Intertropical ocean-atmosphere coupling in a state of the art Earth System Model: Evaluating the representation of turbulent air-sea fluxes in IPSL-CM5A

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Turbulent fluxes

Sensible heat flux
\[ \rho C_p C_H (U - U_s) (T_s - T_a) \]

Momentum flux
= Wind stress
\[ \rho C_D (U - U_s)^2 \]

Latent heat flux
\[ \rho L_v C_E (U - U_s) (Q_s - Q_a) \]
Approach

Direct evaluation of the model of interest
Approach

Direct evaluation of the model of interest

LMDZ5A AMIP

IPSL-CM5A

OBS

VS.

VS.

VS.

Atmospheric processes vs. Ocean-atmosphere feedbacks
Approach

Direct evaluation of the model of interest

Atmospheric processes vs. Ocean-atmosphere feedbacks

Model development perspective
Approach

- Direct evaluation of the model of interest

- **climatologies**
  - annual mean large-scale patterns
  - seasonality in selected regions

Atmospheric processes vs. Ocean-atmosphere feedbacks

Model development perspective
## Data

<table>
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<tr>
<th>Models</th>
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<td>IPSL-CM5A</td>
<td>3 in situ</td>
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<td>LMDZ5A → “AMIP”</td>
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<td>IPSL-CM5AMR</td>
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<td>2 ocean model forcing</td>
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**Period of reference:** 1979-2005
Important model biases

IPSL-CM5A

GPCP
Important model biases

Δ: IPSL-CM5A - OBS
Important model biases

**IPSL-CM5A**

**GPCP**

**AMIP**

$\Delta$: IPSL-CM5A - OBS
What about the fluxes?

\[ \text{LHF} \text{ [W/m}^2\text{]} \]
What about the fluxes?

<OBS>

Δ: IPSL-CM5A - <OBS>
What about the fluxes?

- \( \text{LHF [W/m}^2] \)
- \( \Delta: \text{IPSL-CM5A - OBS} \)
- \( \text{MAX|IPSL-CM5A - OBS|} \)
What about the fluxes?

\[ \text{LHF [W/m}^2\text{]} \]

\[ \Delta: \text{IPSL-CM5A - <OBS>} \]

\[ \text{MAX|OBS - <OBS>|} \]

\[ \text{MAX|IPSL-CM5A - <OBS>|} \]
What about the fluxes?

\[
\begin{align*}
\text{<OBS>} \\
\Delta: \text{IPSL-CM5A - <OBS>} \\
\text{MAX|OBS - <OBS>} | \\
\text{MAX|IPSL-CM5A - <OBS>} |
\end{align*}
\]
NINO3 (150°W-90°W; 5°S-5°N)
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NINO3 (150°W-90°W; 5°S-5°N)

- LHF [W/m²]
- SHF [W/m²]
- SST-T2m [°C]
- SST [°C]
- W10m [m/s]
- Q2m [g/kg]

Lines and markers represent different sources:
- Satellite
- In situ
- Reanalysis
- Hybrid
- Ocean model surface forcing
NINO3 (150°W-90°W; 5°S-5°N)

- LHF [W/m²]
- SHF [W/m²]
- SST [°C]
- SST-T2m [°C]
- W10m [m/s]
- Q2m [g/kg]

Legend:
- OBS
- Satellite
- In situ
- Reanalysis
- Hybrid
- Ocean model surface forcing
NINO3 (150°W-90°W; 5°S-5°N)

\[ \tau_x [\text{Pa}] \quad \tau_y [\text{Pa}] \quad \text{SHF} [\text{W/m}^2] \quad \text{LHF} [\text{W/m}^2] \]

\[ \text{W10m [m/s]} \quad \text{SST-T2m [°C]} \quad \text{SST [°C]} \quad \text{Q2m [g/kg]} \]
NIN03 (150°W-90°W; 5°S-5°N)

- τx [Pa]
- τy [Pa]
- SHF [W/m²]
- LHF [W/m²]
- W10m [m/s]
- SST-T2m [°C]
- SST [°C]
- Q2m [g/kg]
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...
“Validation” data

**NOC2**
(National Oceanography Center flux dataset)

**FSU3**
(Florida State University flux product)

**Da Silva**

**IFREMER**
(Institut français de recherche pour l’exploitation 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)
Important model biases

IPSL-CM5A

AMIP