Attribution of 2012 extreme climate events: does air-sea interaction matter?

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- Why 2012?
- Model experiments
- Role of air-sea coupling
- Comparison with observations
- Summary

Observed anomalies in 2012 in both boreal winter and summer

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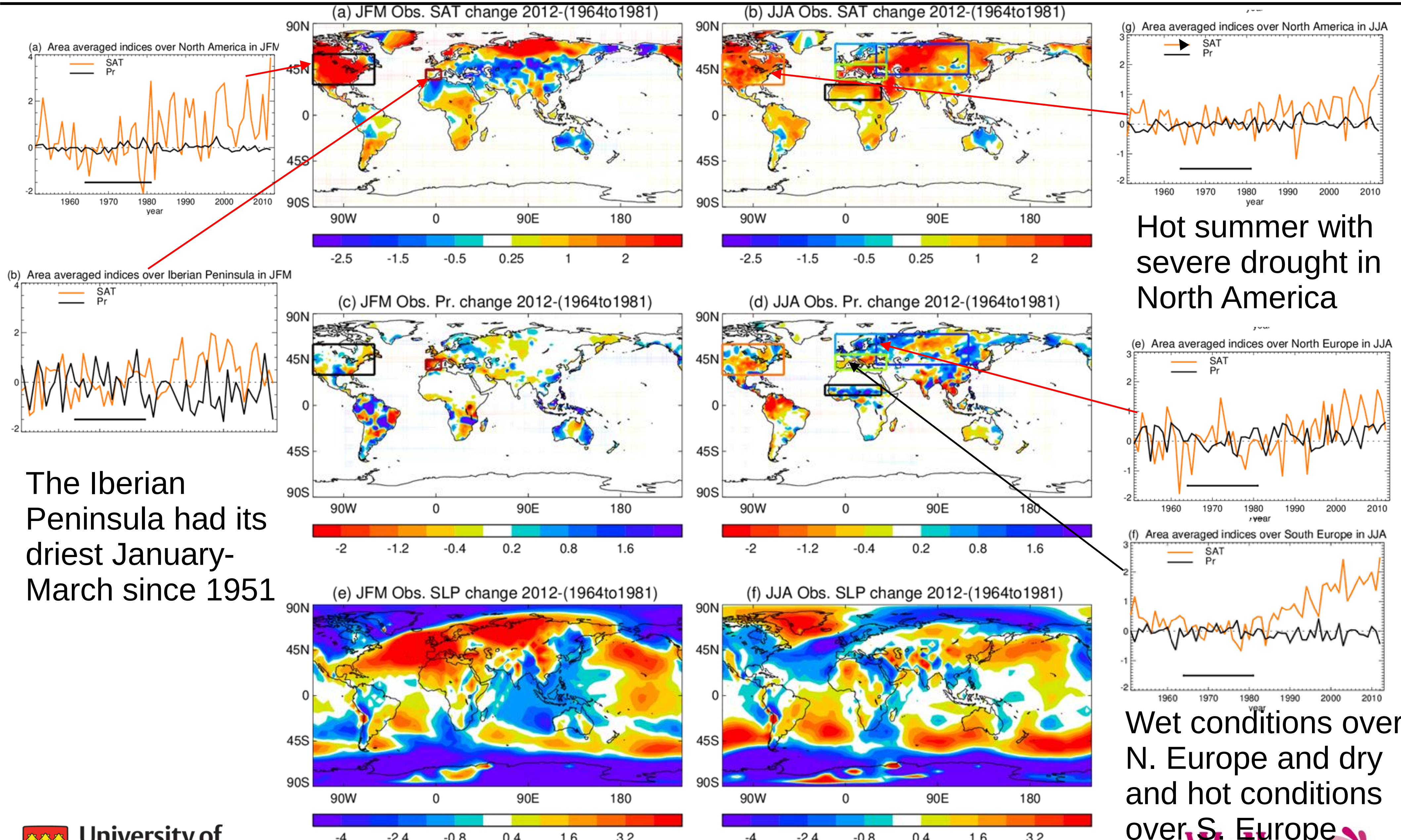

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What had caused these large climate anomalies in various regions?

Climate event attribution

- **There is still no consensus about the best methodology for climate event attribution (CEA).**
- **A common approach uses AGCMs forced by prescribed SSTs with and without anthropogenic influences (e.g., Pall et al. 2011, Otto et al. 2012, Christidis et al. 2013, Christidis and Stott 2014 …).**
- **AGCM's lack explicit air-sea interaction, so:**
  -> *Are the attribution conclusions from such studies robust?*

Role of air-sea interaction in climate event attribution

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We test robustness using a "perfect model" approach

MetUM-GOML: HadGEM3-A (1.875° x 1.25°, 85 levels) coupled to the Multi-Column K-Profile Parameterization ocean model (Klingaman et al. 2011).

Key advantages:

- **Cheap**: < 5% of the cost of the atmosphere, allowing high (1 metre) ocean vertical resolution. Small SST biases.
- **Disadvantage** : Lack of interactive ocean dynamics.

Coupled experiments: C2012 (2012 GHG & AA forcing) and Cclim (Time mean 1964-1981 GHG & AA forcings)
Uncoupled experiments: A2012 and Aclim (forcings as Coupled experiments, but SSTs also from coupled experiments)

The differences of impacts of anthropogenic forcing changes in 2012 simulations from clim simulations between the coupled simulations and uncoupled simulations are predominantly due to the lack of air-sea interaction.

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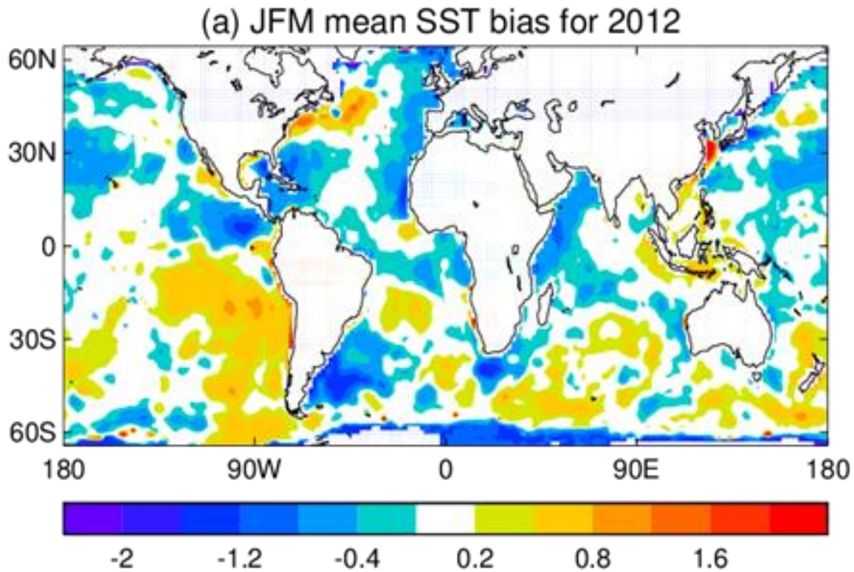
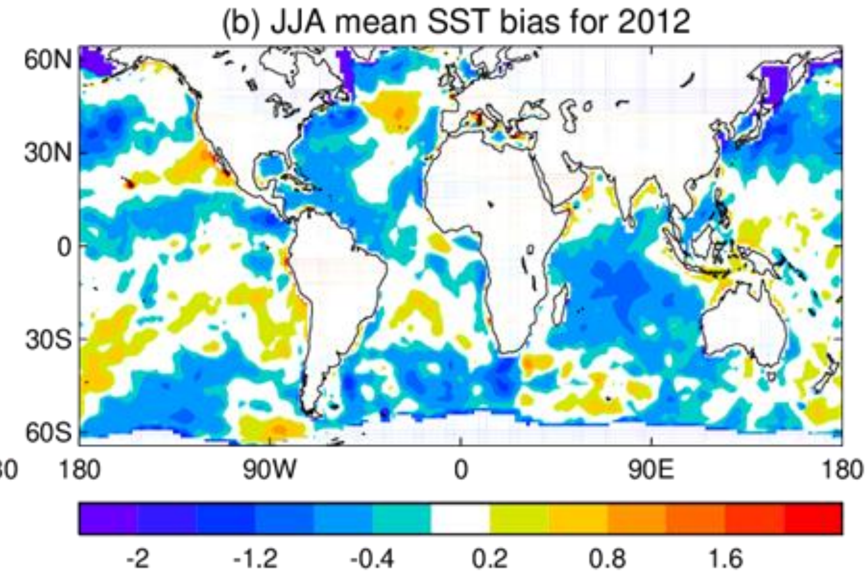
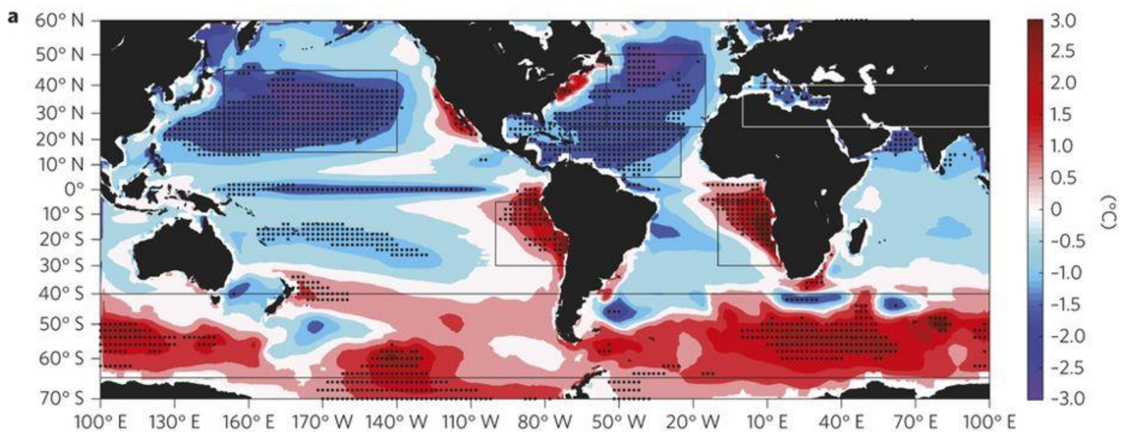
Seasonal mean SST biases in model 2012 simulation

JFM



JJA





(Wang et al. 2014)

mean SST biases in both boreal winter and summer in the model are much smaller (typically between -0.5°C and 0.5°C) than those in CMIP5 models

Seasonal mean SST changes in Obs and model simulations

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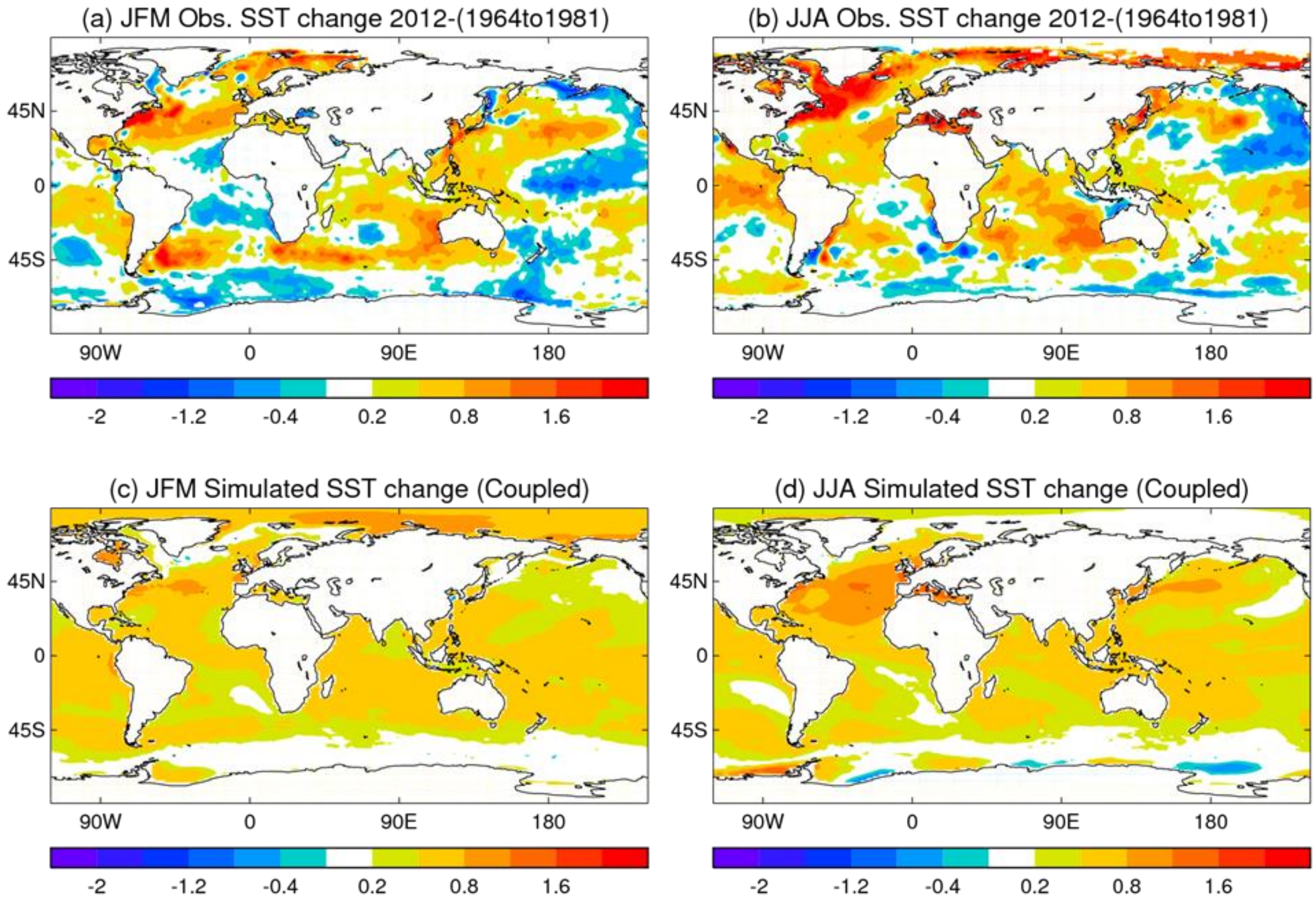
JFM

JJA

Obs

Model



Relatively large warming over North Atlantic, Indian and western tropical Pacific oceans in all seasons.

Model simulates some features well.

Role of internal variability in Obs.

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Seasonal mean SAT changes in coupled and uncoupled simulations

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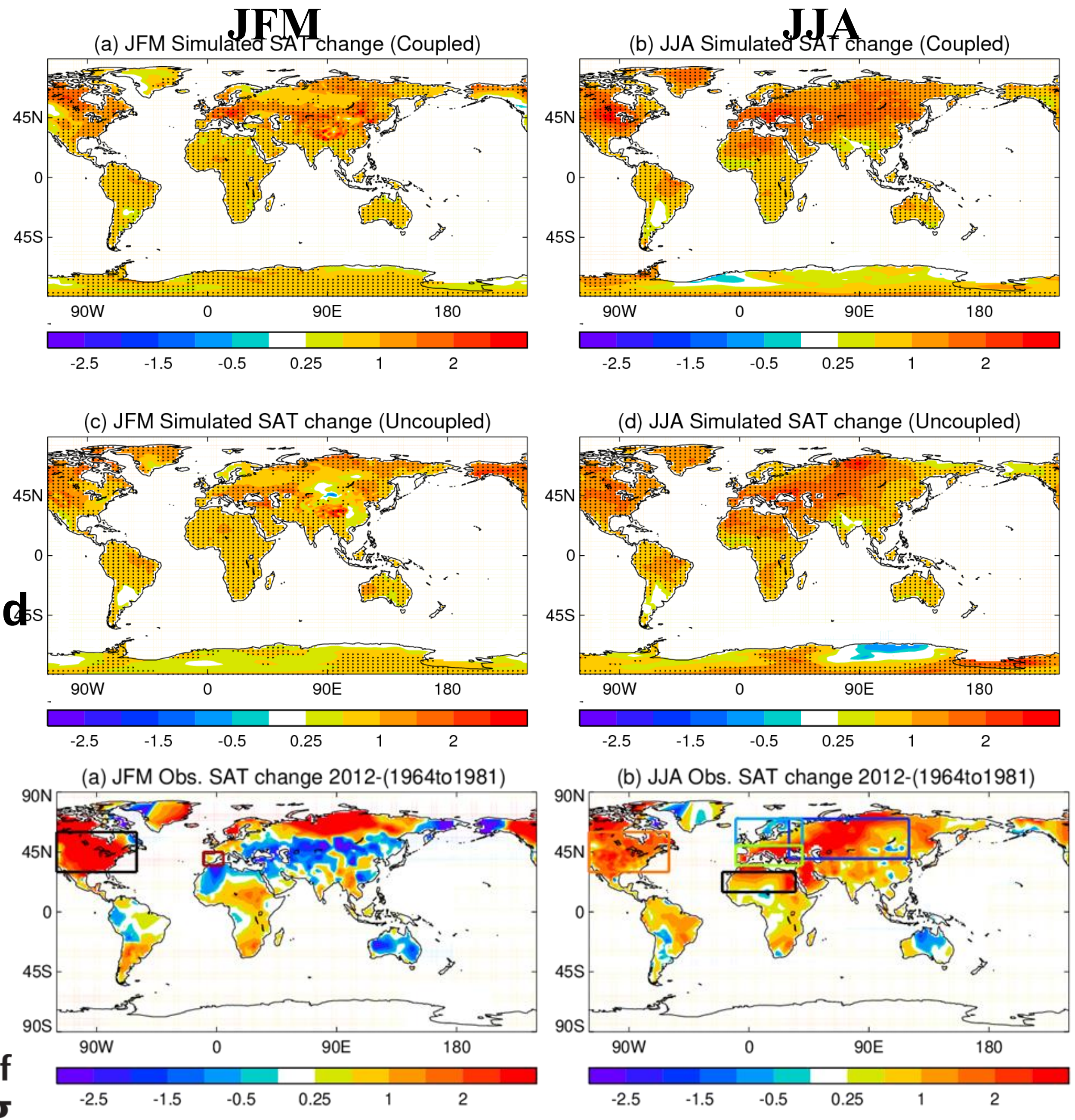
Coupled

Uncoupled

Obs.



large warming over NH continent in JJA.

Not sensitive to air-sea coupling

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Seasonal mean SLP changes in coupled and uncoupled simulations

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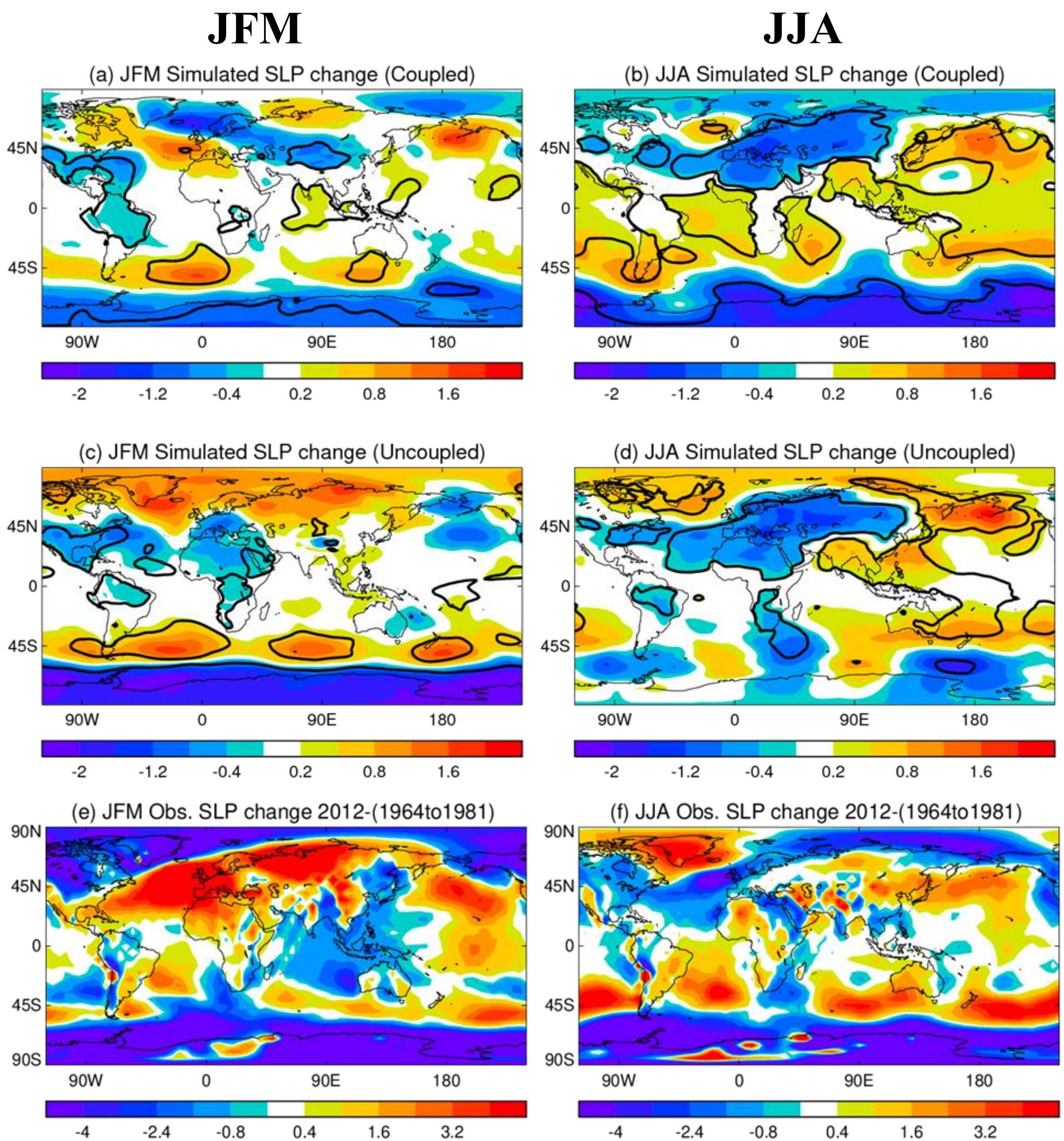
Coupled

Uncoupled

Obs.



Some contrasting features of circulation changes in North Atlantic in JFM and over East Asia in JJA

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Circulation and precipitation changes in the Atlantic sector in JFM

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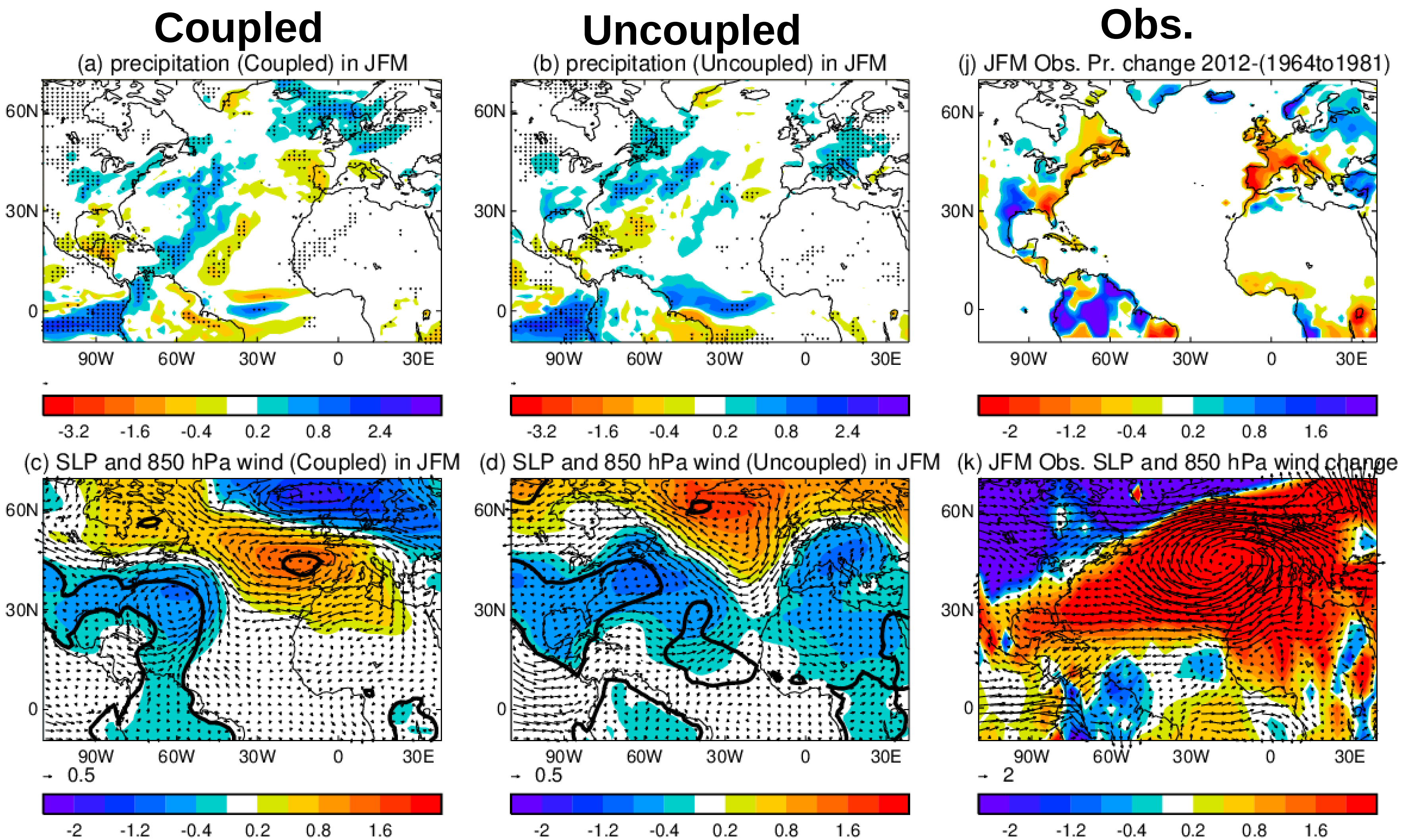

Some contrasting features of circulation changes in North Atlantic and the precipitation responses Western Europe

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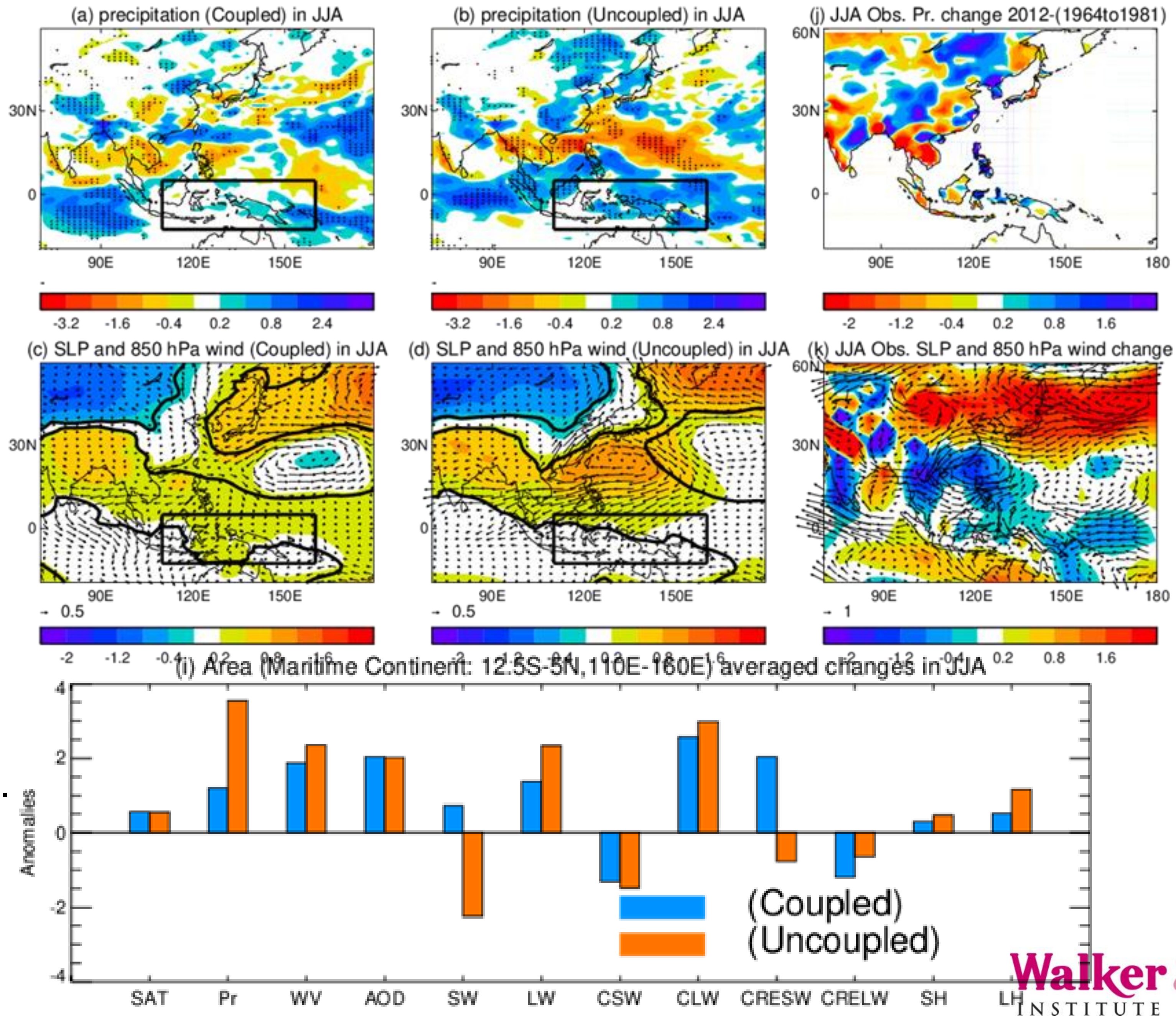
Circulation and precipitation changes the Maritime continent and East Asia in JJA

Some contrasting features of circulation and precipitation changes over the Maritime continent and western tropical Pacific



Very different precipitation changes and surface energy changes in the Maritime continent.

Summary

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- Attribution conclusions for large scale surface air temperature (SAT) changes in both boreal winter and summer are generally robust and not sensitive to air-sea interaction.
- However, attribution of circulation and precipitation changes for some other regions (the Atlantic sector in boreal winter and East Asia in summer) indicate a sensitivity to air-sea interaction.
- Coupled simulations show generally better agreement with observations for changes in circulation and precipitation.
- The lack of explicit air-sea interaction may lead to erroneous attribution conclusions for changes circulation and precipitation in some regions.

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