WP2.5 – Strengths/weaknesses in existing coupled DA, coupled error covariances and model drift/bias correction

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UREAD: Deliverables

- D2.8 Report on strengths and weaknesses of weakly coupled DA methods for Earth system reanalysis.

  UREAD 18; *Feng et al., QJRMS, 2017, in press.*

- D2.9 Report on techniques for calculating coupled error covariances from outputs of a weakly coupled DA experiment.

  METO+UREAD 18

- D2.10 Report on assessment of coupled-model drift and approaches for obtaining consistent ocean and atmospheric bias corrections.

UREAD 34 +12 =46; *Feng et al., GRL, 2017, submitted.*

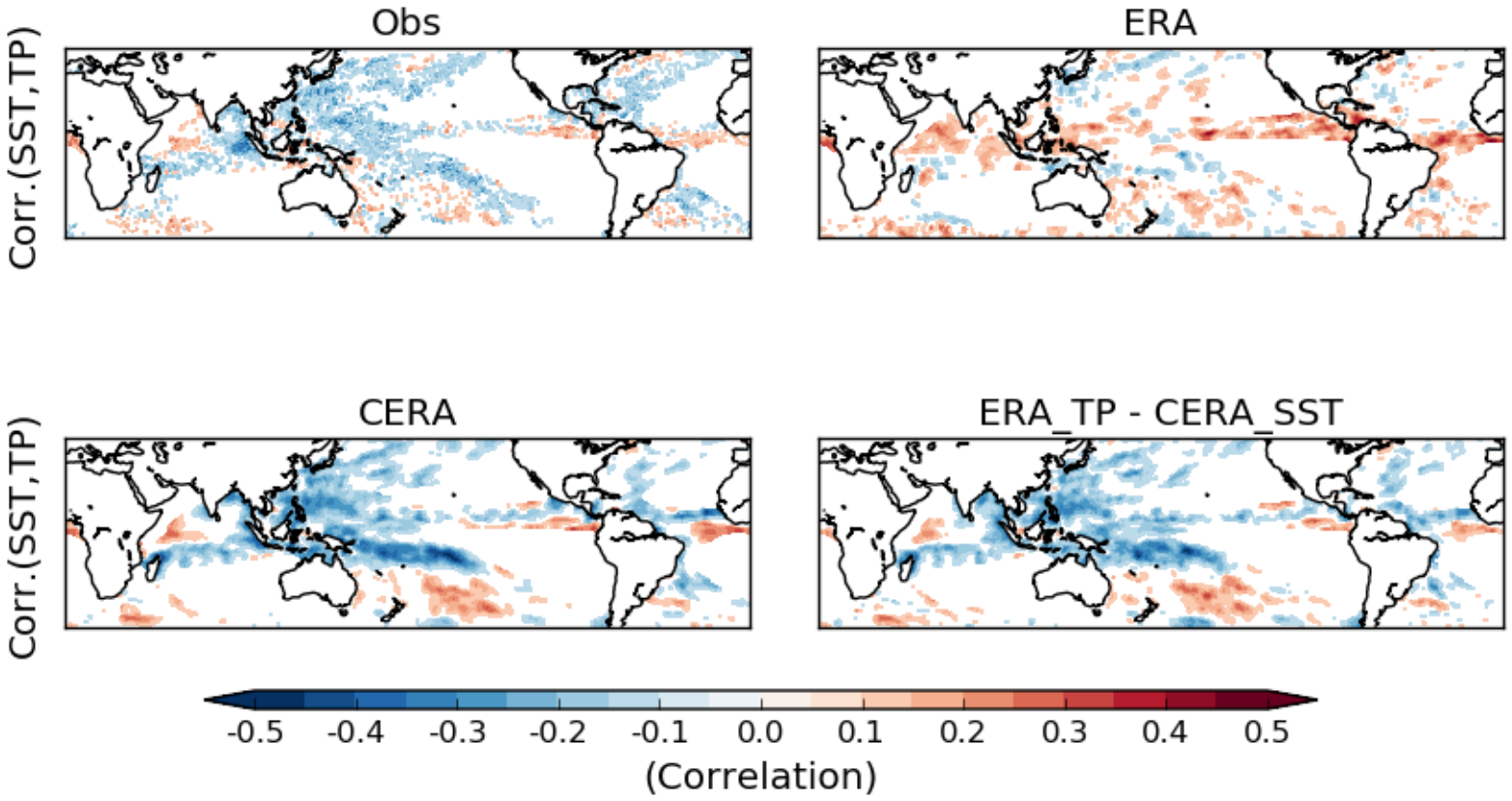
D2.8 Strengths of weakly coupled DA methods for Earth system reanalysis

- **Objective**
  - SST-precipitation relationships on intra-seasonal timescales, as an important measure for air-sea coupling, are being examined in CERA-20C, and compared with ERA-20C and observations.
- **Data**
  - CERA-20C and ERA-20C Reanalyses: Pentad SST, total precipitation (TP) and other surface fluxes.
  - Observations: Pentad NOAA-OISST and NASA-TRMM.
  - Periods: 2006-2010, 1906-1910.
- **Method**
  - Pentad data are filtered with 10-60 day bandpass.
  - Linear correlations.

Feng X., Haines, K and Liu C., Improved SST-precipitation relationship in coupled reanalysis, submitted.

SST-TP correlations, 2006-2010

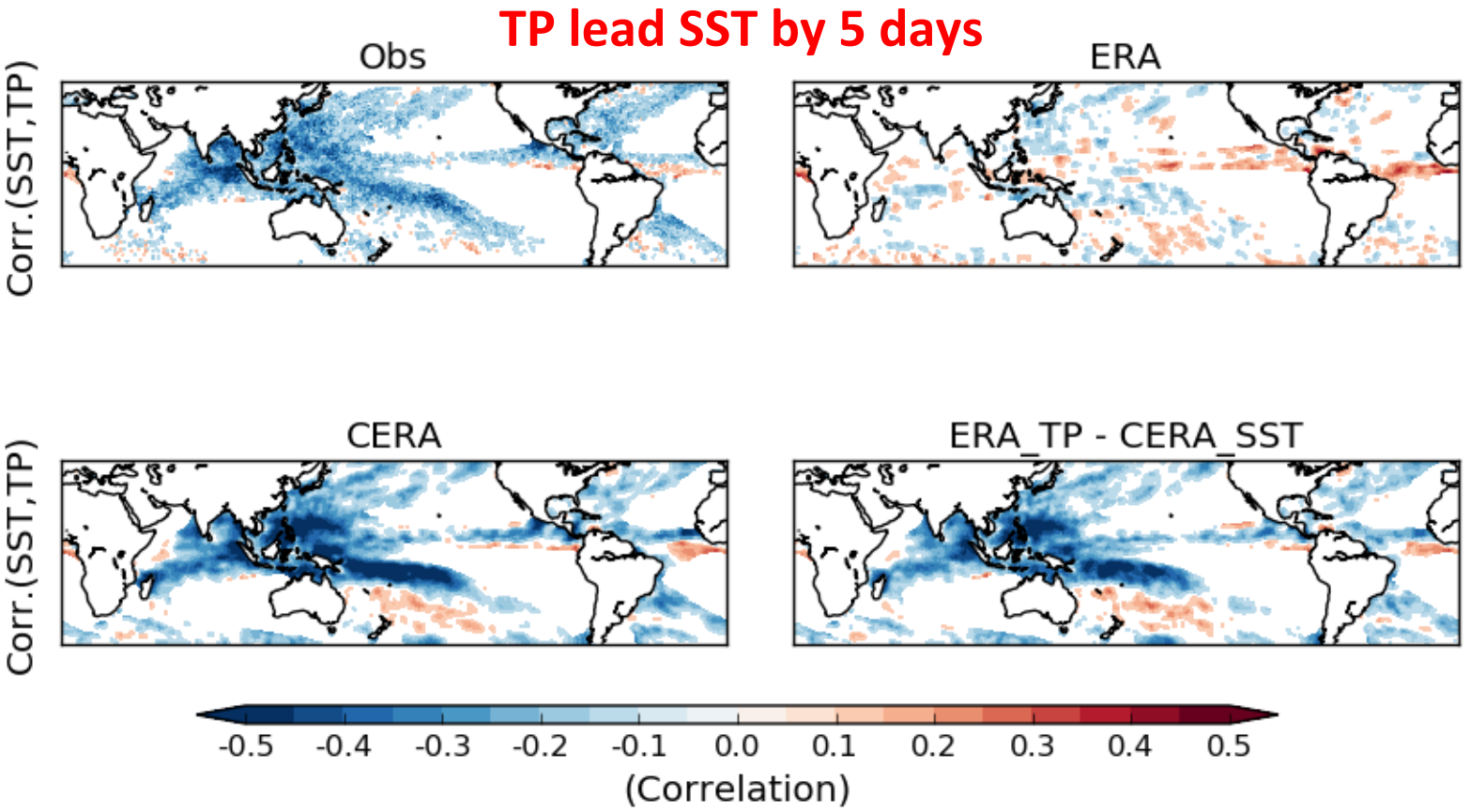
where *p*>95% and TP mean > 2.5 mm/day



- SST-TP correlations are better produced in CERA-20C than in ERA-20C, due to better SSTs.
- Correlations are weaker in Obs.

SST-TP correlations, 2006-2010

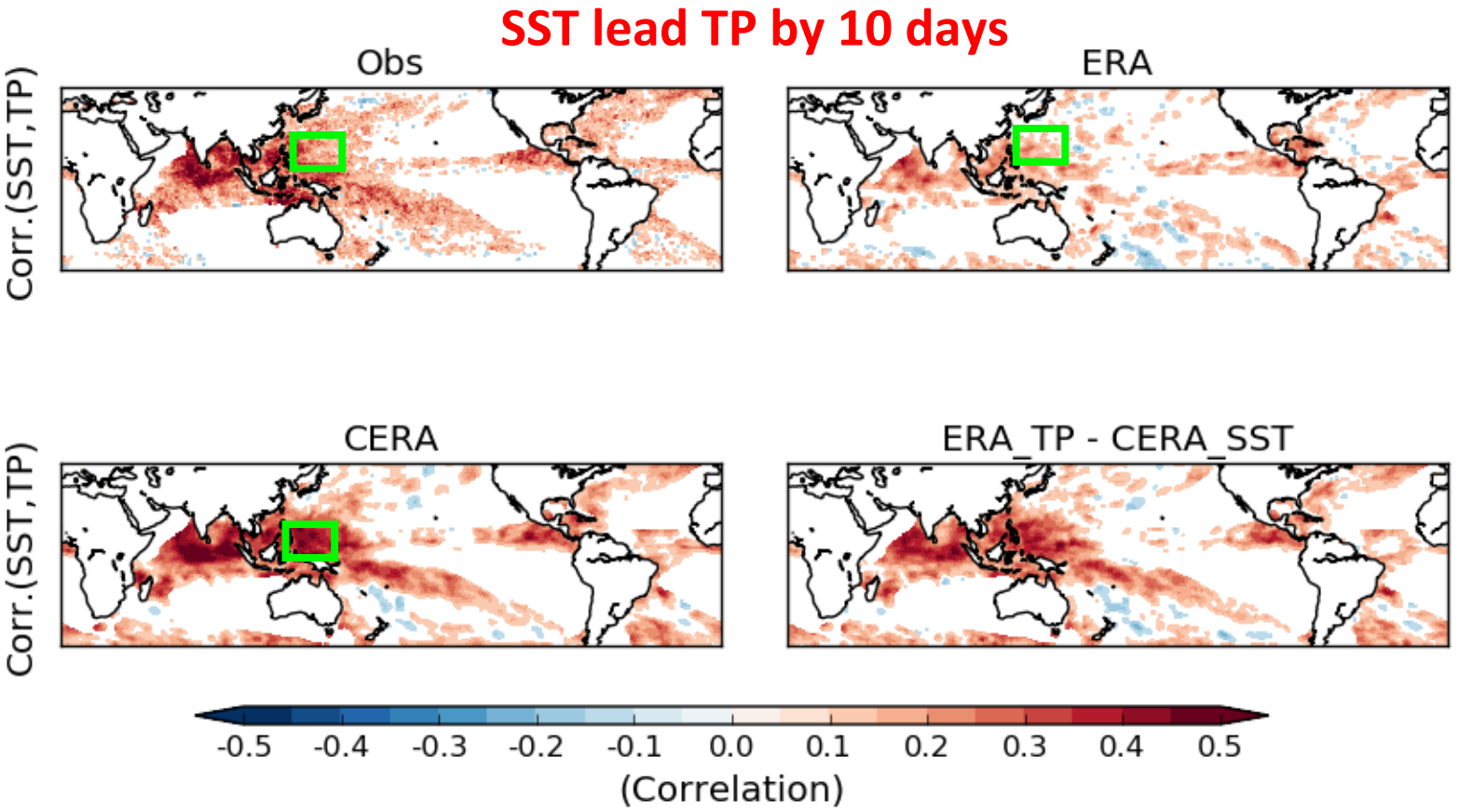
where *p*>95% and TP mean > 2.5 mm/day



- Negative correlation indicating the atmospheric feedbacks to SST.

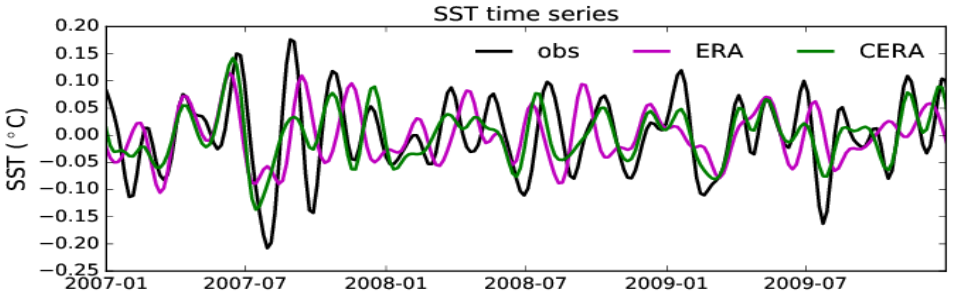
SST-TP correlations, 2006-2010

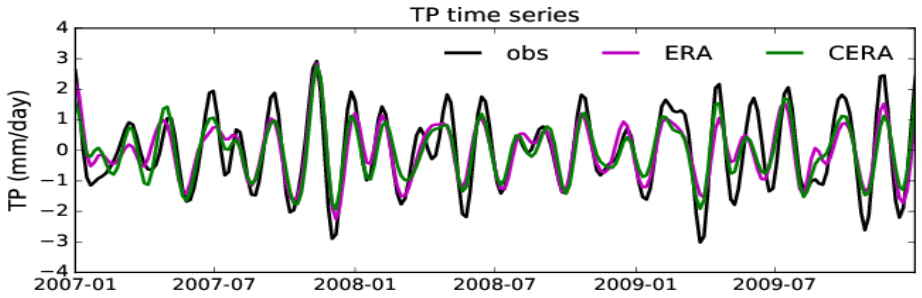
where *p*>95% and TP mean > 2.5 mm/day

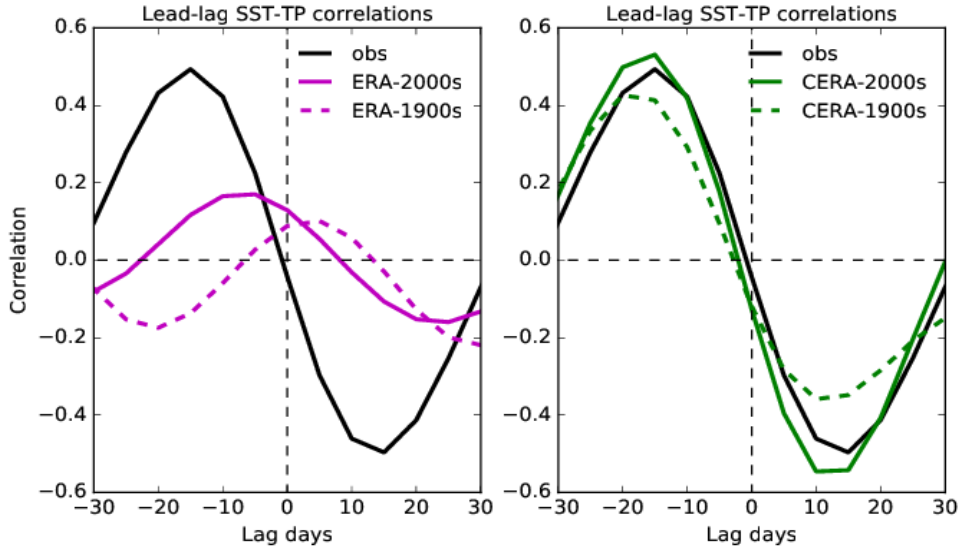


- Positive correlation indicating the SST forcing.

In area [10S-10N, 130E-150E]



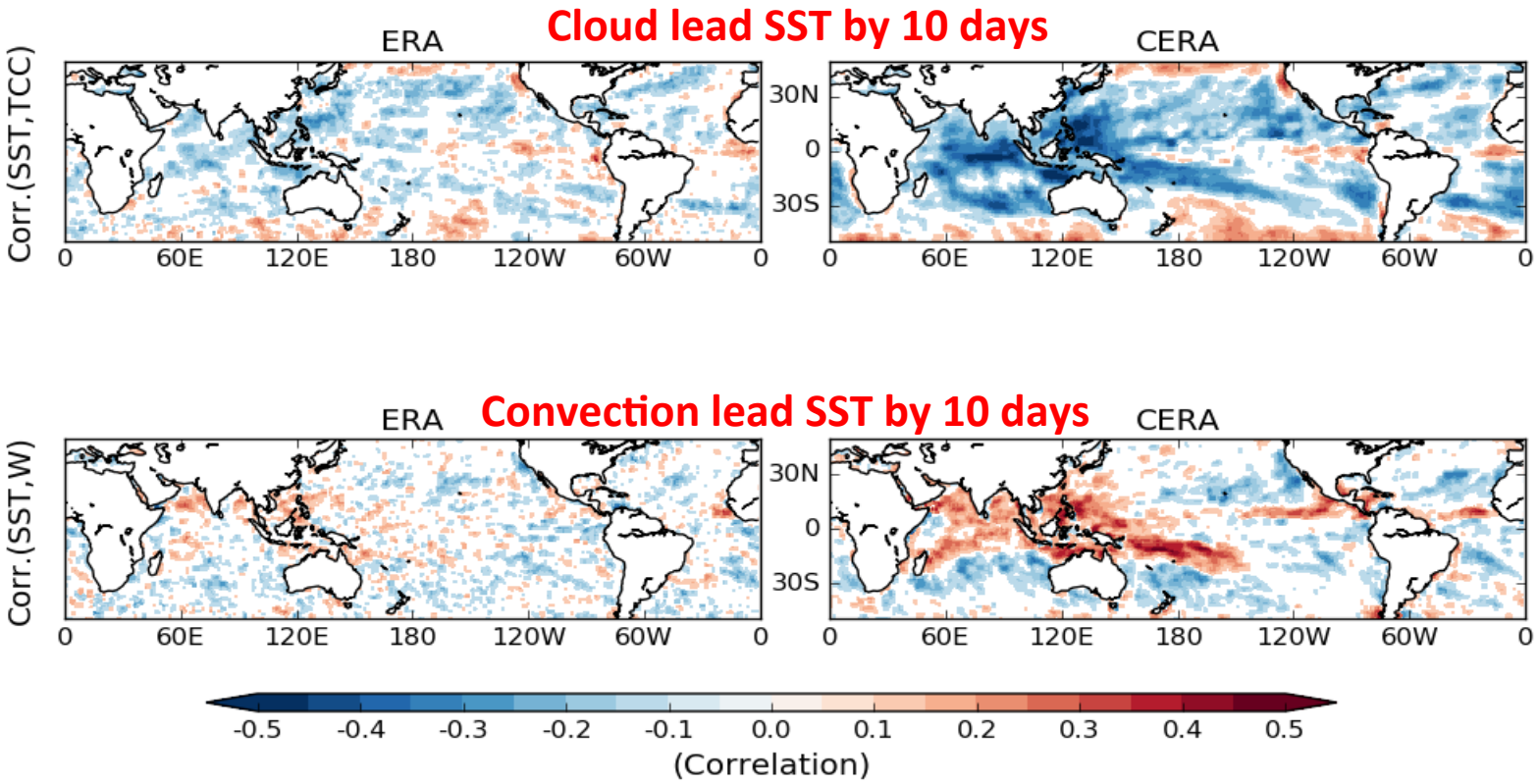




- TP variability is nicely predicted in CERA-20C and ERA-20C, due to constraint of surface atmospheric observations.
- SST variability is better reproduced in CERA-20C at intra-seasonal timescales.
- SST-TP correlations are better reproduced in CERA-20C than in ERA-20C, due to better SSTs.

- Lead-lag correlations are better represented in CERA-20C.
- It is established mainly through model coupling (i.e. early-years analysis).
- However, DA enhances the model-produced relationship.

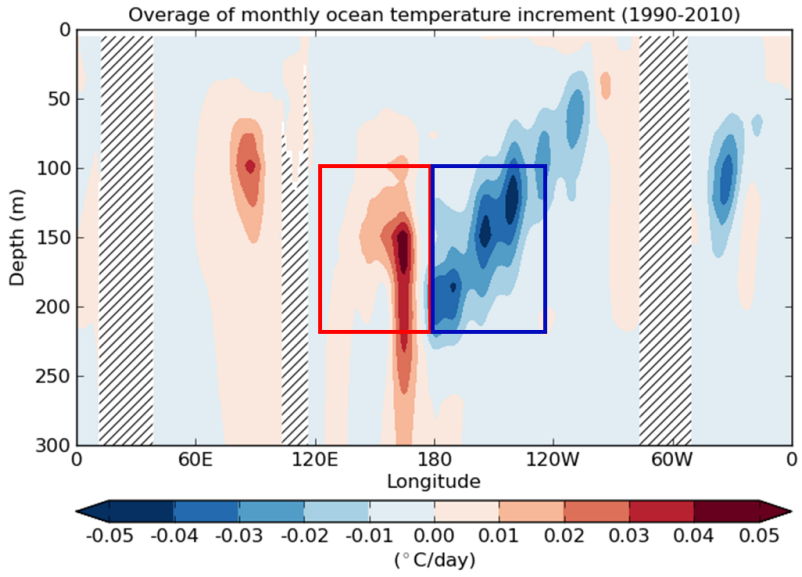
Negative SST-TP correlations are explained by negative surface heat flux anomalies in precip events.

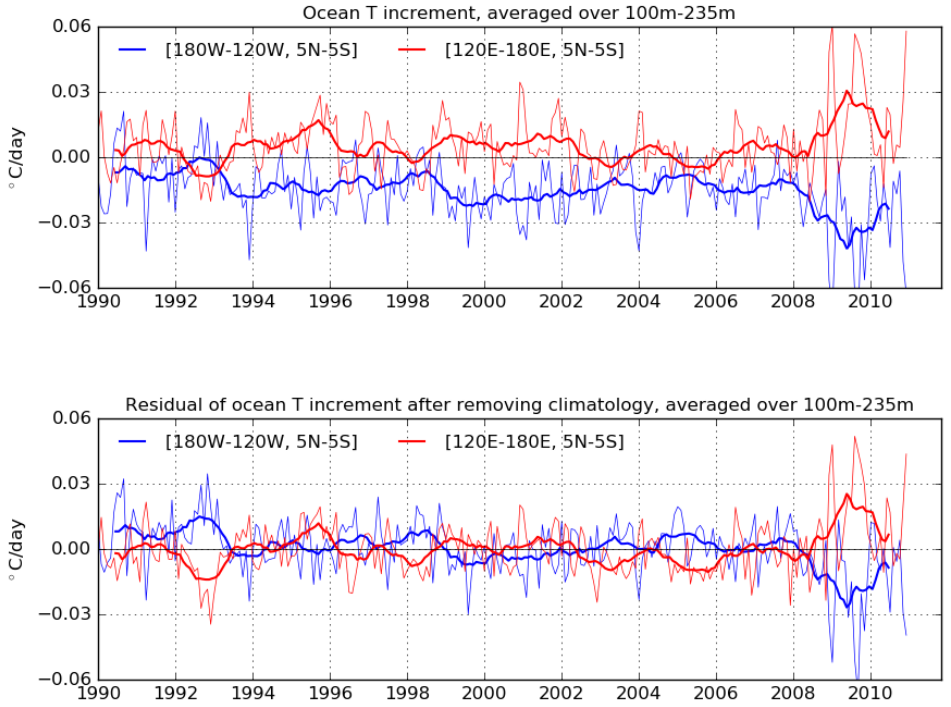


- In IFS, TP is generated by cloud scheme for large-scale precip (LSP), and by convection scheme for convective precip (CP).
- In precip events, cloud (TCC) prevents the surface solar radiation warming up the ocean, in CERA-20C.
- Convection (vertical air motion, W) cooling down SST via evaporation.

D2.10 Assessment of coupled-model drift and approaches for having consistent bias corrections

➢ Diagnostics of ocean biases (5S-5N) in CERA-20C





- Large ocean bias increments in the tropics are diagnosed in CERA-20C.
- They show strong temporal variations.
- Indicating the ‘offline’ bias correction may not represent the features of ocean bias very well.

➢ Objective

- Reduce ocean increments by applying ocean bias correction schemes
- Assess the benefits of applying bias correction
- Assess the impacts on atmospheric analysis

➢ Bias correction schemes

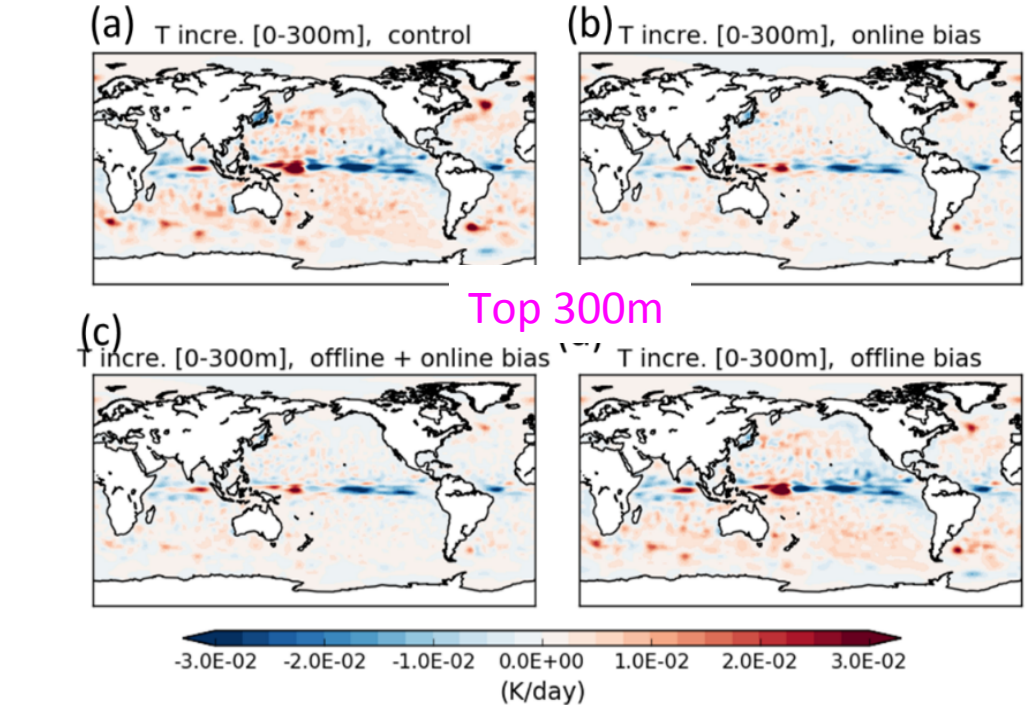
$$\boldsymbol{b}_c = \overline{\boldsymbol{b}} + \boldsymbol{b}'_c$$

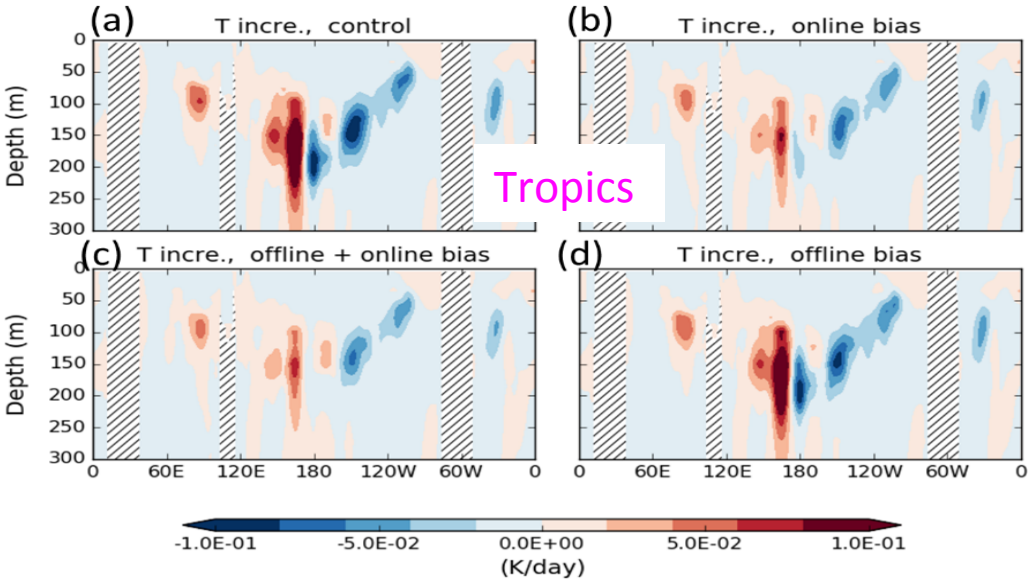
- 'offline' term $\overline{\boldsymbol{b}}$ is calculated as a monthly climatology from T/S increments over 1989-2008
- 'online' term $\boldsymbol{b}'_c$ is updated on each previous cycle $\boldsymbol{b}'_c = \alpha \boldsymbol{b}'_{c-1} - \boldsymbol{A}\delta \boldsymbol{x}^a_{c-1}$

➢ Tests for applying bias correction in CERA, in 2009

4 Tests	'offline' term $\overline{\boldsymbol{b}}$	'online' term $\boldsymbol{b}'_c$
Control (CERA-20C)	No	No
onl. corr.	No	Yes
offl. corr.	Yes	No
onl.+offl. corr.	Yes	Yes

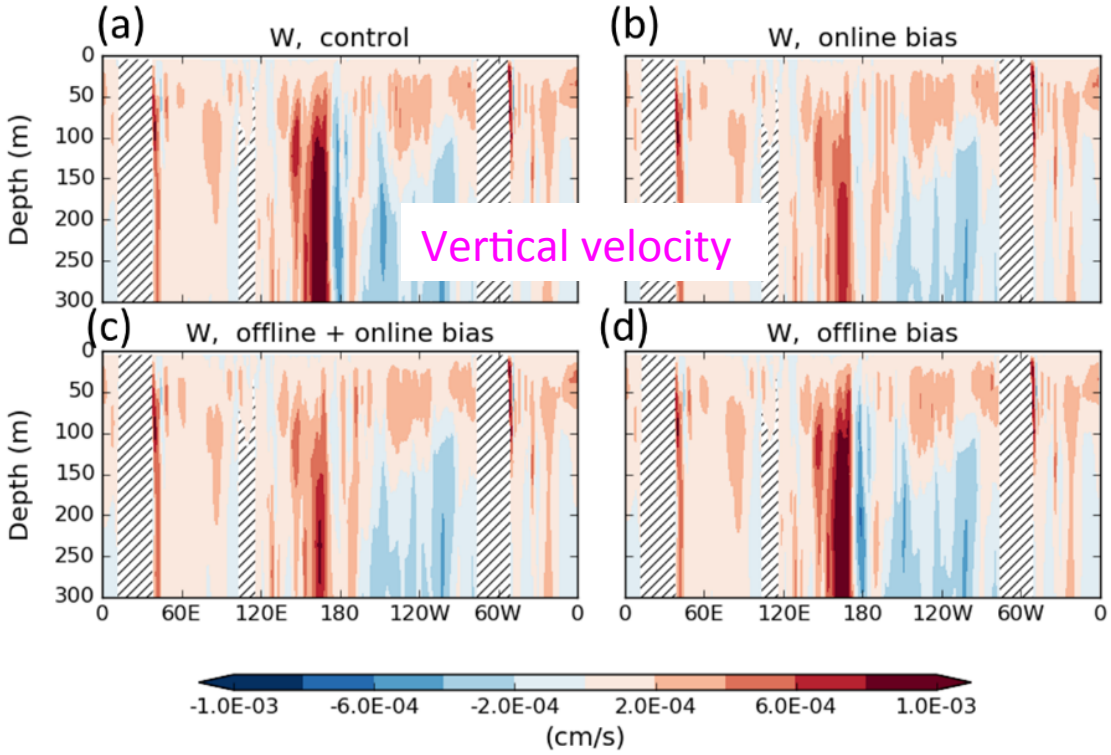
Ocean T increment



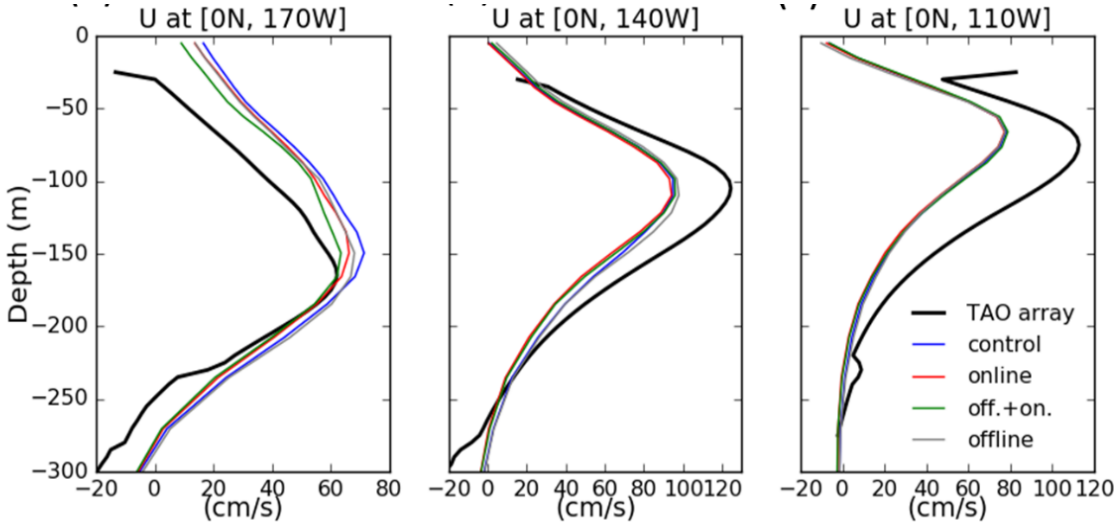


- Applying bias correction largely reduces T increments.
- Reduction can be mostly explained by the 'online' bias correction.
- 'Offline' bias correction has limited impacts.

Ocean analysis

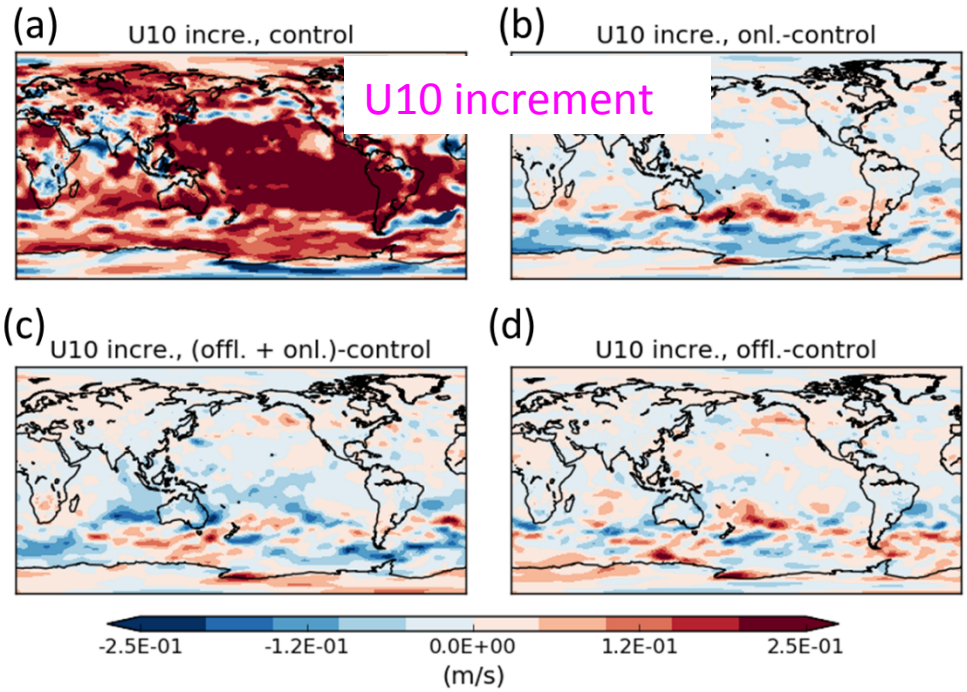


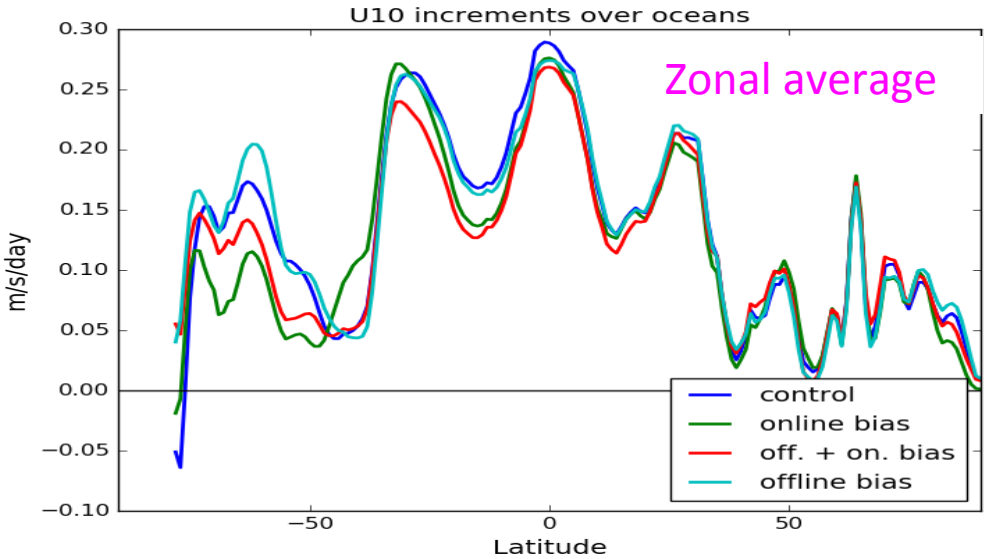
- Spurious upwelling (W) at the Equator is apparently reduced by applying bias corrections, due to the correcting of horizontal pressure gradient.
- Upwelling still remains strong.



- Bias corrections reduce the bias of the zonal undercurrent (U) in the central equatorial Pacific.
- Has little improvement at the eastern Equator.

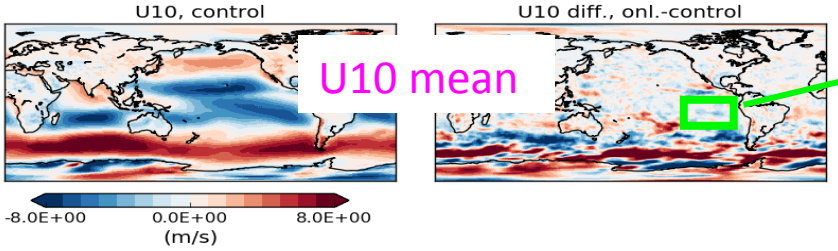
Atmosphere increments

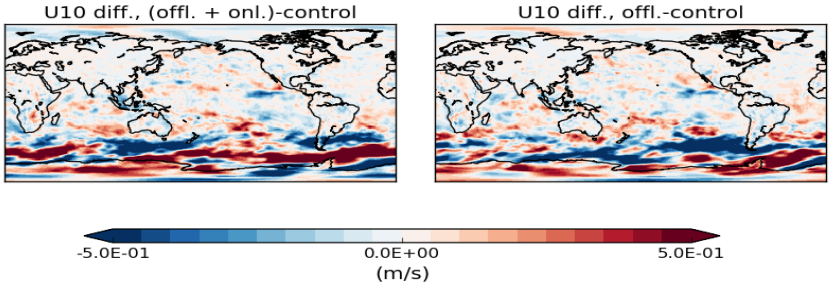


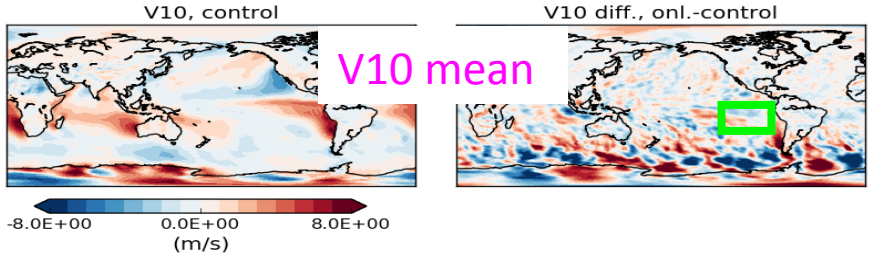


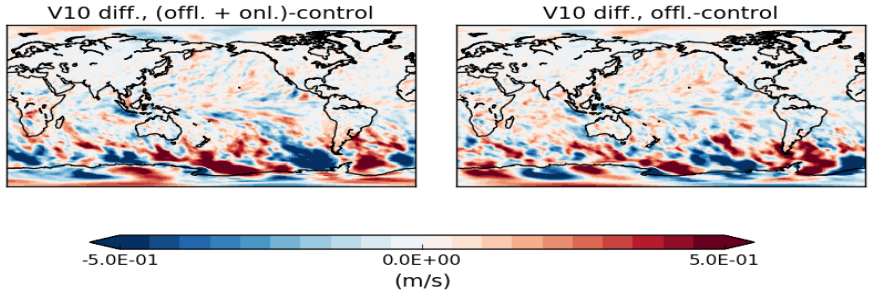
- U10 increments tend to be smaller in the ‘online’ bias correction runs, mainly in SH.
- However, other variables (V10, T2m, MSL) have similar increments as control run.

Atmosphere analysis

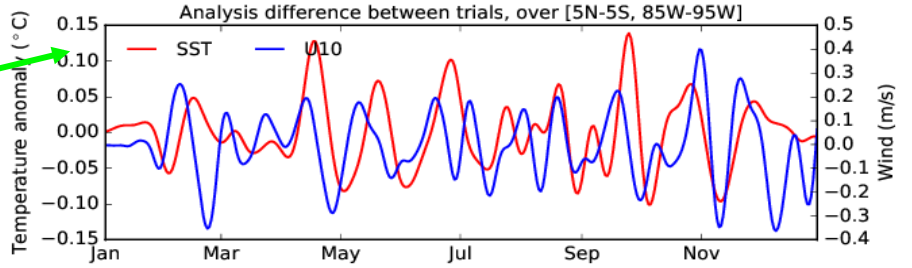


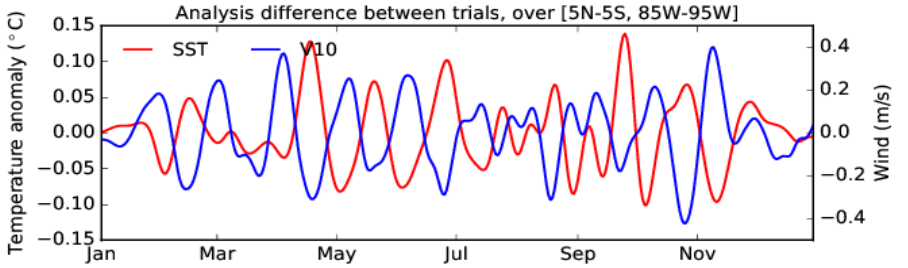






Temporal variability





- Applying ocean bias corrections has significant impacts on mean fields of atmosphere analysis at high latitudes.
- Temporal variability of the atmospheric analyses is also altered.
- More work is needed to diagnose causes of such changes.

Summary

D2.8 SST-TP relationships

- ✓ SST-TP relationships are better produced in CERA-20C in than ERA-20C.
- ✓ The relationship in CERA-20C is mainly due to the model coupling.
- ✓ However, having model coupling does not improve the final estimations on precipitation. This points some further works in CERA.

D2.10 Ocean bias correction

- ✓ The temporally large ocean increments in 2009, in CERA-20C, are considerably reduced by implementing the 'online' bias correction scheme, while the 'offline' scheme has limited effects.
- ✓ This suggests that for some years with rich observations such as 2009 we may not necessarily need an *a priori*-run bias scheme to eliminate the ocean model bias.
- ✓ Ocean bias correction has detectable impacts on the atmospheric fields.
- ✓ Have implications for CERA-SAT?

Thank you!