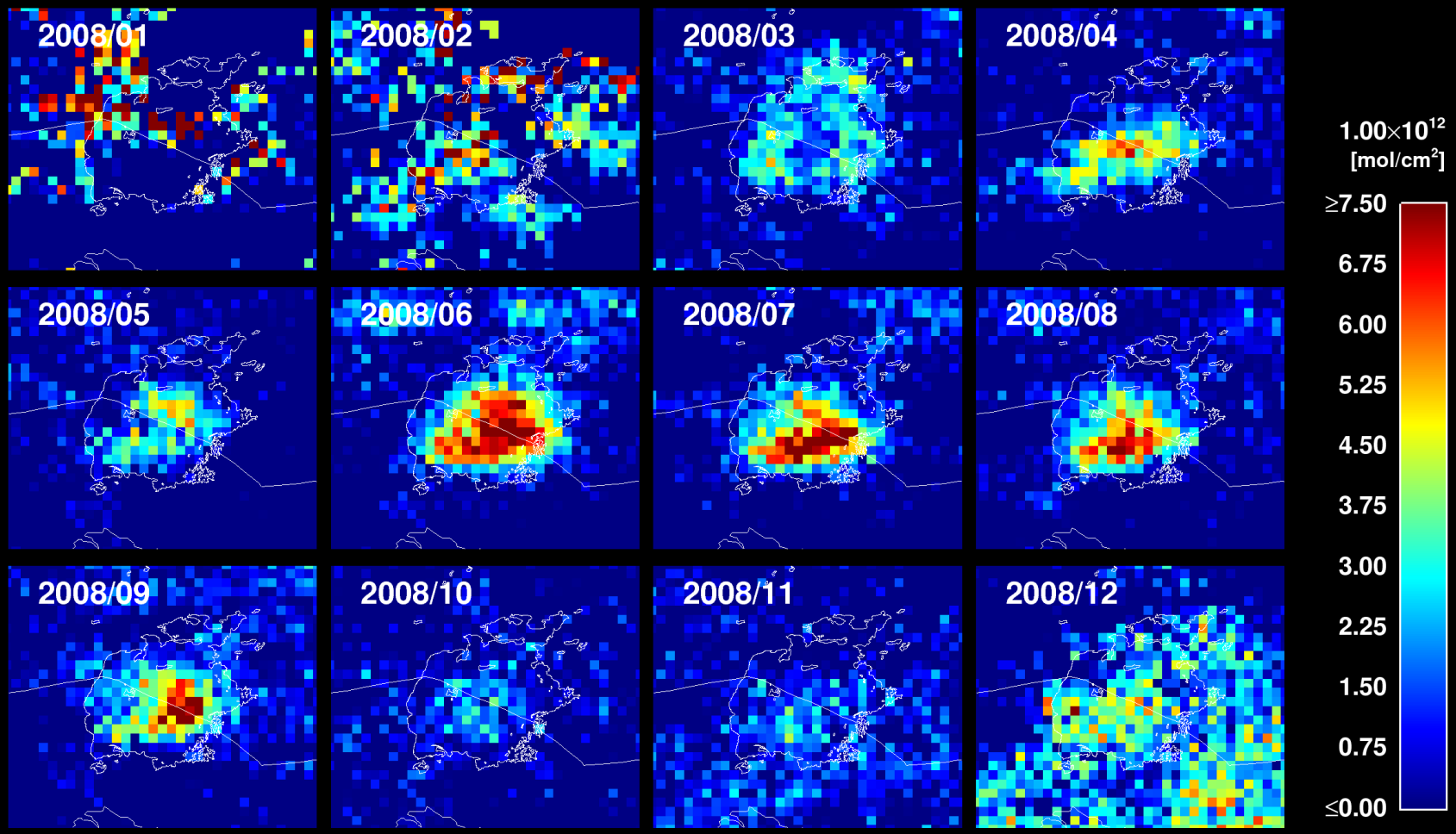




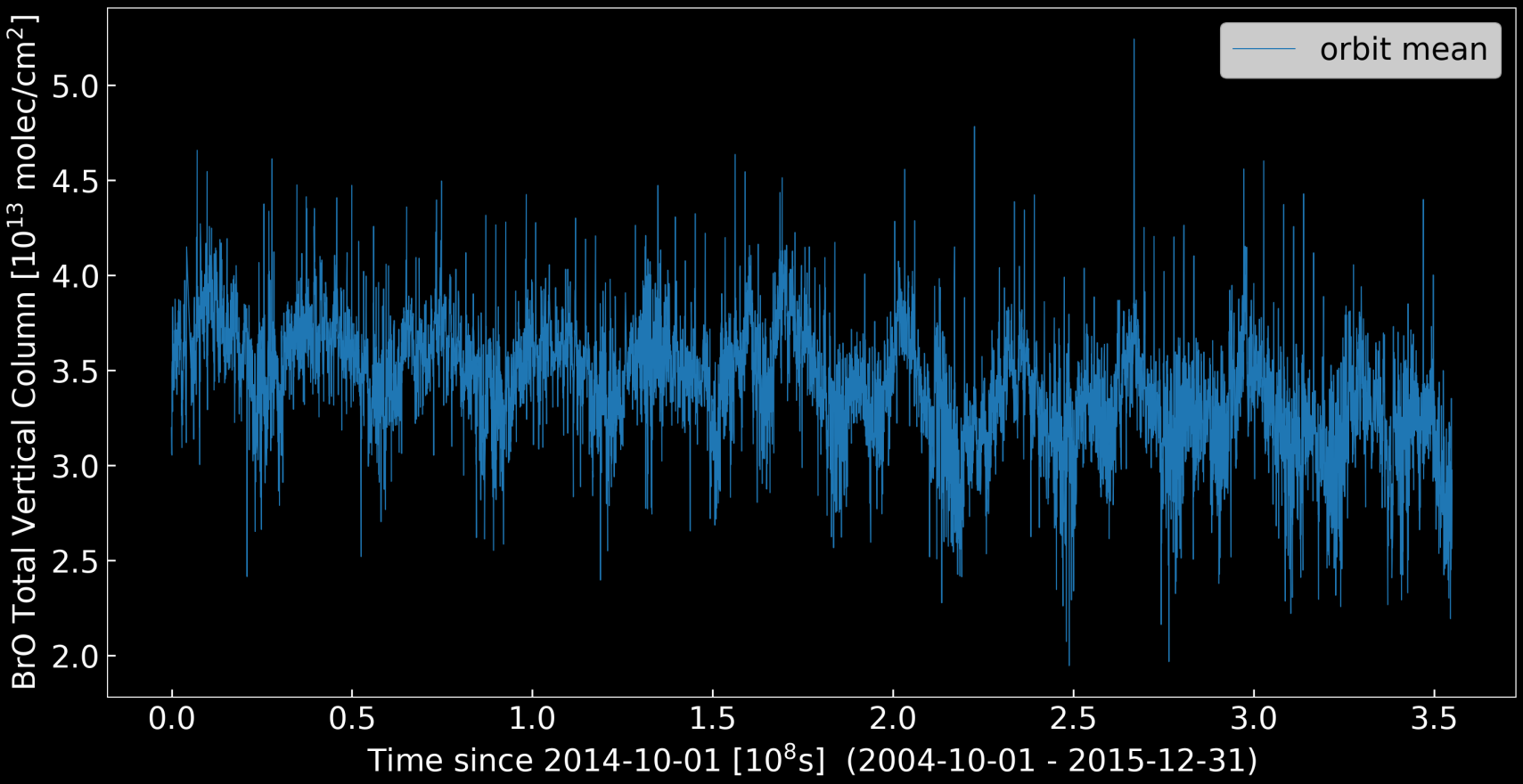
BrO from salt lakes – the Rann of Kutch, India; annual cycle



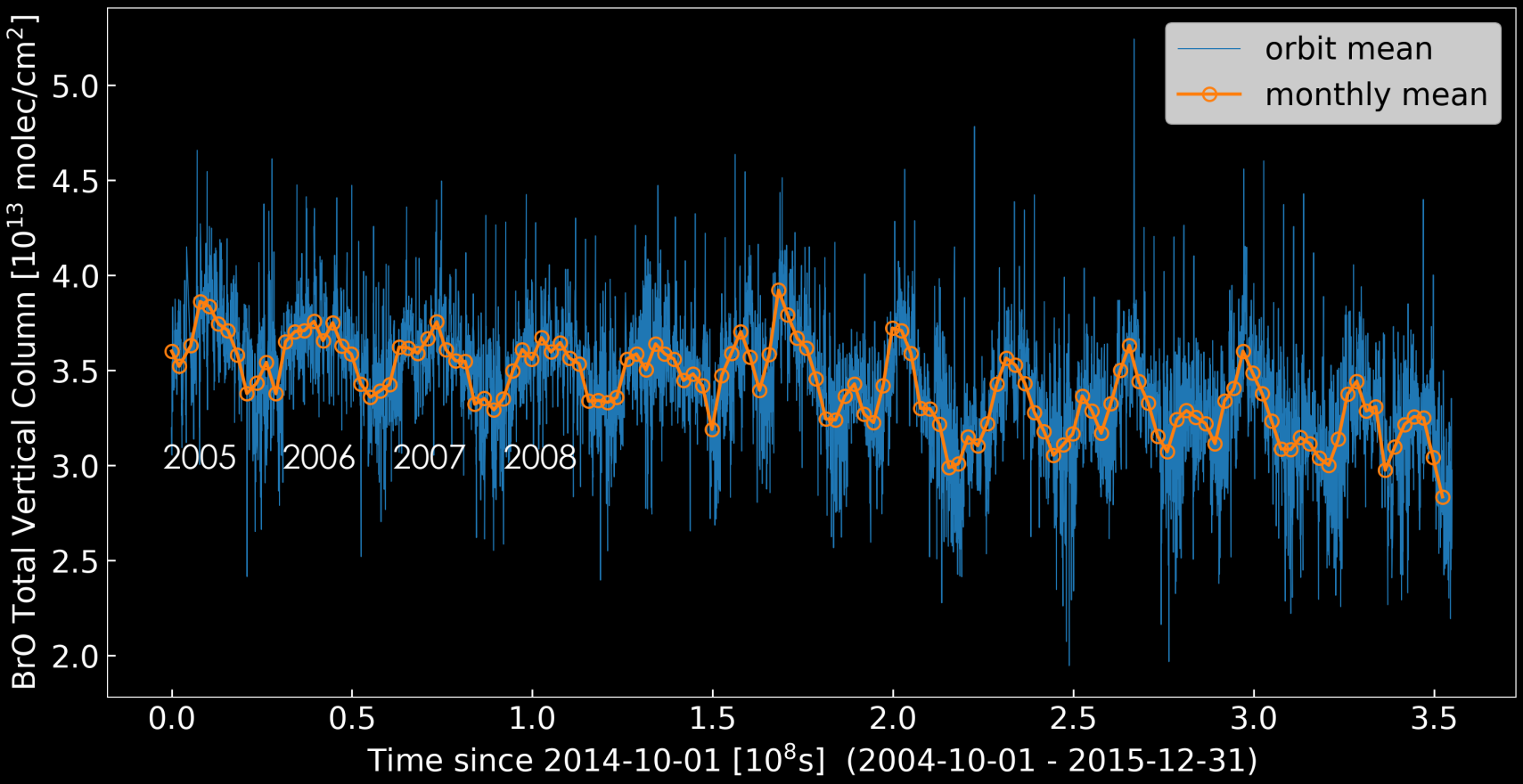
BrO from salt lakes – the Aral Sea, Kazakhstan; annual cycle



Rann of Kutch – orbit-averaged data (“daily”)

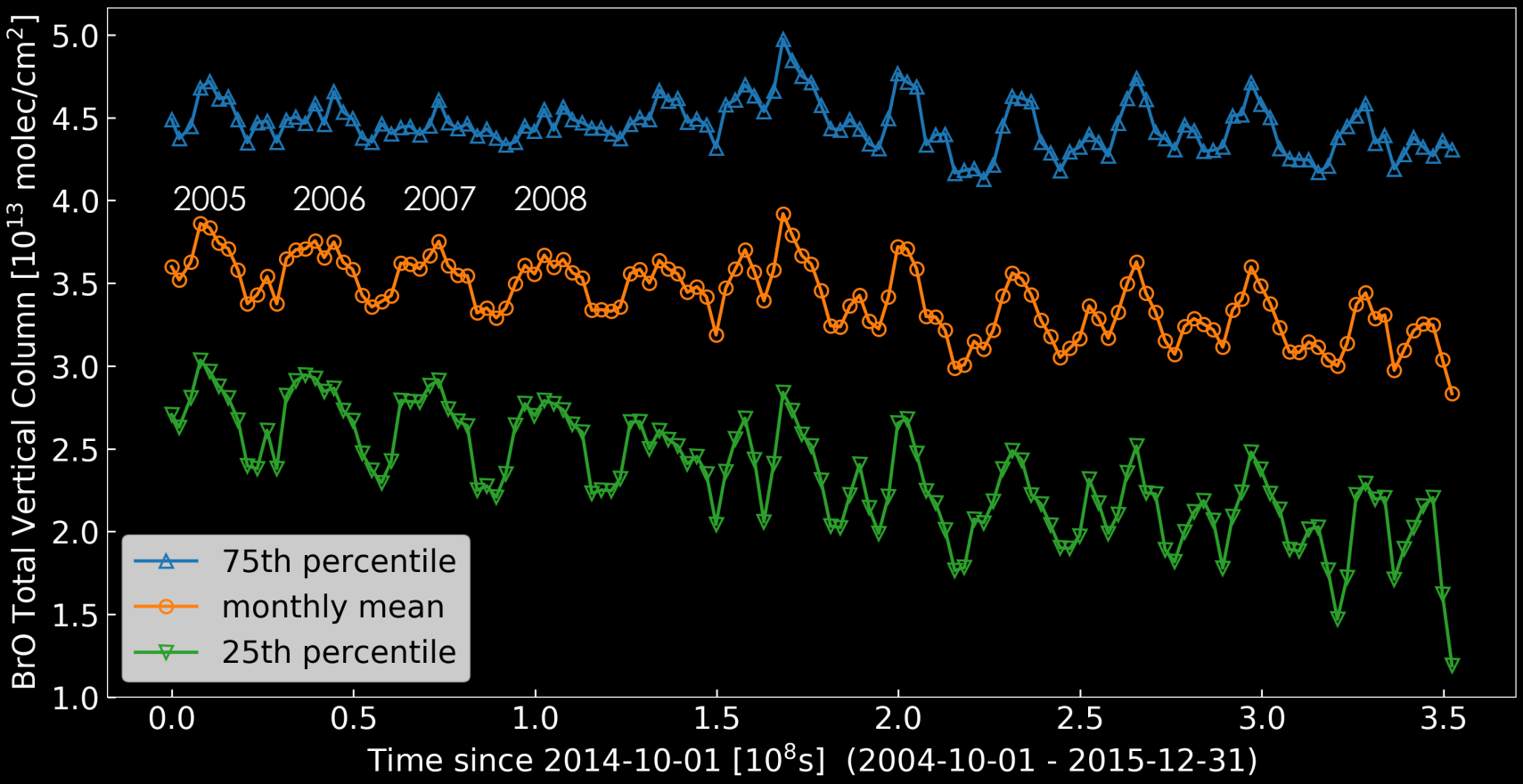


Rann of Kutch – orbit- and monthly mean data



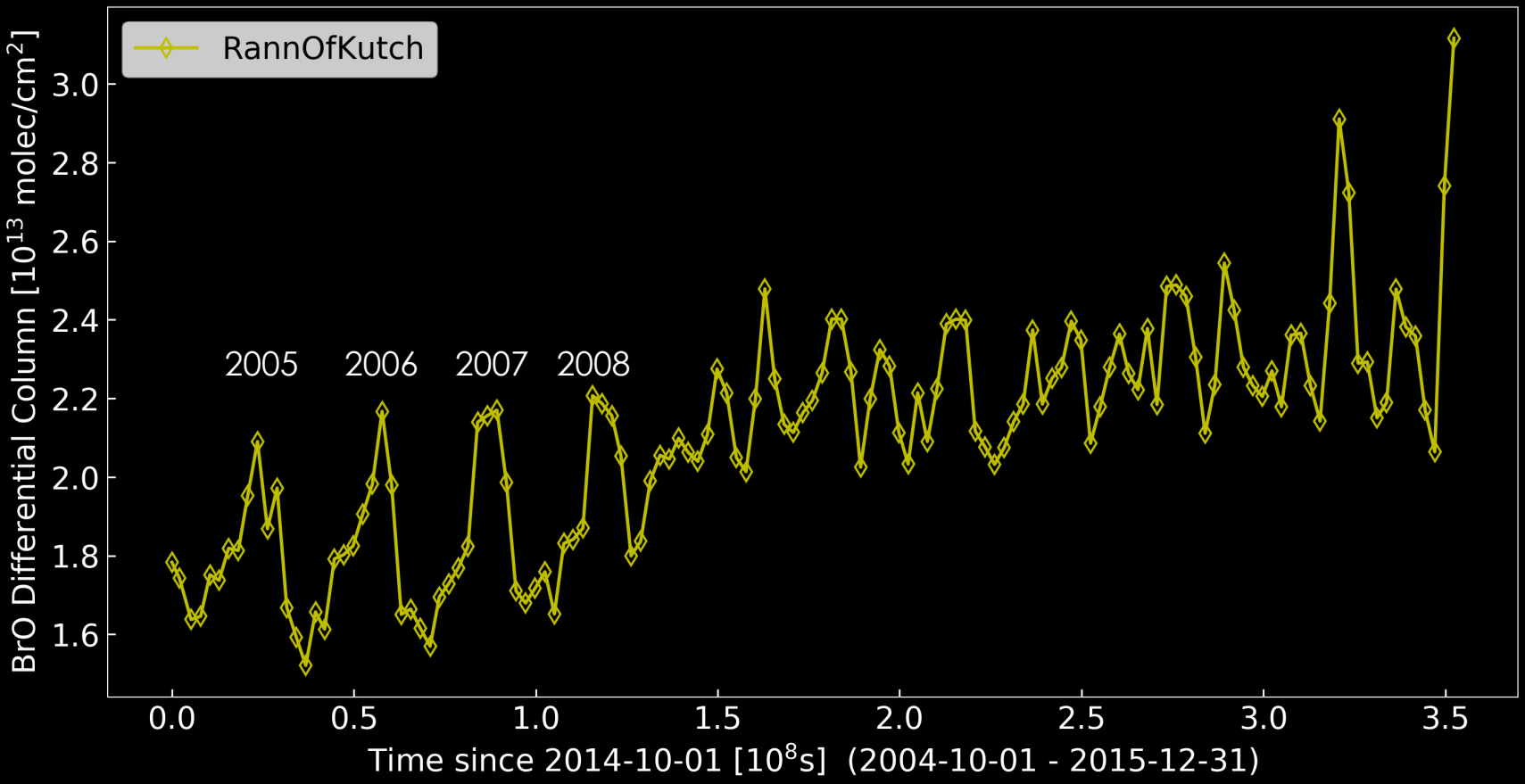
preliminary observation: there appears to be a downward trend in OMI BrO with time

Rann of Kutch –monthly mean, 25th and 75th percentile



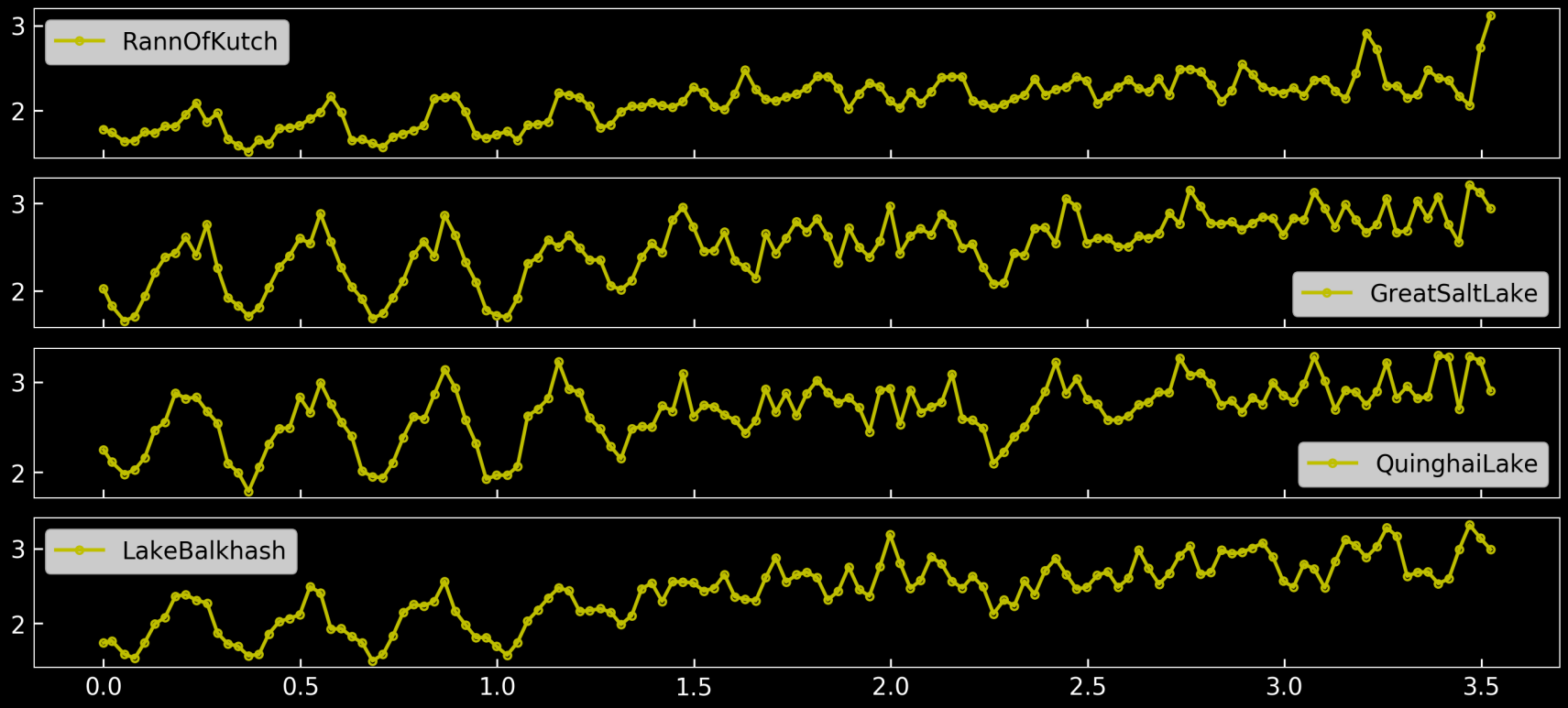
preliminary observation: the downward trend appears to be higher in smaller values

Rann of Kutch – difference between 75th and 25th percentile



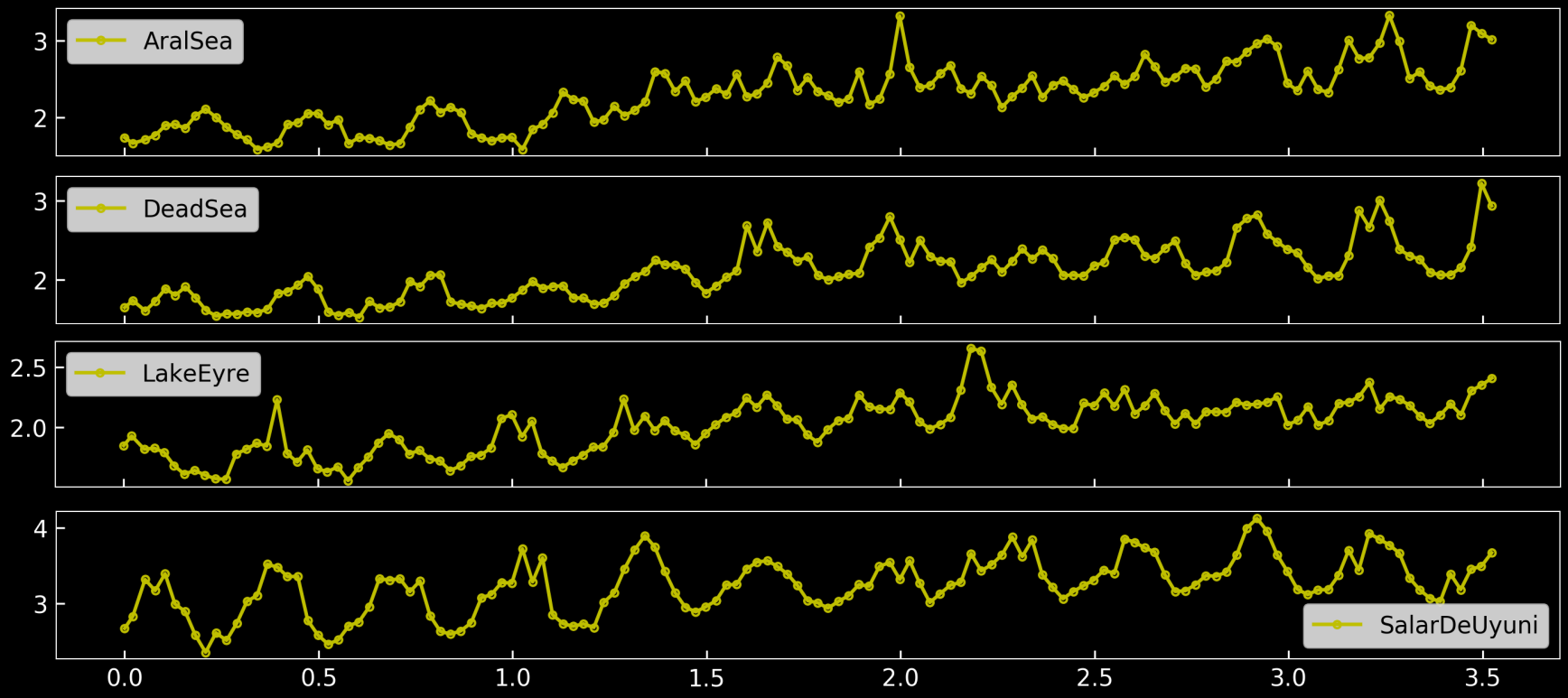
it is difficult to observe seasonal variations past 2008 – possibly related to row anomaly

summary of northern-hemisphere salt lakes



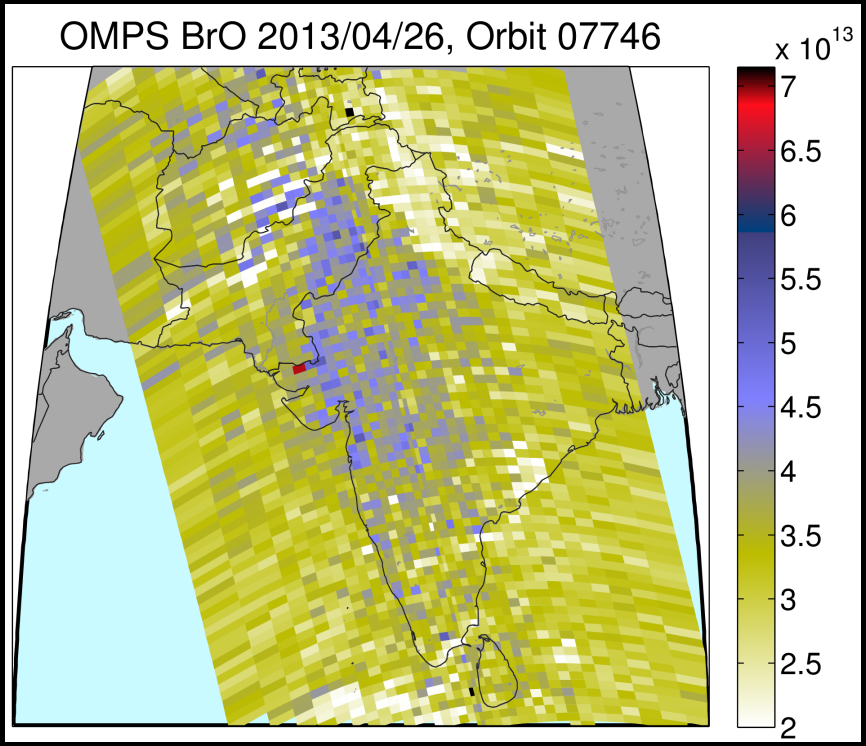
all salt lakes essentially show the same seasonal cycle. post-2008 data need thorough analysis for drifts and biases.

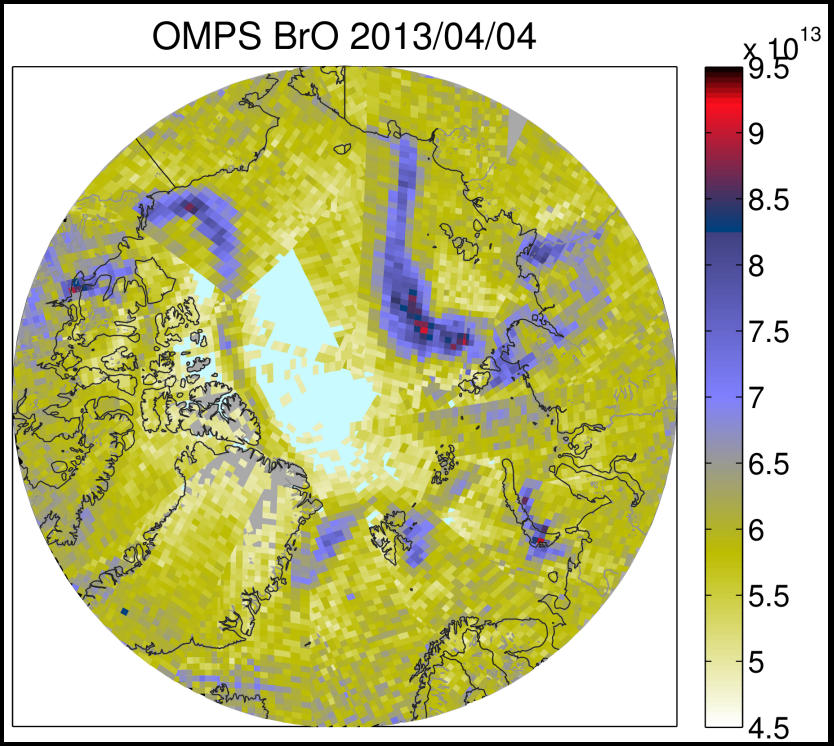
summary of northern- and southern-hemisphere salt lakes



Lake Eyre and Salar de Uyuni are in the southern hemisphere and hence have shifted seasonality in their BrO release. the same caveat holds for post-2008 data

what about BrO from OMPS on Suomi/NP?





first results are encouraging, but it requires quite a bit more work to turn it into a proper product

summary/next steps

OMI observes BrO release from a wide range of salt lakes
(peaks are dependent on temperature and lake dessication)

residual percentile method is a first approach to quantify the release
(careful analysis is required to define adequate thresholds)

OMI operational BrO appears to develop a bias/trend after 2008
(discussion with R. Suleiman, SAO to investigate)

tropospheric BrO retrieval should use proper air mass factors
(residual retrievals with tropospheric AMFs)

BrO retrievals from OMIS on Suomi/NPP and JPSS-1
(currently being worked on)

thank you