SPEAR seasonal prediction system: ocean data assimilation and applications

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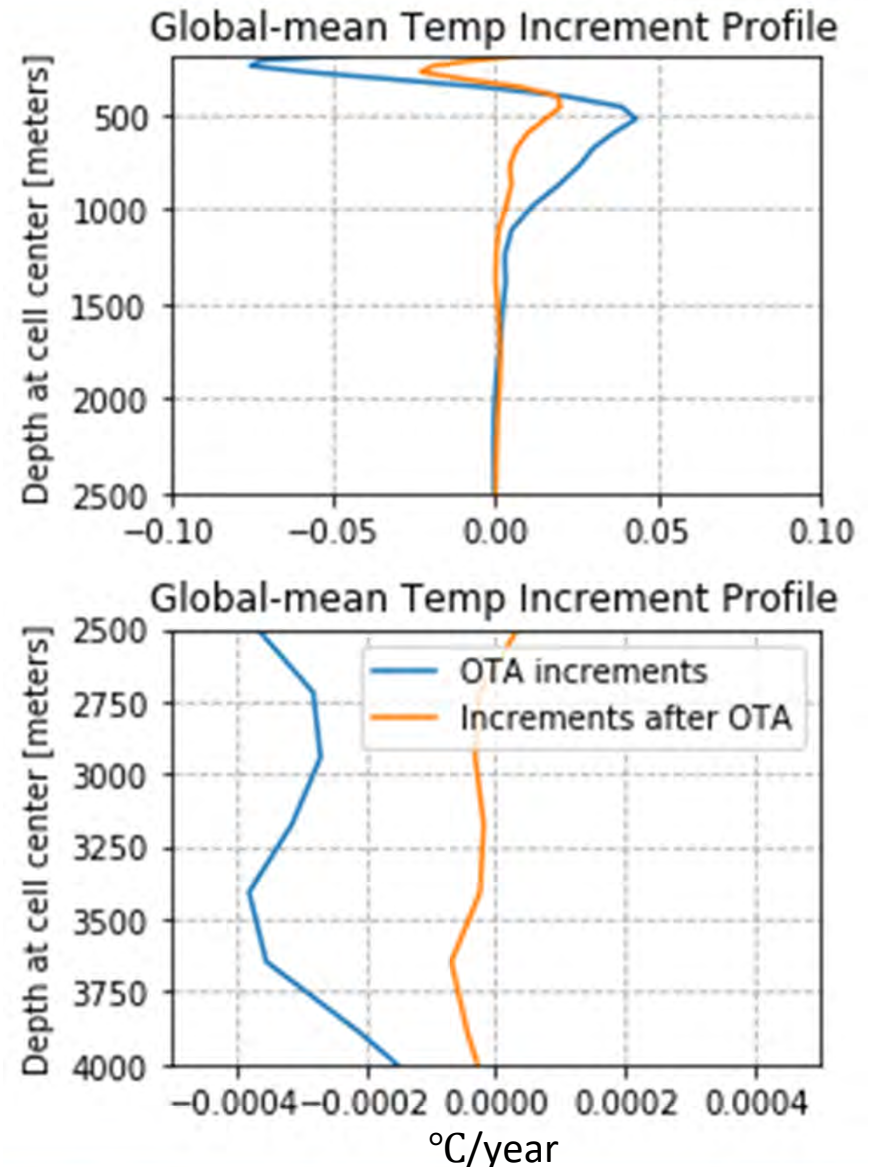Geophysical Fluid Dynamics Laboratory Review

October 29-31, 2019

New ocean data assimilation (ODA) system for MOM6

- **Motivation: long-term memory for seasonal-to-decadal climate predictions resides primarily in the ocean**
- Current system: **ECDA** (Ensemble Coupled Data Assimilation) **v3.1**
  - Initial conditions for CM2.1/FLOR/HiFLOR seasonal predictions
  - Ocean analysis publicly available and participates in reanalysis comparison
- **Ensemble Kalman Filter**
- **All-new online ODA workflow built on FMS and MOM6 capabilities**
  - High flexibility and efficiency
- **Production ODA adds only 15-20% additional computation time on top of MOM6 ocean component**
- **New ODA system enables iterative research and development**
  - Improving prediction skills
  - OTA: ocean tendency adjustment

OTA (Ocean Tendency Adjustment)

- Climatological **temperature and salinity increments** during 2003-2018 based on **ARGO and SST**

- OTA   vs.   Flux adjustment

  3-D increments   2-D adjustments

  in-situ ocean obs   surface obs

- Made possible by the unprecedented coverage of the ARGO network

- The increments can be used to evaluate and guide model development

Global-mean Temp Increment Profile

Global-mean Temp Increment Profile

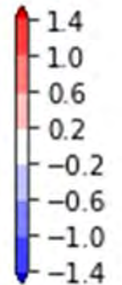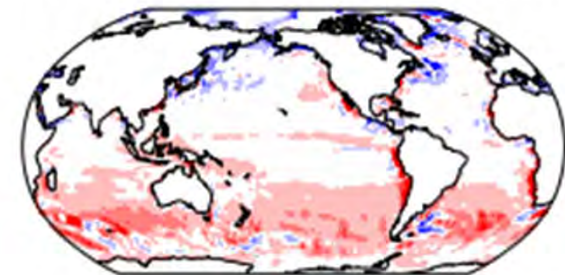- OTA increments
- Increments after OTA

°C/year

New ocean analysis since 1990 using SPEAR_LO

- Time period: **1990 to present**

- **30-member** ensemble (12 in ECDA v3.1)

- **Daily assimilation** of Daily NOAA OISST, ARGO profiles, tropical buoys and XBT

- No data assimilation in the atmosphere
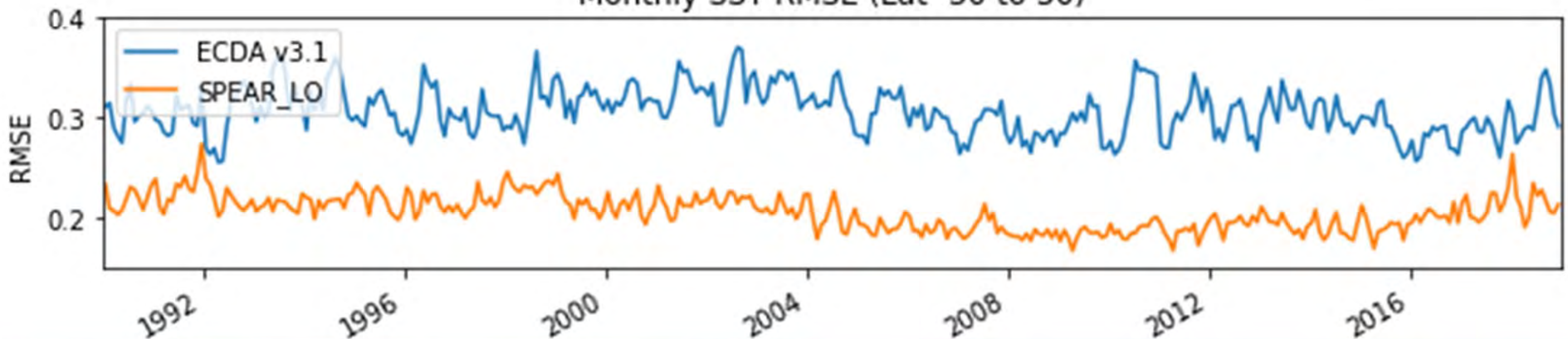
- **OTA** adopted during assimilation


SPEAR_LO - OI Bias:-0.093 MAE:0.136
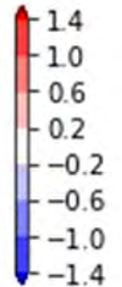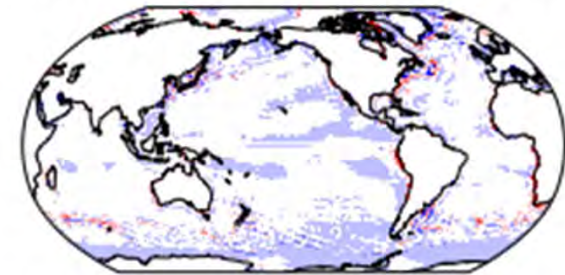
ECDA v3.1 - OI Bias:0.114 MAE:0.192


Monthly SST RMSE (Lat -30 to 30)

New initialization scheme for seasonal predictions

- Ocean initial conditions from ODA
- Atmosphere/land/sea ice initial conditions from atmosphere/SST restoring run in coupled SPEAR models
- The most recent set of seasonal reforecasts in SPEAR_LO:
  - 15 members (out of 30), comparable to 12 for FLOR
  - 4 per year (1st of Jan., Apr., Jul. and Oct.) for 1995-2018
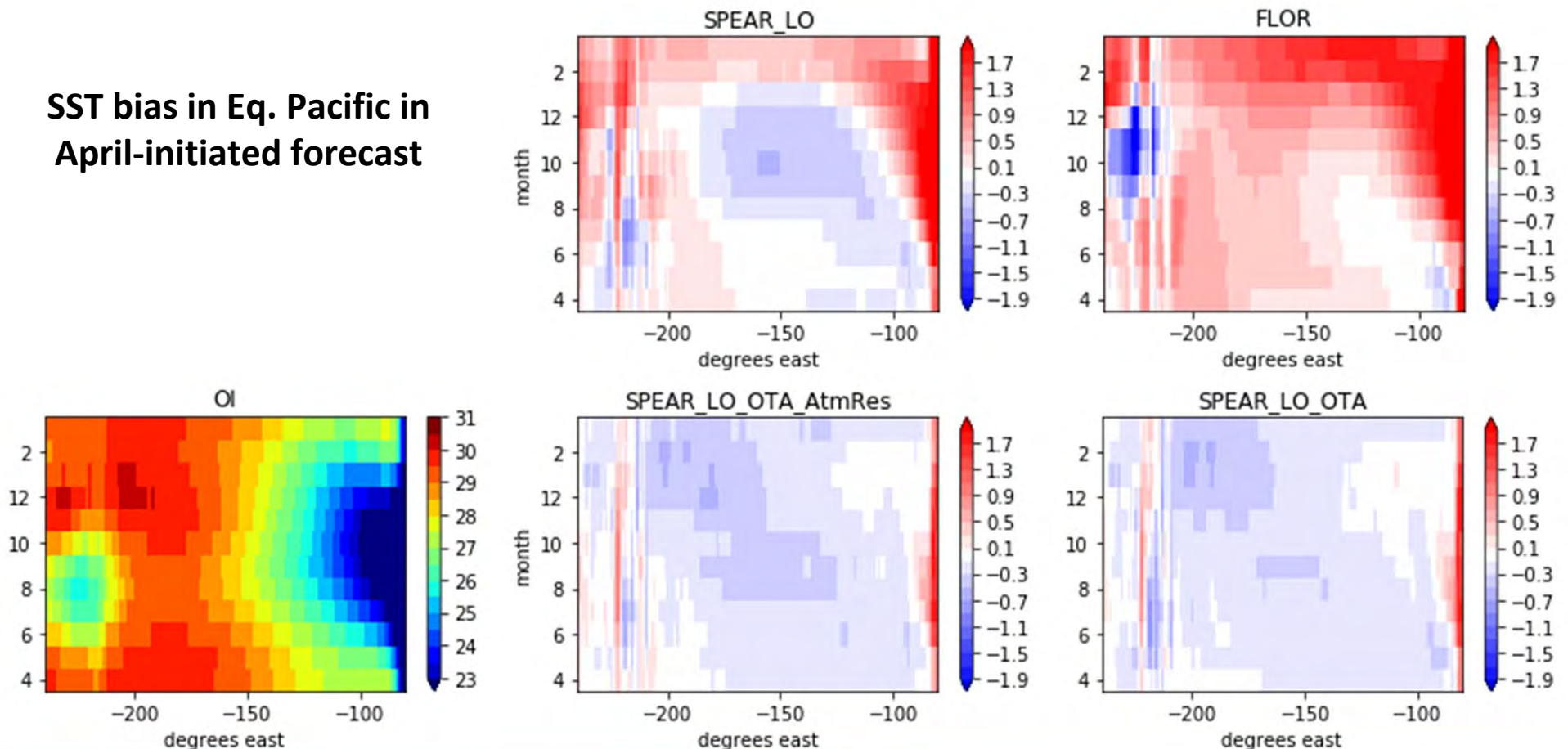- OTA is tested in forecast mode
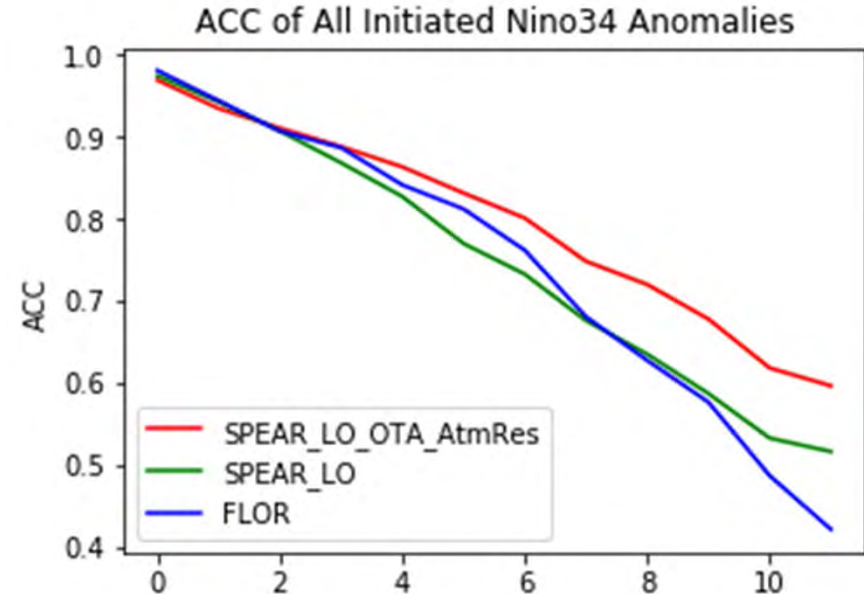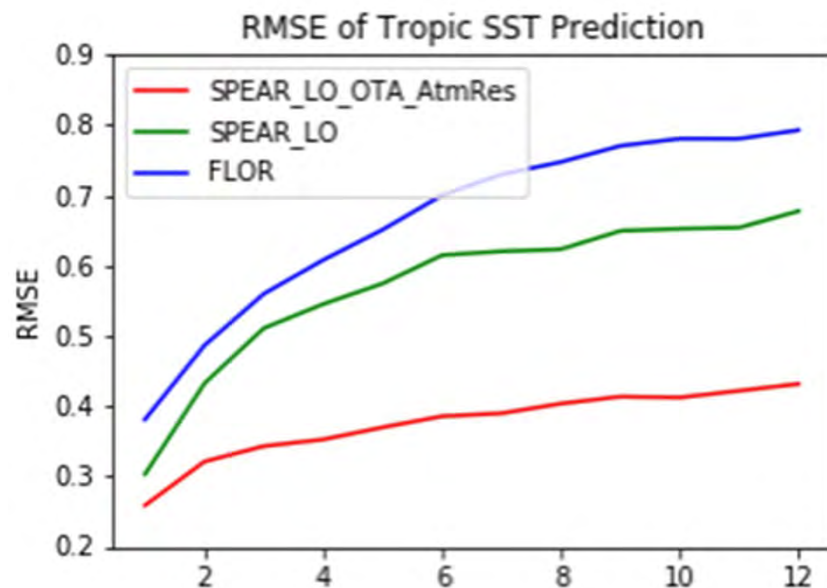
Preliminary results from new seasonal reforecasts
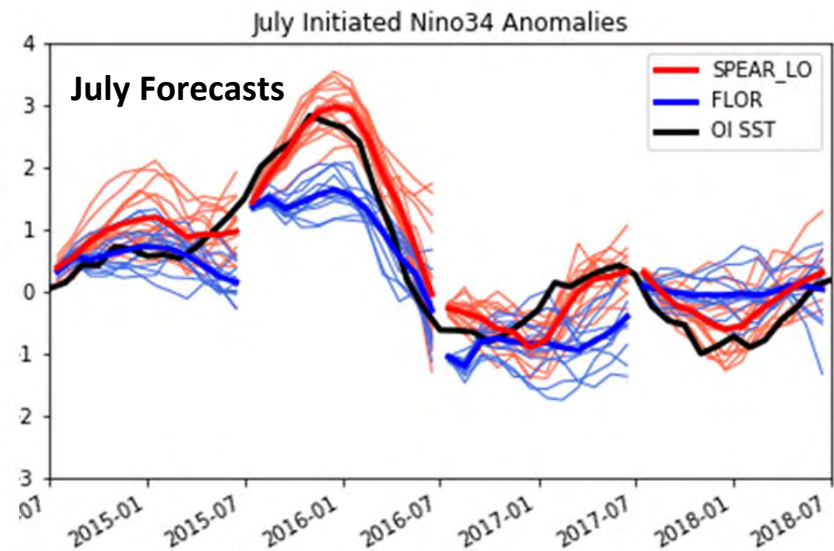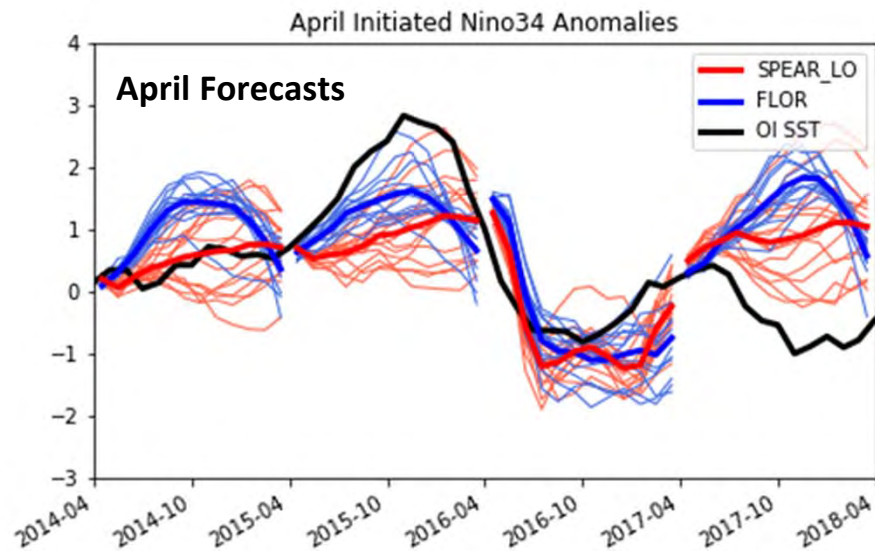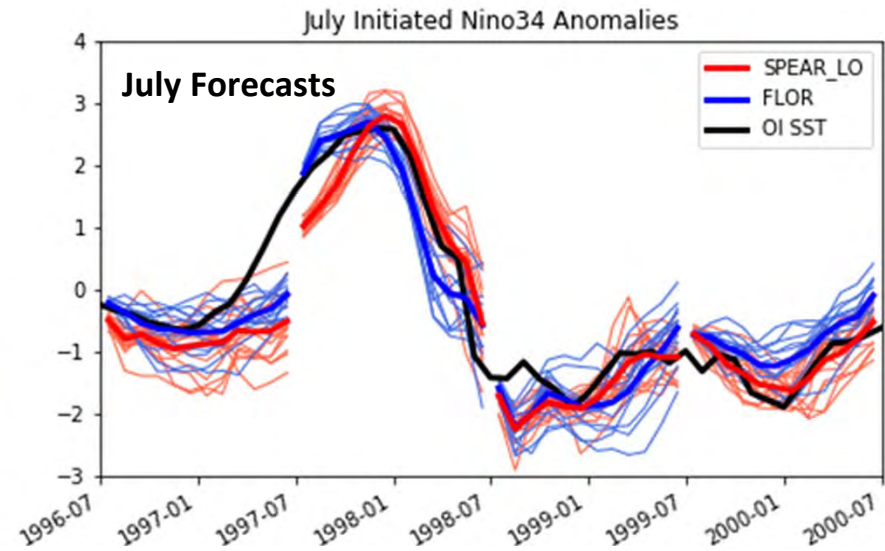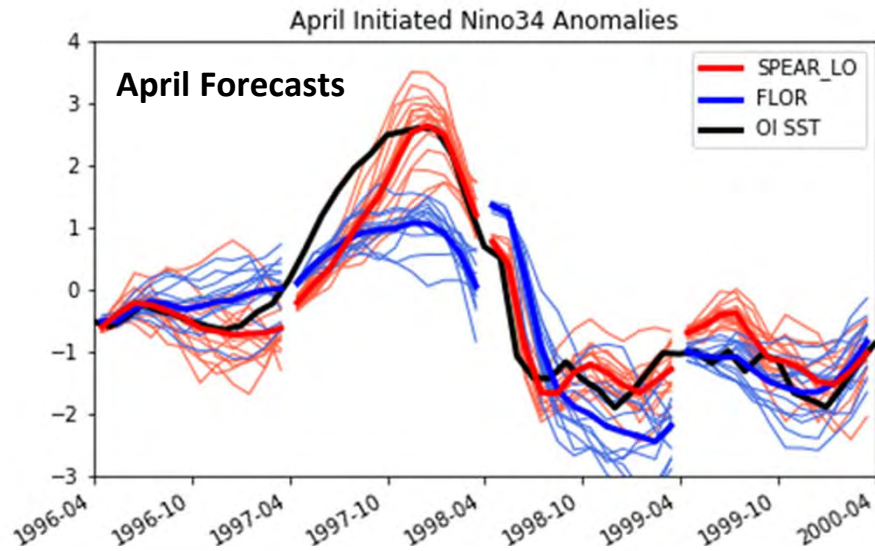
Preliminary results from new seasonal reforecasts

- SPEAR prediction system significantly reduces the model drift (growth of model bias in forecasts) compared to previous system
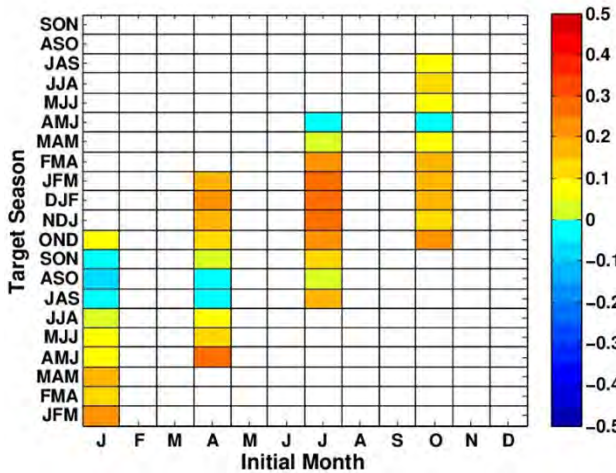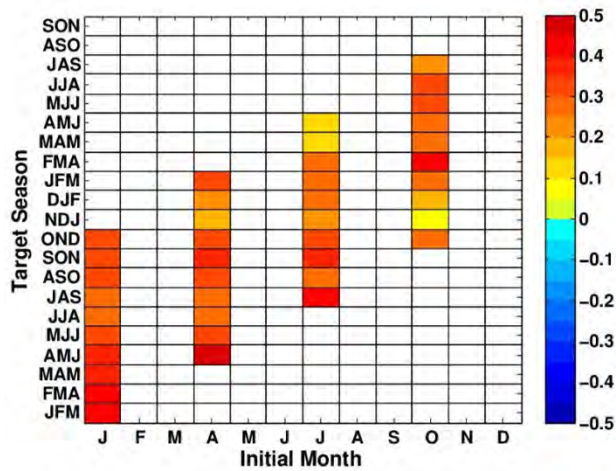 - Both the new SPEAR model and OTA contribute to the improvement

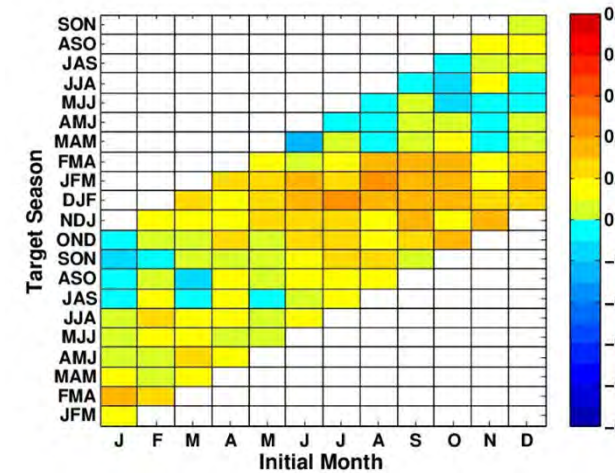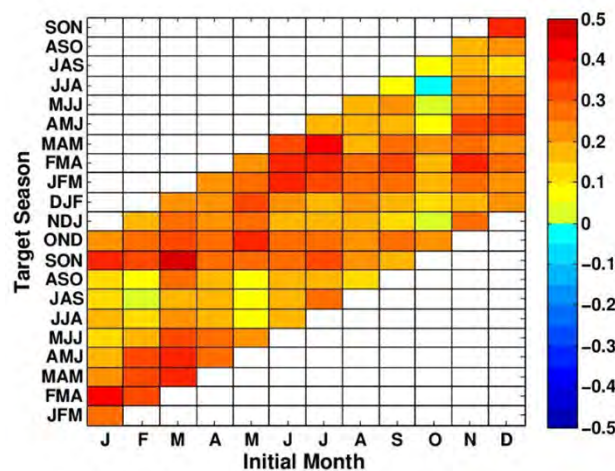**SST bias in Eq. Pacific in April-initiated forecast**

Preliminary results from new seasonal reforecasts

Forecast Skill (ACC) over CONUS for t_surf (top) and precip (bottom)
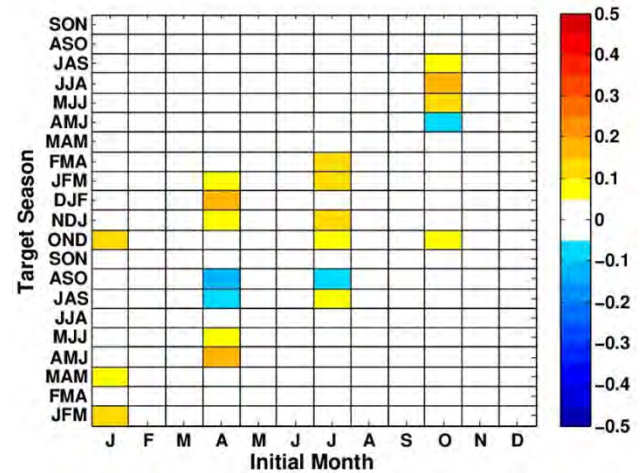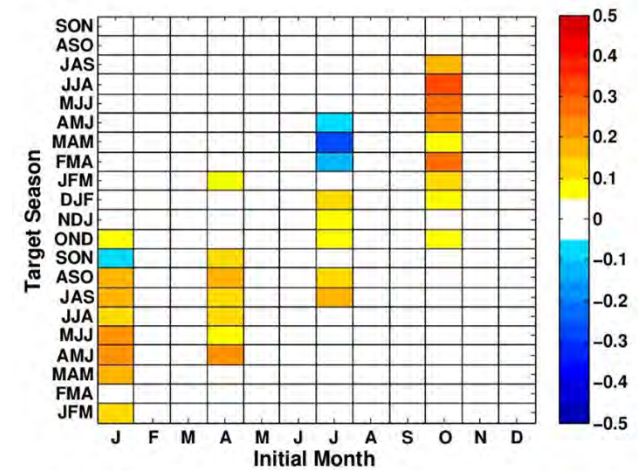
SPEAR   FLOR   SPEAR - FLOR

Future Plans & Challenges

- New experimental seasonal prediction system using SPEAR_MED_L65 to be ready for NMME in 2020

- Explore bias correction techniques (e.g. wind stress adjustment) for the atmosphere component

- Expand to decadal (poster by Xiaosong Yang) and subseasonal (talk by Baoqiang Xiang) predictions

- The use of OTA in a suite of model runs, including assimilation, control, transient and historical runs.

- Further explore the use of OTA in combination with machine learning

- Higher resolution MOM6 for assimilation

Summary

- New flexible and efficient ocean data assimilation (ODA) system is built for MOM6, and produces improved ocean analysis and initialization.

- Ocean tendency adjustment (OTA) reduces model drift in model analysis/reanalysis and forecast.

- Preliminary SPEAR seasonal predictions using OTA show improved prediction skills for processes such as ENSO and CONUS surface temperature.