Evaluation of TAO Observation System on ENSO Predictions from the GMAO S2S Forecast System

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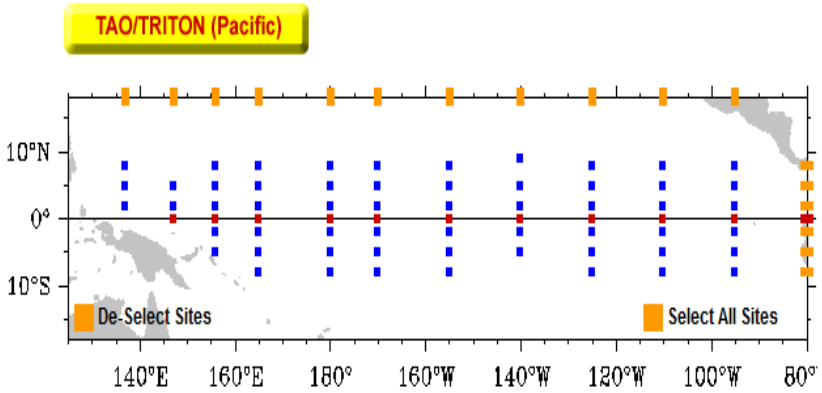

Joint Workshop of the OS-Eval TT and CP-TT and SynObs Kick-Off
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Motivation

- Since the mid 1980's TAO observations have provided useful information to observe equatorial Kelvin and Rossby waves that are key to ENSO forecasts
- Funding issues and availability of other data (e.g., Argo) have highlighted the need to rigorously assess the impact of the TAO
- Here the TAO observing system is evaluated using ocean data assimilation observation denial (e.g., Observing System Evaluation) experiments
- First, the impact of TAO on coupled atmosphere/ocean reanalyses is assessed, then the predictions for the 2015 El Nino are presented

Details of the GEOS-S2S-3 System Characteristics

(MERRA2 Ocean improvements to Molod et al., 2020 are denoted in purple text)

Model

- AGCM: Recent GMAO NWP (including aerosol model), newer version but similar to MERRA2
- OGCM: **MOM5, ~0.25 deg, 50 levels with 10 m spacing in the top 100 m**
- **New "atmosphere-ocean interface layer" - diurnal warm/cool layer (no SSS yet)**
- Sea Ice: CICE-4.0

Weakly-Coupled Data Assimilation System

- Atmosphere - "replayed" to **MERRA-2**; precipitation correction over land, **modified "replay" methodology = "Dual Ocean"**
- Ocean Data Assimilation System - LETKF (Penny et al, 2013), using **(updated)** static background error statistics

Experiment Design

Ocean Reanalyses –

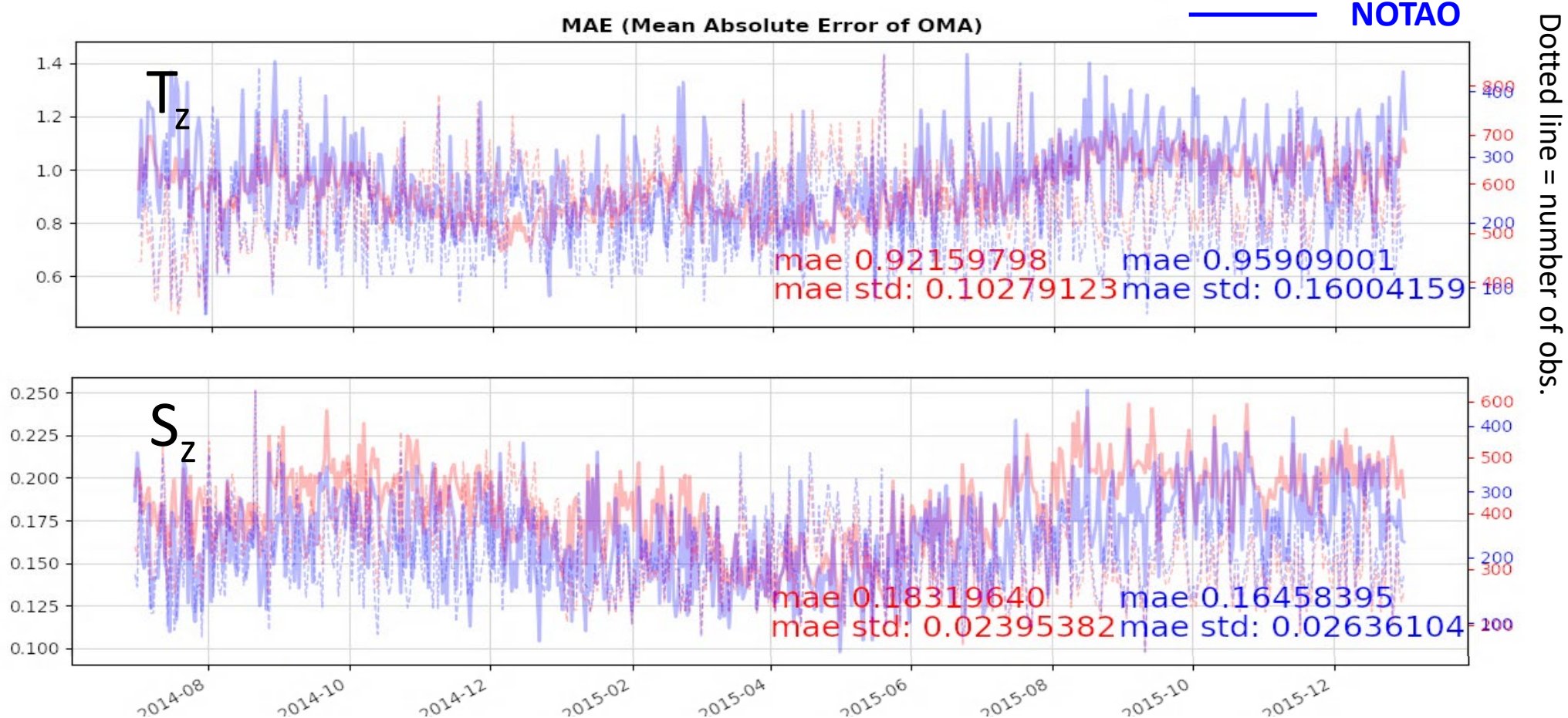
- Both reanalyses assimilate all available T_z, S_z (Argo, XBT, RAMA, PIRATA, CTD), along-track satellite ADT (Jason-2, Saral-Altika, Hy-2A, Cryosat-2), and SSS (SMOS, Aquarius, SMAP)
- We withhold 20% Argo for validation
- Experiment Period = July 1, 2014 – December 31, 2015
- Experiments
  - **CONTROL** – includes tropical Pacific TAO/Triton data assimilation (assimilated as daily mean at 12z)
  - **NOTAO** – withholds TAO/Triton

Coupled Forecasts

- Forecasts are initialized from reanalysis states in January, April, July, and October 2015 (Ensembles are from 5th, 10th , 15th , 20st , 25th, and 30th for each month)
- 9-month forecasts are executed

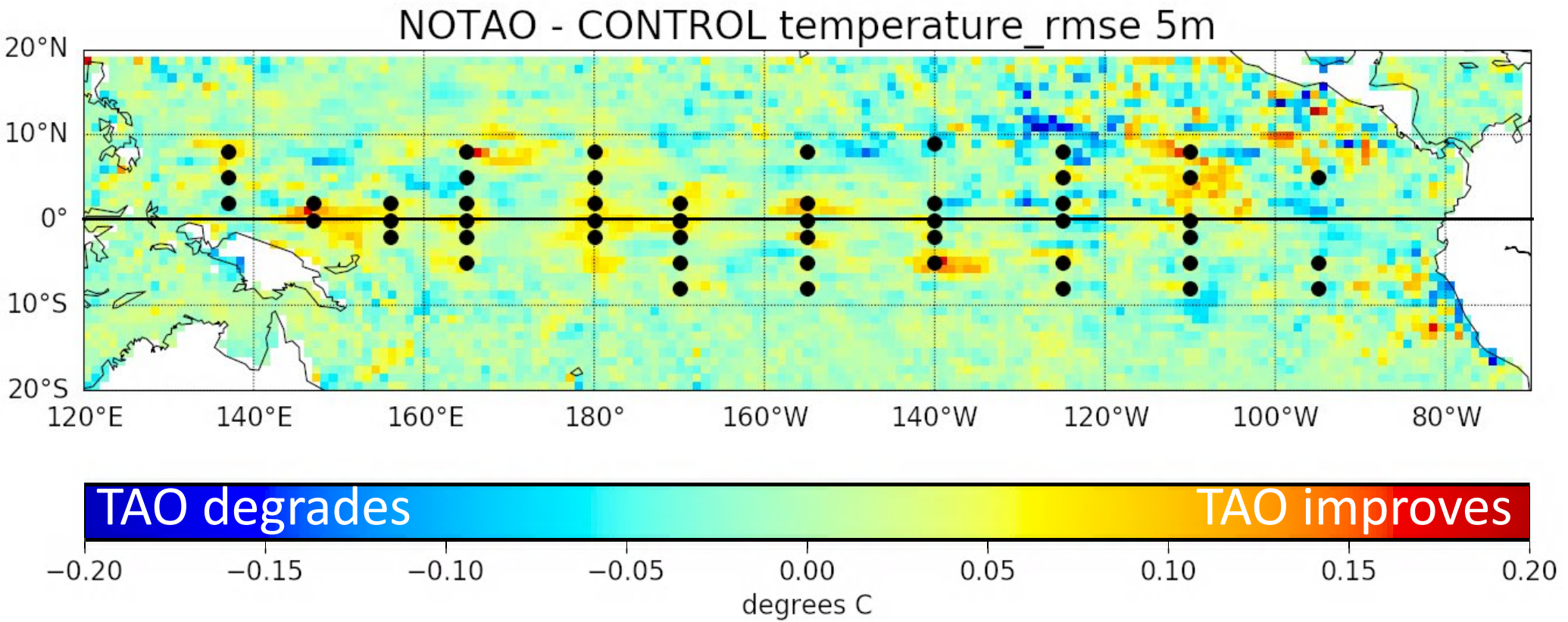
Tropical Pacific (8N-8S) 0-300m

CONTROL
NOTAO



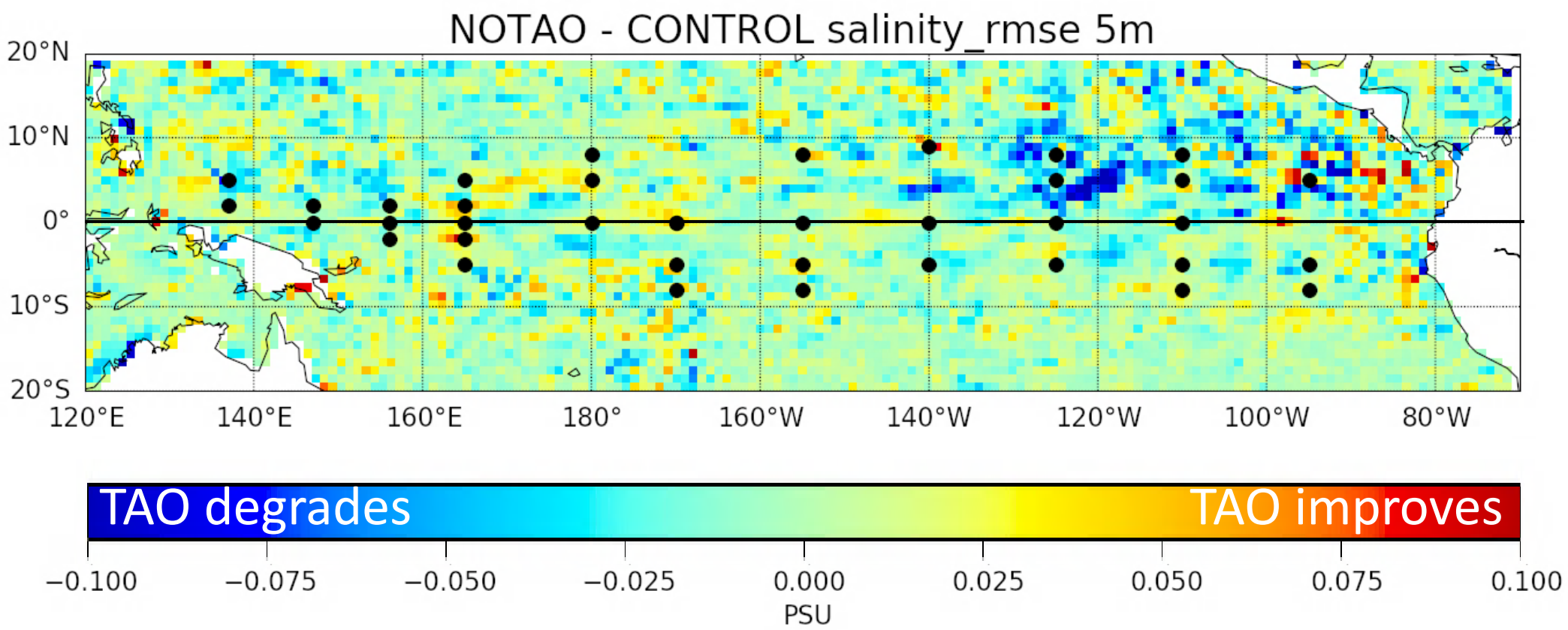
Dotted line = number of obs.

RMSE versus EN4 for July 2014 – December 2015



EN4.2.1 Data from Good, S. A., M. J. Martin and N. A. Rayner, 2013. EN4: quality controlled ocean temperature and salinity profiles and monthly objective analyses with uncertainty estimates, Journal of Geophysical Research: Oceans, 118, 6704-6716, doi:10.1002/2013JC009067

RMSE versus EN4 for July 2014 – December 2015



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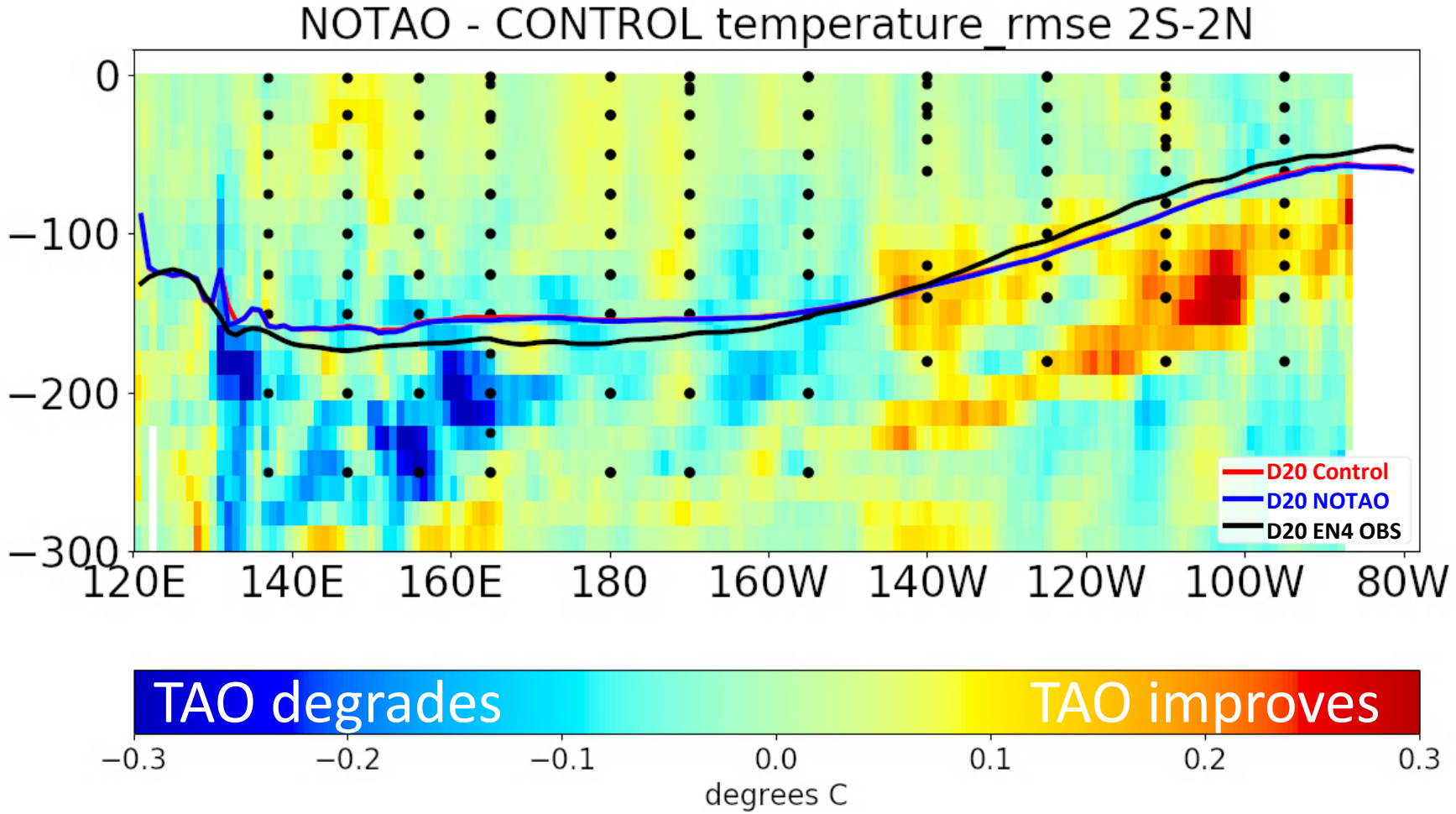

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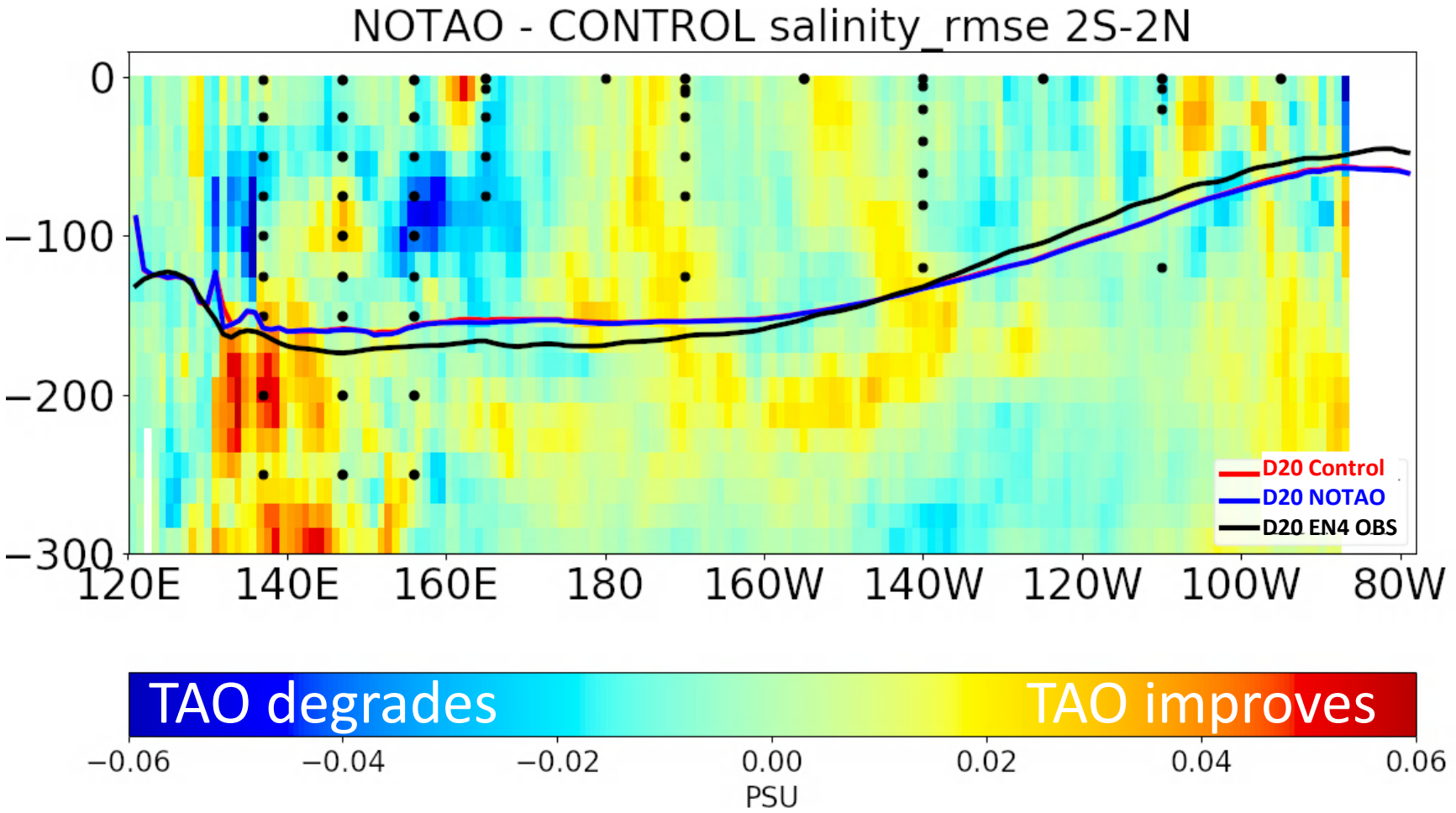
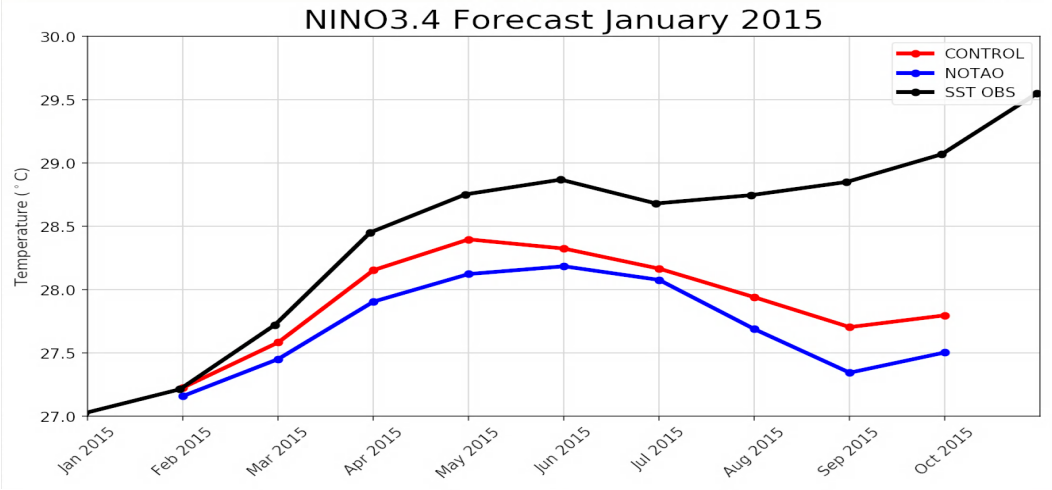
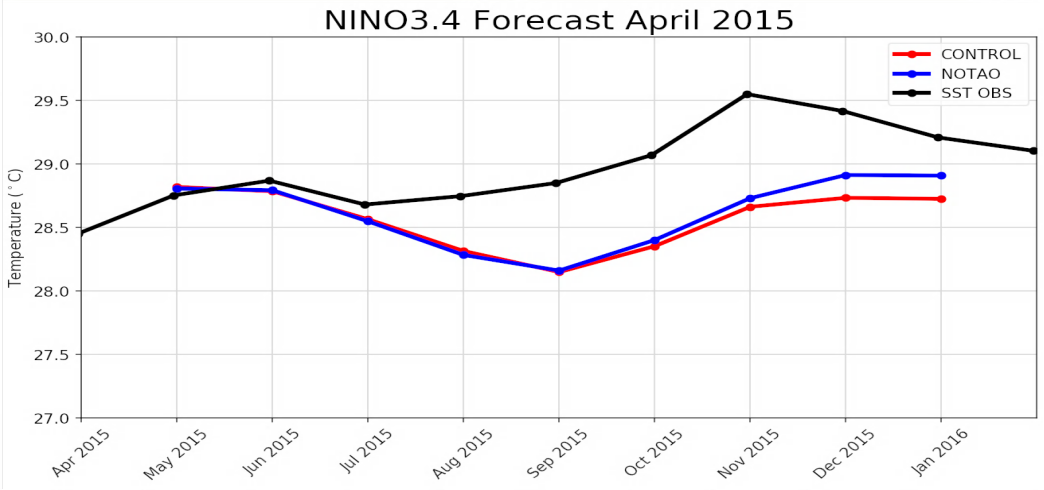
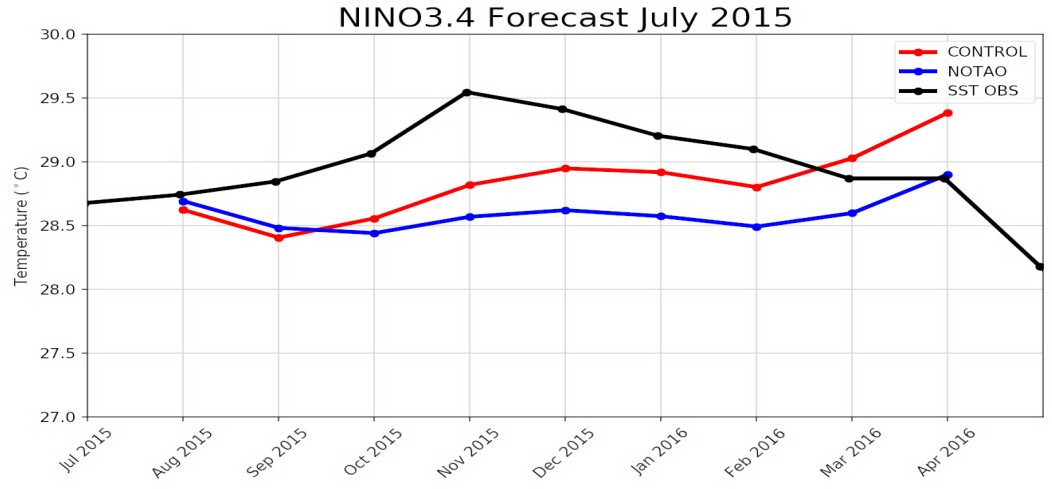
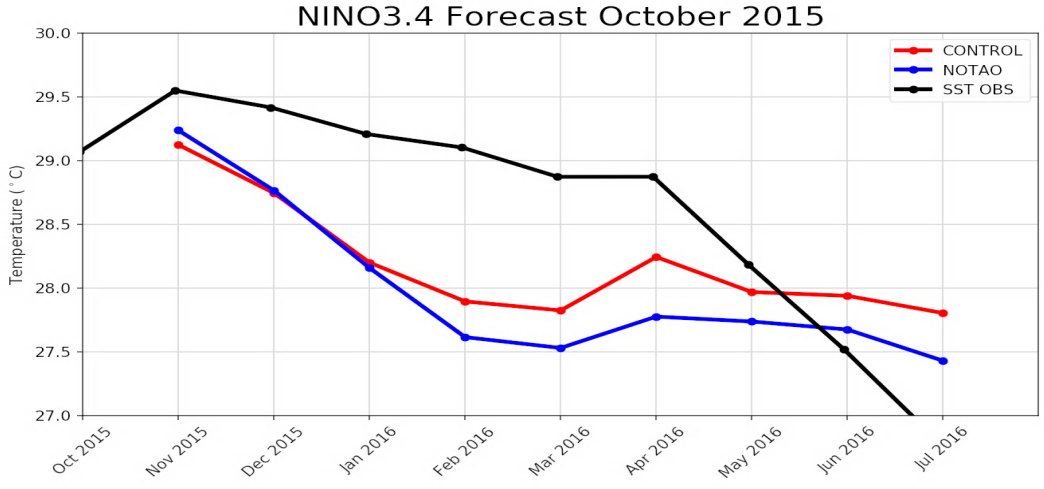


NINO3.4 Forecast

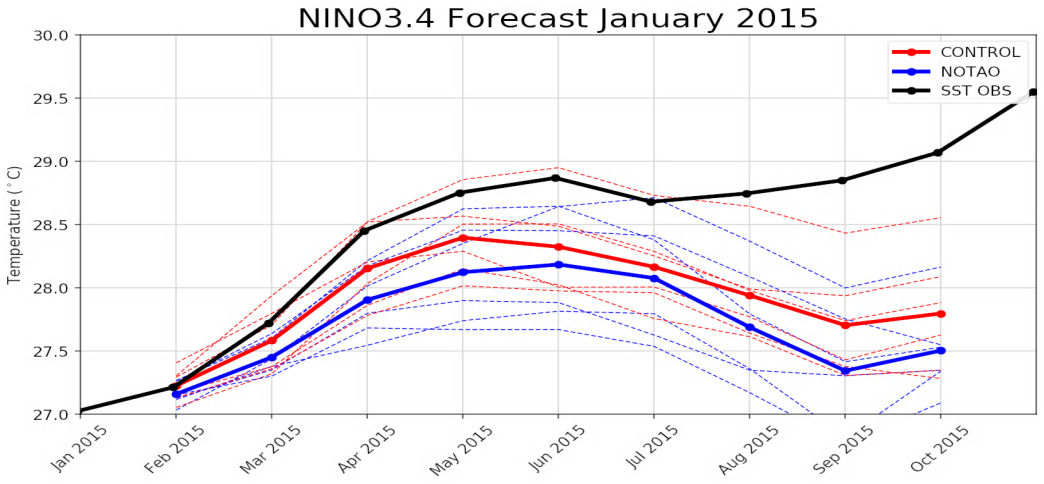


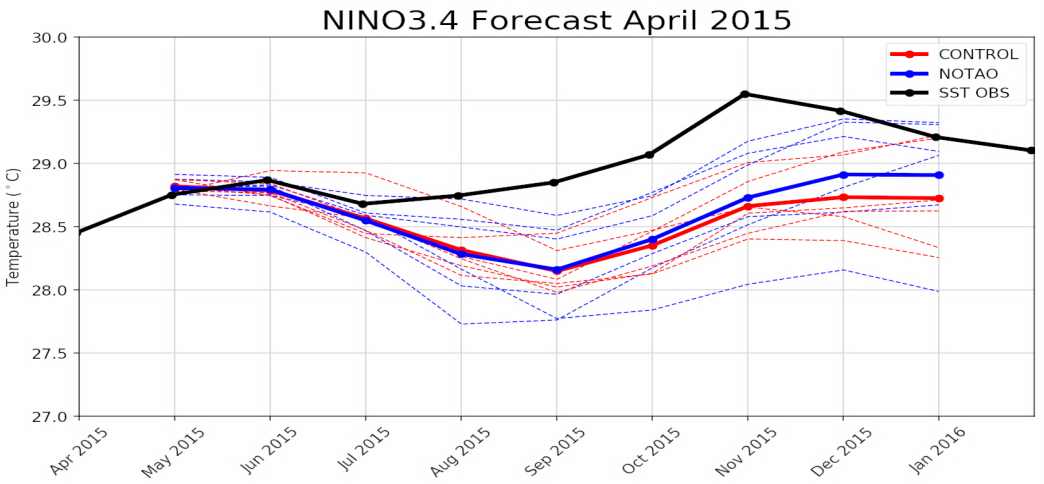


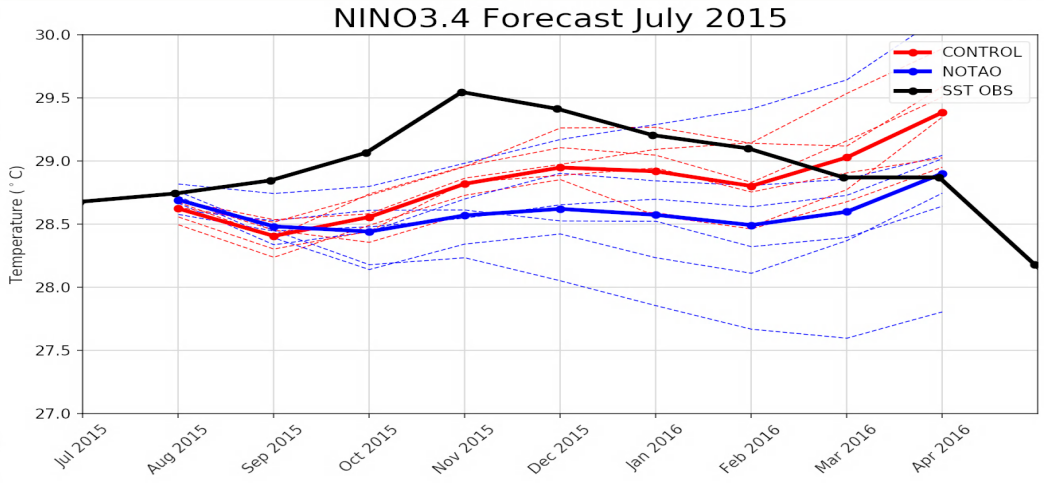


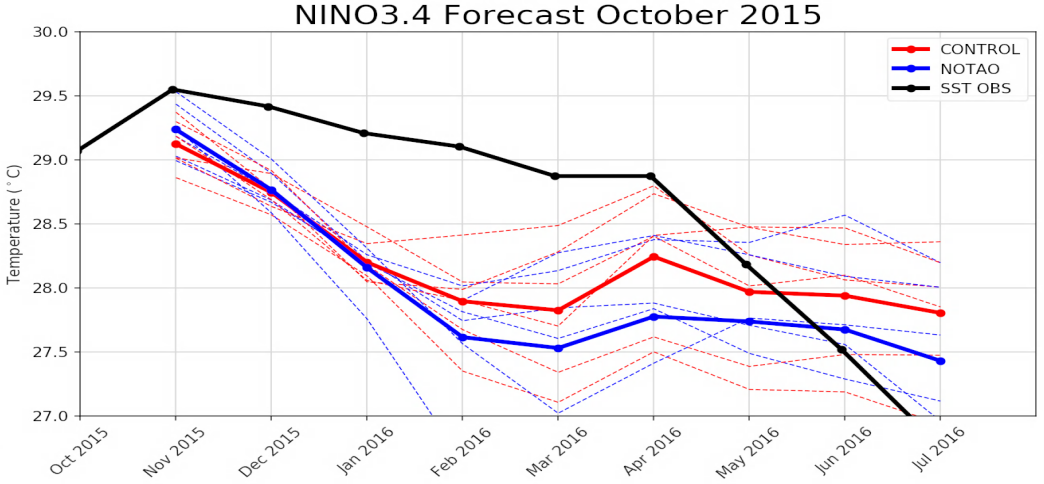


NINO3.4 Forecast









Summary

1. OSE experiments were completed assimilating everything (CONTROL) and withholding TAO observations (NOTAO)
2. For 0-300 m statistics, CONTROL has lower MAE than NOTAO and the variability is lower for temperature (stats are worse for Sz)
3. RMSE (NOTAO vs EN4) minus RMSE (CONTROL vs EN4) shows improvement over much of the basin for T(5m) and S(5m)
4. At equator, clear improvement in temperature above the thermocline across the entire basin and especially strong improvement just below the thermocline in the east (an area key for ENSO forecasting)
5. Forecasts generated from these two OSEs show that CONTROL is closer to the observed 2015 El Nino and that the CONTROL has less variability in the ensemble spread

TAKE HOME MESSAGE

TAO observations have a unique capability to improve ENSO forecasts through specification of the temperature and salinity fields near the equator.

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