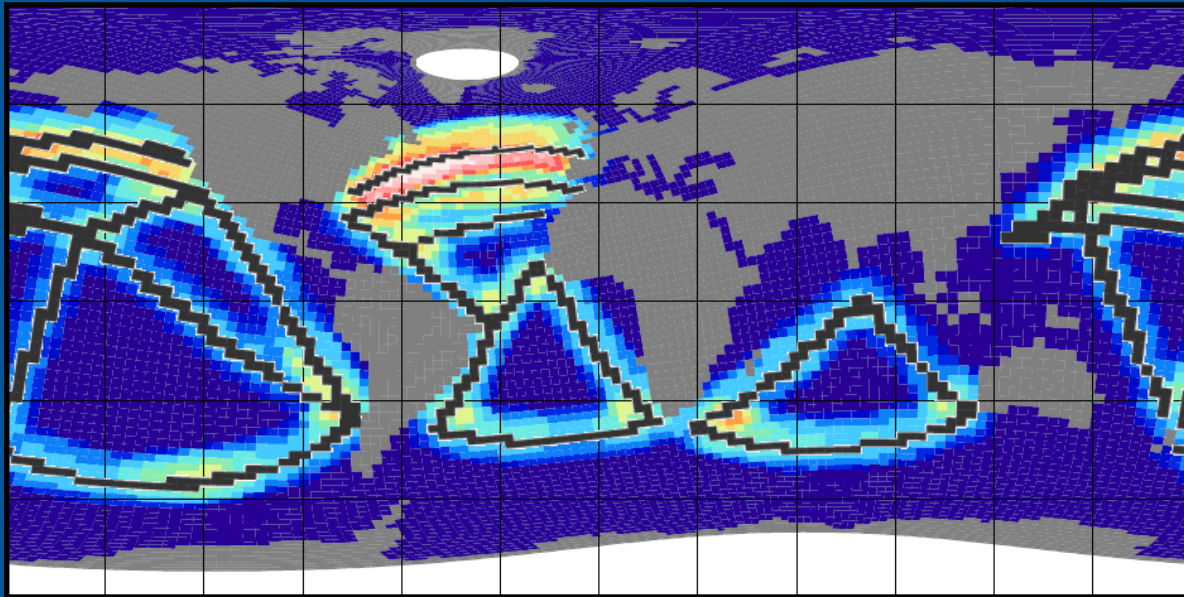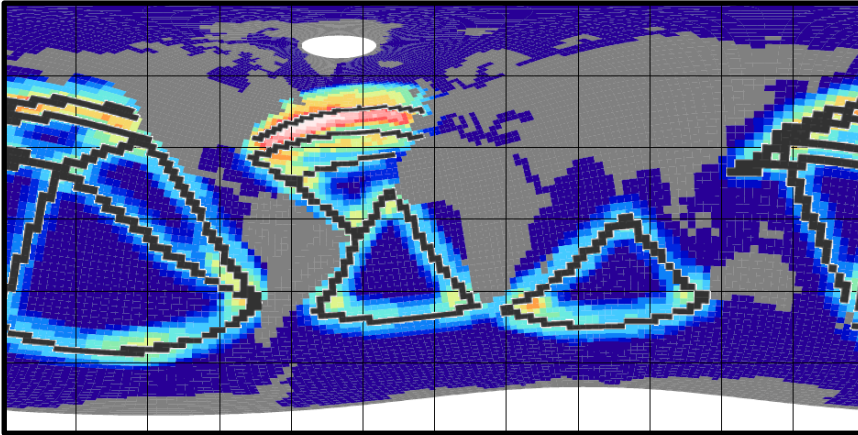# Constraining ocean models with ocean bottom pressure from SMART cables

T. Weber [1], M. Thomas [1,2]

(1) Helmholtz Centre Potsdam, GFZ German Research Centre For Geosciences, Potsdam, Germany
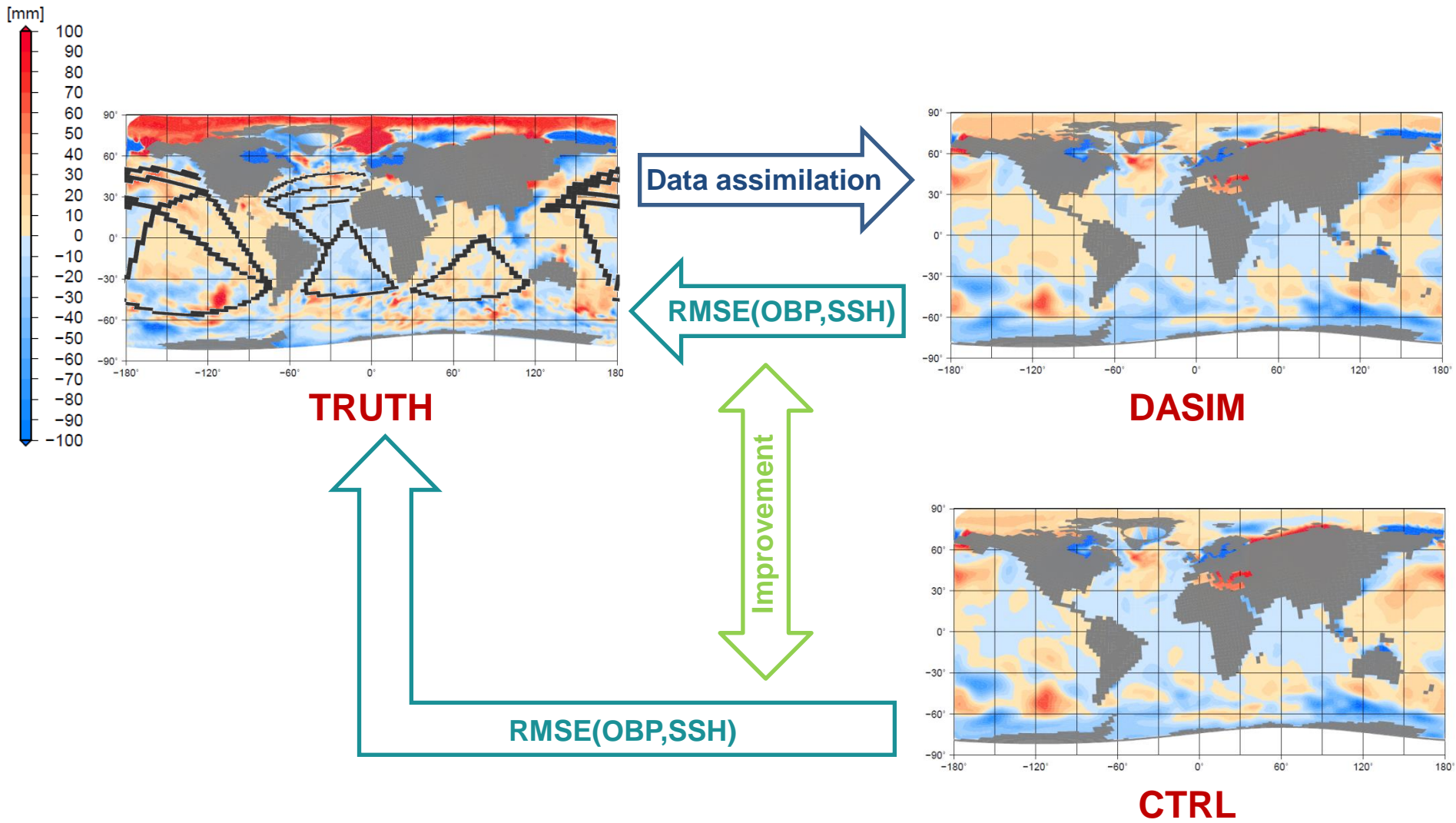(2) Institute of Meteorology, Free University Berlin, Germany

GFZ
Helmholtz Centre
POTSDAM

HELMHOLTZ
ASSOCIATION

Questions
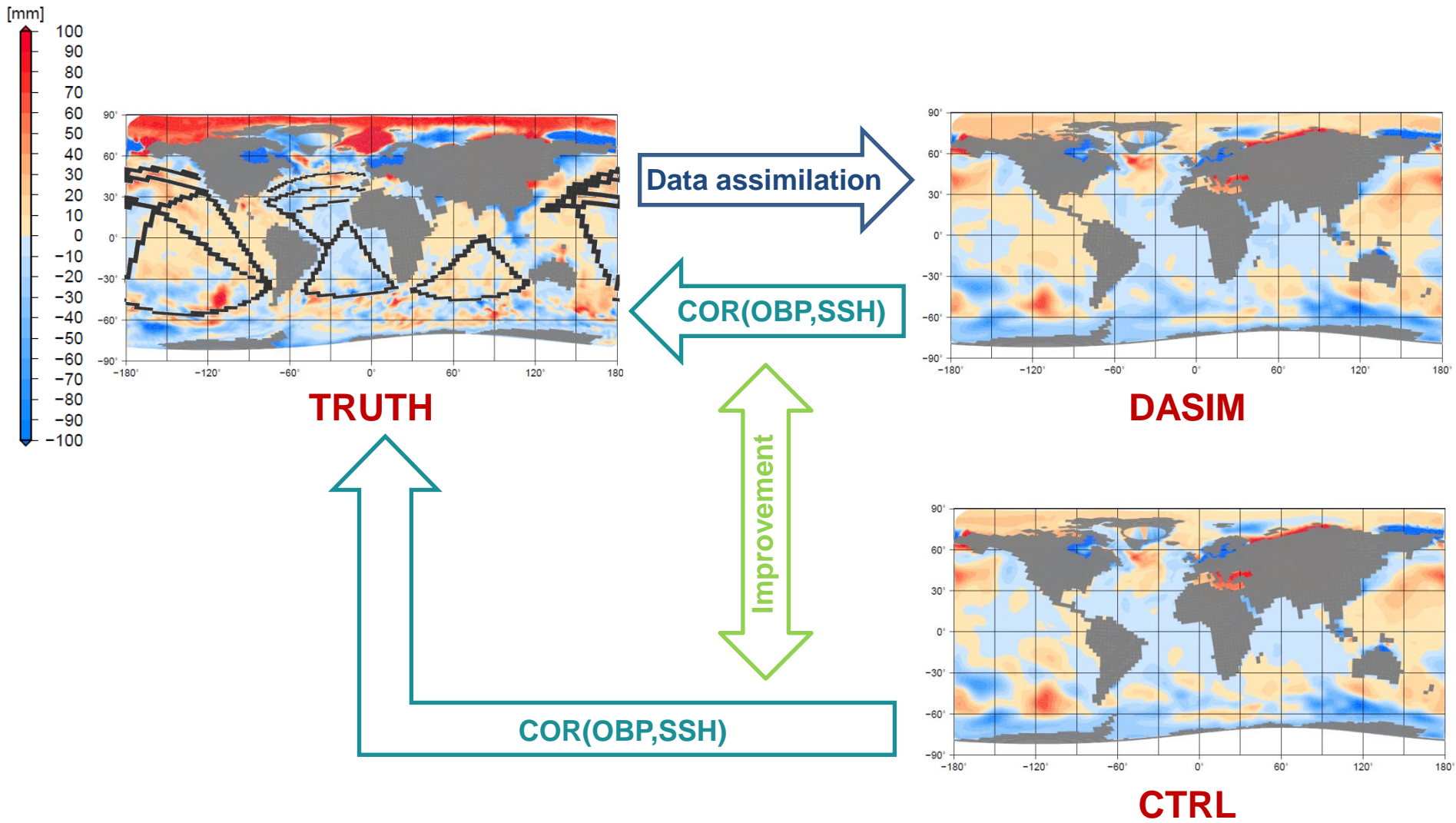

- How large are improvements in modeled ocean dynamics by integrating SMART cable observations of ocean bottom pressure?
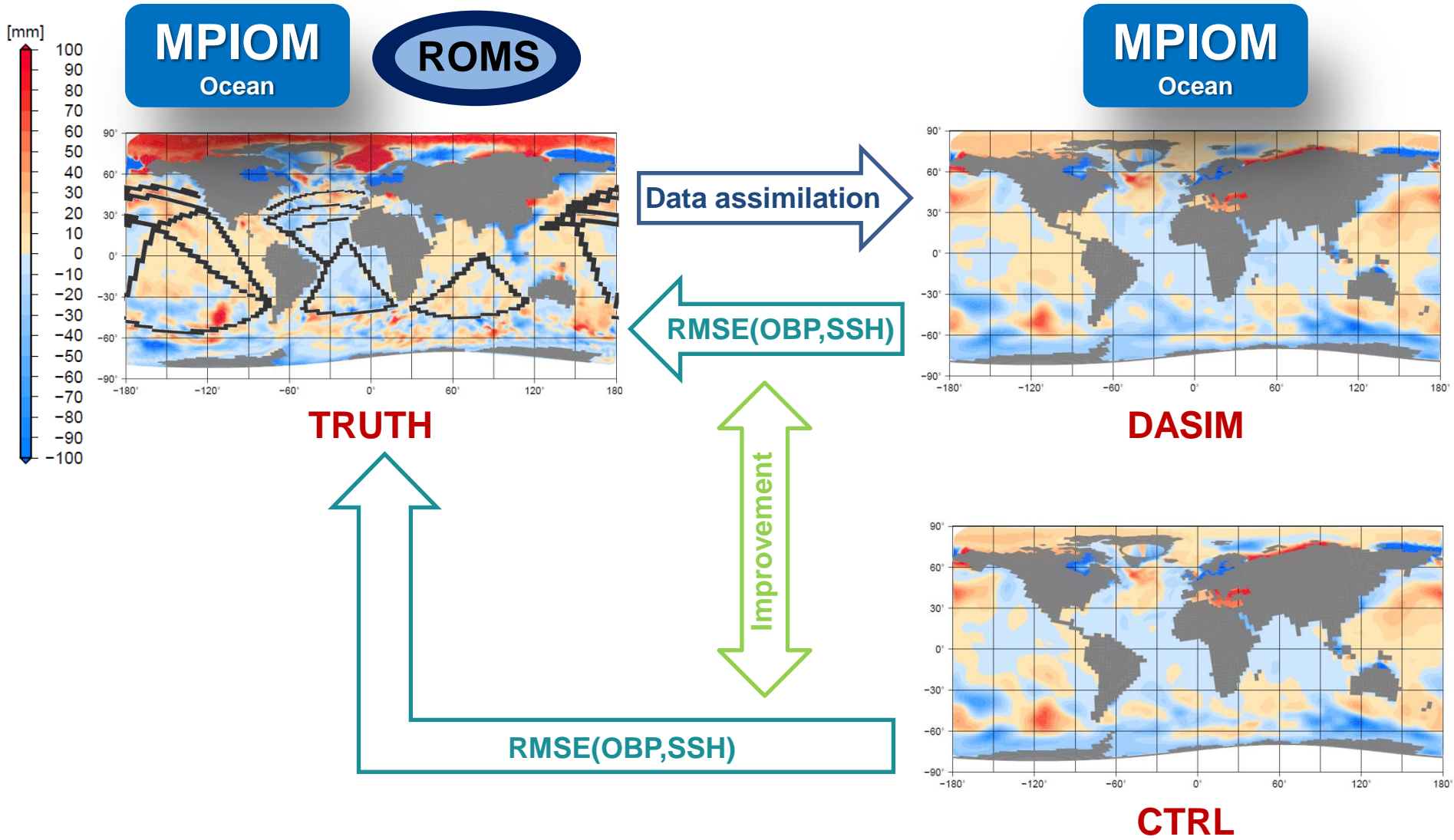
- Which cables have the largest impact?

→ Twin experiment

Twin experiment: OBP anomalies

Twin experiment: OBP anomalies

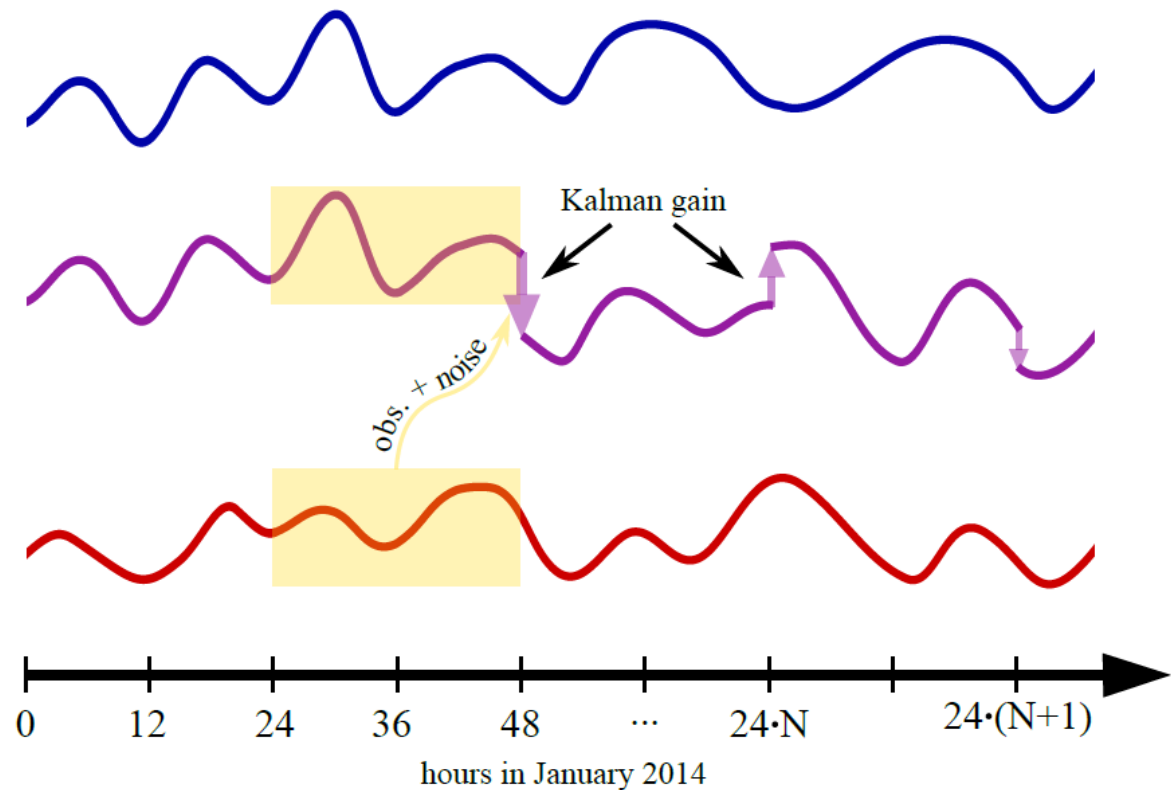# Twin experiment: OBP anomalies

MPIOM
Ocean

ROMS

MPIOM
Ocean

[mm]
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100

Data assimilation

RMSE(OBP,SSH)

Improvement

RMSE(OBP,SSH)

TRUTH

DASIM

CTRL

GFZ
Helmholtz Centre
POTSDAM

HELMHOLTZ
ASSOCIATION

Twin experiment: OBP anomalies

MPOM Ocean

MPIOM Ocean

ROMS

CTRL
MPIOM Jan 2014

DASMART
MPIOM Jan 2014
+
DA ROMS Jan 2014

TRUTH
ROMS Jan 2014

Kalman gain

obs. + noise

0   12   24   36   48   ...   24·N   24·(N+1)

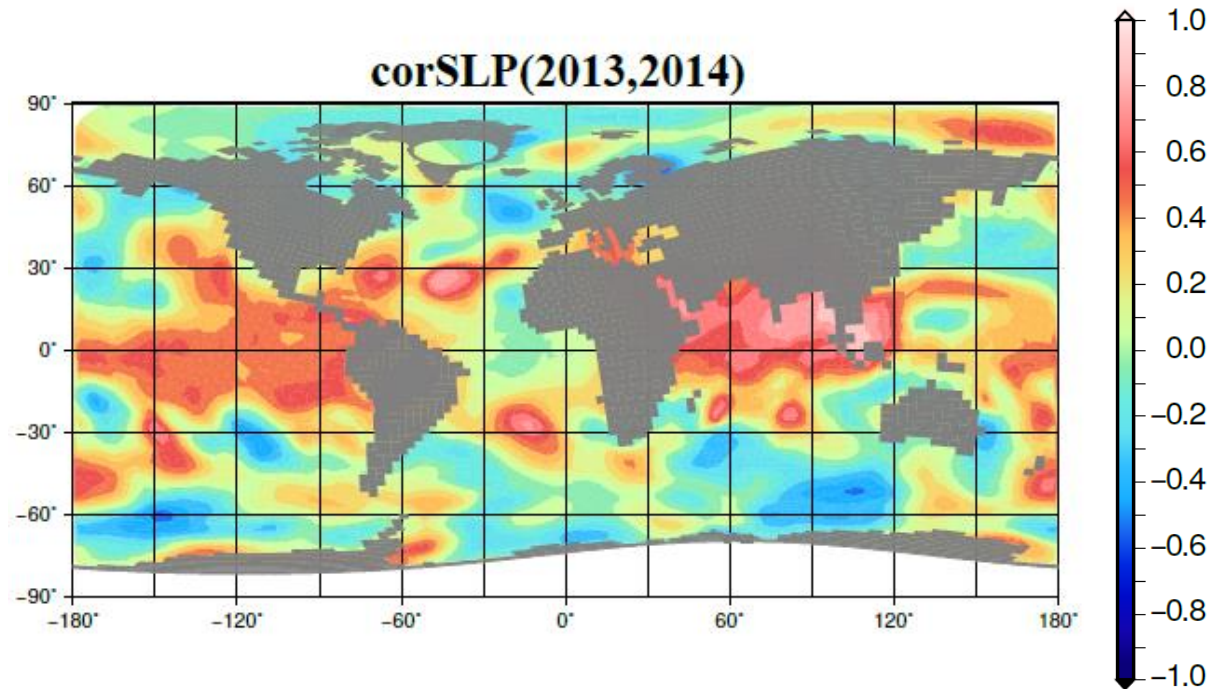hours in January 2014

Ocean model

MPIOM
Ocean

- Max Planck Institute Ocean Model (MPIOM, Marsland et al. (2013))

- Primitive equation model (C-grid, z-coordinates, free surface)

- GR30 (~ 3°x 3°), 40 vertical levels

- Time step: 90 minutes

- Atmospheric forcing: ERA-Interim, 3h

- Data assimilation:
  - ➢ ocean bottom pressure
  - ➢ daily means at the end of every day

- 48 ensemble members

- Singular Evolutive Interpolated Kalman filter (SEIK, Pham et al. (1998), Nerger et al. (2005a,b))

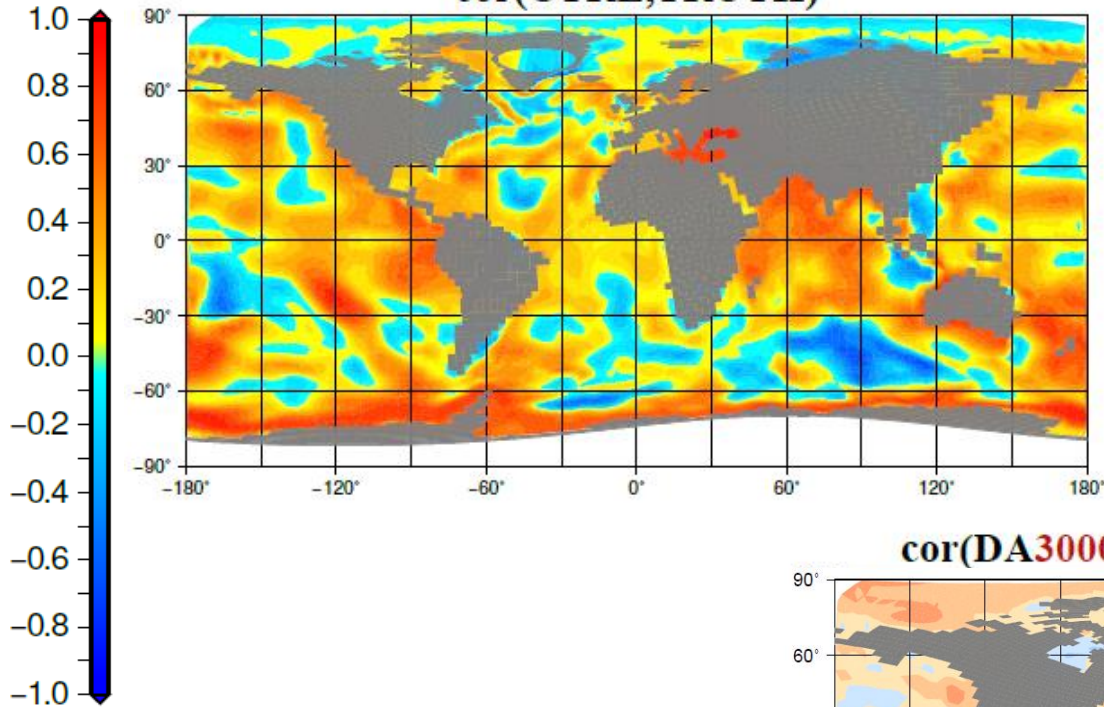# **Identical twin experiment:** MPIOM

- TRUTH and CTRL have different ocean initial states

- TRUTH and CTRL have (very) different atmospheric forcing

  → On timescales of one day, atmospheric forcing dominates OBP and SSH signal
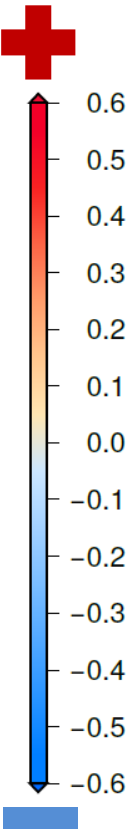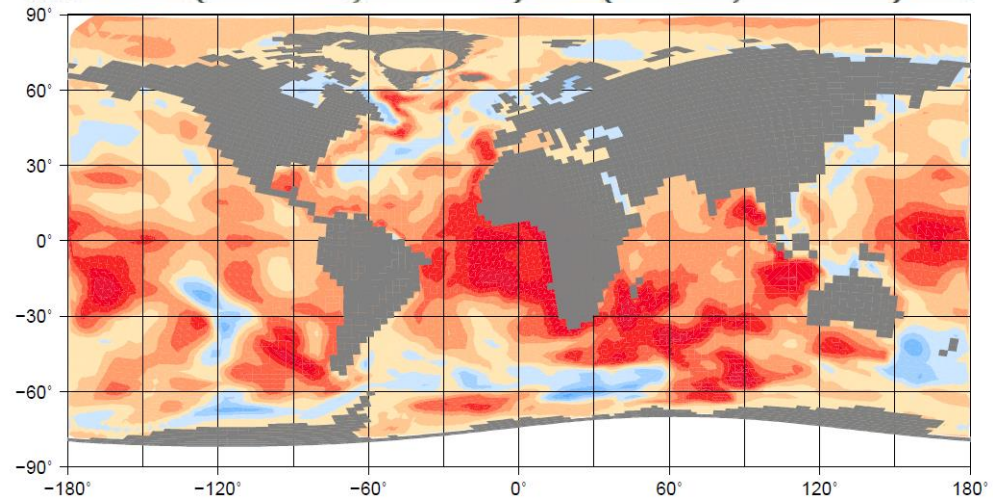
- Same model physics and parametrizations

MPIOM
Ocean

corSLP(2013,2014)

Correlation: improvement OBP

Correlations

cor(OBP,SSH)

MPIOM
Ocean

Correlation: improvement SSH

cor(CTRL,TRUTH)

cor(DA3000,TRUTH)-cor(CTRL,TRUTH)
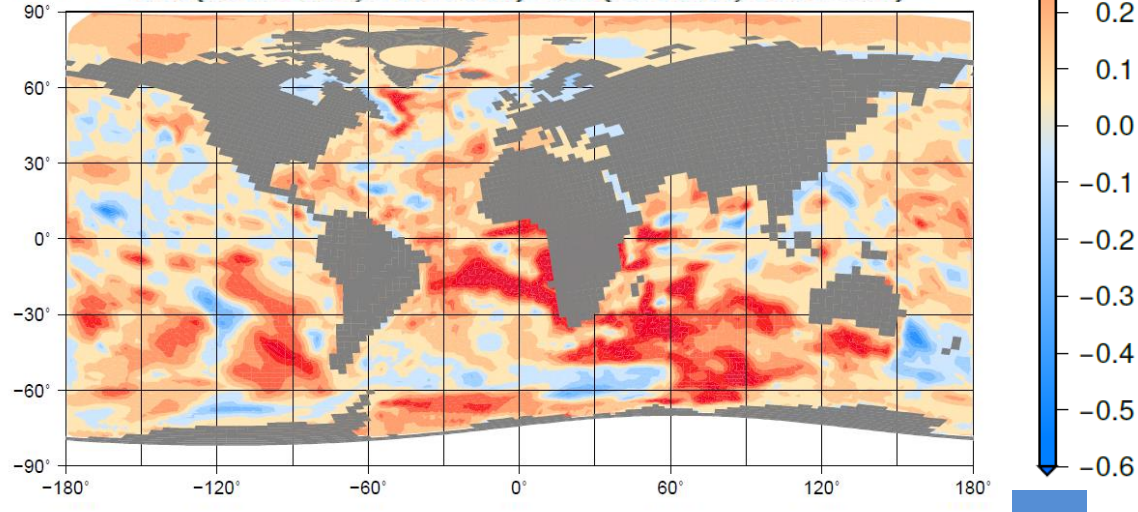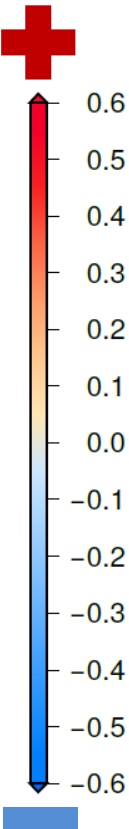
MPIOM
Ocean

Correlation: improvement velocities

zonal velocity

cor(DA3000,TRUTH)-cor(CTRL,TRUTH)
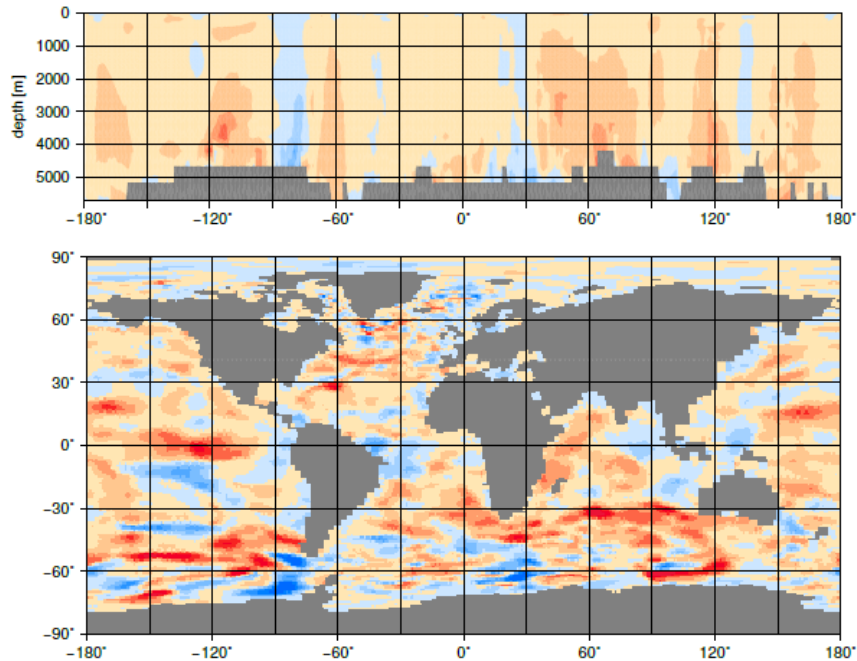
meridional velocity

cor(DA3000,TRUTH)-cor(CTRL,TRUTH)
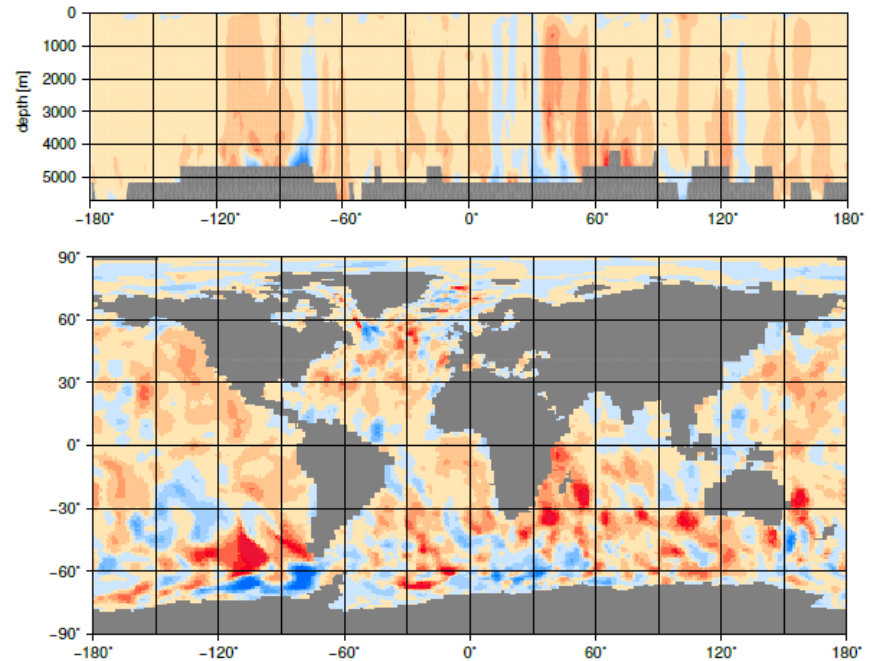
MPIOM
Ocean

Identical twin experiment: MPIOM

- **TRUTH and CTRL have different ocean initial states**

- TRUTH and CTRL have (very) different atmospheric forcing

  → On timescales of one day, atmospheric forcing dominates OBP and SSH signal

- Same model physics and parametrizations

MPIOM
**Ocean**

Fraternal twin experiment: ROMS

- TRUTH and CTRL have different ocean initial states, but of the same year

- TRUTH and CTRL have different atmospheric forcing, but of the same year

  ➔ On timescales of one day, atmospheric forcing dominates OBP and SSH signal

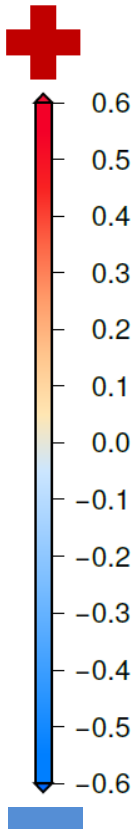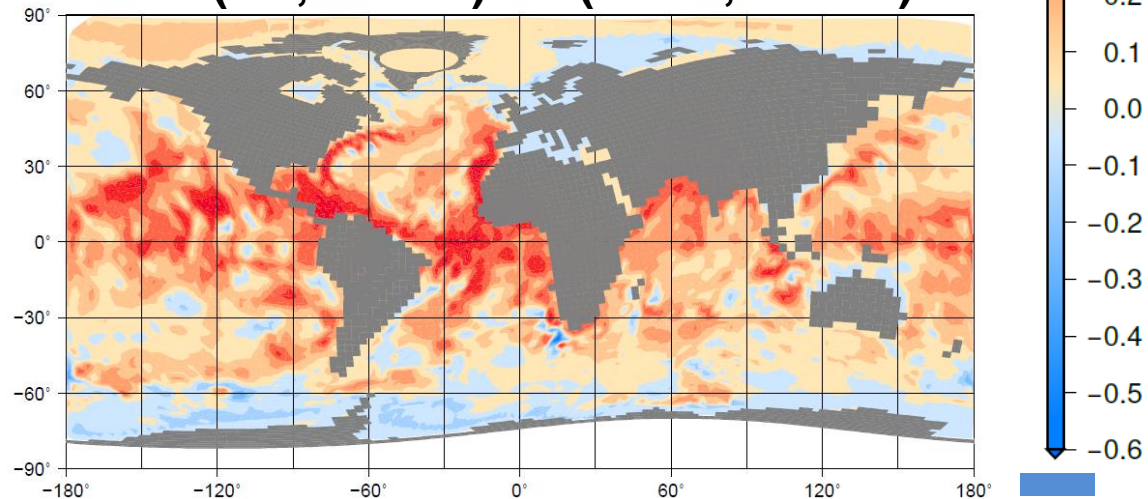- **Different** model physics and parametrizations

ROMS ROMS model output courtesy of Tony Song, JPL & Caltech

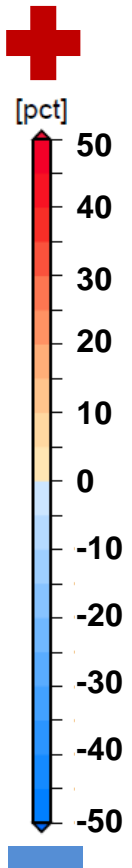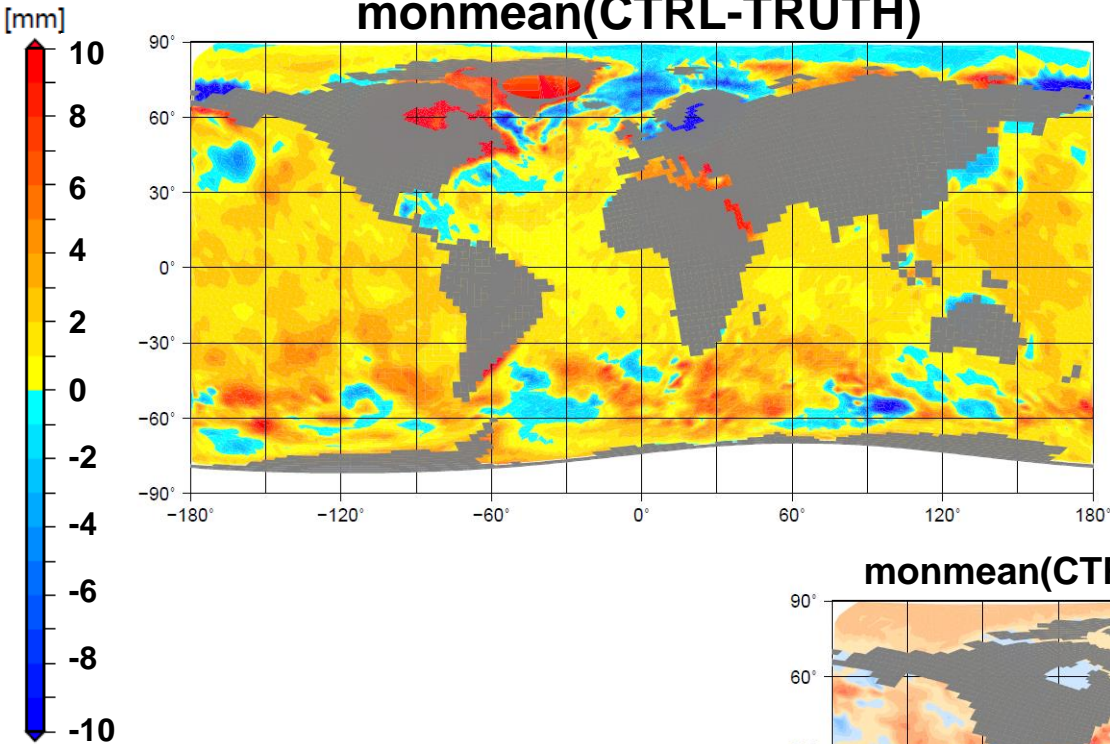# **Correlation:** improvement OBP

cor(CTRL,TRUTH)
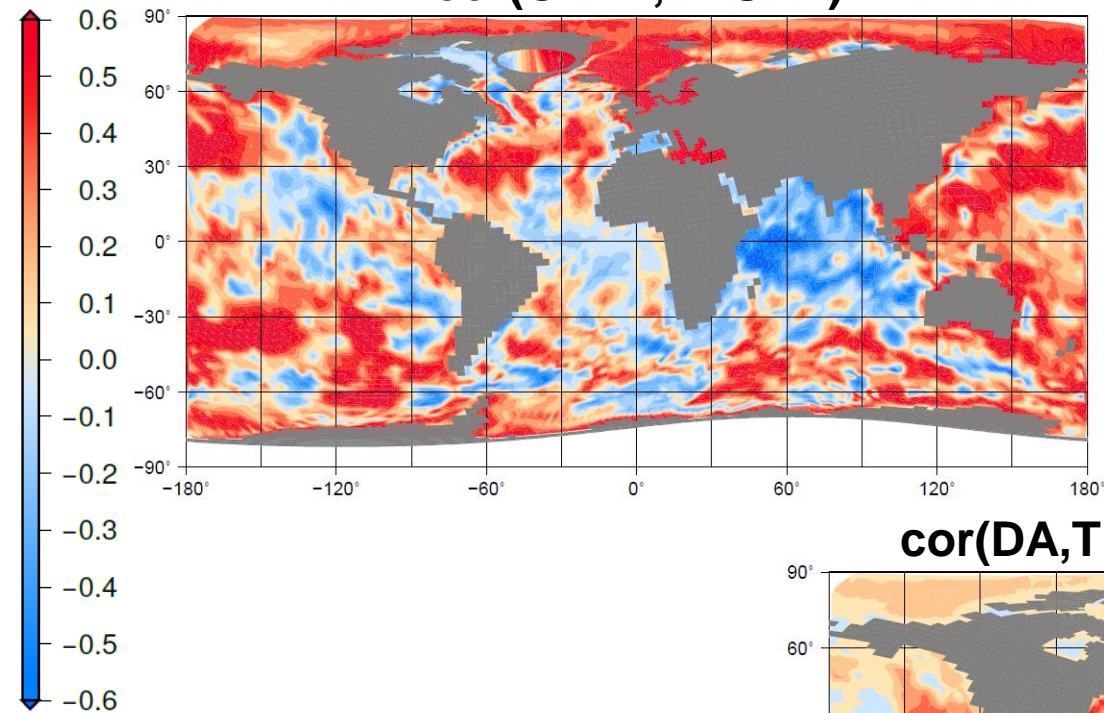
cor(DA,TRUTH)-cor(CTRL,TRUTH)

ROMS

Error: improvement OBP

monmean(CTRL-TRUTH)

monmean(CTRL-TRUTH)-monmean(DA-TRUTH)

ROMS
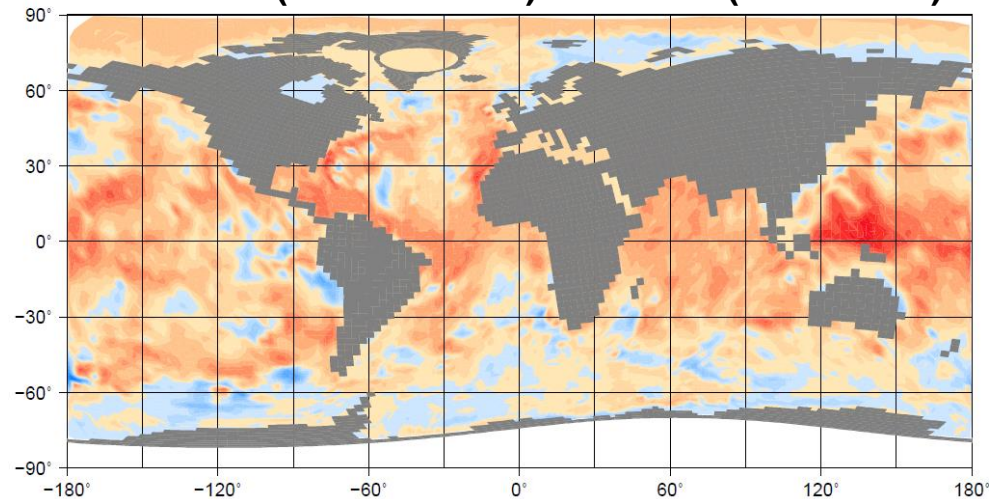
RMSE: temporal evolution

global **RMSE of OBP**
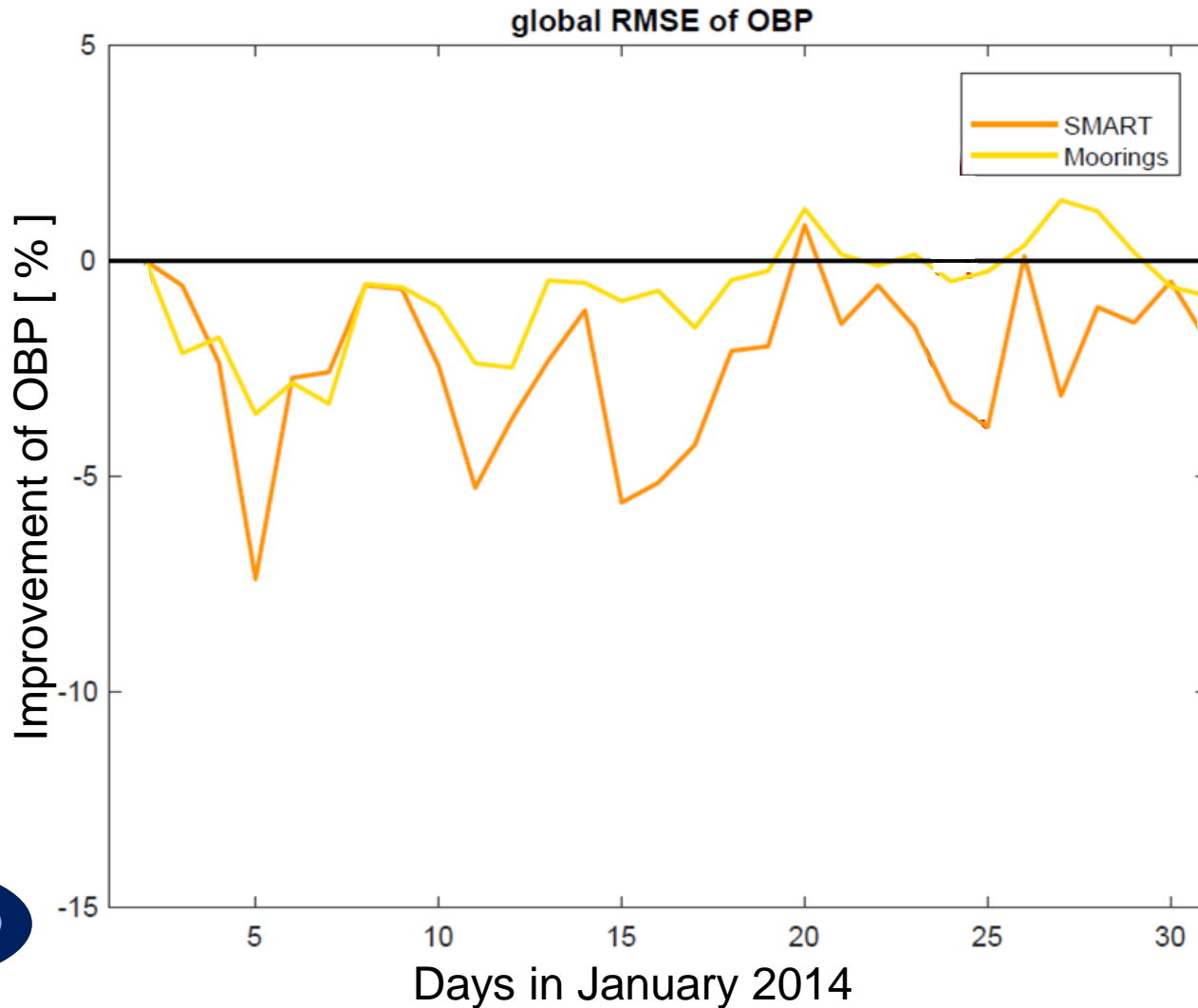
Importance of singular cables
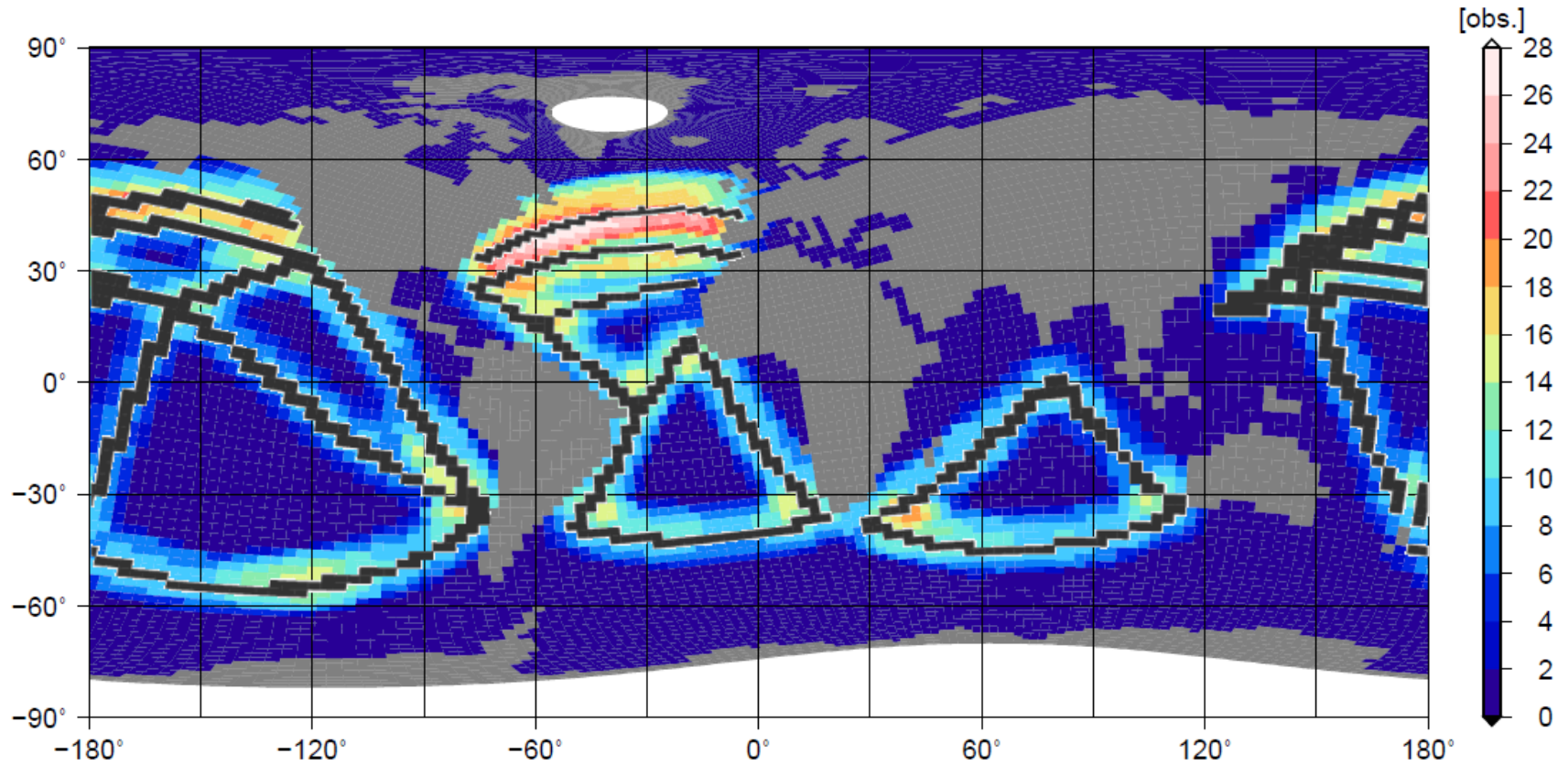
RMSE: improvement OBP

monmean(CTRL-TRUTH)-monmean(DA-TRUTH)

<u>one</u> SMART cable in the SE Pacific

<u>all</u> SMART cables
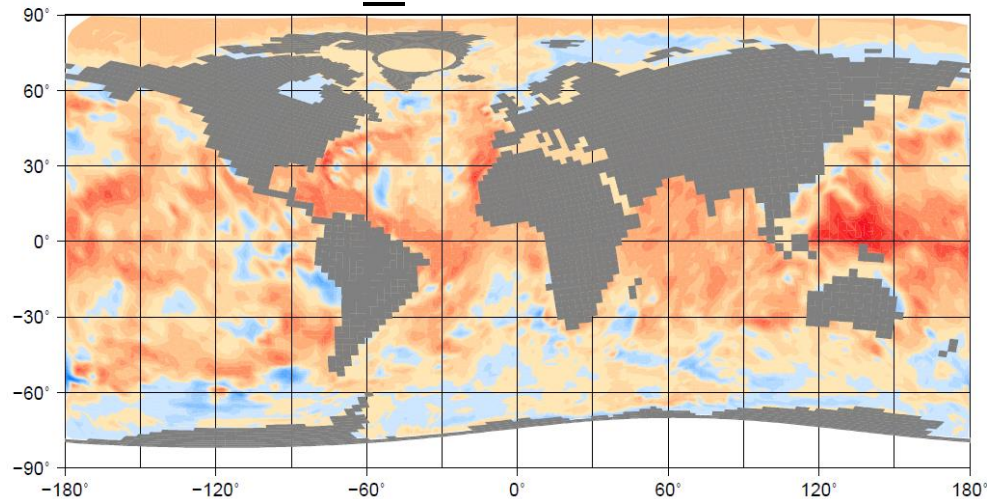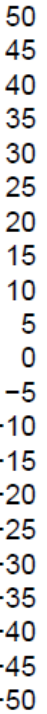
ROMS

Conclusions

MPIOM
Ocean

ROMS
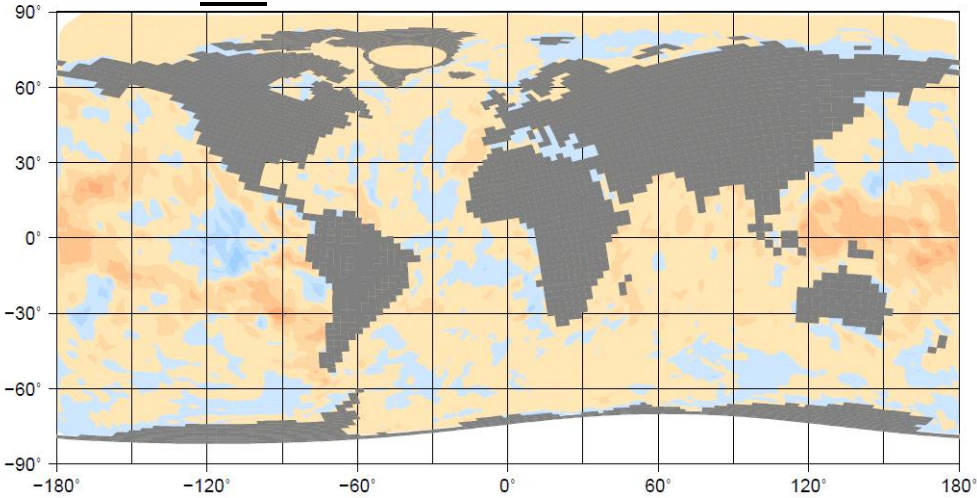
- increase in correlation in OBP, SSH, velocities between TRUTH and CTRL

- No decrease in RMSE because of very different initial states of TRUTH and CTRL

- increase in correlation in OBP between TRUTH and CTRL

- decrease in errors in OBP (mainly in the vicinity of SMART cables)

- Global RMSE improvement over time: ~5%

GFZ
Helmholtz Centre
POTSDAM

Tobias Weber - SMART JTF Workshop - 13.11.2017   20

HELMHOLTZ
ASSOCIATION

To Do's

- Analysis of correlation and RMSE of SSH and velocities of fraternal twin study (ROMS)

- Data assimilation of sub-daily observations in the fraternal twin study

- Combination of SMART cables with other observing systems (GRACE, PIES, …)

Thank you for your attention!

? !

References

Marsland, S. J., Haak, H., Jungclaus, J. H., Latif, M. & Röske, F. The Max-Planck-Institute global ocean/sea ice model with orthogonal curvilinear coordinates. Ocean Model. 5, 91–127 (2003).

Nerger, L., Hiller, W. & Schröter, J. in Use of High Performance Computing in Meteorology (eds. Zwieflhofer, W. & Mozdzynski, G.) 63–83 (2005a).

Nerger, L., Hiller, W. & Schröter, J. A comparison of error subspace Kalman filters. Tellus, Ser. A Dyn. Meteorol. Oceanogr. 57, 715–735 (2005b).

Pham, D. T., Verron, J. & Gourdeau, L. Filtres de Kalman singuliers évolutifs pour l'assimilation de données en océanographie. C. R. Acad. Sci. 326, 255–260 (1998).

Copyright

The presented results and conclusions are preliminary and subject of current research.

Please cite the presentation or figures as:
Weber, T., Thomas, M., "Constraining ocean models with ocean bottom pressure from SMART cables", 6th Workshop on "SMART Cable Systems: Science, Demonstration, and Funding", Brest, France, November 13, 2017.