DUST DEPOSITION TO THE SARGASSO SEA: A COMPARISON OF ESTIMATES USING SEASONALLY-RESOLVED MEASUREMENTS OF ALUMINUM IN THE UPPER WATER-COLUMN VERSUS AEROSOLS AND RAINWATER COLLECTED ON BERMUDA

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INTRODUCTION

- Dust deposition is a major source of bioactive trace elements to the surface ocean, yet remains difficult to quantify in space and time
- Time-averaged dust fluxes have been estimated using surface ocean dissolved aluminum (DAl) concentrations together with assumed values for the fractional solubility of aerosol aluminum (%Al_S) and the replacement time of DAl in the surface mixed layer (τ_{Al})[1]
- We have obtained seasonally-resolved measurements of DAl in the upper water column in the BATS region, along with ~weekly samples of aerosols and rainwater from the Tudor Hill tower on Bermuda
- Analysis of these samples allows a comparison of two independent estimates of dust deposition, based on (1) the water-column DAl inventory, and (2) total Al in aerosols and rain from Tudor Hill

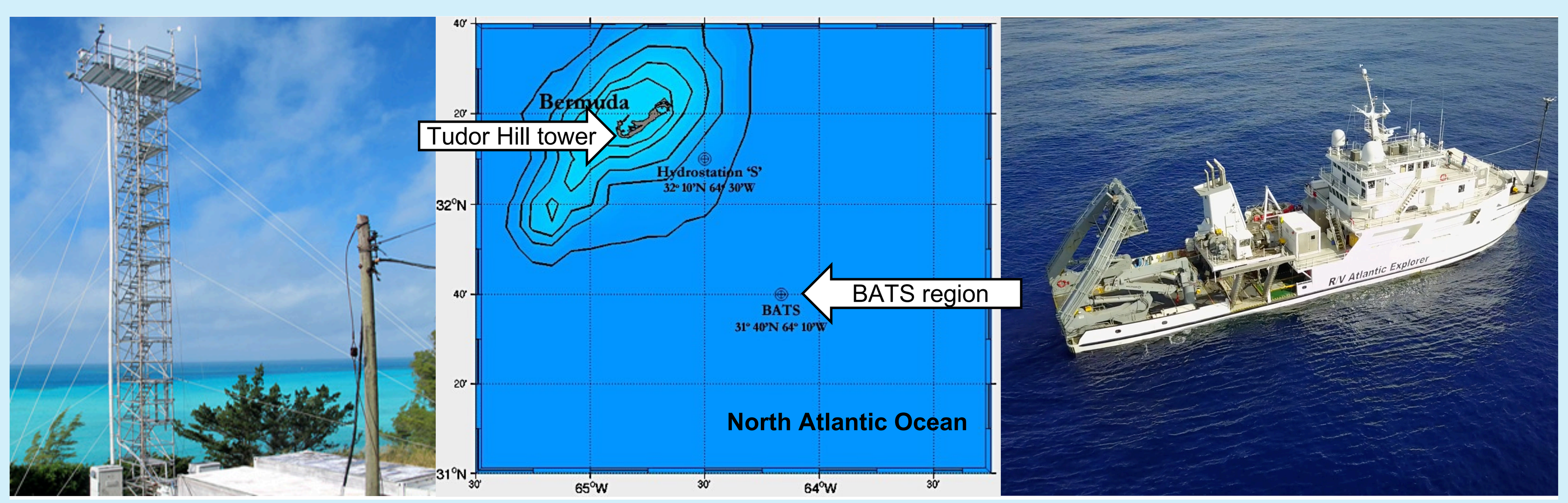

Figure 1. Tudor Hill tower (left), map of Bermuda and BATS sampling region (center), and Research Vessel *Atlantic Explorer* (right)

SAMPLING AND ANALYSES

- Water-column samples were collected from the BATS site and adjacent spatial stations (Fig. 1) during cruises in March (spring), May (early summer), August (late summer) and November (fall) 2019
- Bulk aerosols and rainwater were collected over the same period on the Tudor Hill tower on Bermuda, using a high-volume aerosol sampler with Whatman-41 filters and an automatic rain collector
- Water-column samples were filtered through 0.2 µm-pore Acropak Supor capsule filters, and DAl was determined in the filtered water column samples using flow-injection analysis[2]
- Aerosol sample portions were subjected to strong-acid microwave digestion, and to leaching with ultrapure deionized water (DIW) then 25% acetic acid (HOAc)[3]; rainwater samples were acidified to pH < 2
- Al in aerosol digests, leach solutions and acidified rainwater was measured using inductively-coupled plasma mass spectrometry

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RESULTS

Aerosol- and rain-based dust flux estimates

- Dry dust deposition was estimated from total aerosol Al loadings and an assumed dust deposition velocity[4] of 1 cm/s (Fig. 2), using an Al crustal abundance of 8.1%[5], yielding an average flux of 0.67 $g/m^2/y$
- Wet dust deposition was estimated from total-dissolvable Al in rain and measured rainwater volumes (Fig. 2), and an Al crustal abundance of 8.1%, yielding an average flux of 0.51 $g/m^2/y$
- These estimates then yield an average total (dry+wet) dust deposition flux of 1.18 $g/m^2/y$ over our 318 day sampling period

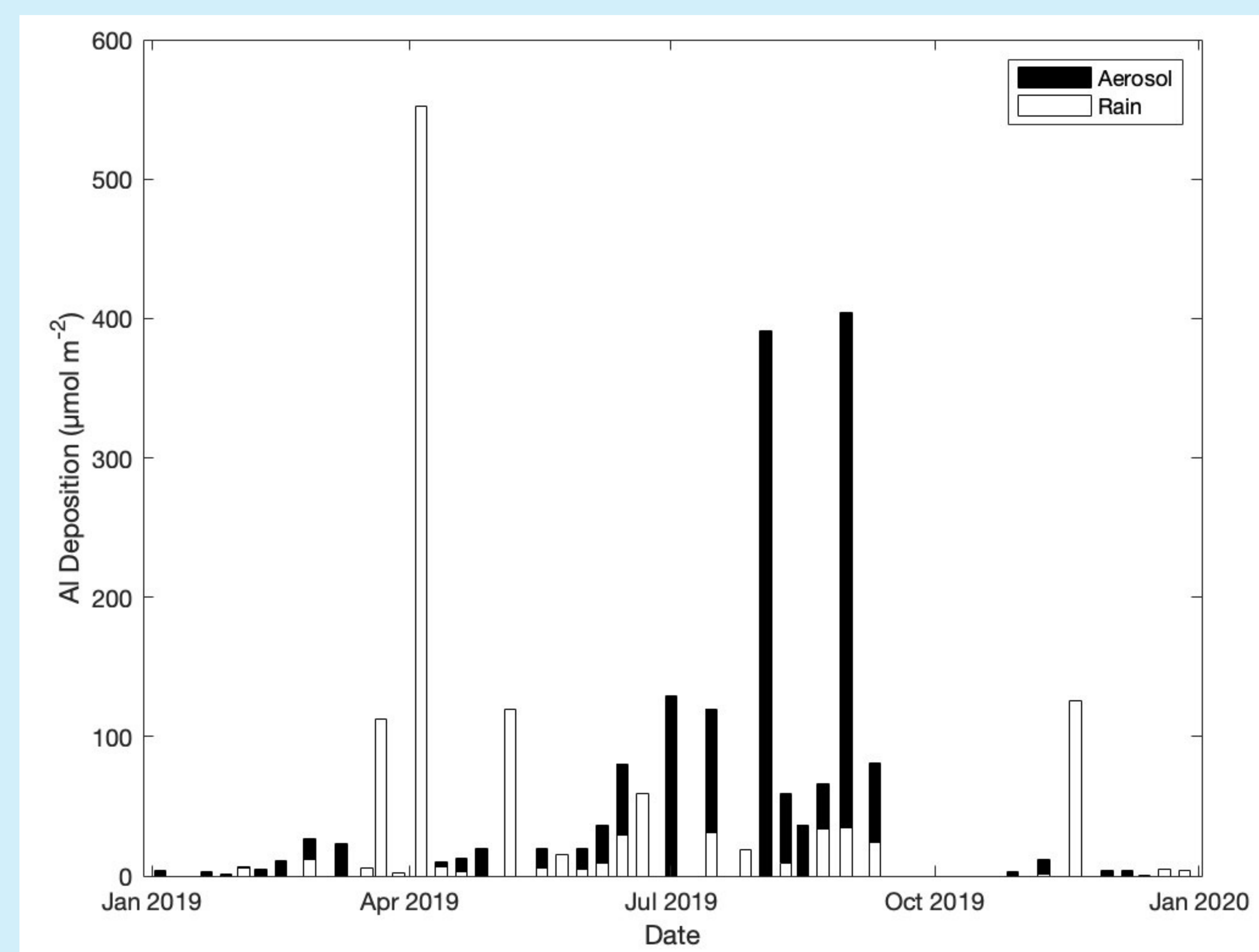

Figure 2. Dry and wet deposition of total Al for each sampling period, as estimated from aerosols and rain collected at Tudor Hill tower; dust mass fluxes were derived assuming 8.1% crustal abundance of Al

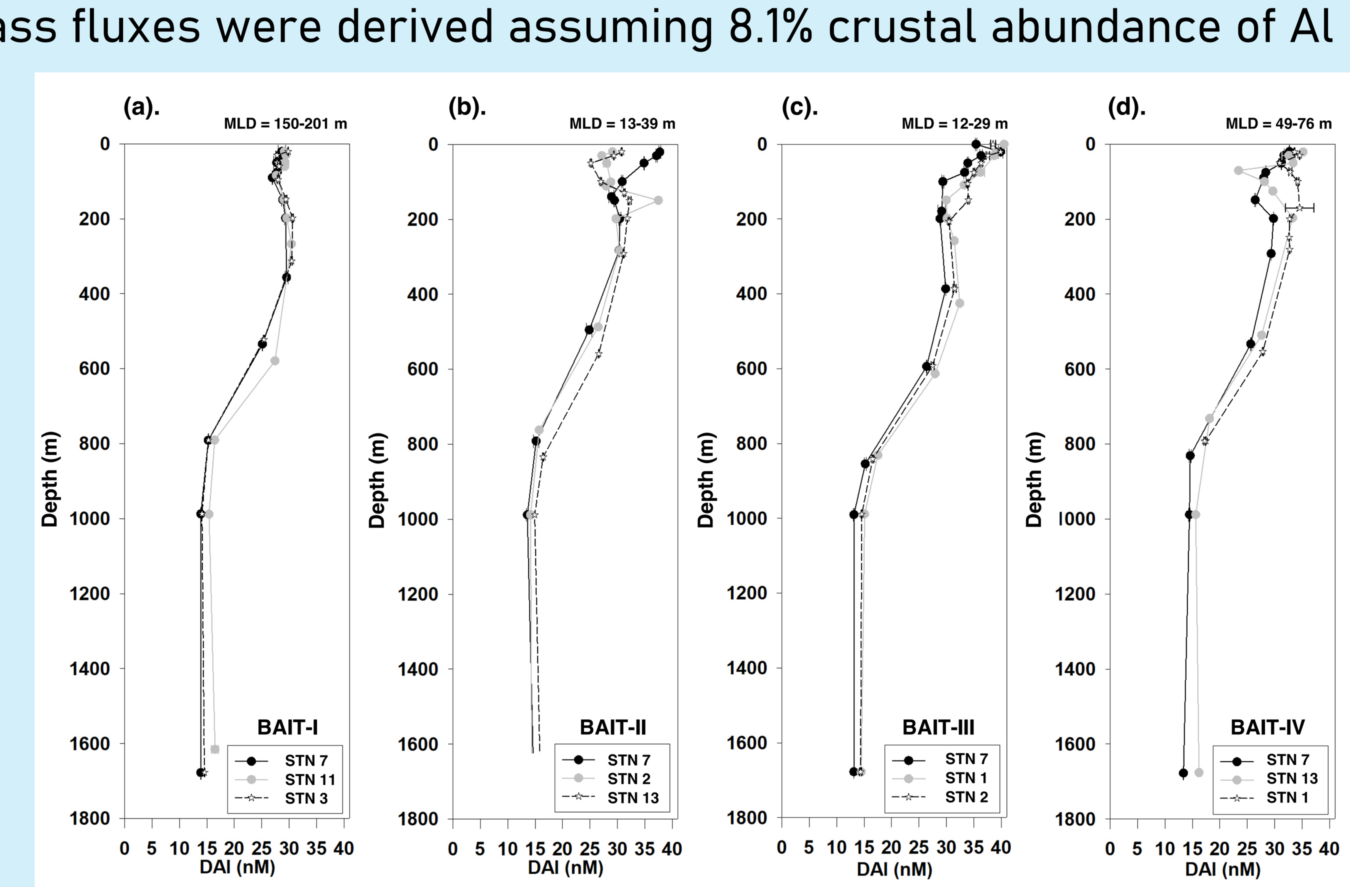

Figure 3. Water-column profiles of DAl concentration from four seasonal BAIT cruises in the BATS region (MLD = mixed-layer depth)

Water-column DAl-based dust flux estimates

- Water-column profiles of DAl (Fig. 3) from the BATS region reveal concentrations ranging from ~30 nM to ~40 nM during the year, as mixed layer depths (MLD) shoaled from ~150-200 m to ~10-30 m
- Assuming a mixed-layer τ_{Al} value of 5 years[1], average %Al_S values based on our Tudor Hill aerosol leaches, and Al crustal abundance of 8.1%[5], DAl inventories over the upper 200 m yield mean dust fluxes:
  - **11.1 $g/m^2/y$** (based on average %Al_S using DIW leach = 3.8%)
  - **5.2 $g/m^2/y$** (based on average %Al_S using HOAc leach = 8.1%)
- ***These values are ~5-10 fold higher than our estimates based on aluminum in aerosols and rain*** (Fig. 4), and may reflect uncertainties in aerosol deposition velocity or, more likely, the assumed τ_{Al} value

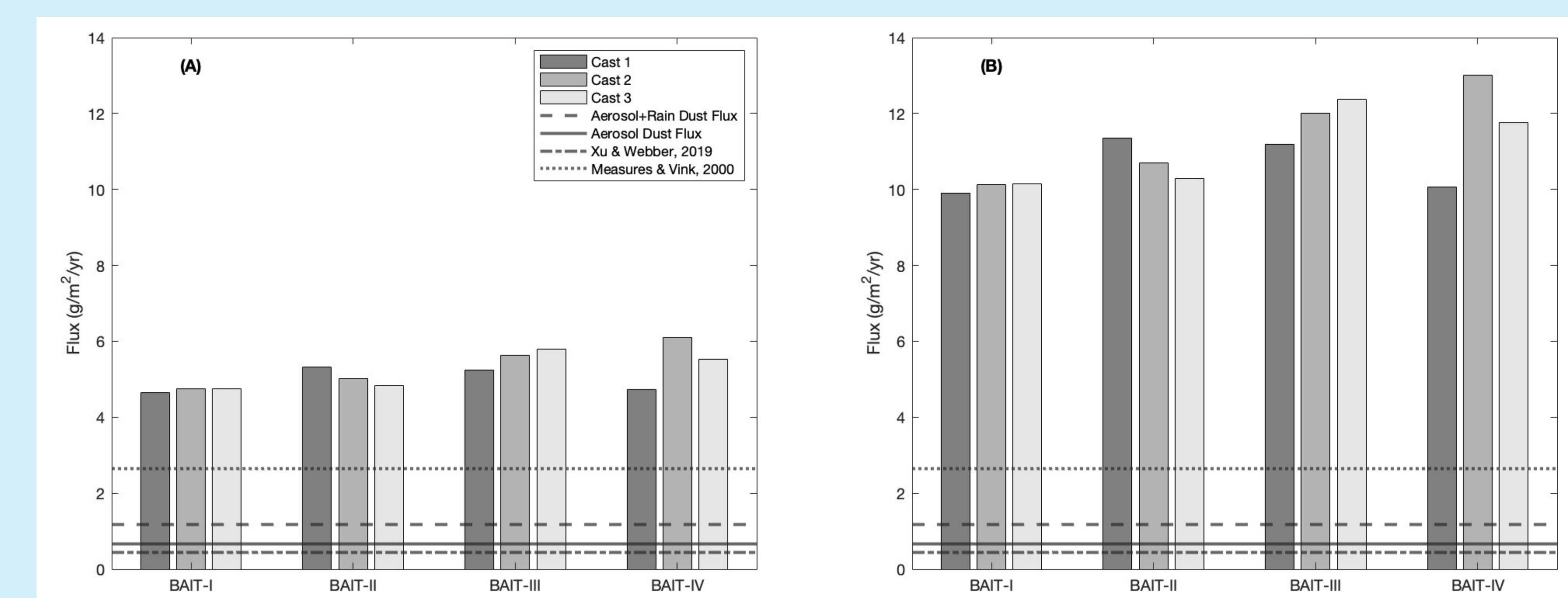

Figure 4. Comparison of dust flux estimates based on water-column DAl inventories (bars) using %Al_S based on aerosol leaches using (A) HOAc and (B) DIW, with estimates based on total Al in aerosols and aerosols+rainwater. Also shown are fluxes estimated by other studies.

IMPLICATIONS

- One way to reconcile the aerosol- and rain-based dust flux estimates with those based on water-column DAl inventories is to require a longer replacement time for DAl in the upper 200 m
- We can estimate this τ_{Al} value by dividing the average DAl inventory of the upper 200m by the annualized-average deposition of soluble Al in aerosols and rain based on our Tudor Hill aerosol and rain data:
  - **τ_{Al} ~ 49 years** (for Al_s estimated from DIW leaches)
  - **τ_{Al} ~ 23 years** (for Al_s estimated from DIW + HOAc leaches)

  These residence times are higher than an estimate based on thorium supply[6], but are compatible with values extracted from a recent data assimilation modeling study[7].

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