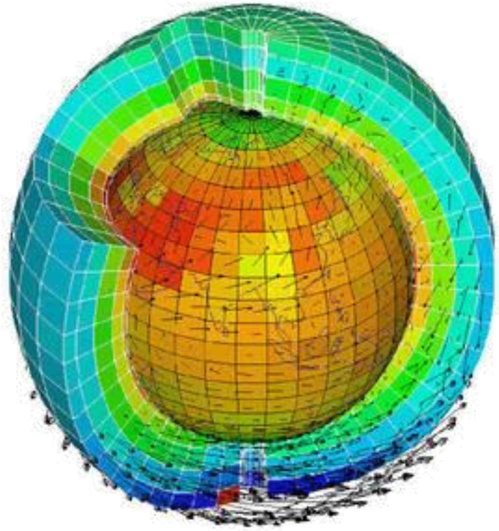
Intertropical ocean-atmosphere turbulent coupling in the IPSL model



vs.

Alina Găinuşă-Bogdan, Pascale Braconnot

Laboratoire des Sciences du Climat et de l'Environnement, Saclay, France

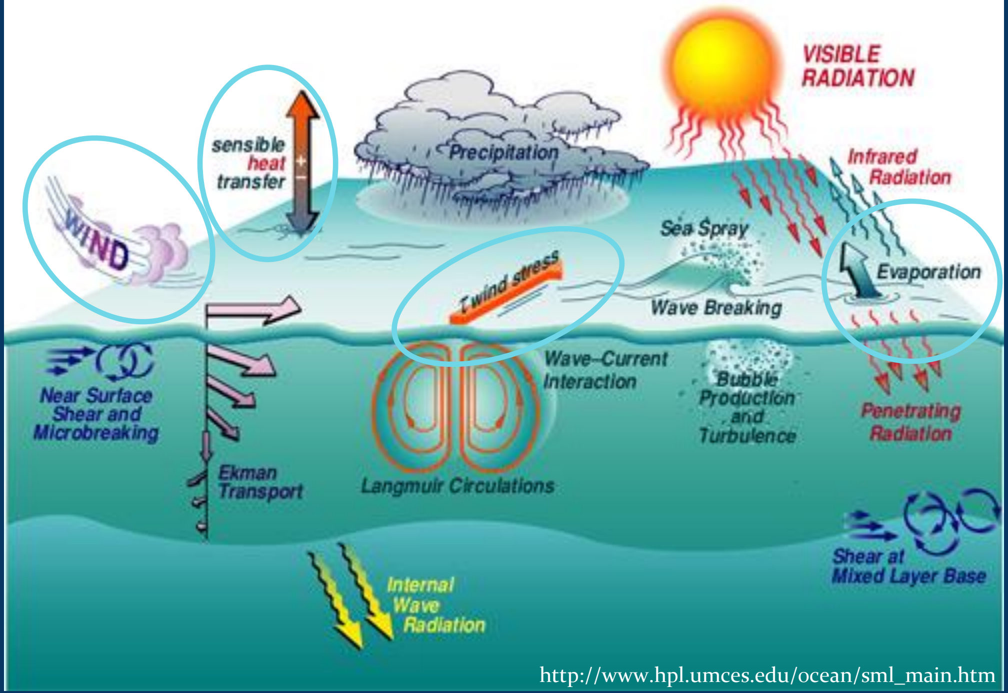
Turbulent fluxes

Sensible heat flux

$\rho C_p C_H (U-U_s)(T_s-T_a)$

Momentum flux = Wind stress

$\rho C_D (U-U_s)^2$

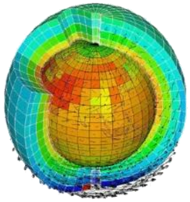

VISIBLE RADIATION
sensible heat transfer
+
−
Precipitation
Infrared Radiation
WIND
Sea Spray
Evaporation
wind stress
Wave Breaking
Wave–Current Interaction
Bubble Production and Turbulence
Near Surface Shear and Microbreaking
Penetrating Radiation
Ekman Transport
Langmuir Circulations
Shear at Mixed Layer Base
Internal Wave Radiation

http://www.hpl.umces.edu/ocean/sml_main.htm

Latent heat flux

$\rho L_v C_E (U-U_s)(Q_s-Q_a)$

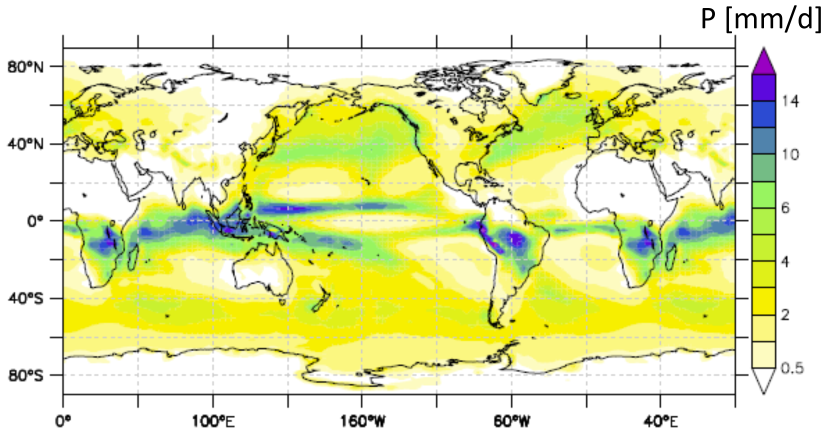
Data



Models	**“Validation” data sets**
IPSL-CM5A	3 *in situ*
LMDZ5A → “AMIP”	3 satellite-based
IPSL-CM5AMR	3 hybrid
IPSL-CM4	3 reanalyses
IPSL-CM5B	2 ocean model forcing

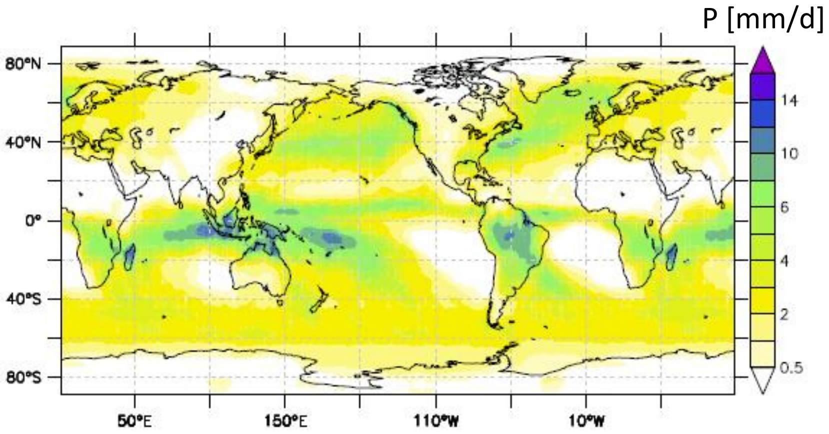
Period of reference: 1979-2005

Important model biases



IPSL-CM5A

P [mm/d]
80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
40°E
14
10
6
4
2
0.5

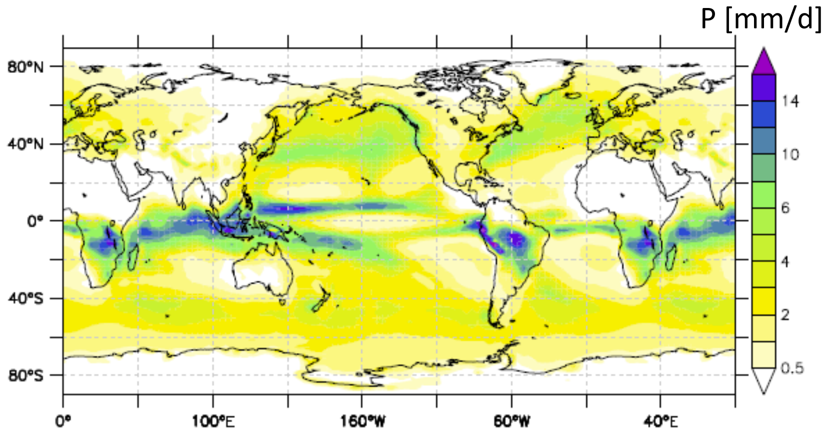


GPCP

P [mm/d]
80°N
40°N
0°
40°S
80°S
50°E
150°E
110°W
10°W
14
10
6
4
2
0.5

Important model biases

IPSL-CM5A


P [mm/d]
80°N
40°N
0°
40°S
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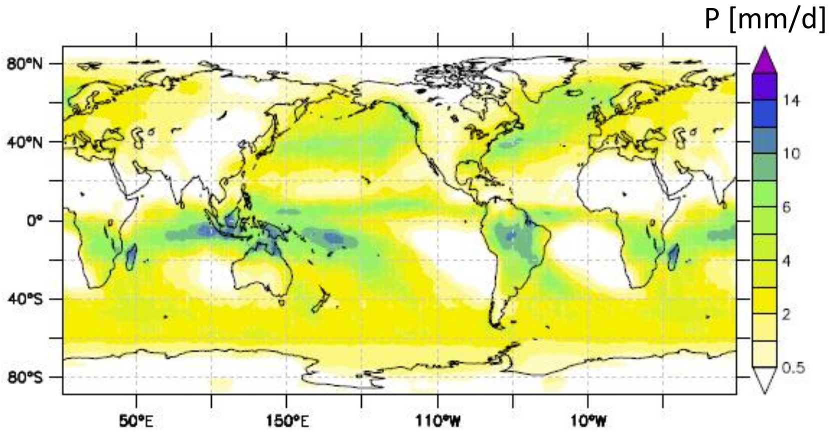
0°
100°E
160°W
60°W
40°E
14
10
6
4
2
0.5

GPCP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80°N
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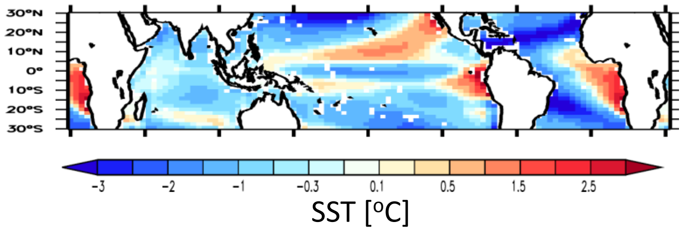
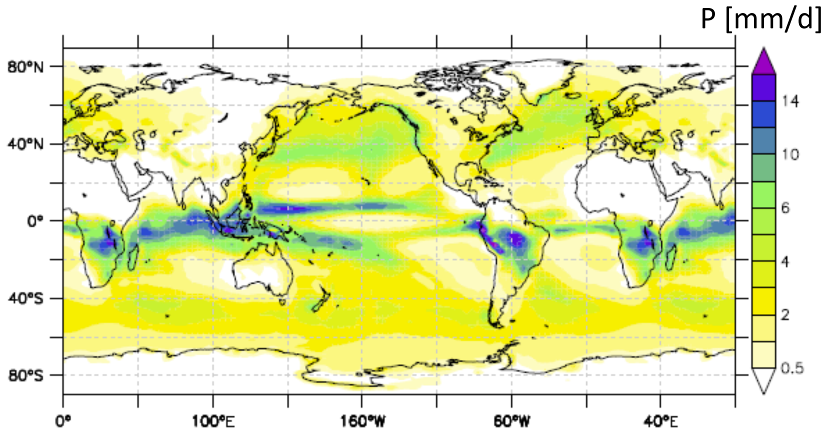
40°S
80°S
50°E
150°E
110°W
10°W
14
10
6
4
2
0.5


30°N
20°N
10°N
0°
10°S
20°S
30°S
-3
-2
-1
-0.3
0.1
0.5
1.5
2.5
SST [°C]

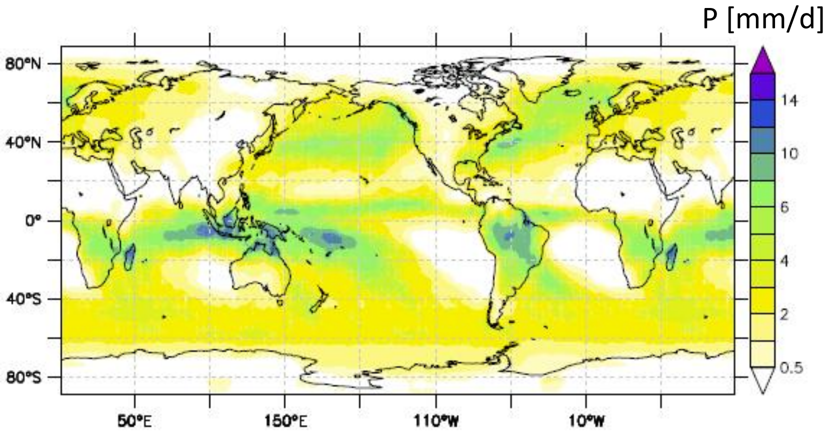
Δ: IPSL-CM5A - OBS

Important model biases

IPSL-CM5A


P [mm/d]
80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
40°E
14
10
6
4
2
0.5

GPCP


P [mm/d]
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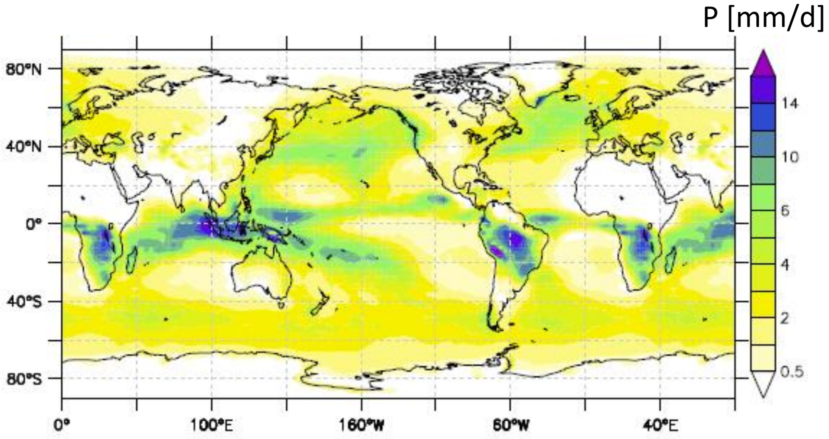
40°N
0°
40°S
80°S
50°E
150°E
110°W
10°W
14
10
6
4
2
0.5

AMIP


P [mm/d]
80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
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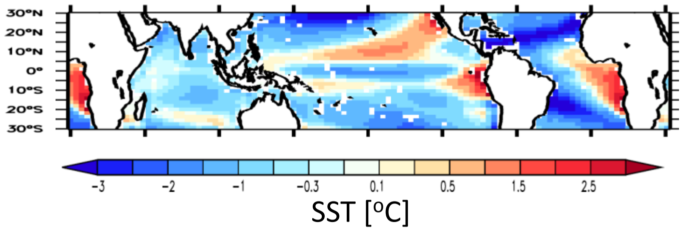
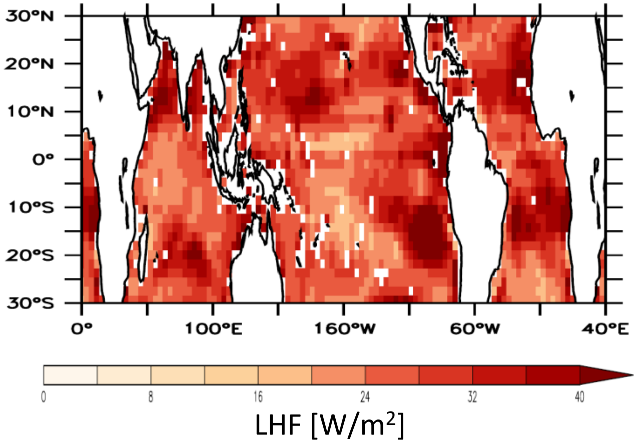
40°E
14
10
6
4
2
0.5


30°N
20°N
10°N
0°
10°S
20°S
30°S
-3
-2
-1
-0.3
0.1
0.5
1.5
2.5
SST [^{o}C]

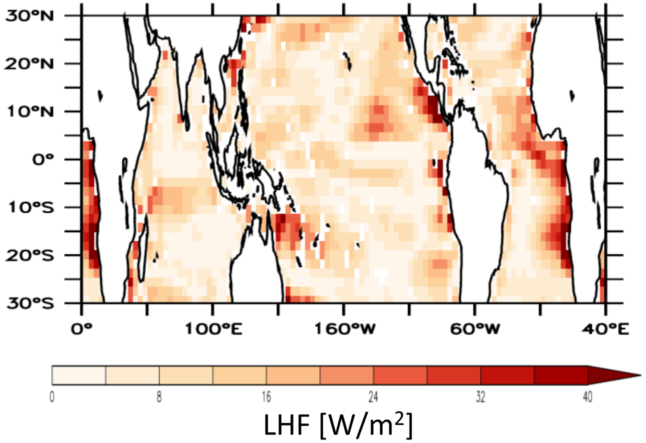
Δ: IPSL-CM5A - OBS

What about the fluxes?



LHF MAX|OBS - <OBS>|

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m^2]

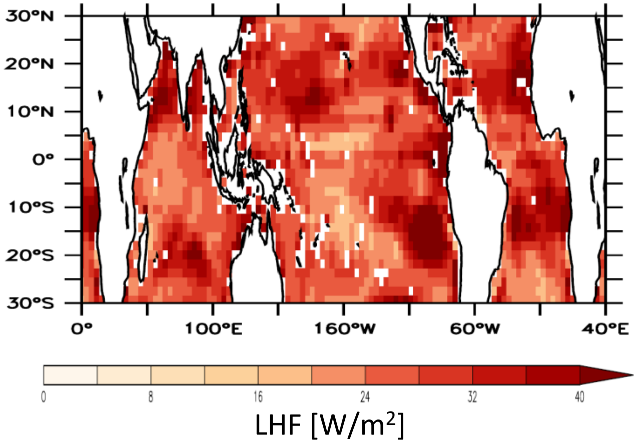


LHF MAX|IPSL-CM5A - <OBS>|

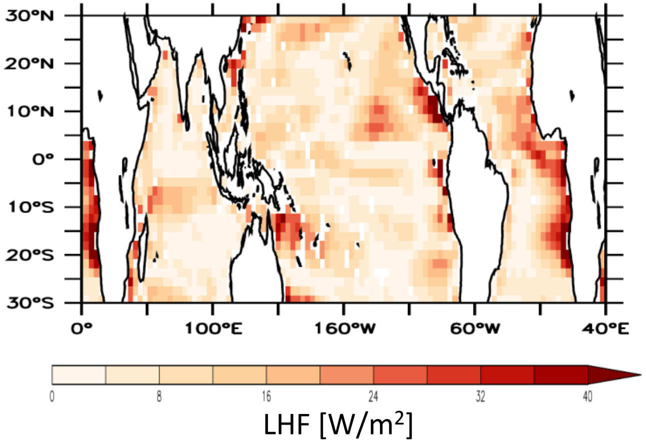
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m^2]

What about the fluxes?

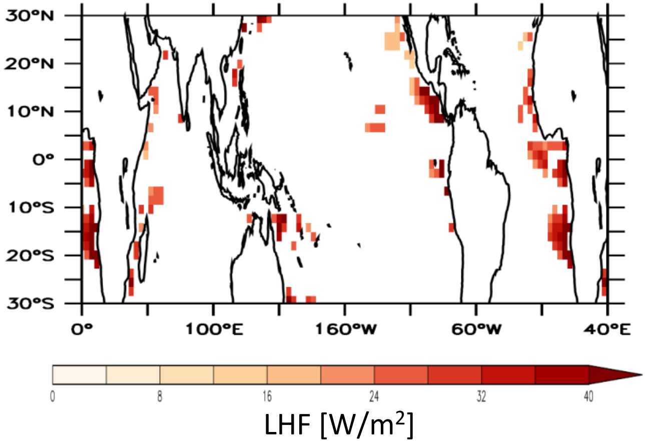
LHF MAX|OBS - <OBS>|


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m^2]

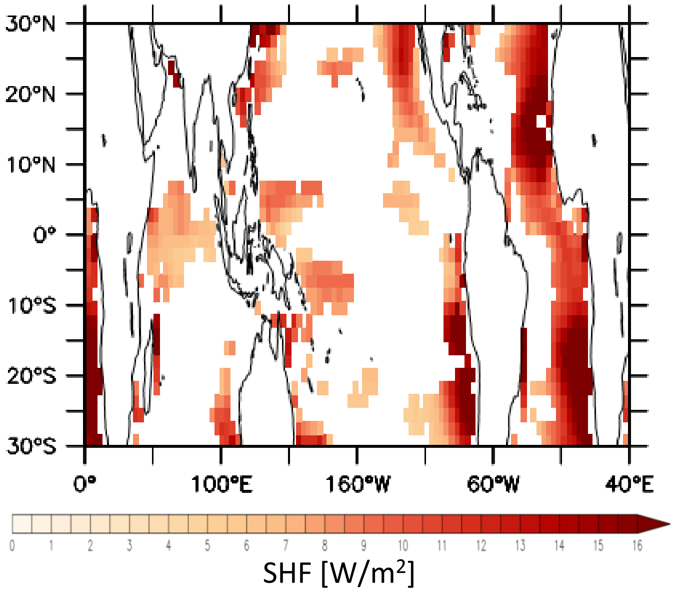
LHF MAX|IPSL-CM5A - <OBS>|


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m^2]

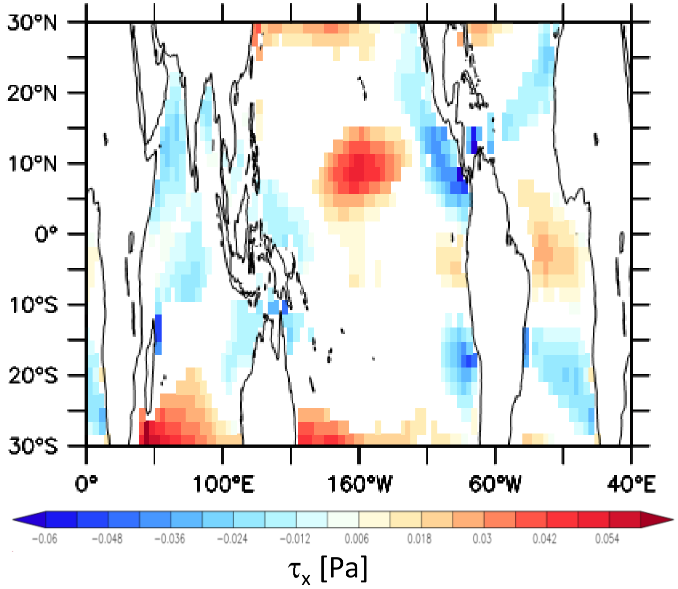
Signif. MAX|IPSL-CM5A - <OBS>|


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m^2]

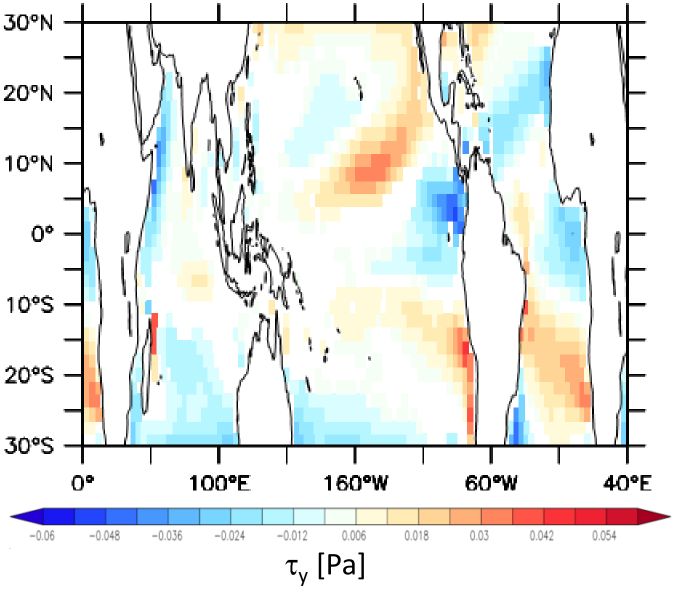
SHF Signif. MAX|IPSL-CM5A - <OBS>|


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SHF [W/m²]

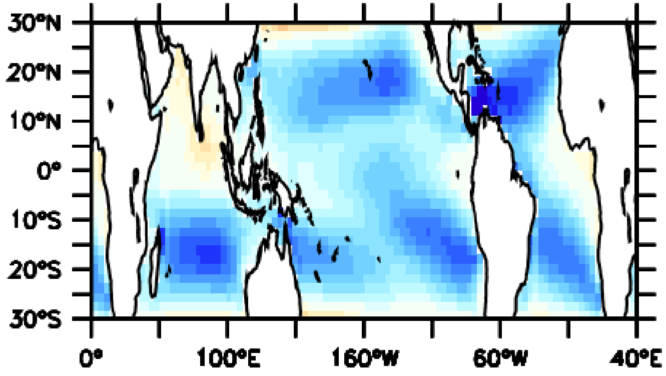
τ_x Signif. (IPSL-CM5A - <OBS>)


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
−0.06
−0.048
−0.036
−0.024
−0.012
0.006
0.018
0.03
0.042
0.054
τ_x [Pa]

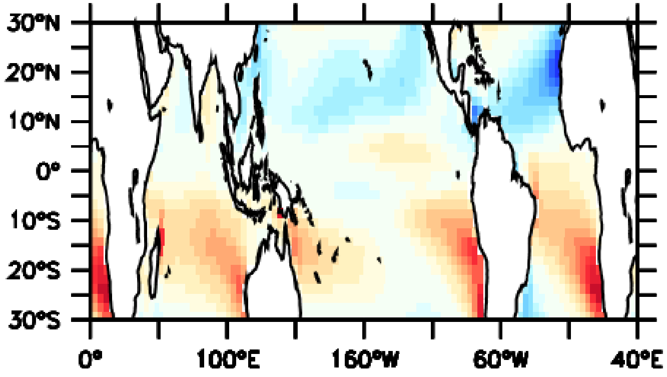
τ_y Signif. (IPSL-CM5A - <OBS>)


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
−0.06
−0.048
−0.036
−0.024
−0.012
0.006
0.018
0.03
0.042
0.054
τ_y [Pa]

τ_x IPSL-CM5A


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E

τ_y IPSL-CM5A


30°N
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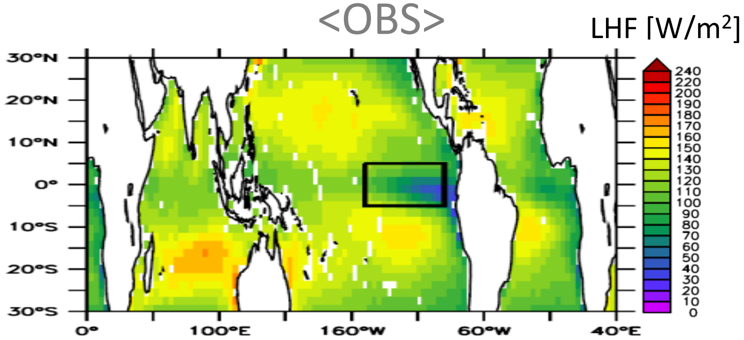
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E



<OBS>

LHF [W/m^2]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
240
220
200
190
180
170
160
150
140
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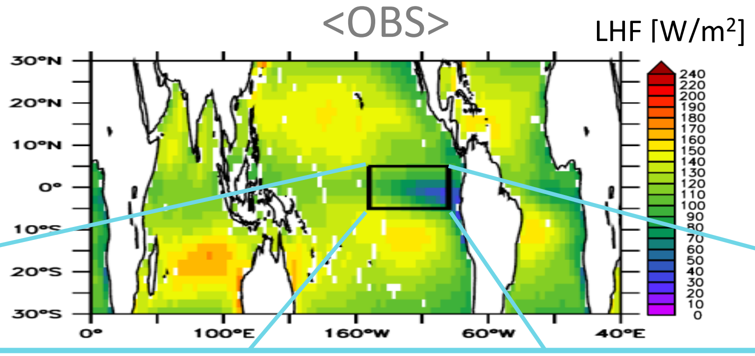
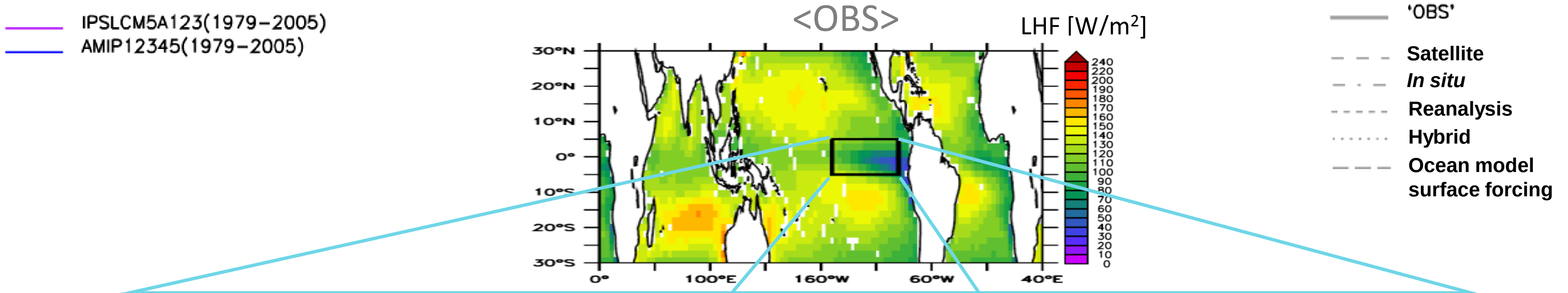
120
110
100
90
80
70
60
50
40
30
20
10
0


<OBS>
LHF [W/m^2]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
240
220
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

NINO3 (150°W-90°W; 5°S-5°N)


IPSLCM5A123(1979–2005)
AMIP12345(1979–2005)
<OBS>
LHF [W/m^2]
30°N
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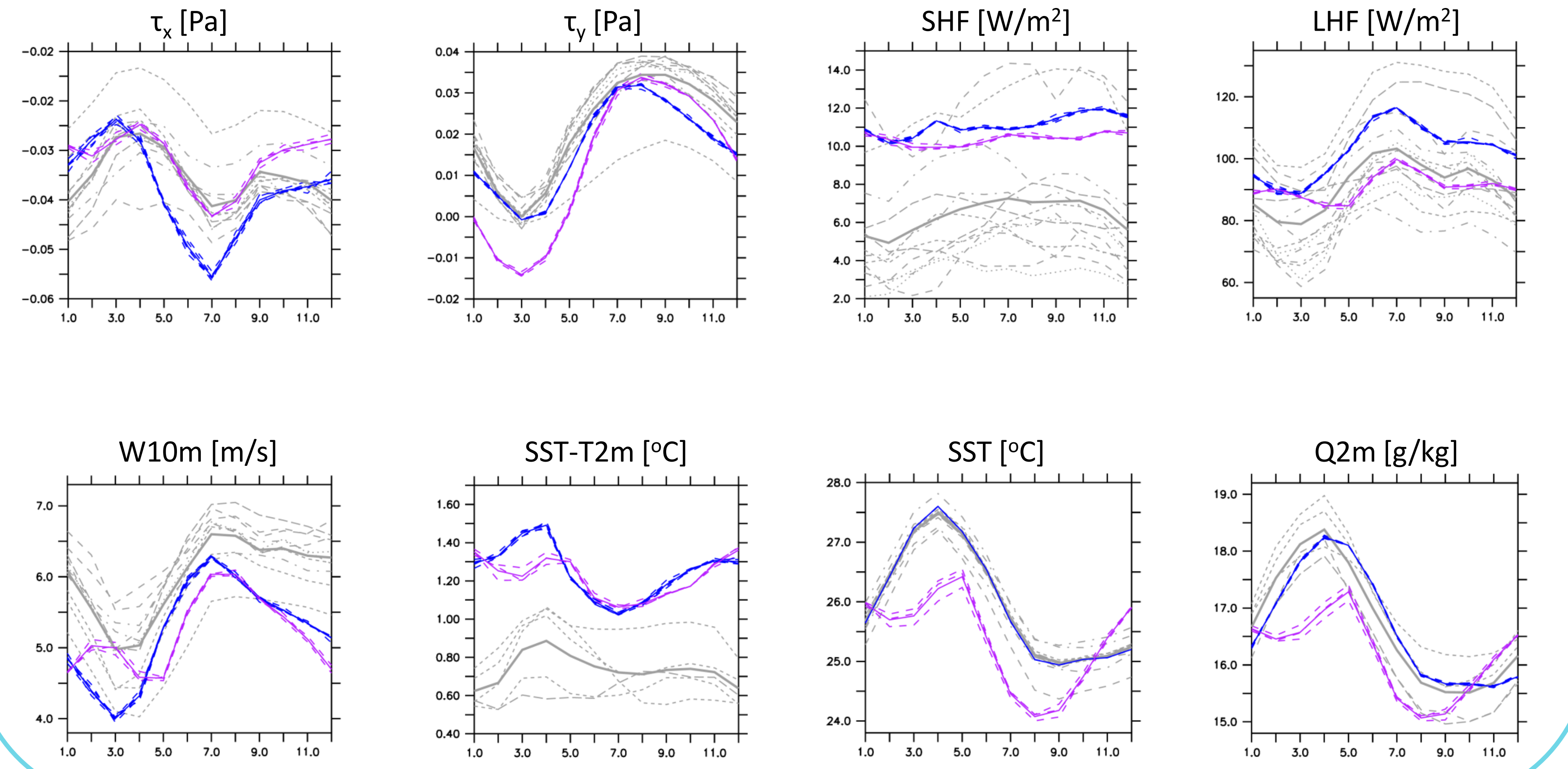
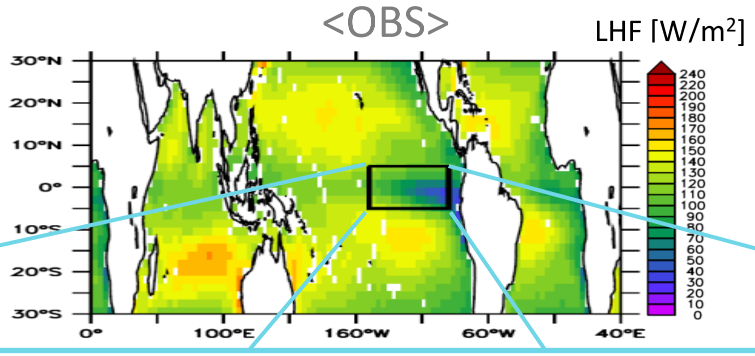
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
240
220
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
'OBS'
Satellite
In situ
Reanalysis
Hybrid
Ocean model surface forcing

NINO3 (150°W-90°W; 5°S-5°N)




<OBS>
LHF [W/m^2]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
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40°E
240
220
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180
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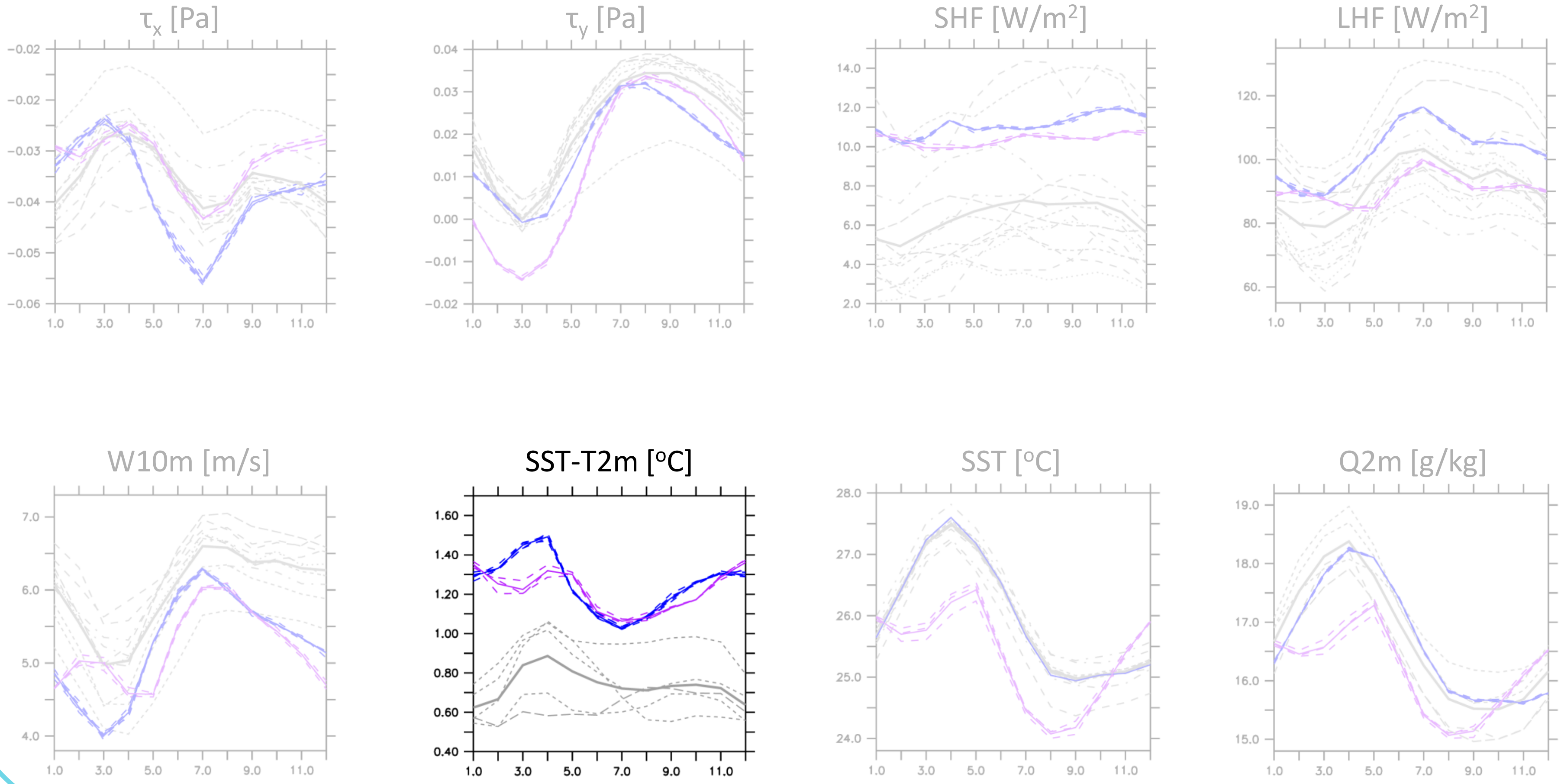
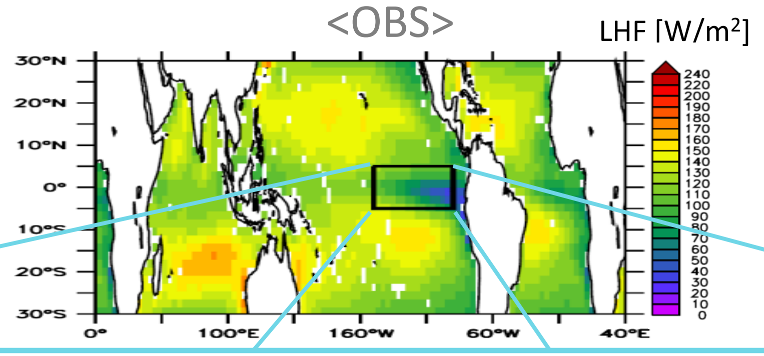
NINO3 (150°W-90°W; 5°S-5°N)

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LHF [W/m^2]
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20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
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40°E
240
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190
180
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160
150
140
130
120
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60
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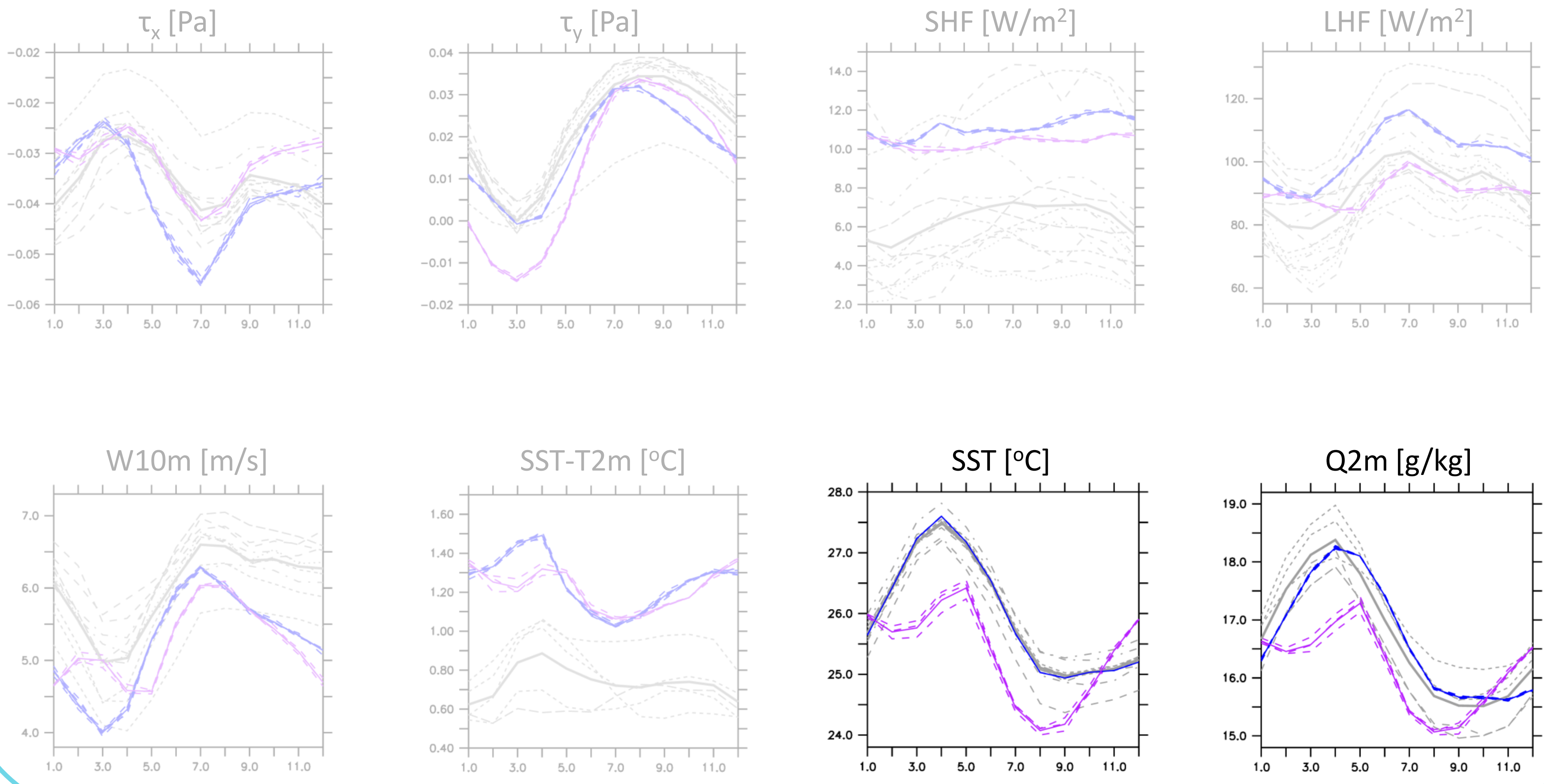
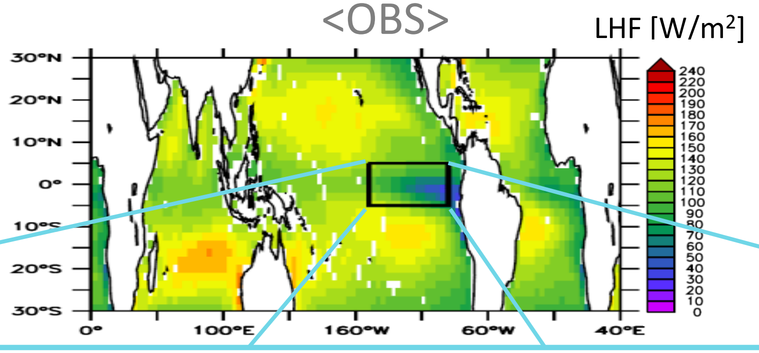
40
30
20
10
0

NINO3 (150°W-90°W; 5°S-5°N)




<OBS>
LHF [W/m²]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
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40°E
240
220
200
190
180
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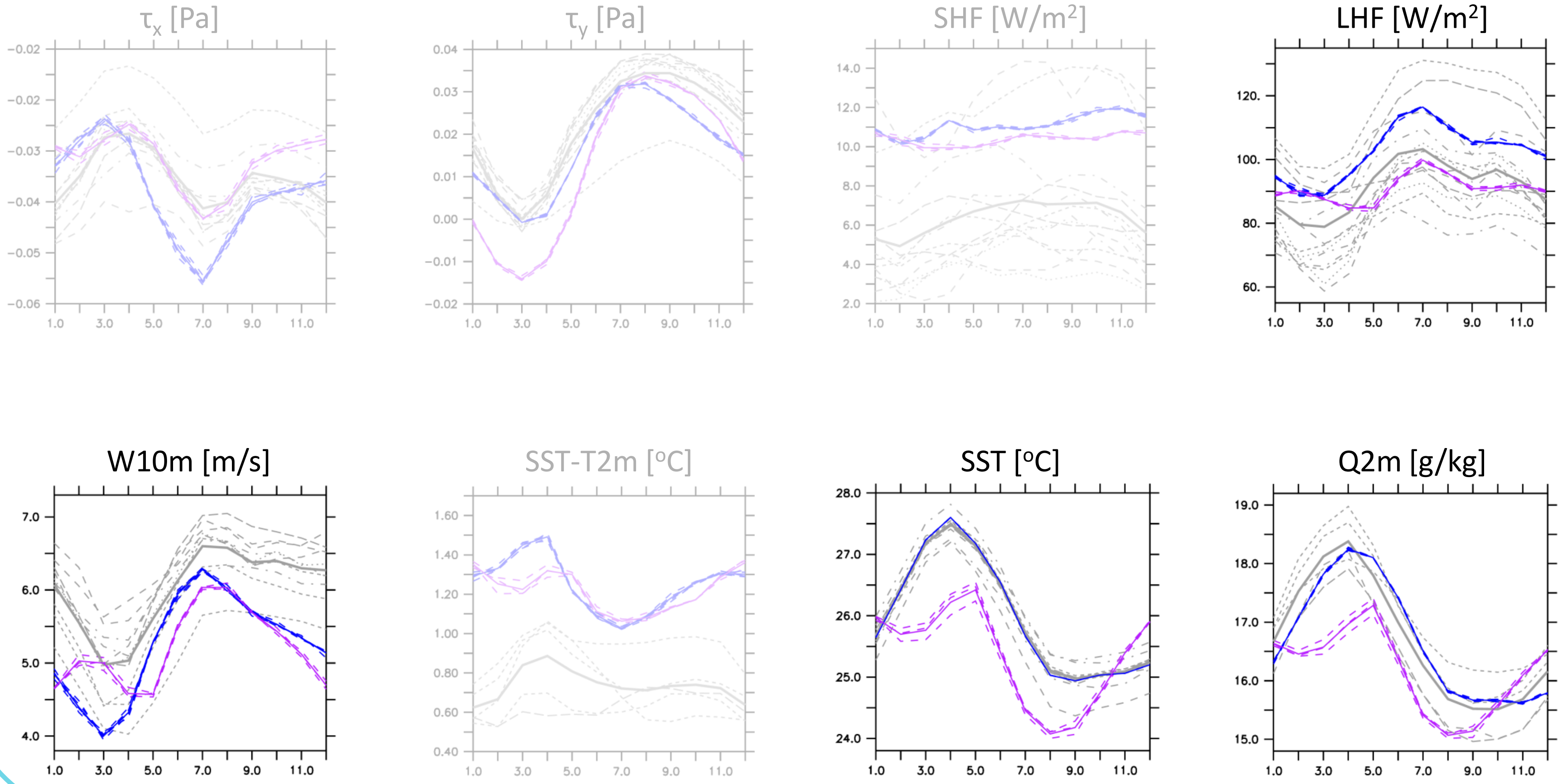
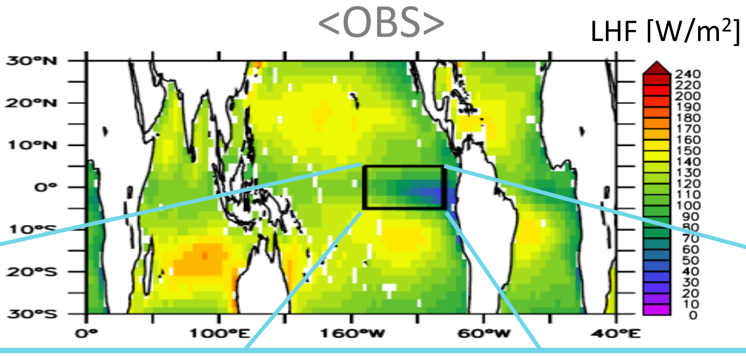
20
10
0

NINO3 (150°W-90°W; 5°S-5°N)



IPSLCM5A123(1979–2005)
AMIP12345(1979–2005)


<OBS>
LHF [W/m^2]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
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40°E
240
220
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90
80
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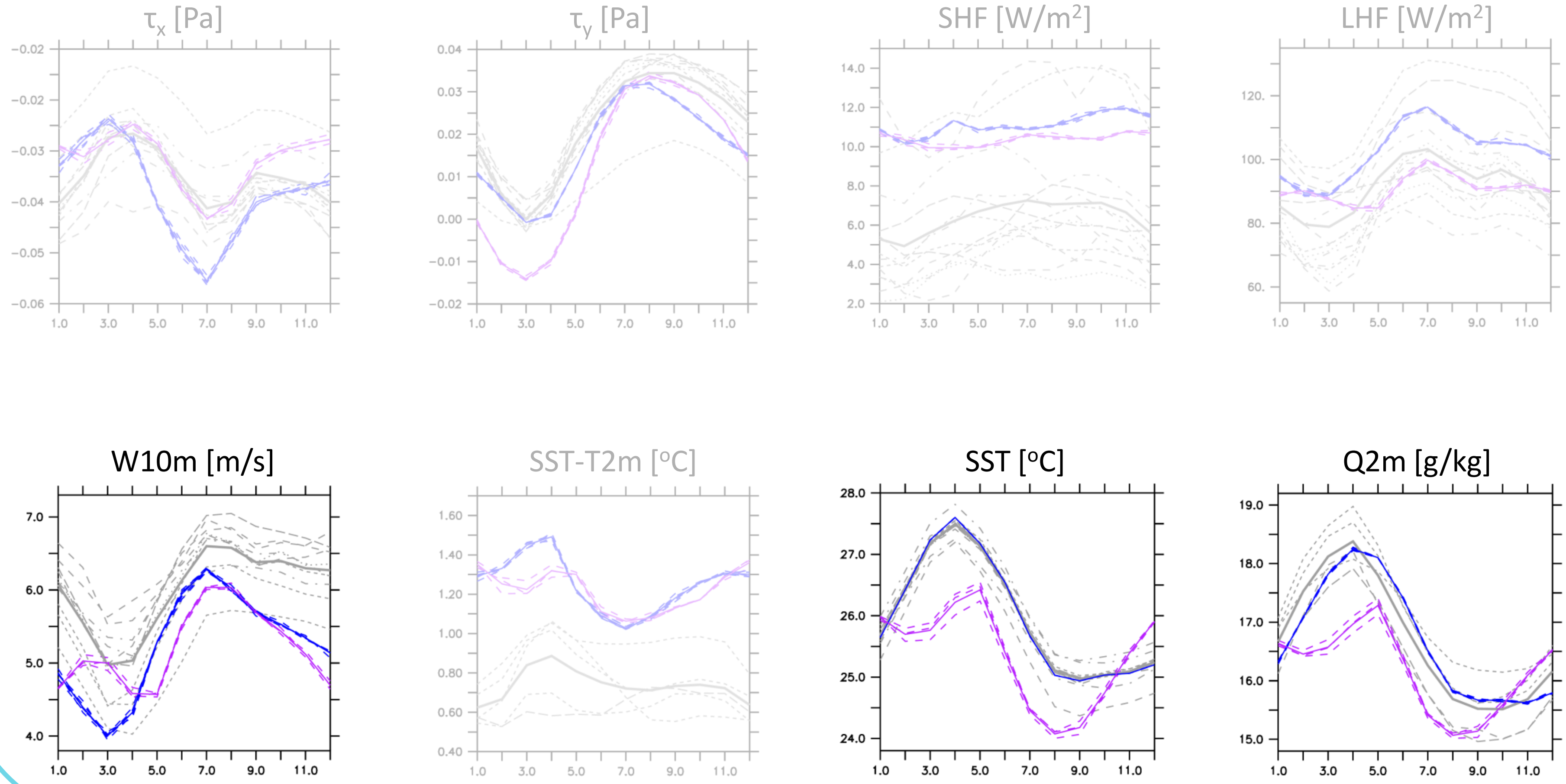
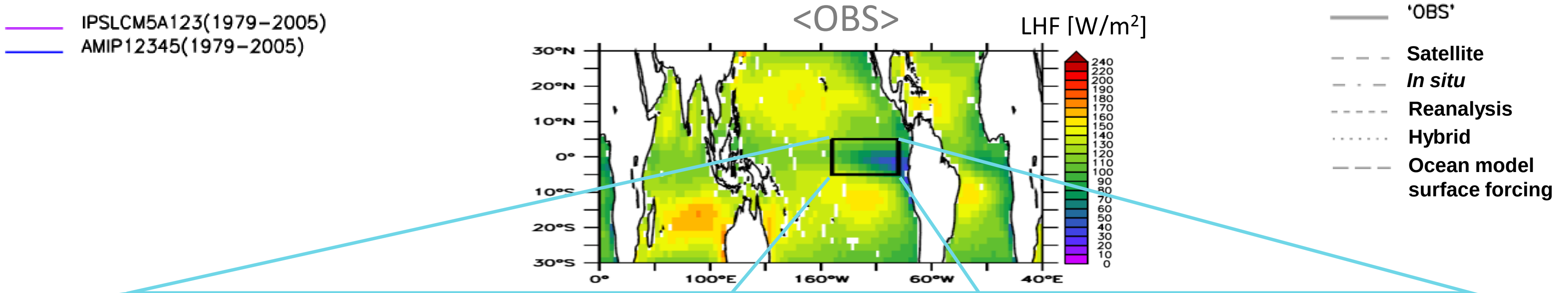
20
10
0

'OBS'
Satellite
In situ
Reanalysis
Hybrid
Ocean model surface forcing

NINO3 (150°W-90°W; 5°S-5°N)




IPSLCM5A123(1979–2005)
AMIP12345(1979–2005)
<OBS>
LHF [W/m^2]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
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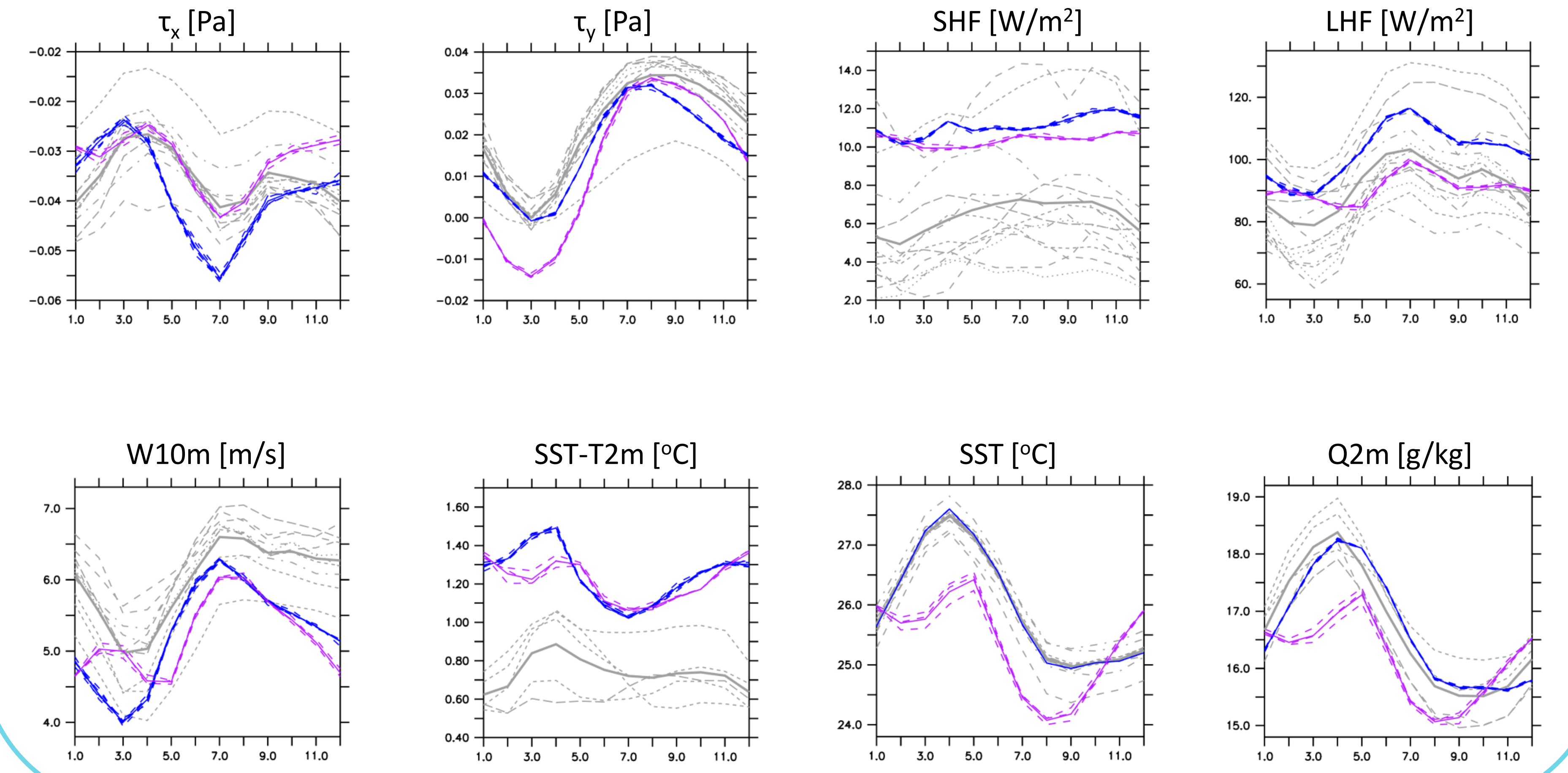
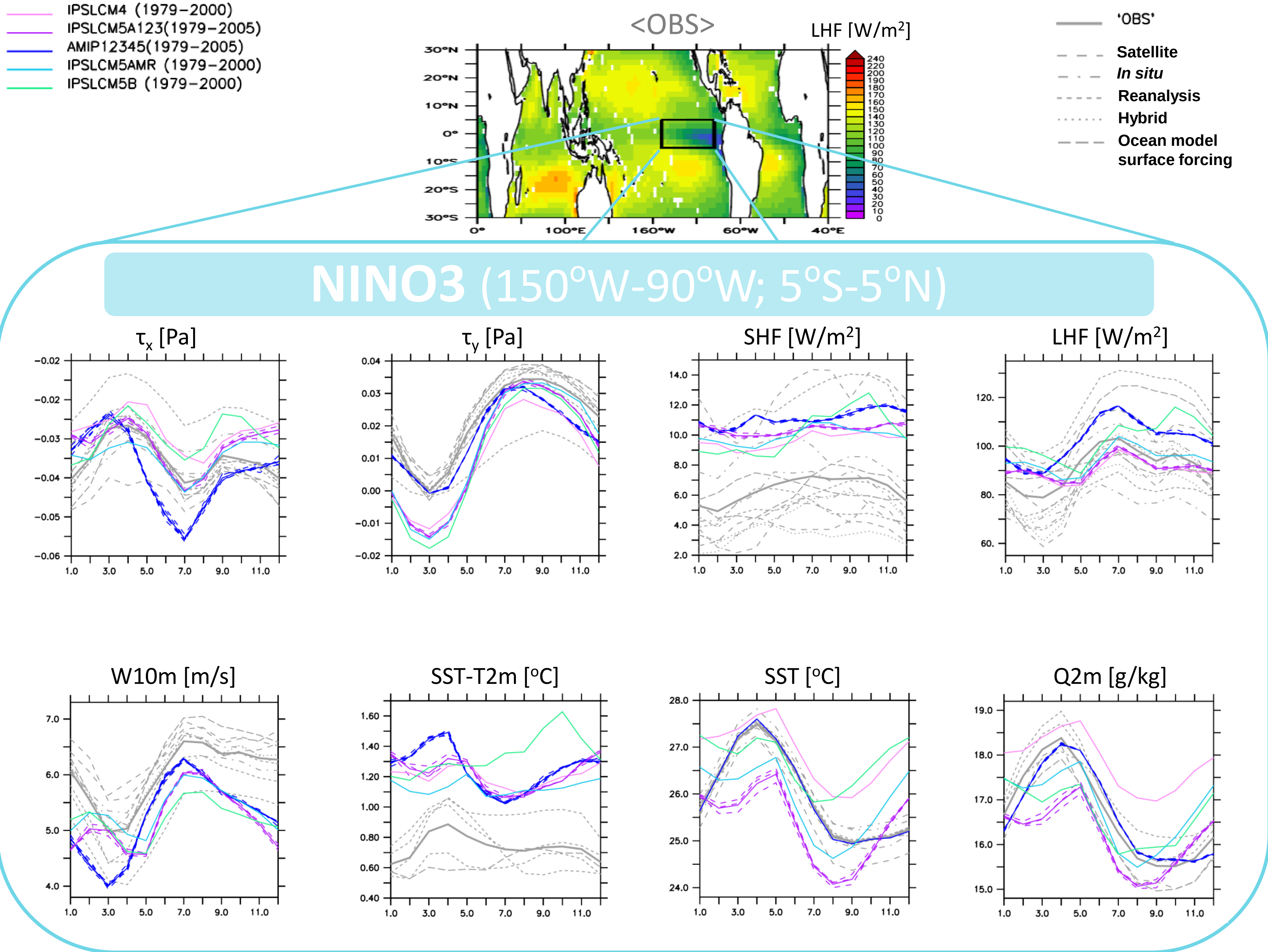
'OBS'
Satellite
In situ
Reanalysis
Hybrid
Ocean model surface forcing

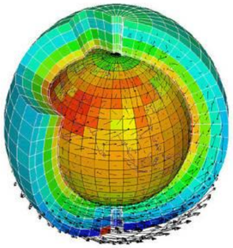
NINO3 (150°W-90°W; 5°S-5°N)

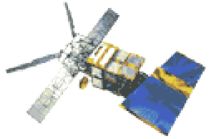


NINO3 (150°W-90°W; 5°S-5°N)



Conclusions





❑ Large observational uncertainties, especially in the surface heat fluxes – need to be addressed by the observational community

❑ When evaluating model results, we need to account for these uncertainties

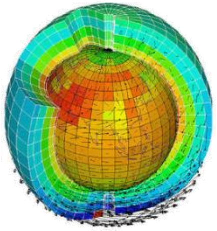
❑ Systematic model biases (cold sea surface, weak winds) do not transfer to the surface fluxes, because of compensation of effects

❑ Except for mean value shifts, the largest differences are found between the old versions of the model and IPSL-CM5B

Extra slides...

Approach

IPSL-CM5A



vs.

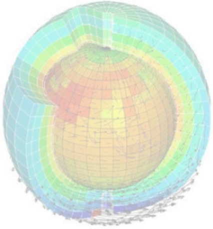
OBS

→

Direct evaluation of
the model of interest

Approach

IPSL-CM5A

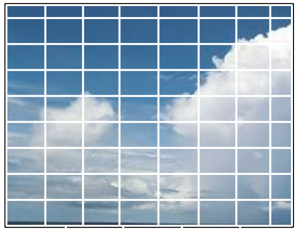


vs.

OBS

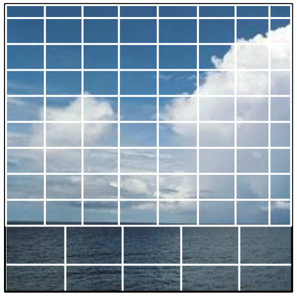
→ Direct evaluation of the model of interest

LMDZ5A AMIP



vs.

IPSL-CM5A



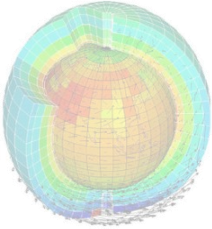
vs.

OBS

→ Atmospheric processes
vs.
Ocean-atmosphere feedbacks

Approach

IPSL-CM5A



vs.

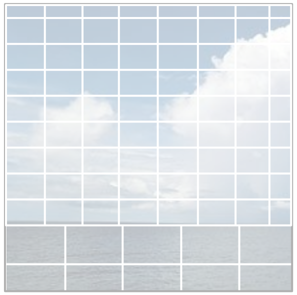
OBS

→ Direct evaluation of the model of interest

LMDZ5A AMIP

vs.

IPSL-CM5A

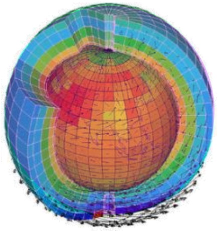


vs.

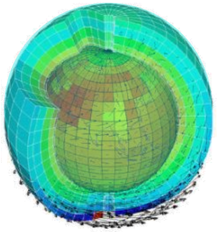
OBS

→ Atmospheric processes vs. Ocean-atmosphere feedbacks

IPSL-CM5A

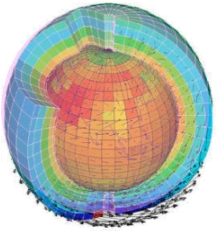


IPSL-CM5AMR

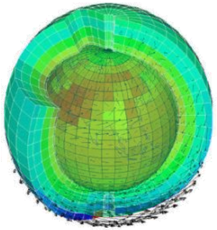


vs.

IPSL-CM4



IPSL-CM5B



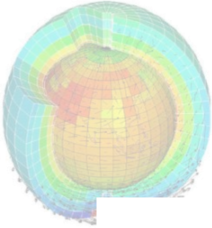
vs.

OBS

→ Model development perspective

Approach

IPSL-CM5A



vs.

OBS

→ Direct evaluation of the model of interest

- ❖ climatologies

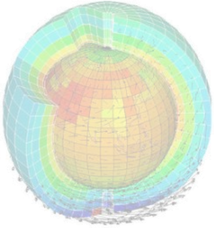
LMDZ5A AMII

- ❖ annual mean large-scale patterns

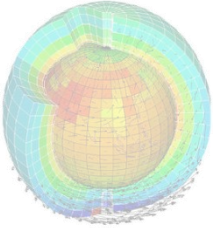
Atmospheric processes vs. Ocean-atmosphere feedbacks

- ❖ seasonality in selected regions

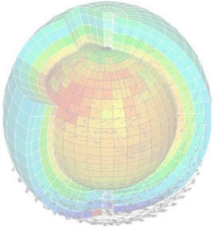
IPSL-CM5A



IPSL-CM4

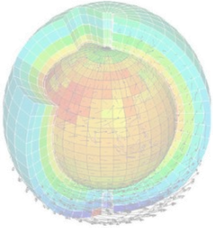


IPSL-CM5AMR



vs.

IPSL-CM5B



vs.

OBS

→ Model development perspective

“Validation” data

NOC2

(National Oceanography Center flux dataset)

FSU3

(Florida State University flux product)

Da Silva

(A. da Silva, A. C. Young, S. Levitus. Atlas of Surface Marine Data 1994, Volume 1: Algorithms and Procedures, number 6, 1994)

IFREMER

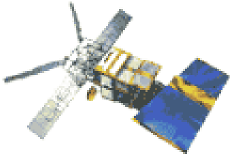
(Institut français de recherche pour l’exploatation de la mer)

J-OFURO

(Japanese Ocean Flux Data Sets with Use of Remote Sensing Observations)

HOAPS3

(Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data)



ECMWF – ERA-Interim(?)

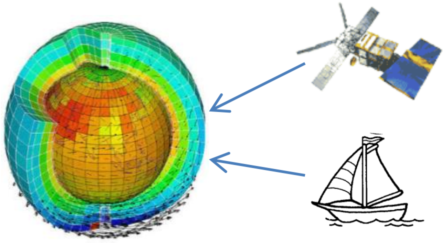
(European Center for Medium-Range Weather Forecasts)

NCEP/NCAR

(National Centers for Environmental Prediction/
National Centre for Atmospheric Research)

JRA25

(Japanese 25-year reanalysis)

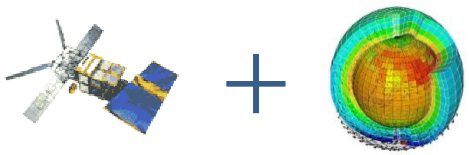


“Validation” data

OAFlux
(Objectively-Analyzed air-sea Fluxes for the Global Oceans – WHOI)

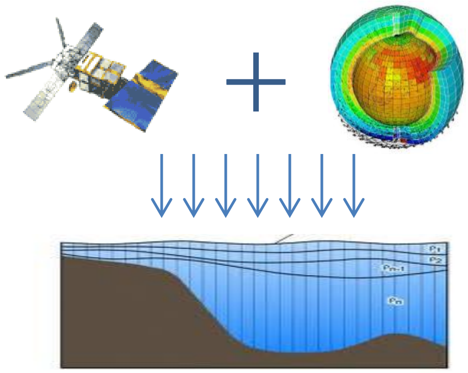
GSSTF2
(Version 2 Goddard Satellite-Based Surface Turbulent Fluxes)

TropFlux
(National Institute of Oceanography, India & IPSL)



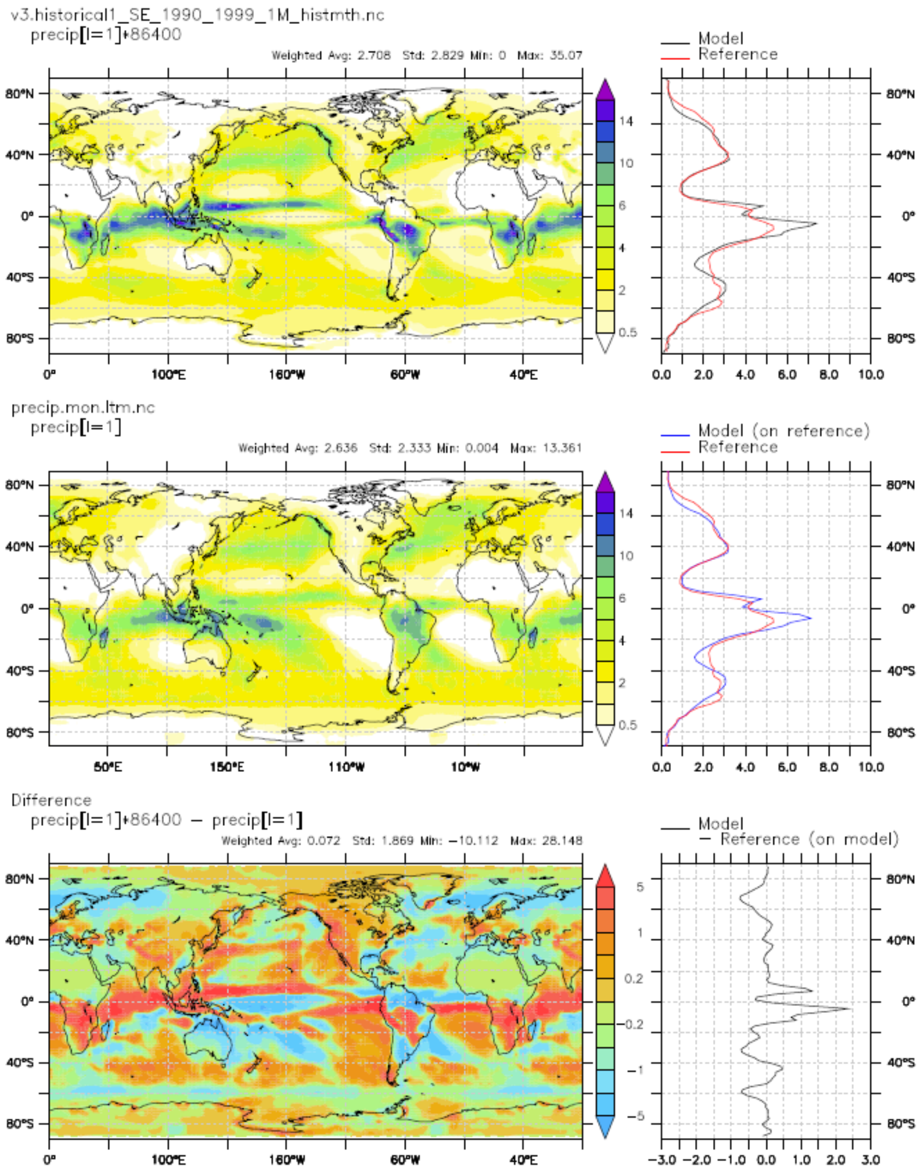
CORE2
(GFDL version 2 forcing for common ocean-ice reference experiments)

DFS4
(DRAKKAR Forcing Set v4.3 – MEOM, Grenoble)

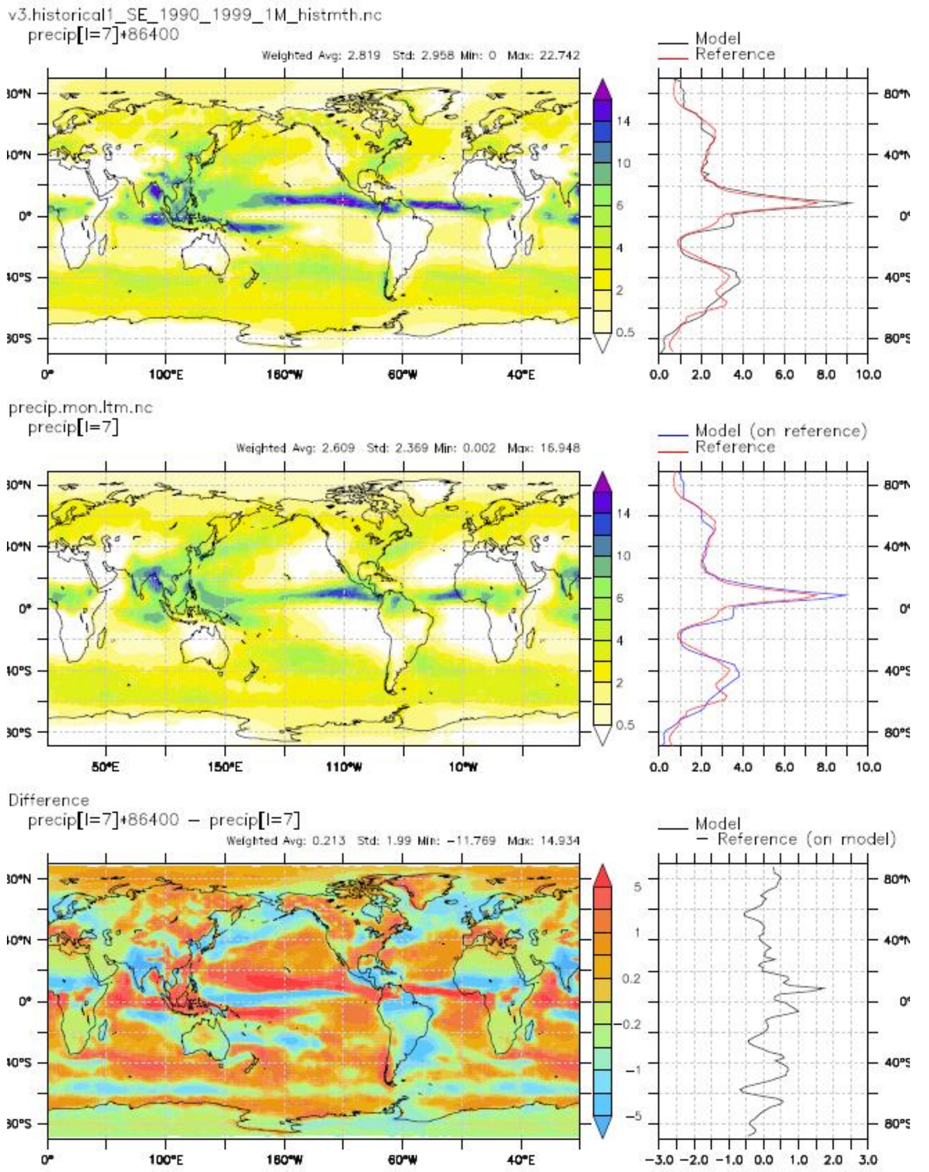


v3.historical1

January

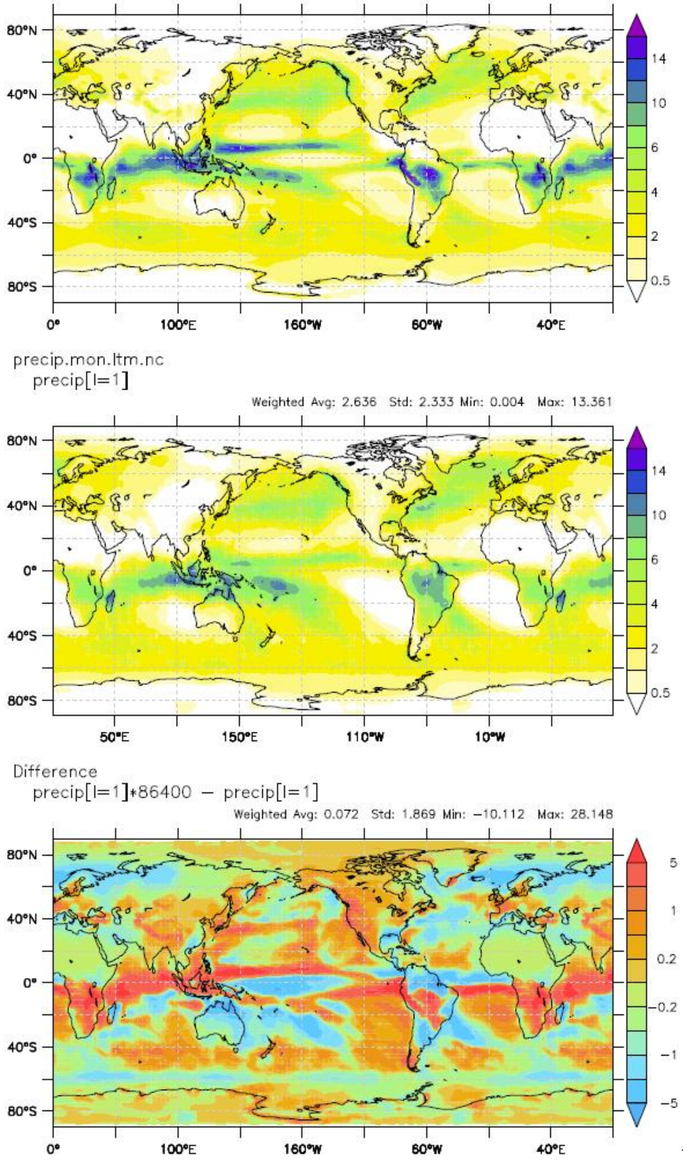

v3.historical1_SE_1990_1999_1M_histmth.nc
precip[l=1]*86400
Weighted Avg: 2.708 Std: 2.829 Min: 0 Max: 35.07
Model
Reference
precip.mon.ltm.nc
precip[l=1]
Weighted Avg: 2.636 Std: 2.333 Min: 0.004 Max: 13.361
Model (on reference)
Reference
Difference
precip[l=1]*86400 – precip[l=1]
Weighted Avg: 0.072 Std: 1.869 Min: –10.112 Max: 28.148
Model
– Reference (on model)
80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
40°E
50°E
150°E
110°W
10°W
0.5
2
4
6
10
14
0.0
2.0
4.0
6.0
8.0
10.0
5
1
0.2
–0.2
–1
–5
–3.0
–2.0
–1.0
0.0
1.0
2.0
3.0

July


v3.historical1_SE_1990_1999_1M_histmth.nc
precip[l=7]*86400
Weighted Avg: 2.819 Std: 2.958 Min: 0 Max: 22.742
Model
Reference
precip.mon.ltm.nc
precip[l=7]
Weighted Avg: 2.609 Std: 2.369 Min: 0.002 Max: 16.948
Model (on reference)
Reference
Difference
precip[l=7]*86400 – precip[l=7]
Weighted Avg: 0.213 Std: 1.99 Min: –11.769 Max: 14.934
Model
– Reference (on model)
80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
40°E
50°E
150°E
110°W
10°W
0.5
2
4
6
10
14
0.0
2.0
4.0
6.0
8.0
10.0
5
1
0.2
–0.2
–1
–5
–3.0
–2.0
–1.0
0.0
1.0
2.0
3.0

Important model biases

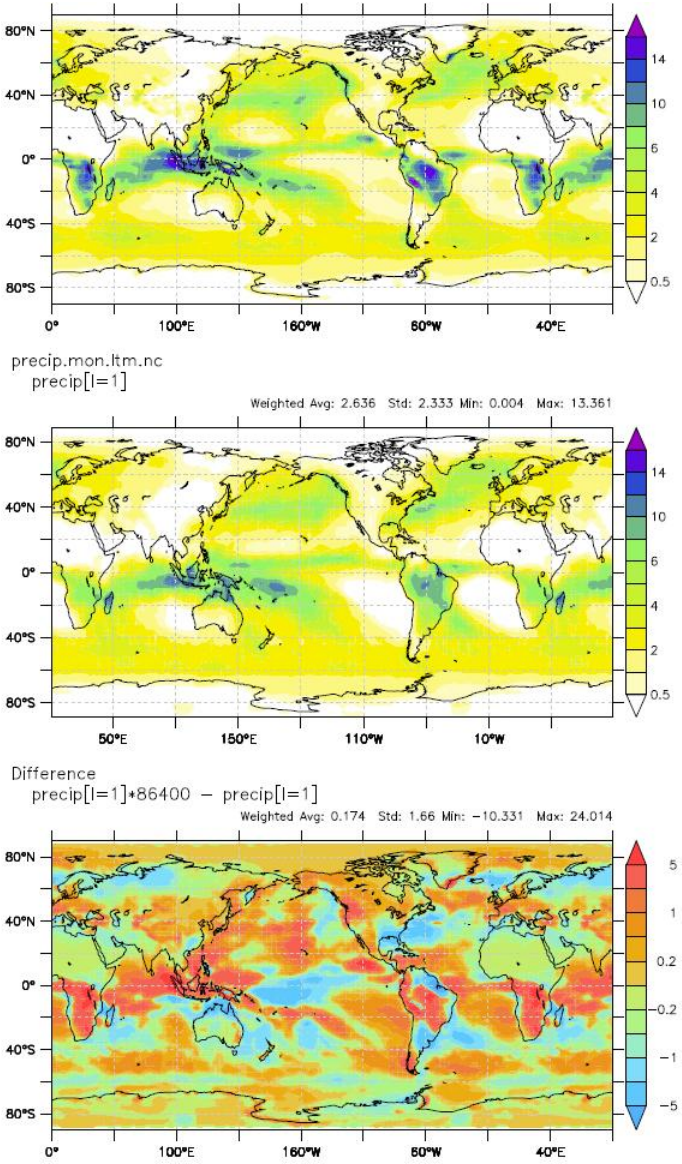
IPSL-CM5A


80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
40°E
50°E
150°E
110°W
10°W
14
10
6
4
2
0.5
5
1
0.2
-0.2
−1
−5

precip.mon.ltm.nc
precip[l=1]
Weighted Avg: 2.636 Std: 2.333 Min: 0.004 Max: 13.361

Difference
precip[l=1]*86400 − precip[l=1]
Weighted Avg: 0.072 Std: 1.869 Min: −10.112 Max: 28.148

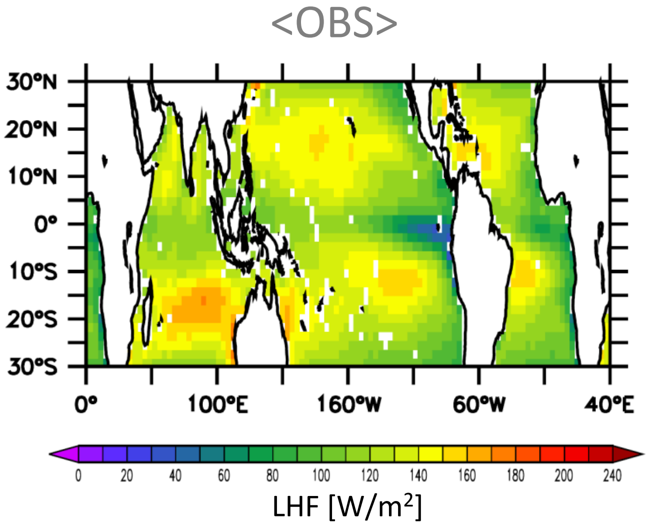
AMIP


80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
40°E
50°E
150°E
110°W
10°W
14
10
6
4
2
0.5
5
1
0.2
-0.2
−1
−5

precip.mon.ltm.nc
precip[l=1]
Weighted Avg: 2.636 Std: 2.333 Min: 0.004 Max: 13.361

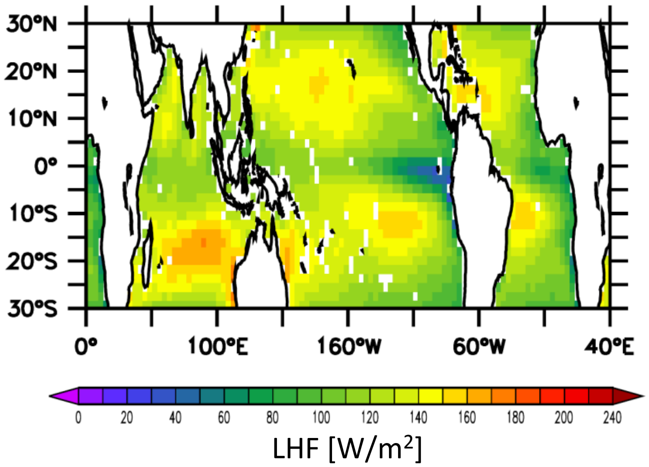
Difference
precip[l=1]*86400 − precip[l=1]
Weighted Avg: 0.174 Std: 1.66 Min: −10.331 Max: 24.014

What about the fluxes?

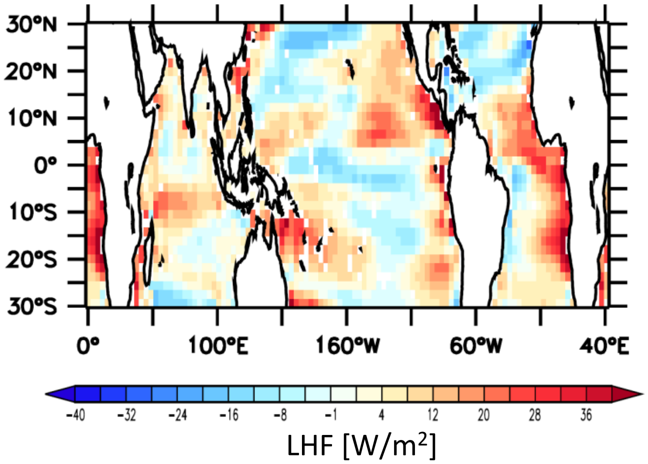

<OBS>
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
20
40
60
80
100
120
140
160
180
200
240
LHF [W/m²]

What about the fluxes?

<OBS>

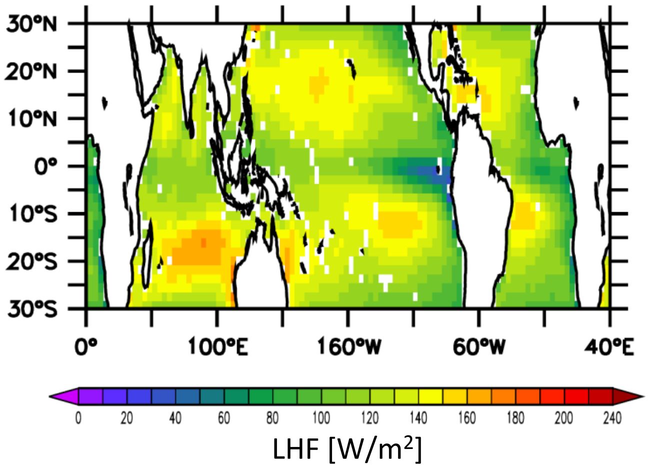

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
20
40
60
80
100
120
140
160
180
200
240
LHF [W/m^2]

Δ: IPSL-CM5A - <OBS>


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
-40
-32
-24
-16
-8
-1
4
12
20
28
36
LHF [W/m^2]

What about the fluxes?

<OBS>


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
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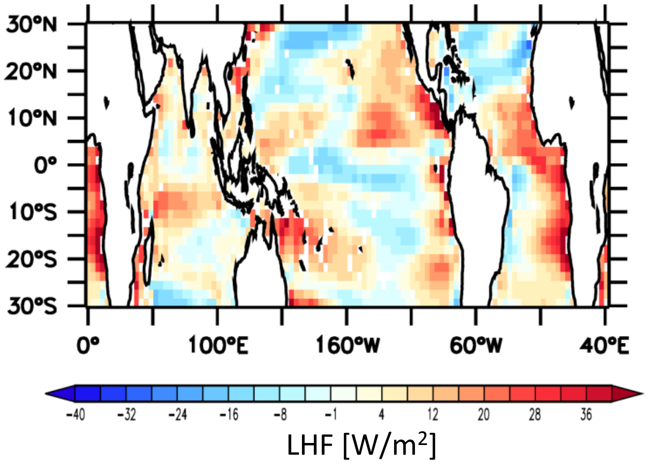
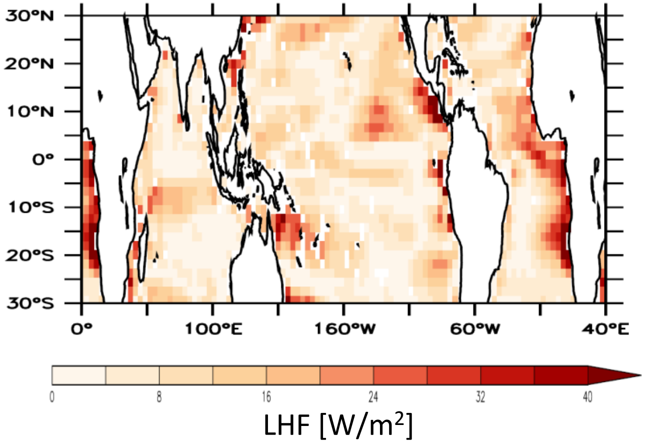
20
40
60
80
100
120
140
160
180
200
240
LHF [W/m²]

Δ: IPSL-CM5A - <OBS>

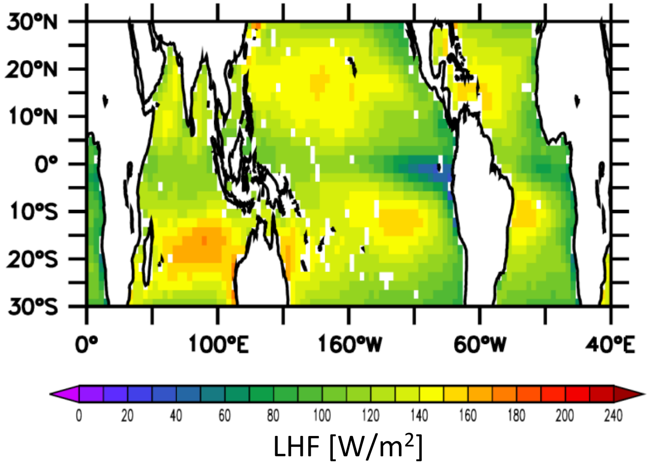

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
-40
-32
-24
-16
-8
-1
4
12
20
28
36
LHF [W/m²]

MAX|IPSL-CM5A - <OBS>|

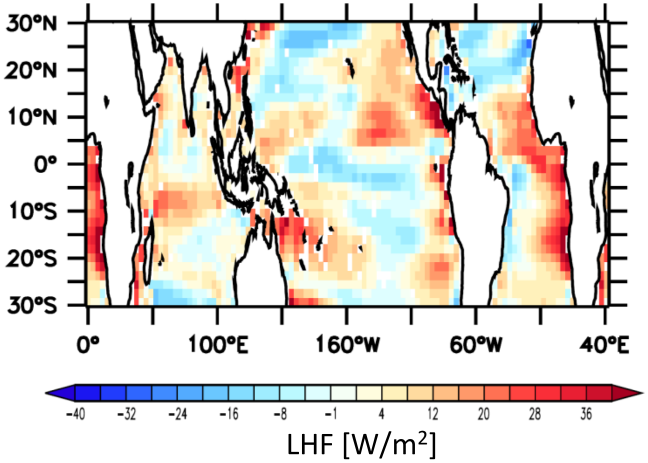

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m²]

What about the fluxes?

<OBS>


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
20
40
60
80
100
120
140
160
180
200
240
LHF [W/m²]

Δ: IPSL-CM5A - <OBS>


30°N
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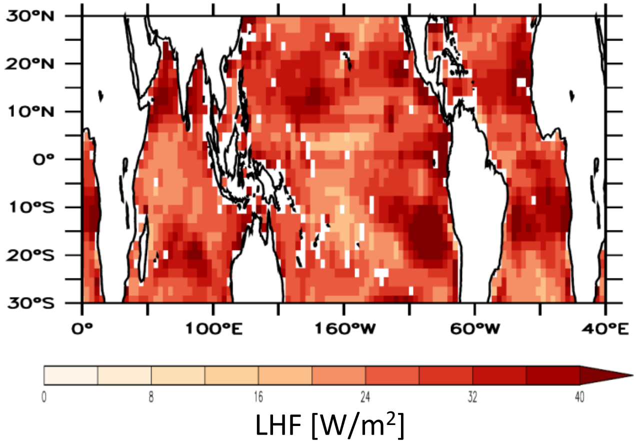
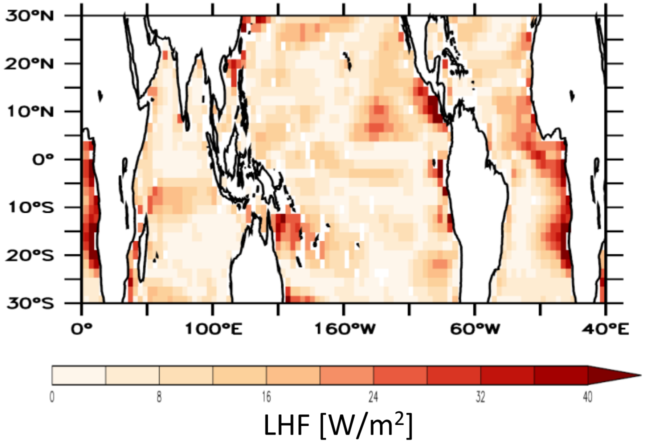
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
-40
-32
-24
-16
-8
-1
4
12
20
28
36
LHF [W/m²]

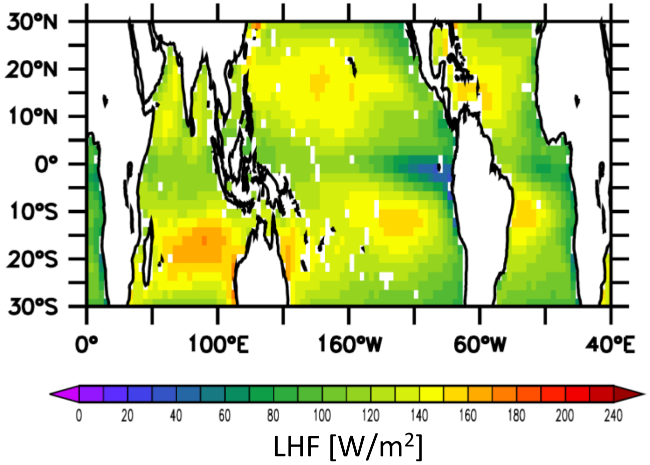
MAX|OBS - <OBS>|


30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m²]

MAX|IPSL-CM5A - <OBS>|

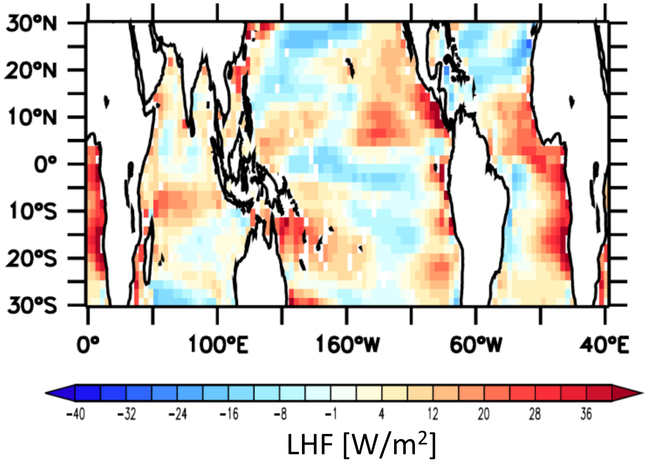

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m²]

What about the fluxes?



<OBS>

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
20
40
60
80
100
120
140
160
180
200
240
LHF [W/m²]



Δ: IPSL-CM5A - <OBS>

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
-40
-32
-24
-16
-8
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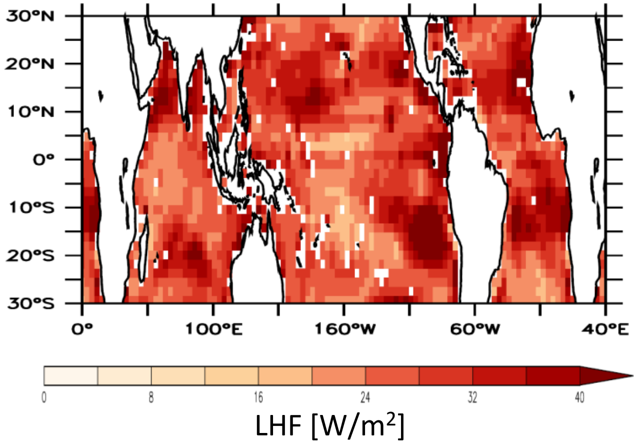
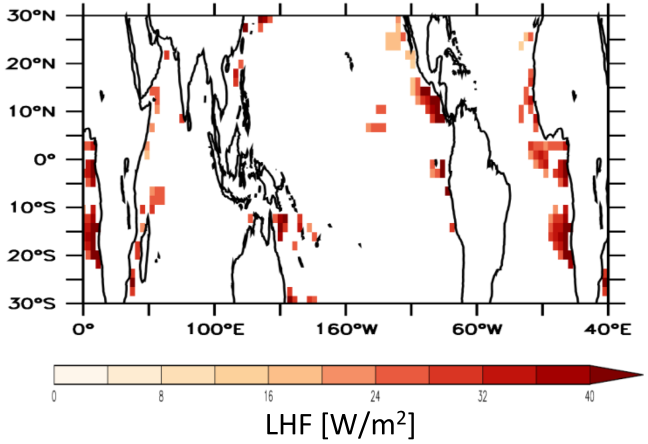
4
12
20
28
36
LHF [W/m²]



MAX|OBS - <OBS>|

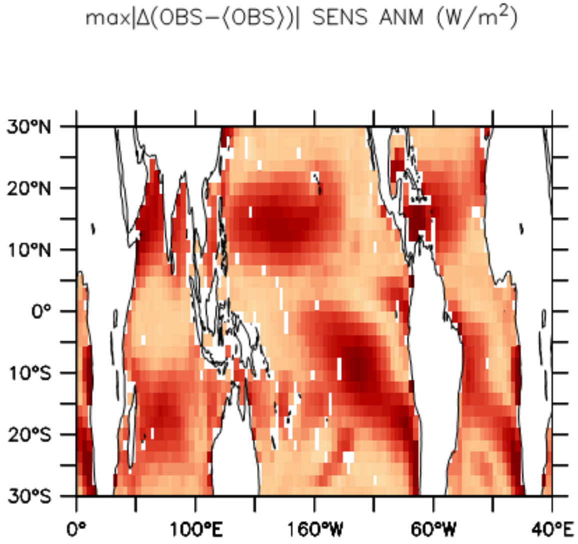
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m²]

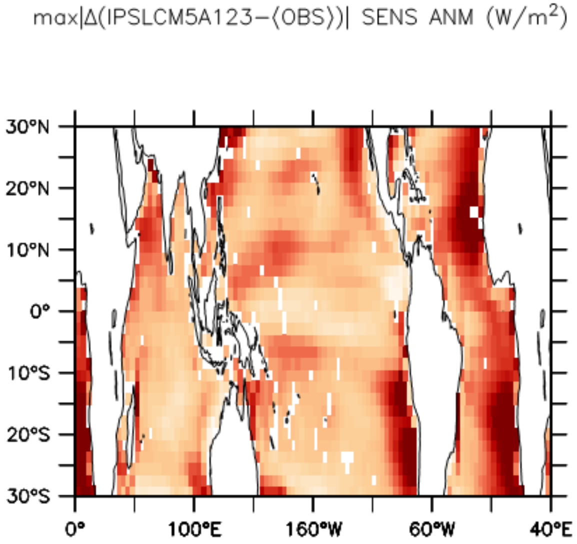


Signif. MAX|IPSL-CM5A - <OBS>|

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
0
8
16
24
32
40
LHF [W/m²]

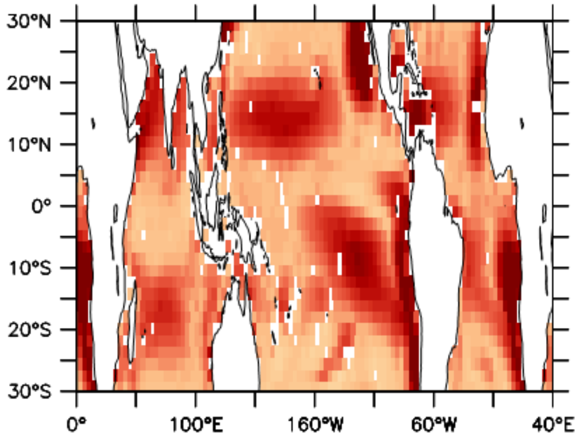
Sensible Heat Flux

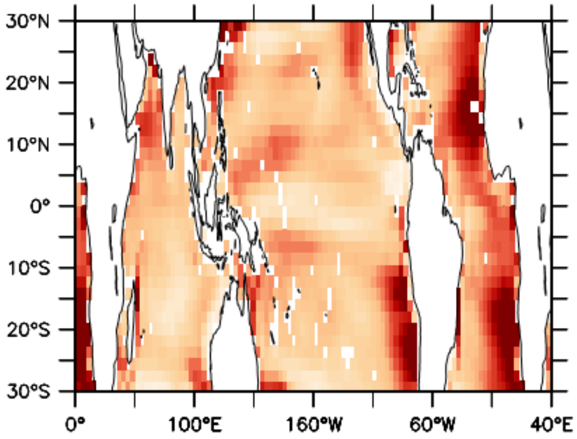

max|Δ(OBS−⟨OBS⟩)| SENS ANM (W/m²)
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E


max|Δ(IPSLCM5A123−⟨OBS⟩)| SENS ANM (W/m²)
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E

OBS without reanalyses

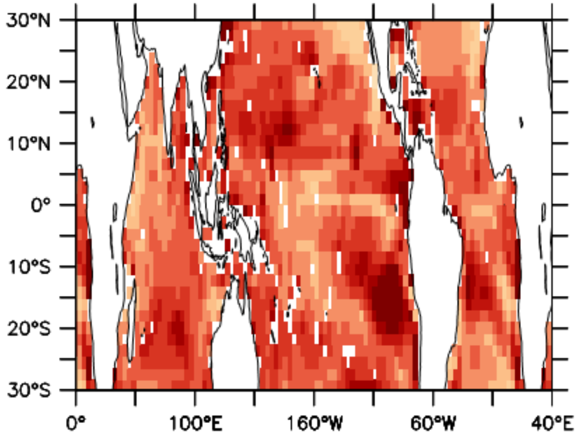
Sensible Heat Flux


max|Δ(OBS−⟨OBS⟩)| SENS ANM (W/m²)
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E


max|Δ(IPSLCM5A123−⟨OBS⟩)| SENS ANM (W/m²)
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E

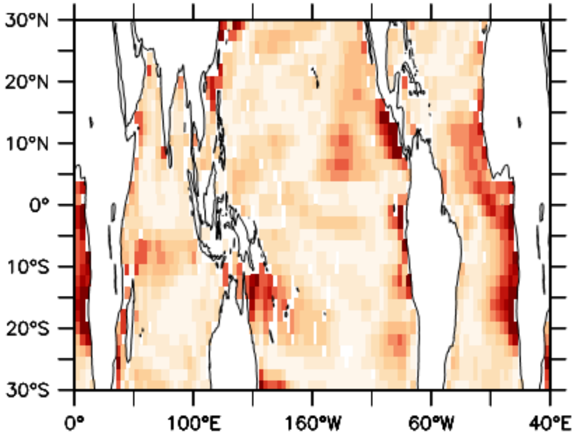
OBS with reanalyses

Latent Heat Flux



max|Δ(OBS−⟨OBS⟩)| FLAT ANM (W/m^2)

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E

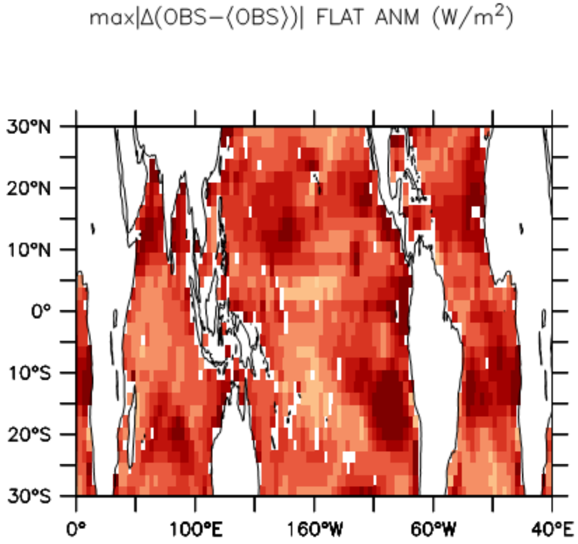


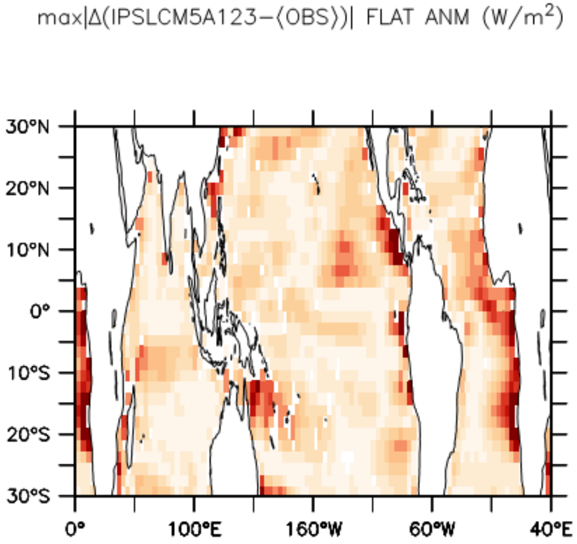
max|Δ(IPSLCM5A123−⟨OBS⟩)| FLAT ANM (W/m^2)

30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E

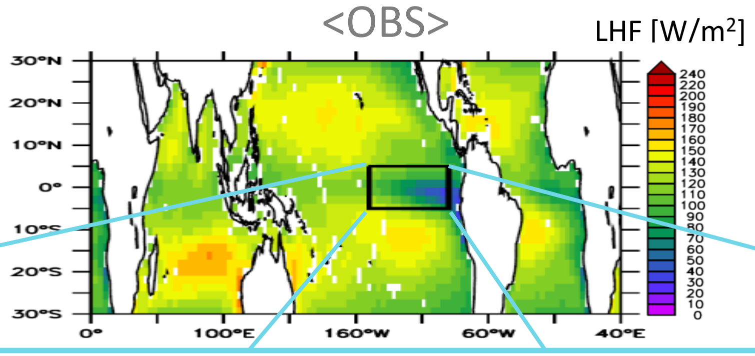
OBS without reanalyses

Latent Heat Flux


max|Δ(OBS−⟨OBS⟩)| FLAT ANM (W/m^2)
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E

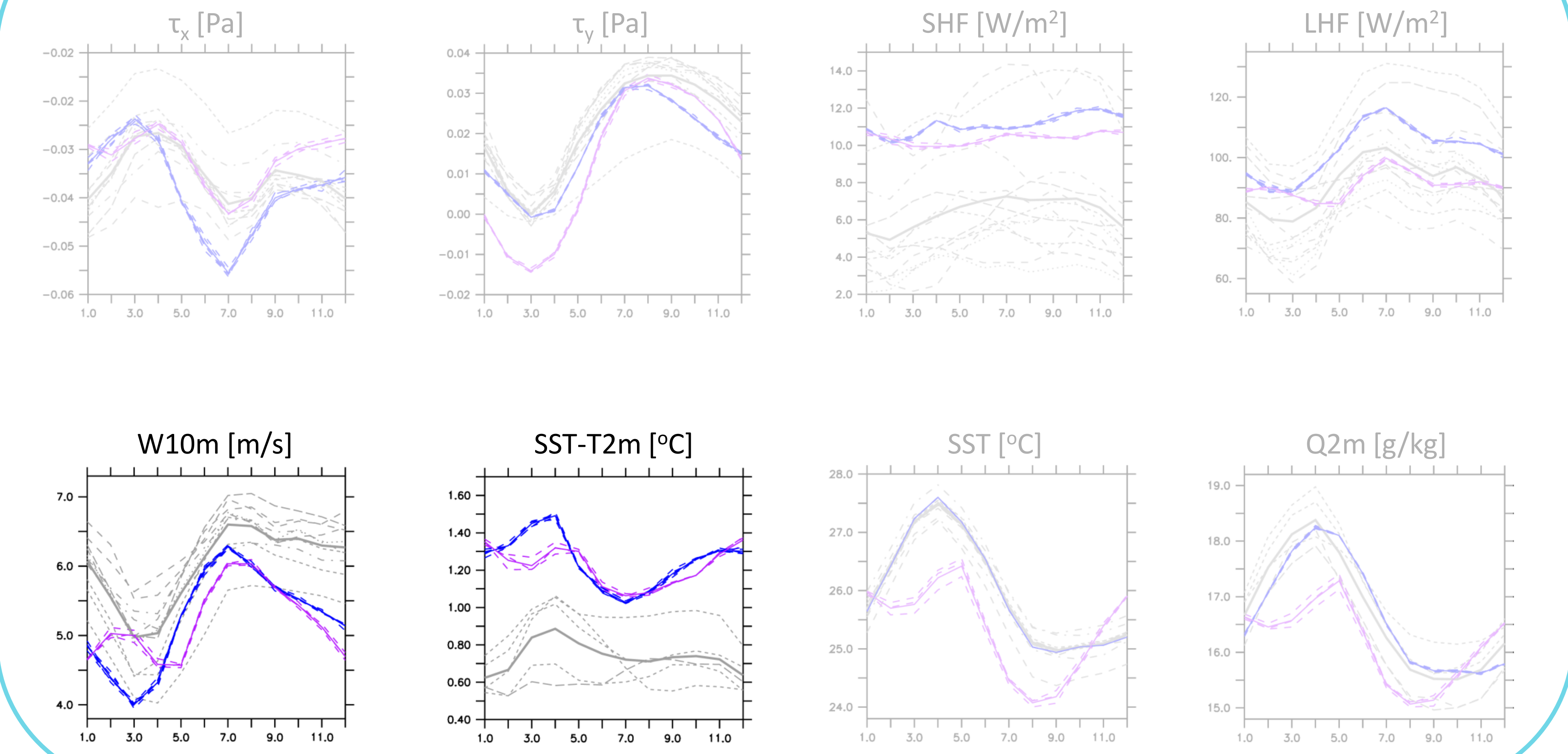

max|Δ(IPSLCM5A123−⟨OBS⟩)| FLAT ANM (W/m^2)
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E

OBS with reanalyses

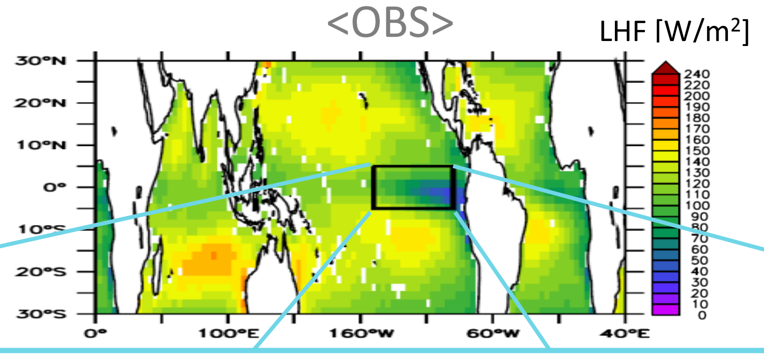


<OBS>
LHF [W/m^2]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
240
220
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

NINO3 (150°W-90°W; 5°S-5°N)

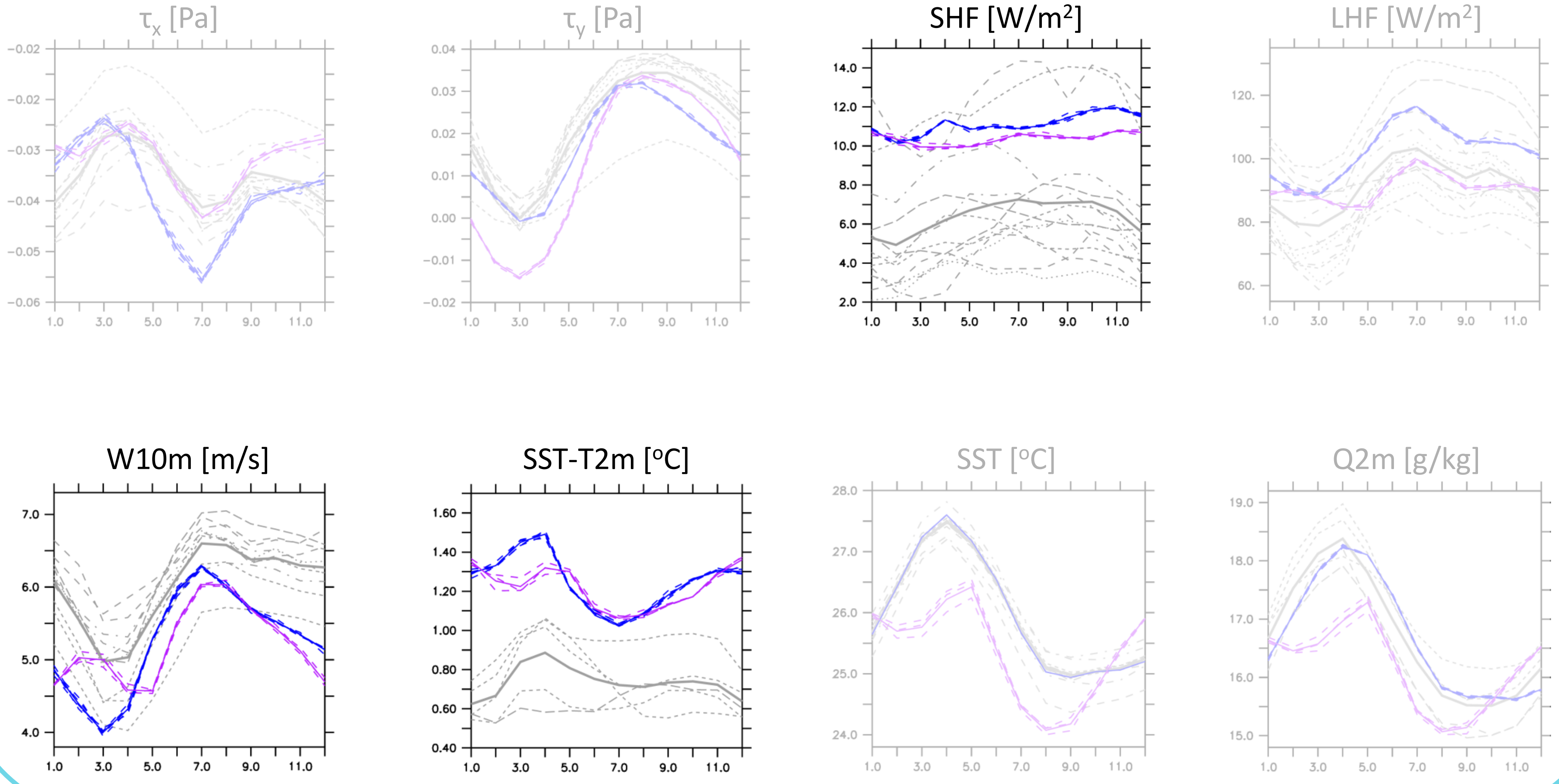


IPSLCM5A123(1979–2005)
AMIP12345(1979–2005)



<OBS>
LHF [W/m²]
30°N
20°N
10°N
0°
10°S
20°S
30°S
0°
100°E
160°W
60°W
40°E
240
220
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

'OBS'
Satellite
In situ
Reanalysis
Hybrid
Ocean model surface forcing

NINO3 (150°W-90°W; 5°S-5°N)