

Multiple approaches in correcting errors of OGCM

Tsuyoshi Wakamatsu †‡

Michael G.G. Foreman †‡

† University of Victoria, ‡ DFO Canada



Fisheries and Oceans
Canada

Pêches et Océans
Canada

OUTLINE:

1. Green's Function package for NEMO: model calibration

▶ related presentation:

June-02: “Refinement of Green's function method for parameter tuning”

2. Model - Data comparison: characters of model errors

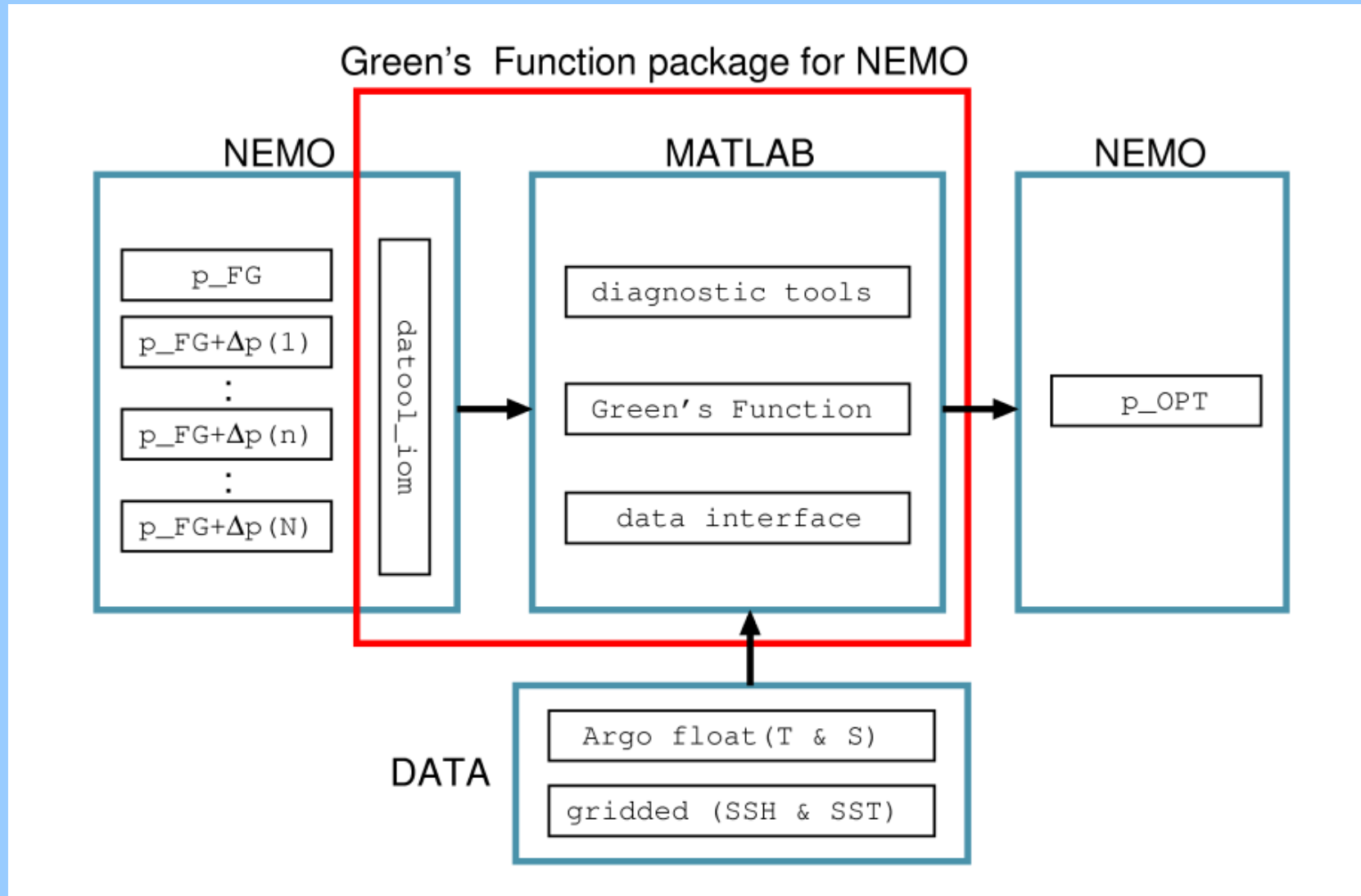
3. Theoretical aspects of 4D-Var: how to fix model errors

▶ related presentation:

June-01 (poster): “Inter-connections among three vector spaces in a 4D-Var system”

1. Green's Function package for NEMO: model calibration

- Function: tuning model parameters against data using Green's Function (Menemenlis et al. 2005)
- System: add-on package on NEMO + MATLAB scripts
- Testbed : twin experiments with GYRE01/12 configuration



1. Green's Function package for NEMO: model calibration

■ Testbed : twin experiments with GYRE01/12 configuration

■ GYRE01 configuration for parameter tuning

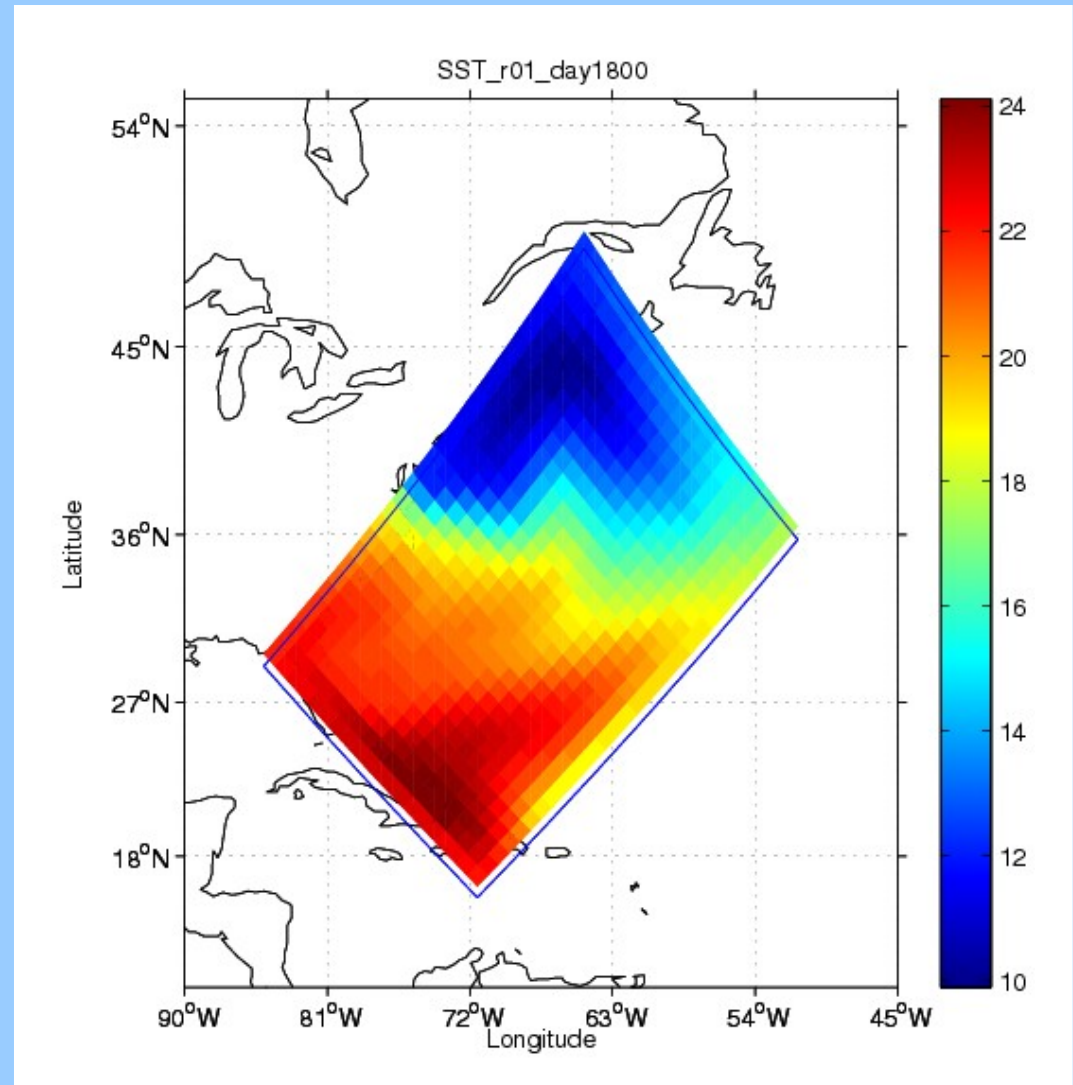
- 1x1 degree GYRE configuration (Hazeleger and Drijfhout, 2000)

- analytical seasonal forcing

- 200 years spinning-up run + 5 years control run

□ GYRE12 configuration

- types of data
- twin experiments



1. Green's Function package for NEMO: model calibration

■ Testbed : twin experiments with GYRE01/12 configuration

- GYRE01 configuration

- GYRE12 configuration for sampling simulated data

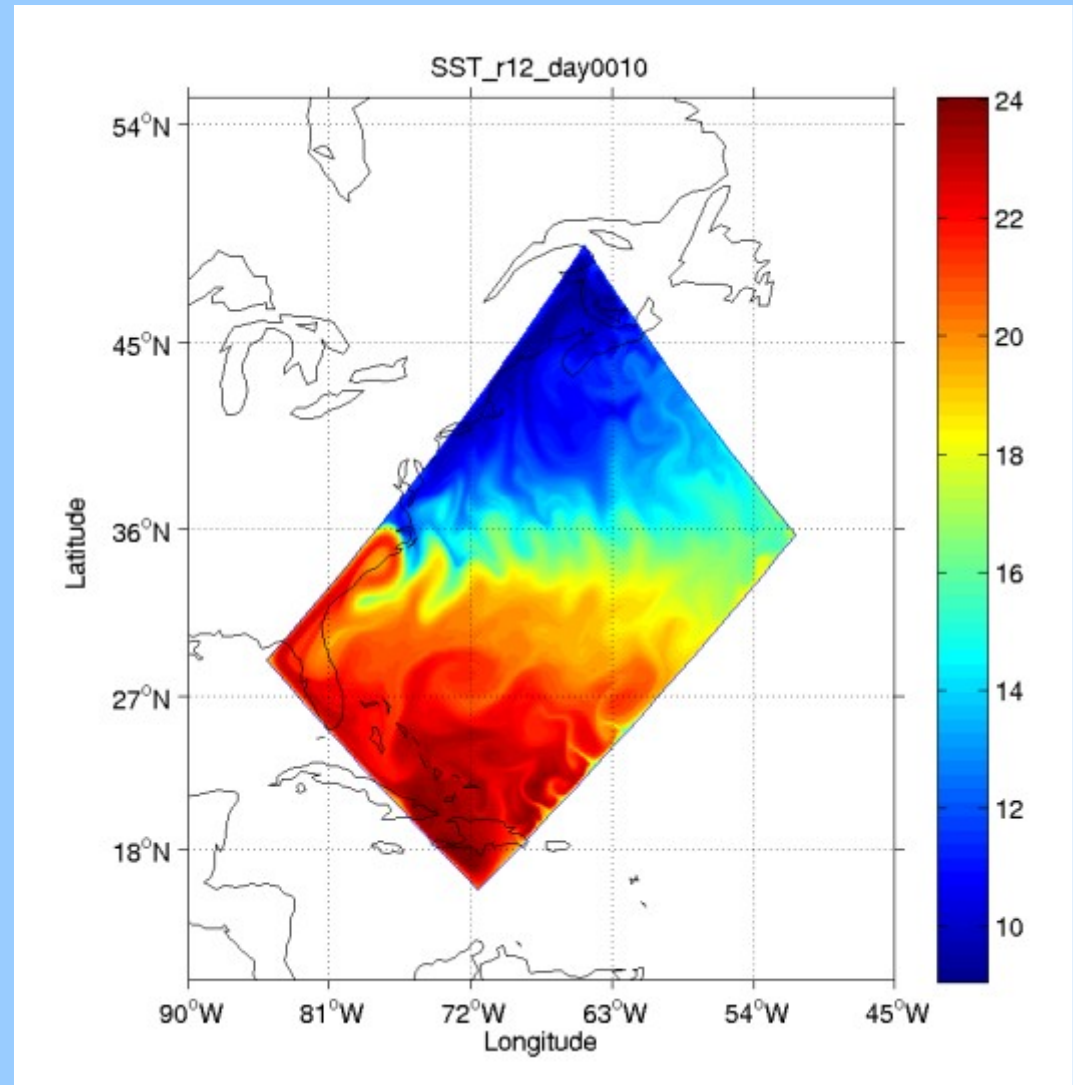
- 1/12 degree GYRE configuration (Hazeleger and Drijfhout, 2000)

- analytical seasonal forcing

- 200 years spinning-up run + 5 years control run

- types of data

- twin experiments

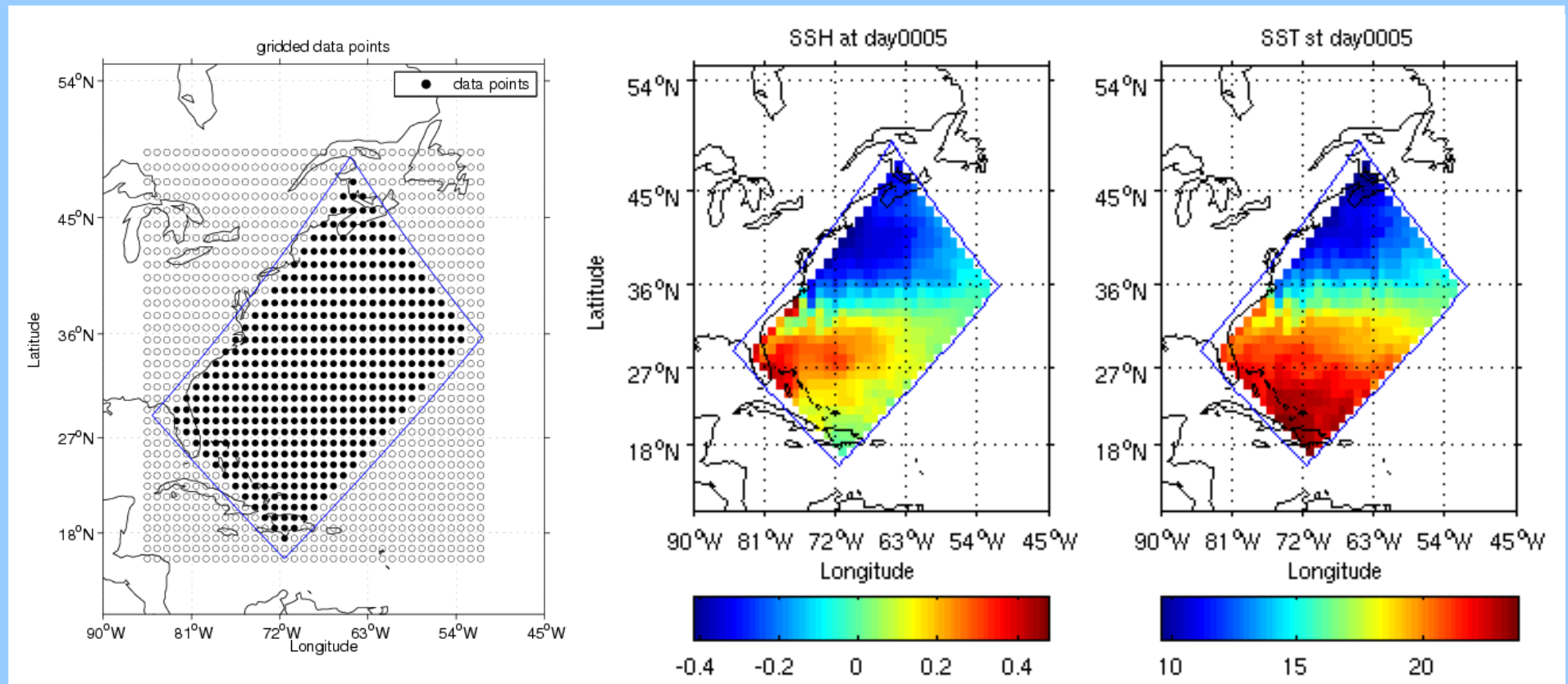


1. Green's Function package for NEMO: model calibration

■ Testbed : twin experiments with GYRE12 configuration

- GYRE01 configuration
- GYRE12 configuration
- type of data

- 1x1 gridded satellite data: SSH and SST (10 days mean)



- 3x3 Argo float data : potential temperature and salinity (every 10 days)

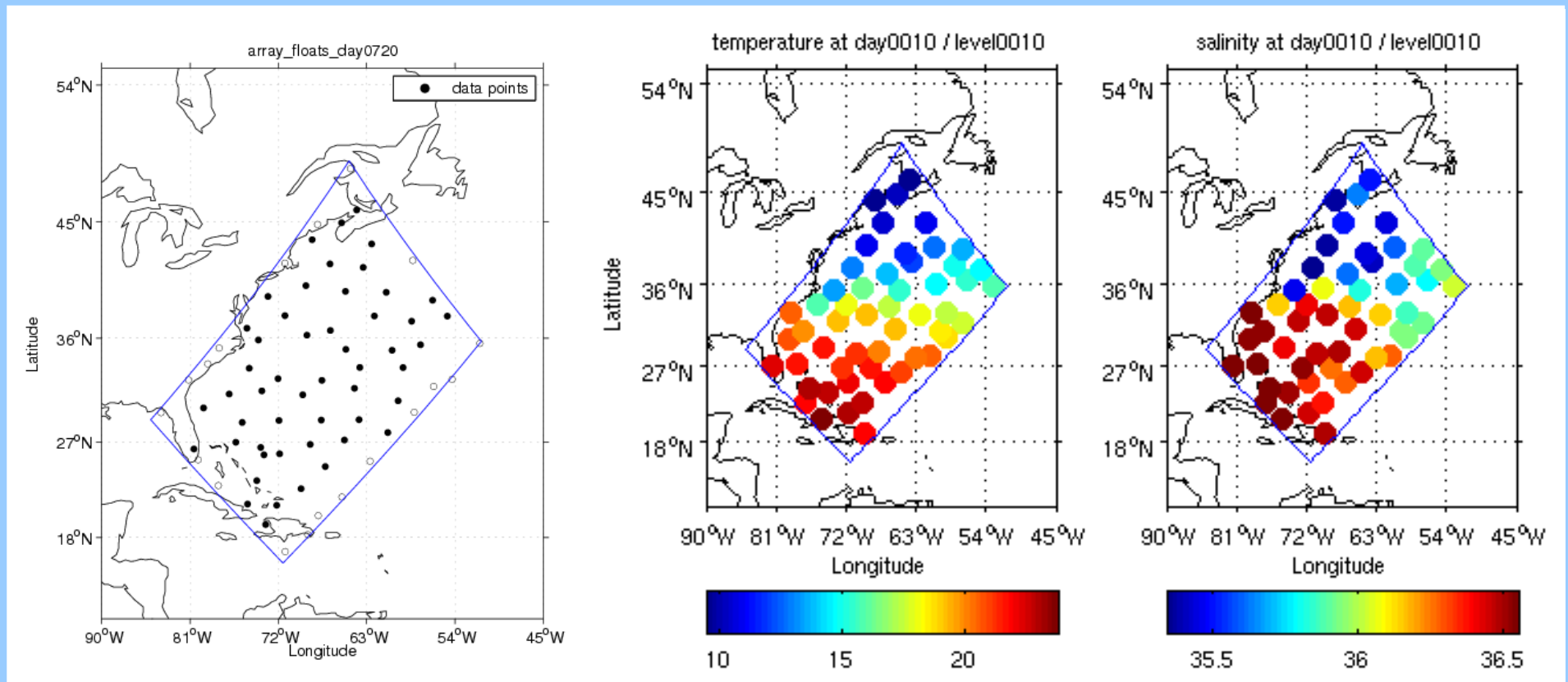
- twin experiments

1. Green's Function package for NEMO: model calibration

■ Testbed : twin experiments with GYRE12 configuration

- GYRE12 configuration
- GYRE01 configuration
- type of data

- 1x1 gridded satellite data: SSH and SST (10 days mean)
- 3x3 Argo float data: potential temperature and salinity (every 10 days, Levitus94 standard depth + enhanced resolution in upper 50m)



- twin experiments

1. Green's Function package for NEMO: model calibration

■ Testbed : twin experiments with GYRE12 configuration

□ GYRE01/12 configurations

□ types of data

■ twin experiments

- assimilation window 5 years
- initial condition: T & S climatology of simulated data (10 years mean of ORCA12)
- control parameters

No	parameter	unit	1st guess	perturbation	best estimate
1	SST relaxation coefficient	$\text{Wm}^{-2}\text{K}^{-1}$	-30	-10	-39.32
2	horizontal eddy diffusivity	m^2s^{-1}	0.75e+3	0.25e+3	1.79e+3
3	horizontal eddy viscosity	m^2s^{-1}	0.75e+5	0.25e+5	0.64e+5
4	bottom drag coefficient		0.75e-3	0.25e-3	-1.85e-3

○ impact of the calibrated parameters

1. Green's Function package for NEMO: model calibration

■ Testbed : twin experiments with GYRE12 configuration

□ GYRE01/12 configurations

□ types of data

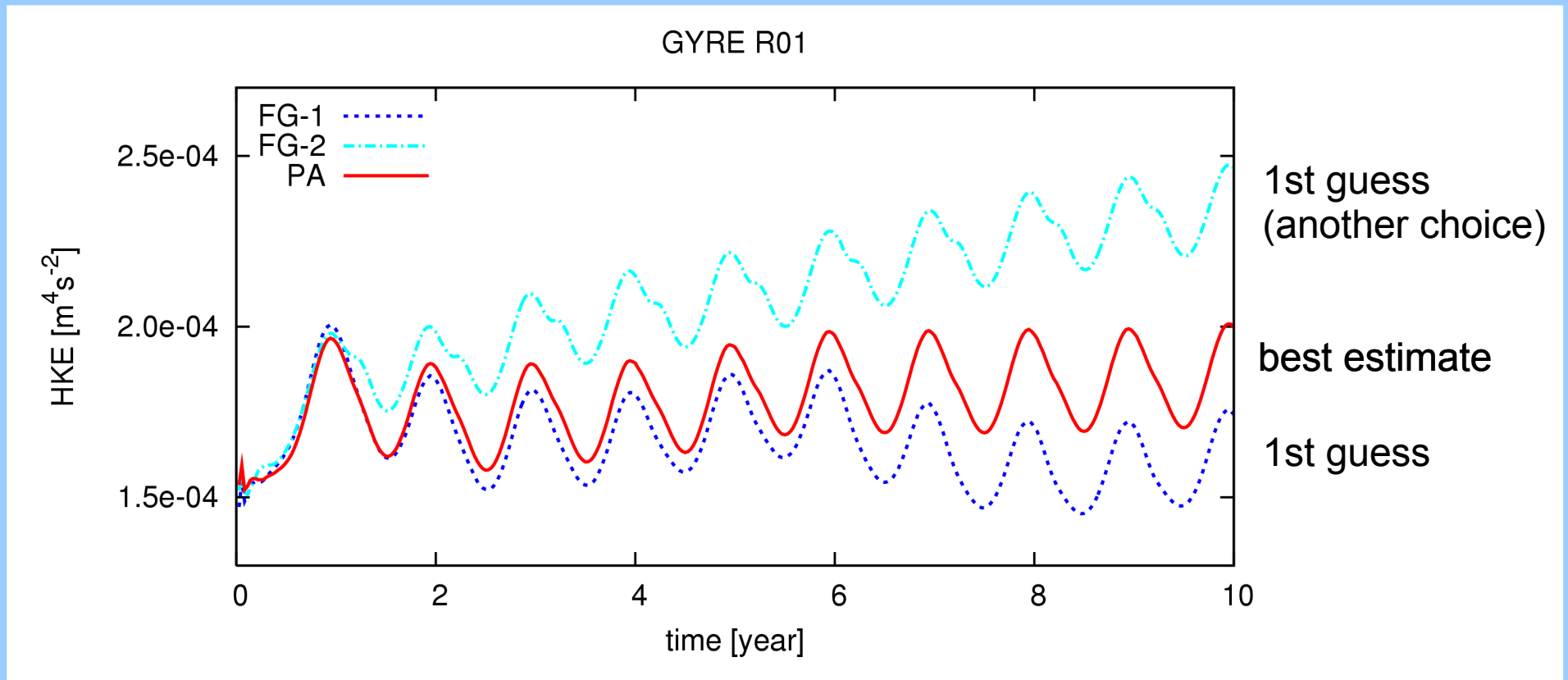
■ twin experiments

- assimilation window 5 years

- initial condition: T & S climatology of simulated data (10 years mean of ORCA12)

- control parameters

- impact of the calibrated parameters



2. Model - Data comparison: characters of model errors

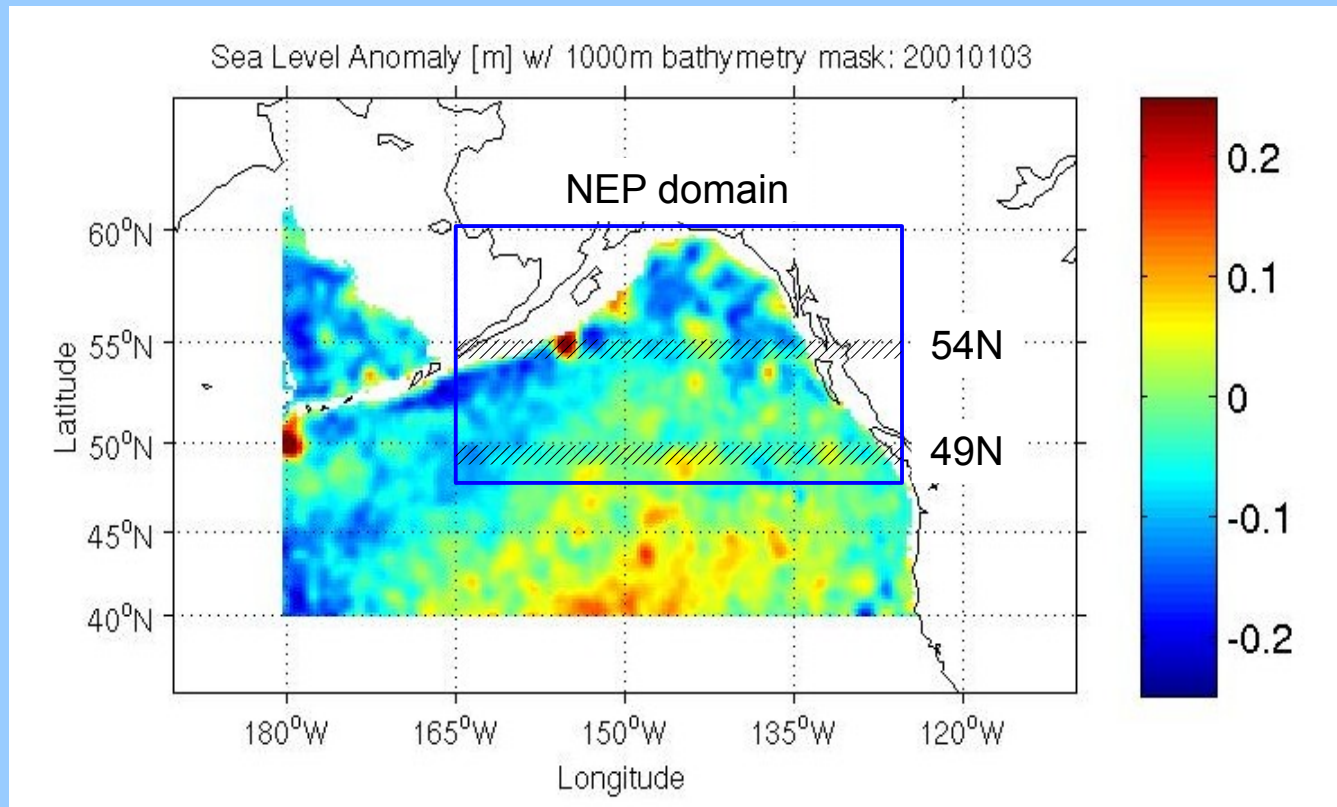
How realistic are ORCA/NEMO eddy permitting/resolving model outputs over the North East Pacific domain: [47N-60N, 165W-120W]?

■ Mercator ORCA4 / ORCA12 hindcast products (no assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

■ Data

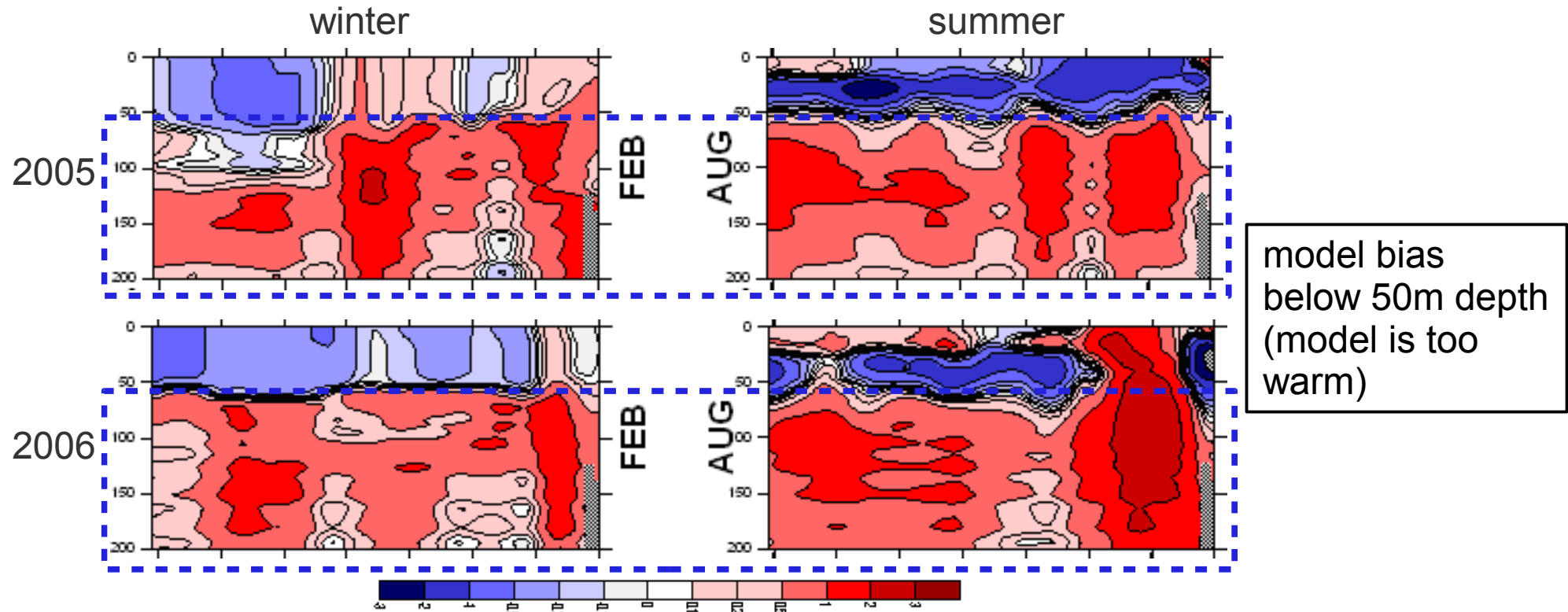
- Argo data + hydrographic data (temperature, salinity)
- AVISO gridded SLA



2. Model - Data comparison: characters of model errors

- Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)
 - ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
 - ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007
- Data
 - Argo data + hydrographic data (temperature, salinity)
 - AVISO gridded SLA

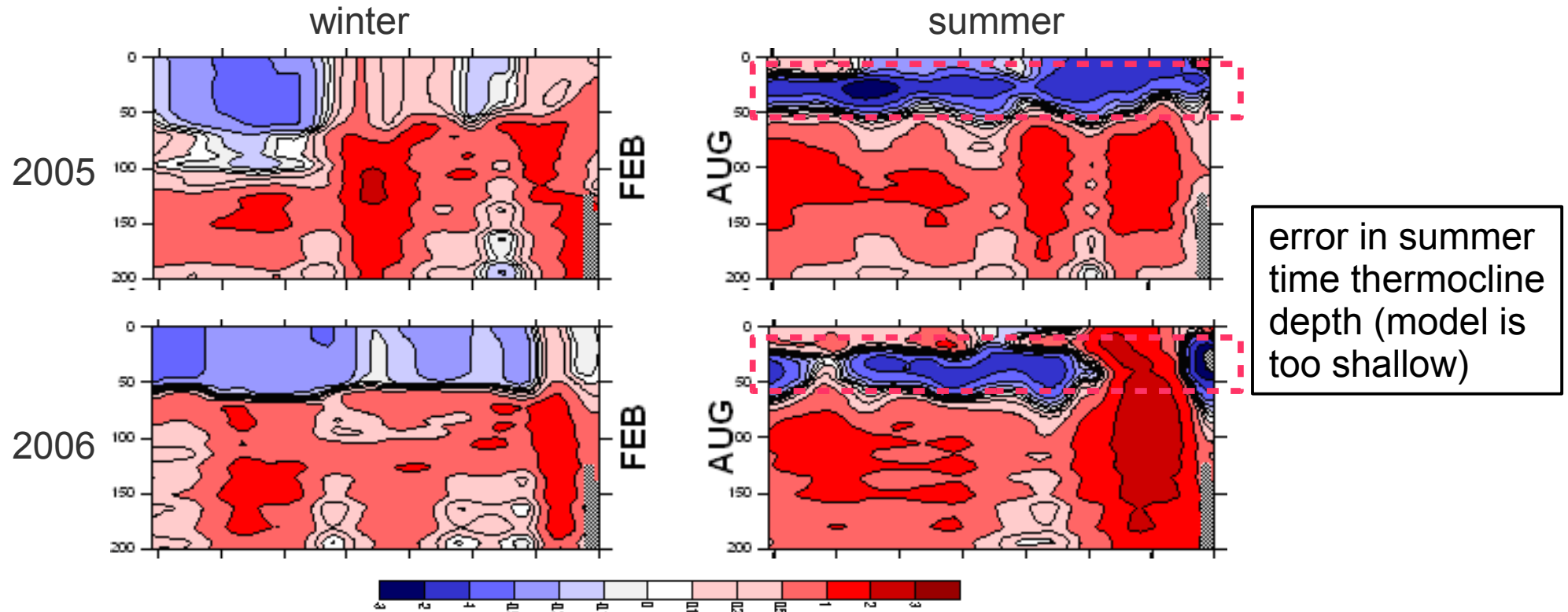
temperature anomaly (Model - Data) along 49N



2. Model - Data comparison: characters of model errors

- Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)
 - ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
 - ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007
- Data
 - Argo data + hydrographic data (temperature, salinity)
 - AVISO gridded SLA

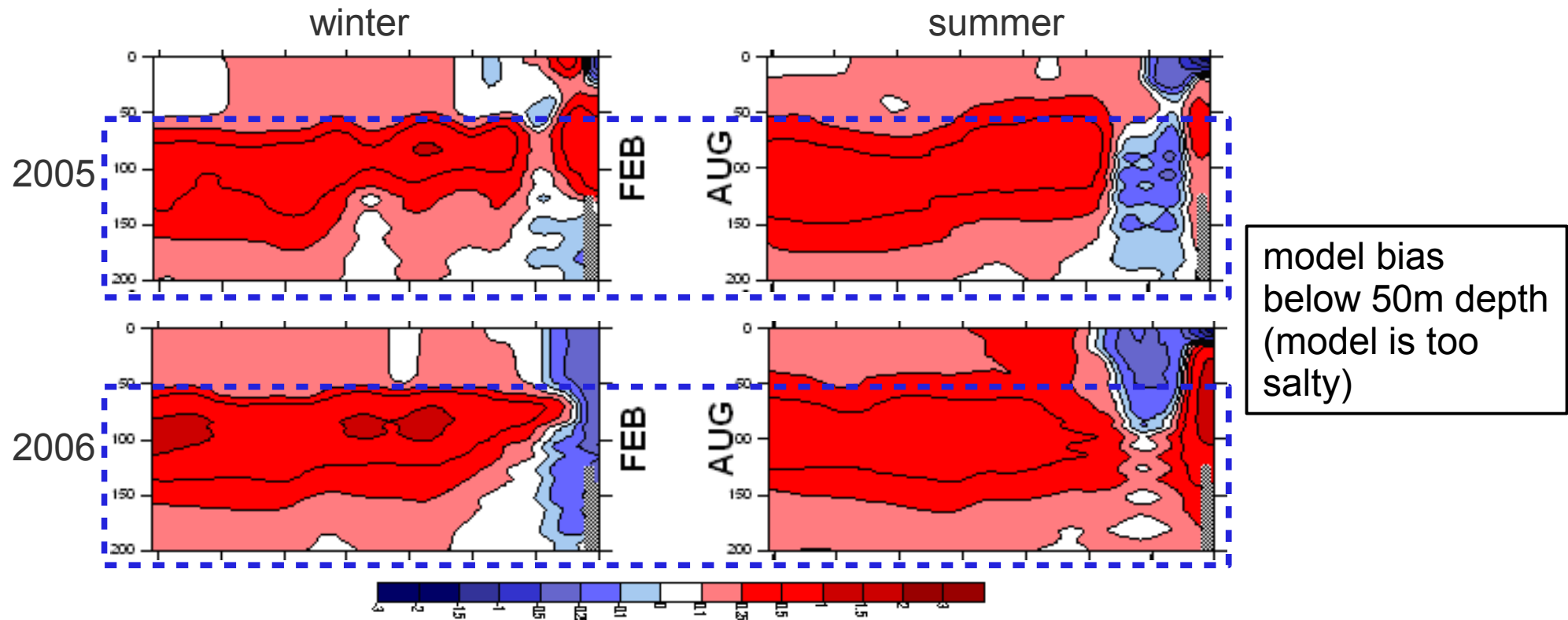
temperature anomaly (Model - Data) along 49N



2. Model - Data comparison: characters of model errors

- Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)
 - ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
 - ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007
- Data
 - Argo data + hydrographic data (temperature, salinity)
 - AVISO gridded SLA

salinity anomaly (Model - Data) along 49N



2. Model - Data comparison: characters of model errors

■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006

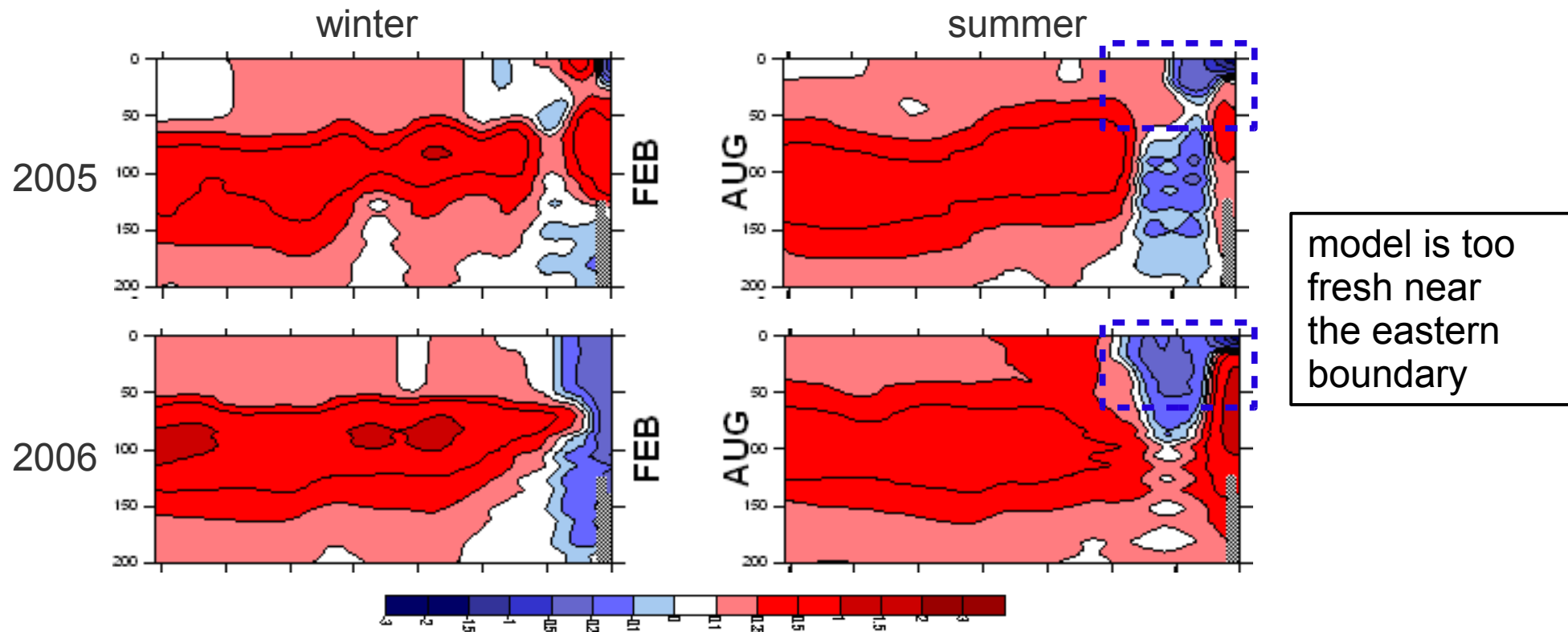
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

■ Data

- Argo data + hydrographic data (temperature, salinity)

- AVISO gridded SLA

salinity anomaly (Model - Data) along 49N



2. Model - Data comparison: characters of model errors

■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

□ ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006

■ ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

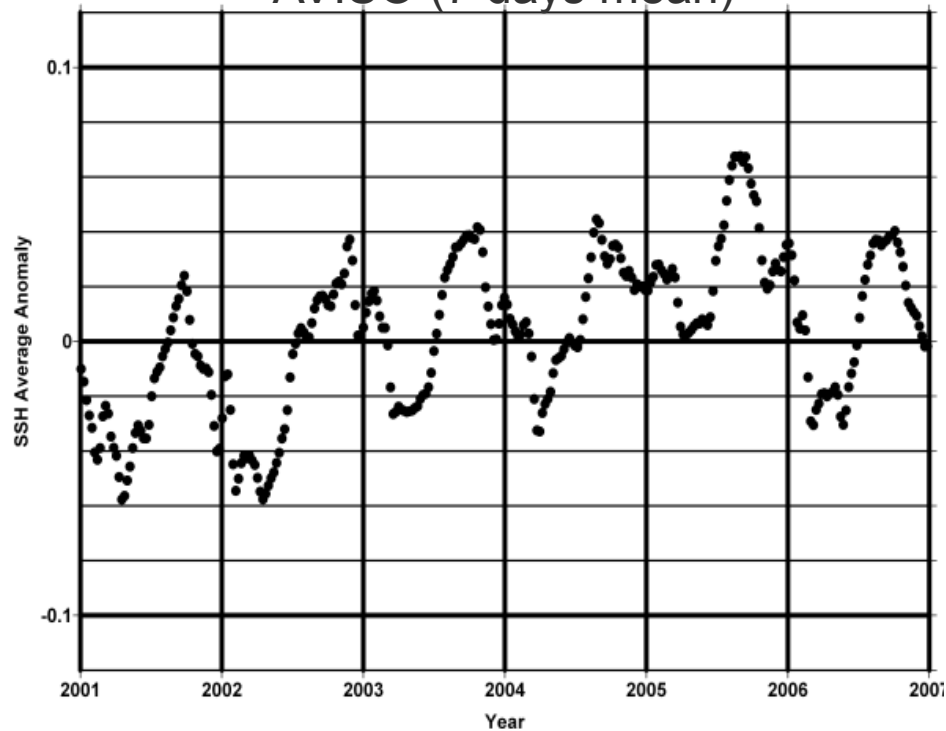
■ Data

□ Argo data + hydrographic data (temperature, salinity)

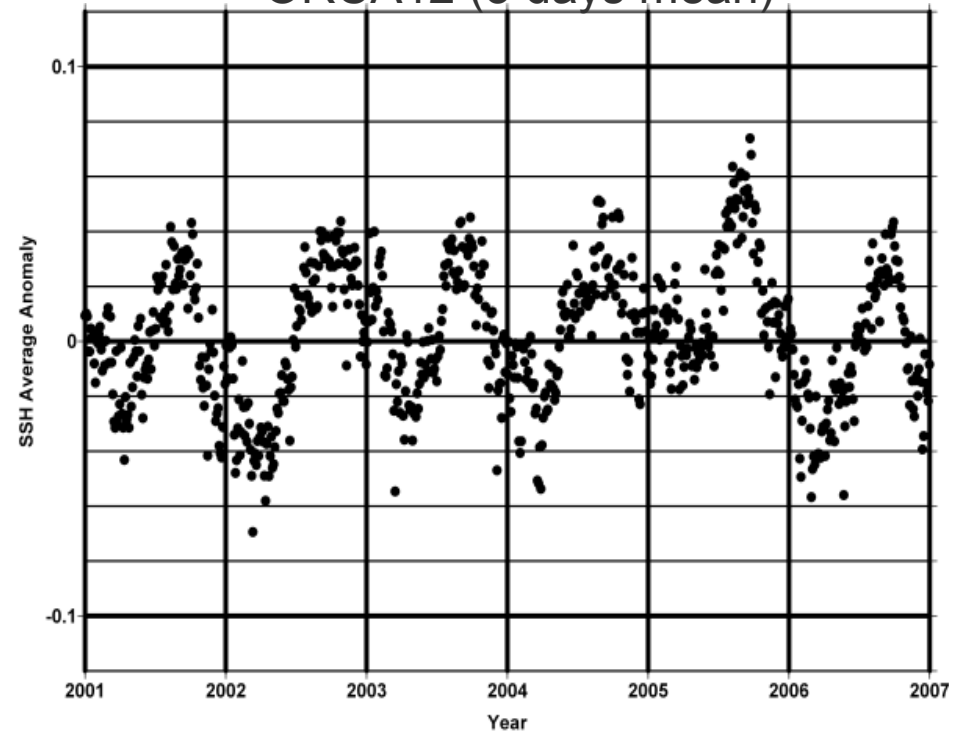
■ AVISO gridded SLA

domain averaged SLA [m] (approximation of steric component)

AVISO (7 days mean)



ORCA12 (3 days mean)



2. Model - Data comparison: characters of model errors

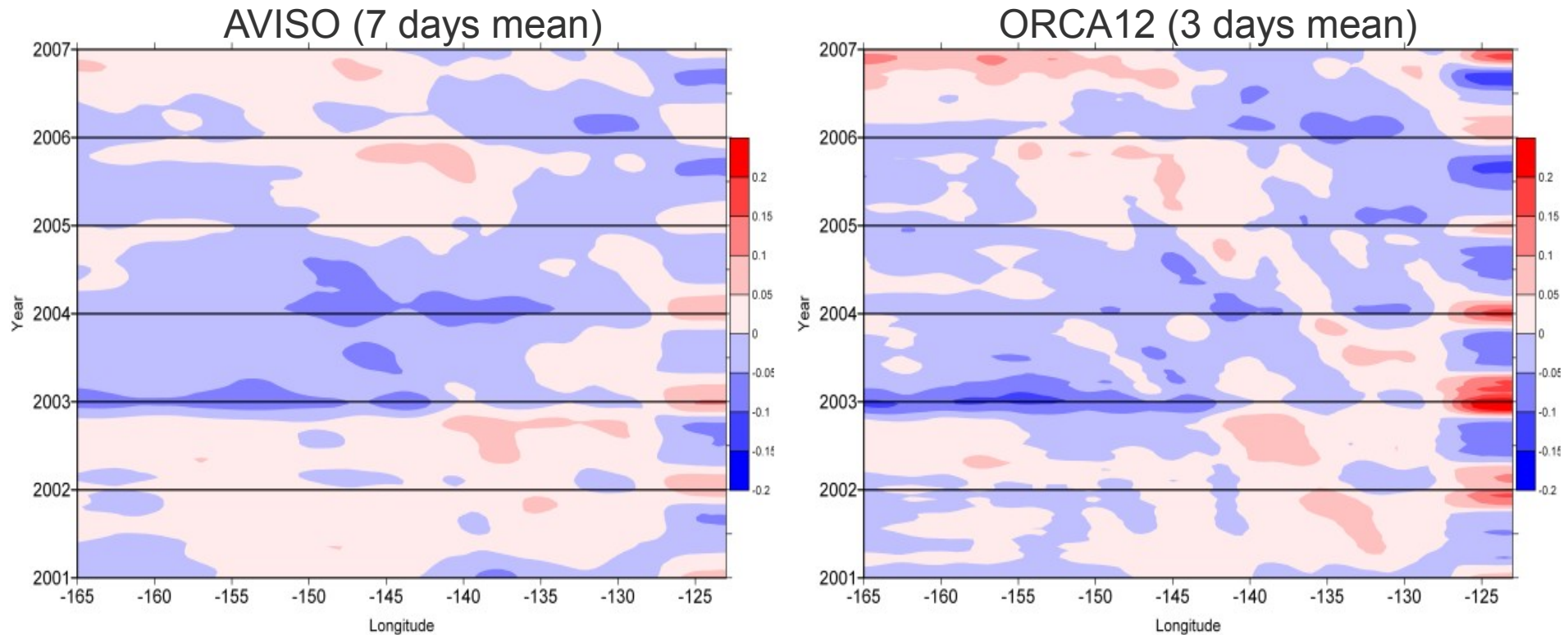
■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

■ Data

- Argo data + hydrographic data (temperature, salinity)
- AVISO gridded SLA

SLA - domain averaged SLA along 49N



2. Model - Data comparison: characters of model errors

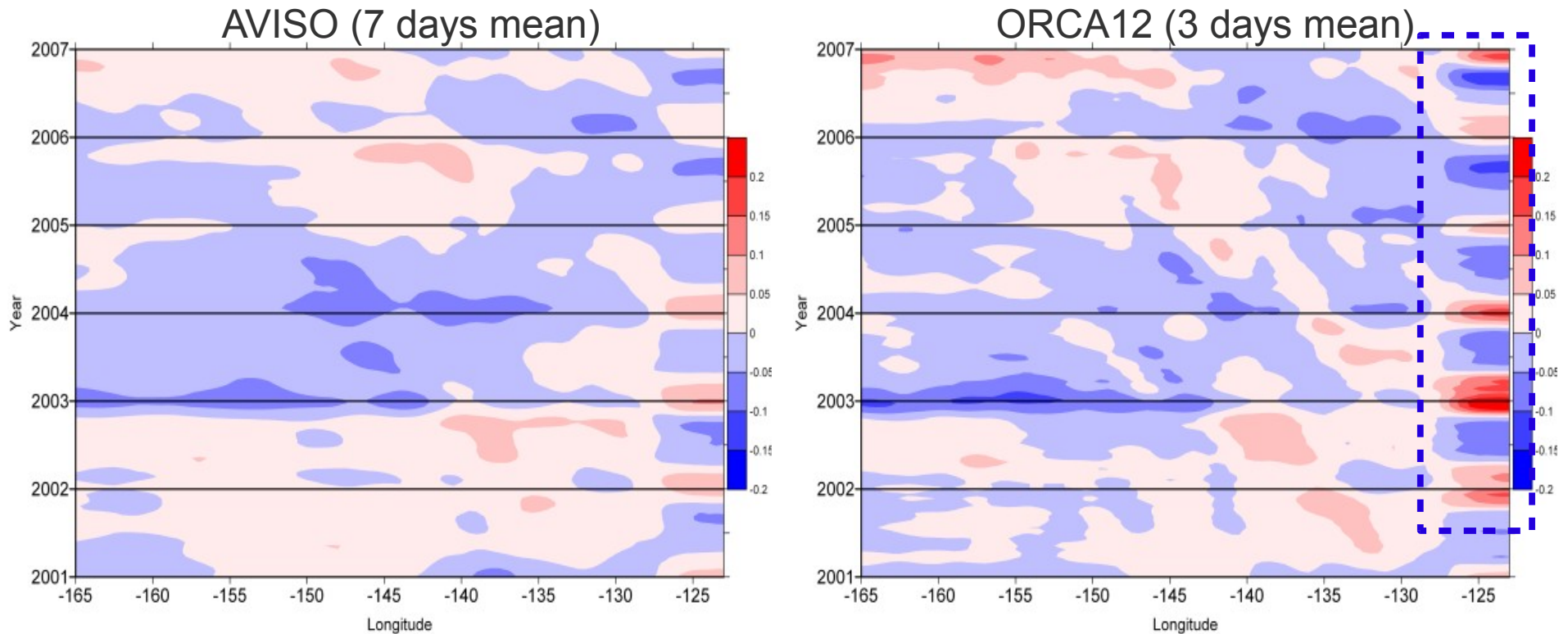
■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

■ Data

- Argo data + hydrographic data (temperature, salinity)
- AVISO gridded SLA

SLA - domain averaged SLA along 49N



2. Model - Data comparison: characters of model errors

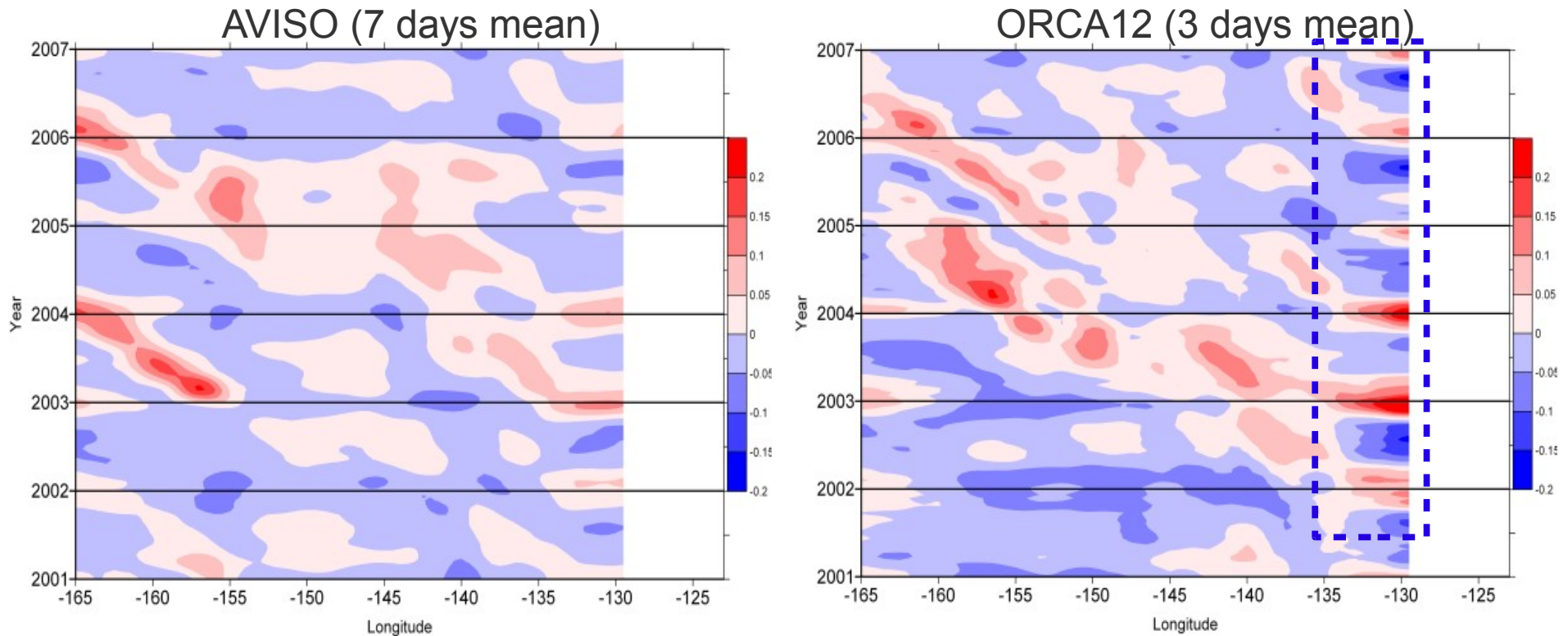
■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

■ Data

- Argo data + hydrographic data (temperature, salinity)
- AVISO gridded SLA

SLA - domain averaged SLA along 54N



2. Model - Data comparison: characters of model errors

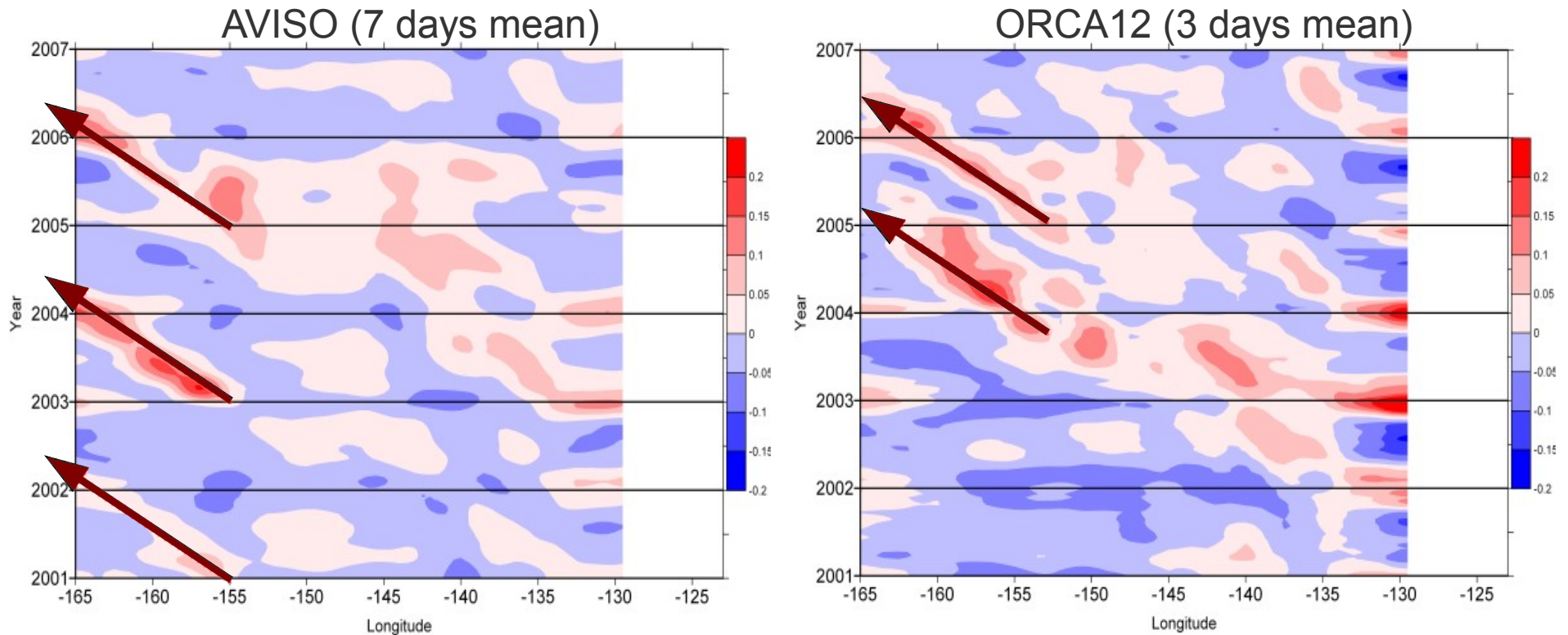
■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

■ Data

- Argo data + hydrographic data (temperature, salinity)
- AVISO gridded SLA

SLA - domain averaged SLA along 54N



2. Model - Data comparison: characters of model errors

■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

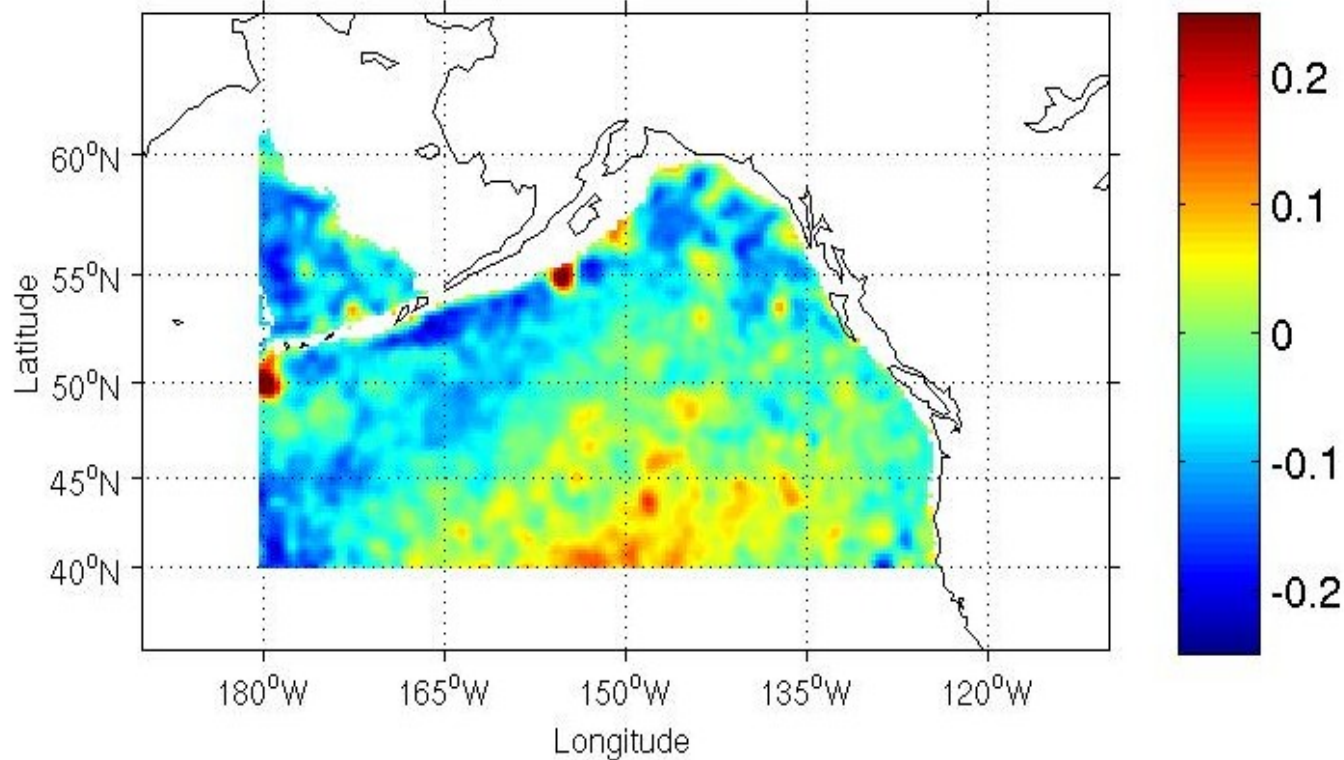
■ Data

- Argo data + hydrographic data (temperature, salinity)
- AVISO gridded SLA

Kodiak Island Eddy in AVISO SLA

Sea Level Anomaly [m] w/ 1000m bathymetry mask: 20010103

2001



2. Model - Data comparison: characters of model errors

- Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006

- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

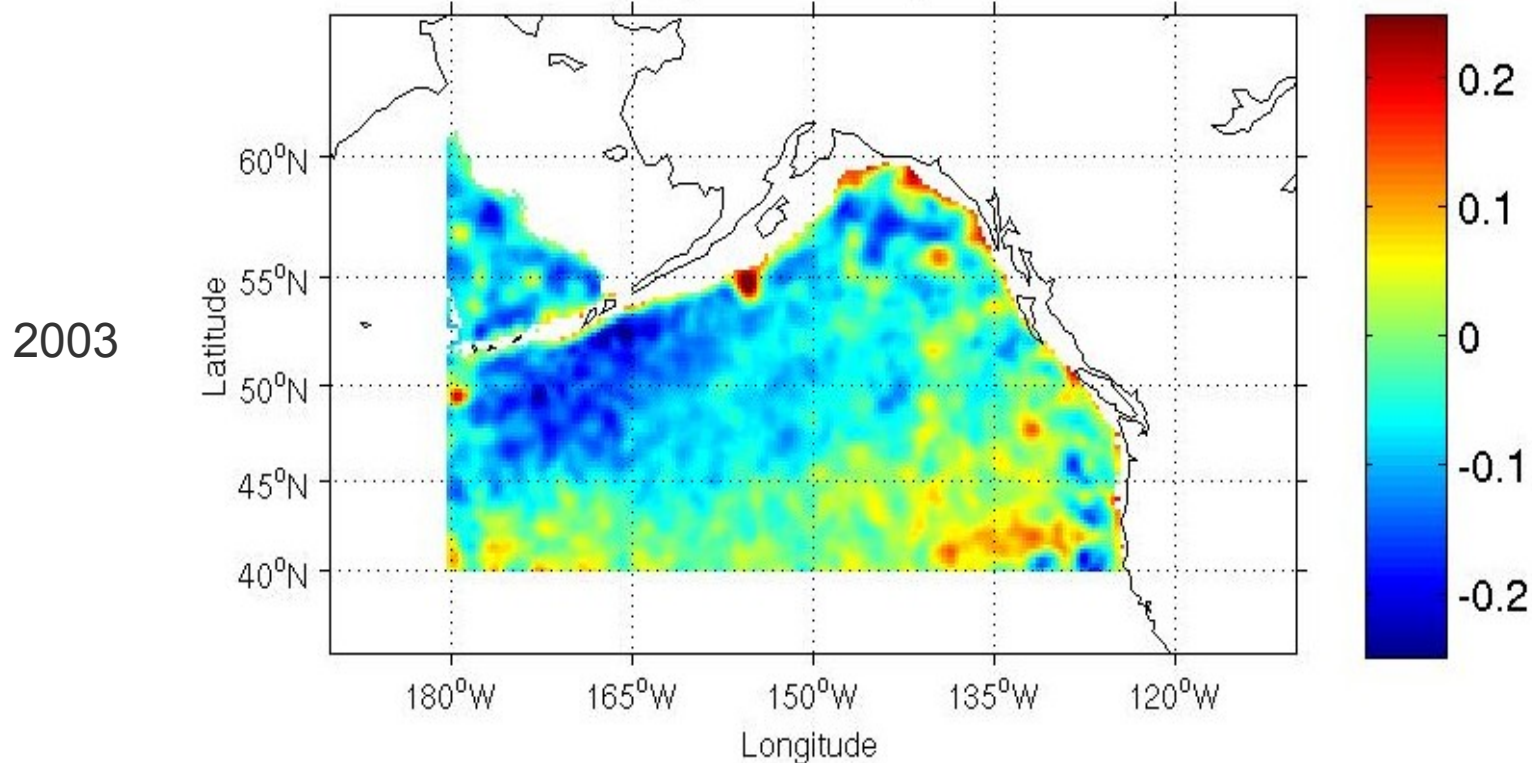
- Data

- Argo data + hydrographic data (temperature, salinity)

- AVISO gridded SLA

Kodiak Island Eddy in AVISO SLA

Sea Level Anomaly [m] w/ 1000m bathymetry mask: 20021225



2. Model - Data comparison: characters of model errors

■ Mercator ORCA4 / ORCA12 hindcast products (no data assimilation)

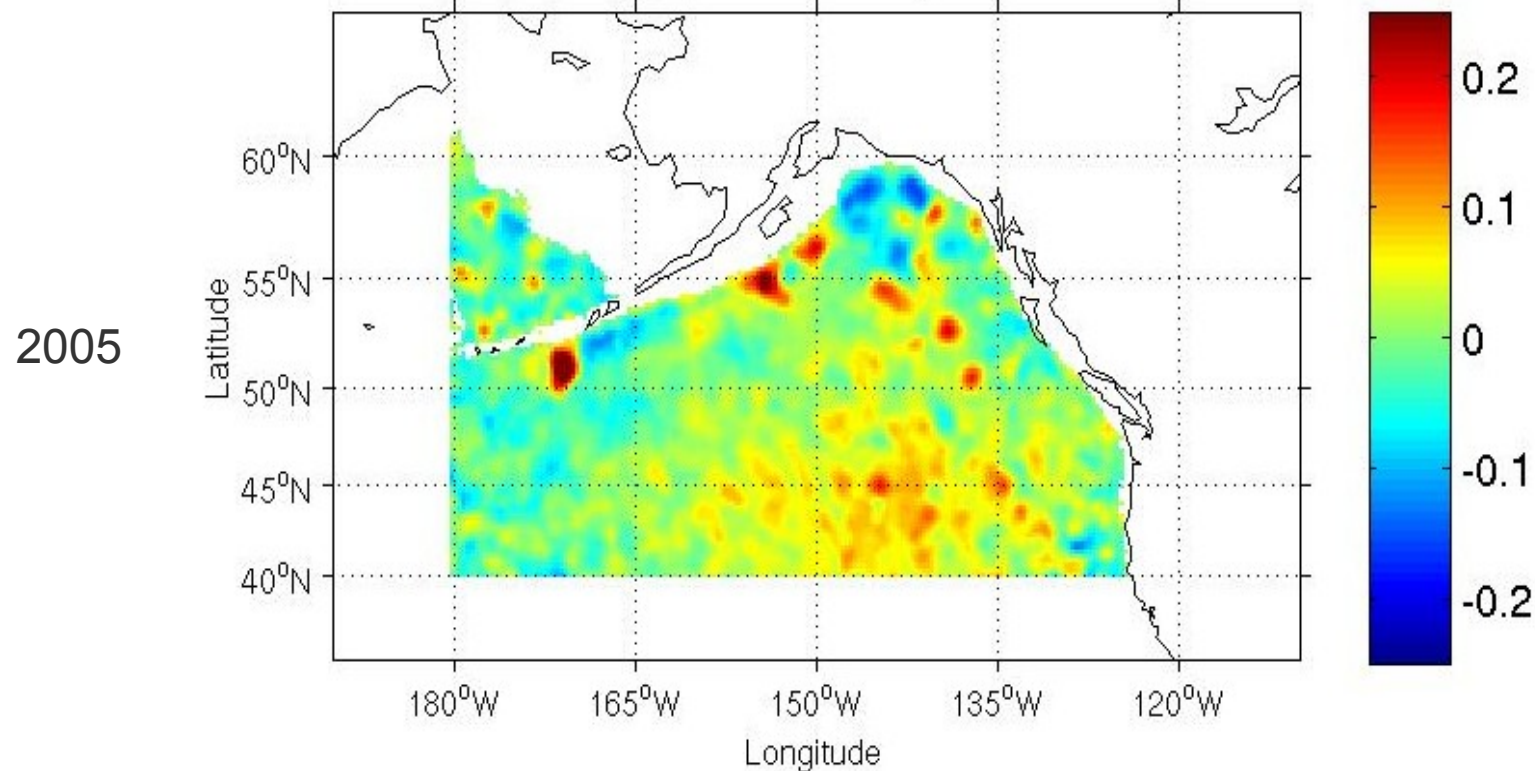
- ORCA4 : Global, $1/4^\circ$ horizontal resolutions, 2000-2006
- ORCA12: Global, $1/12^\circ$ horizontal resolutions, 2001-2007

■ Data

- Argo data + hydrographic data (temperature, salinity)
- AVISO gridded SLA

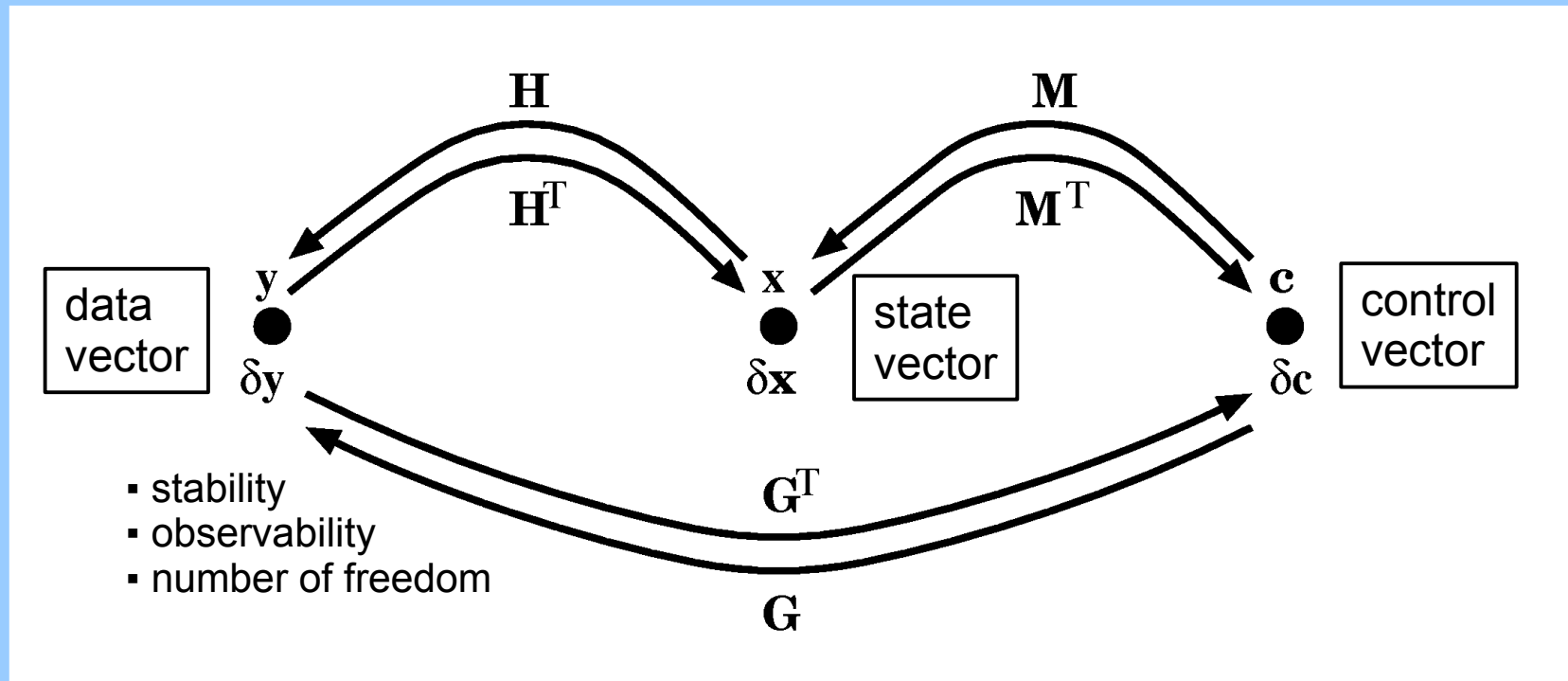
Kodiak Island Eddy in AVISO SLA

Sea Level Anomaly [m] w/ 1000m bathymetry mask: 20041229



3. Theoretical aspects of 4D-Var: how to fix model errors

- Observability of control parameters of large number in 4D-Var
 - CMOS 2009, Halifax NS
 - 5th WMO data assimilation symposium, 2009, Melbourne, Australia
- Inter-connections among three vector spaces in 4D-Var system
 - CMOS 2010, Ottawa ON, June 01 (poster)



- Calibration of control parameters of large number using 4D-Var
 - OPAVAR with North Pacific configuration: on going

Summary

- Green's Function package for NEMO
 - twin experiments with GYRE configuration
 - package will be distributed this summer
- Model-Data comparisons
 - ORCA4 with Argo T & S data
 - ORCA12 with AVISO SLA data
- 4D-Var
 - Theoretical aspect of 4D-Var system
 - OPAVAR: ongoing

Acknowledgment

- CFCAS for research funding
- IOS/DFO for computer/office facilities
- Mercator, France for providing ORCA4/12 outputs
- AVISO, France for providing gridded SLA data
- Group of BIO researchers (Dan Wright, Youyu Lu, Zeliang Wang, Fred Dupont) for helping us to set up NEMO
- Jake Galbraith for processing ORCA outputs and AVISO SLA data