

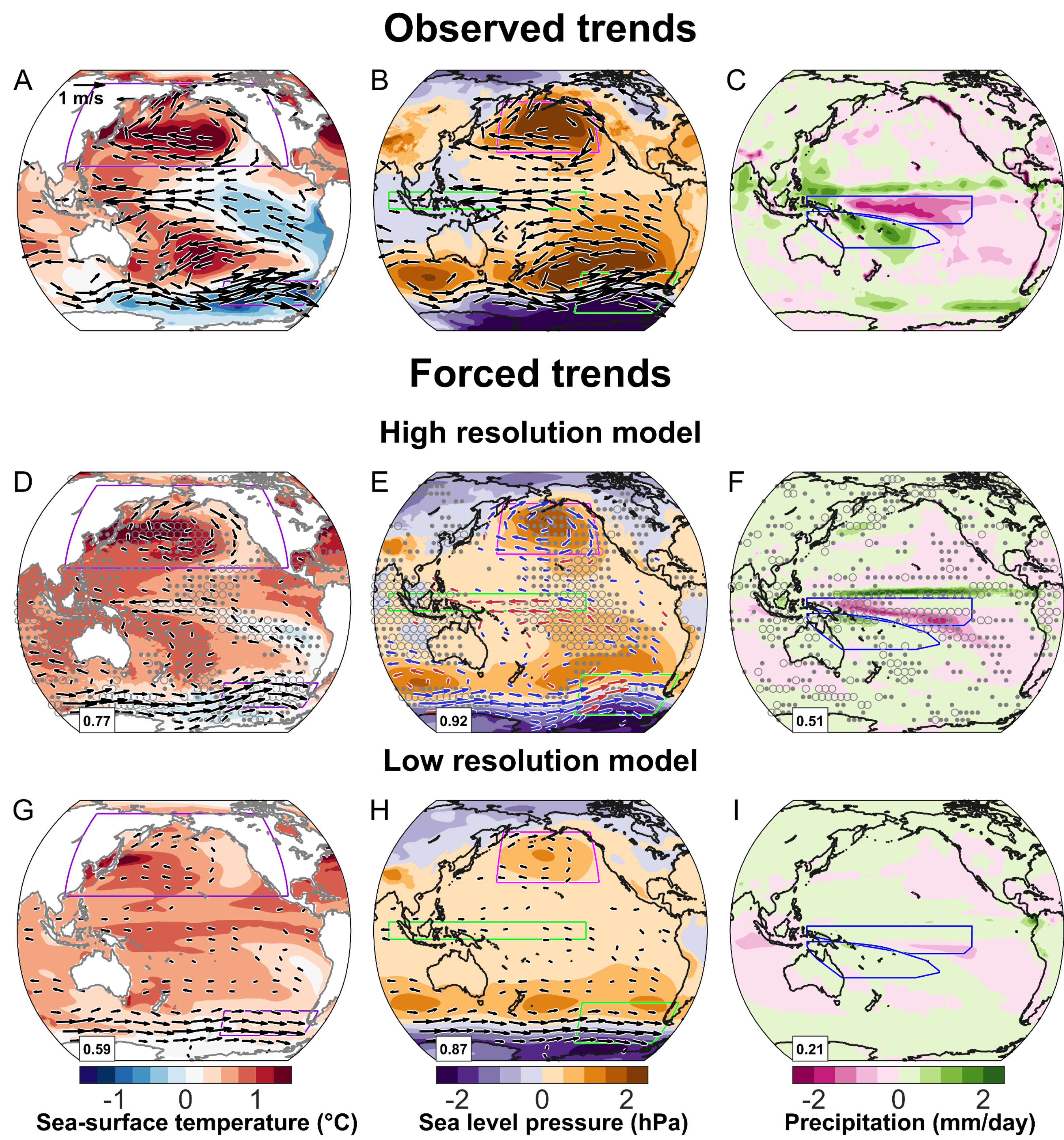
### Question and approach

- ✓ Why do standard-resolution models fail to reproduce observed Pacific trends?
- ✓ Compare observations with 10-member high-resolution (HR) and 40-member low-resolution (LR) ensembles (1980–2022).
- ✓ Separate anthropogenic forcing from internal variability and diagnose the seasonal coupling mechanism.

### Data and methods

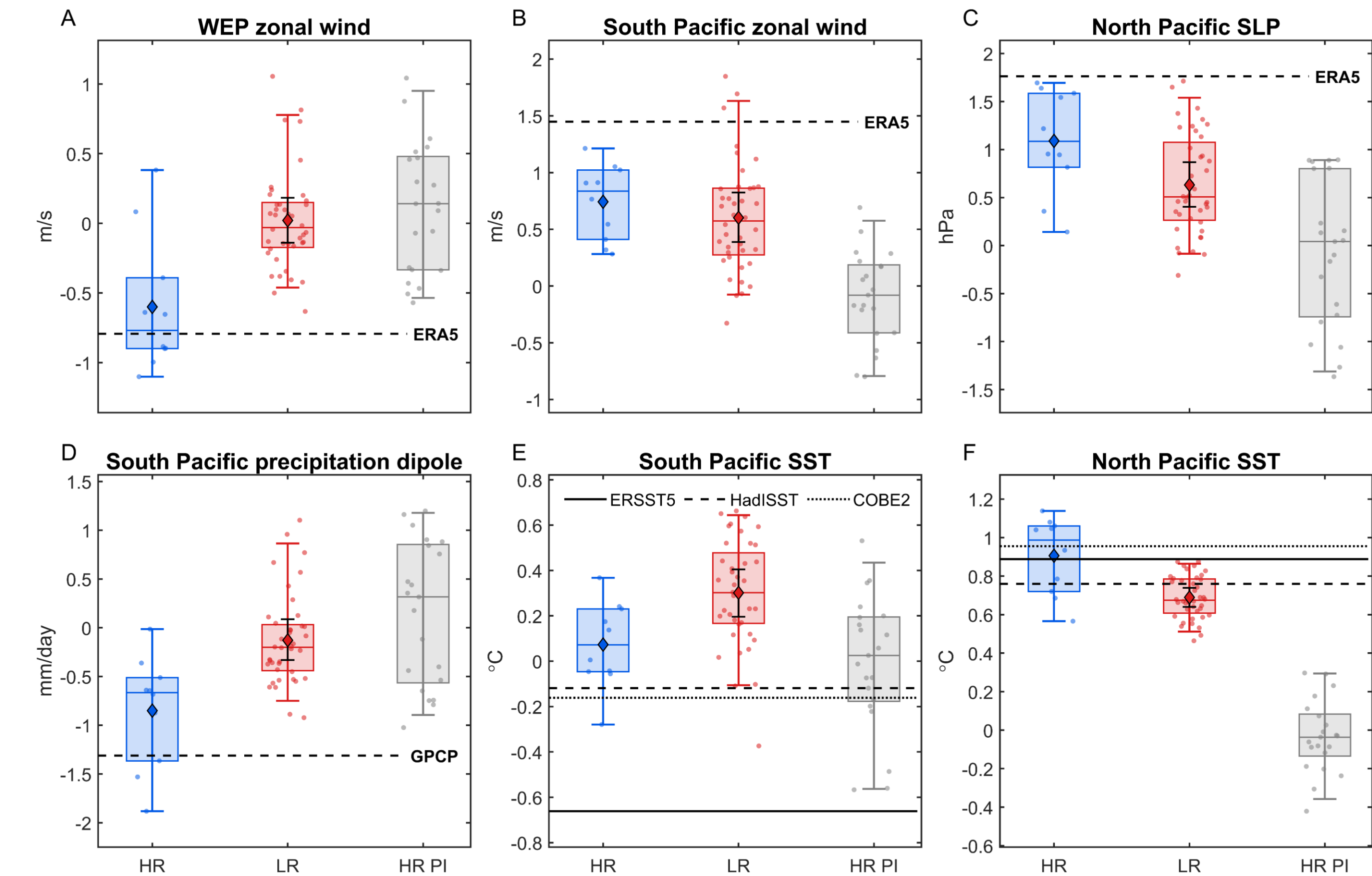
| Resolution | Project  | Model   | Reference         | Ensemble Size | Atmosphere CAM5 physics |               | Ocean POP2   |
|------------|----------|---------|-------------------|---------------|-------------------------|---------------|--------------|
|            |          |         |                   |               | Dynamical Core          | Grid          | Grid         |
| HR         | MESACLIP | CESM1.3 | Chang et al. 2025 | 10            | Spectral element (SE)   | ne120 (25 km) | tl2 (10 km)  |
| LR         | MESACLIP | CESM1.3 | Chang et al. 2025 | 40            |                         | ne30 (100 km) | gl6 (100 km) |

### High resolution simulations reproduces observed Pacific climate trends



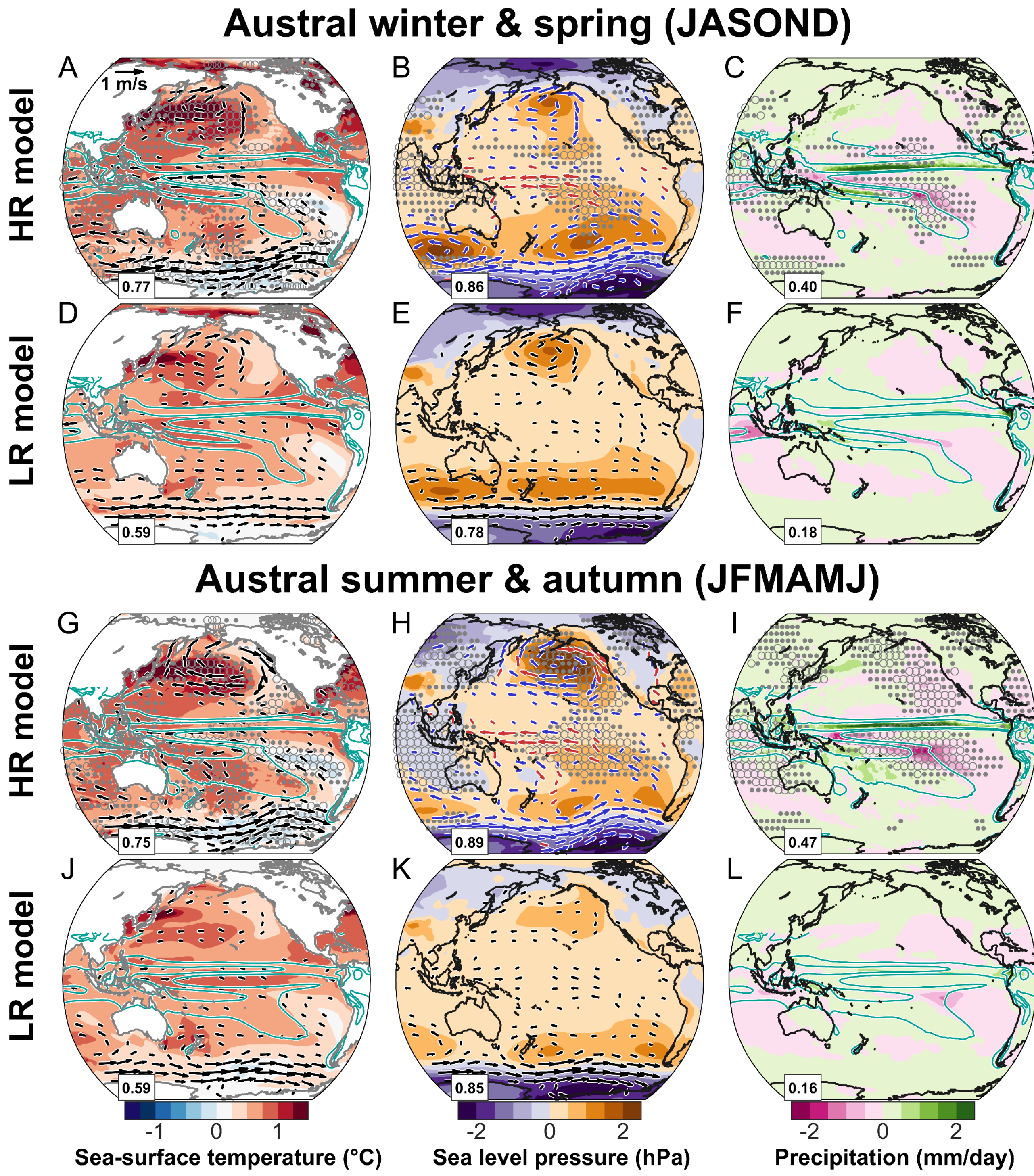
**Fig. 1** | Observed and simulated 1980–2022 trends in SST and 850-hPa winds, SLP and winds, and precipitation. HR and LR panels show ensemble-mean forced responses.

### Forced response explains a large fraction of regional trends



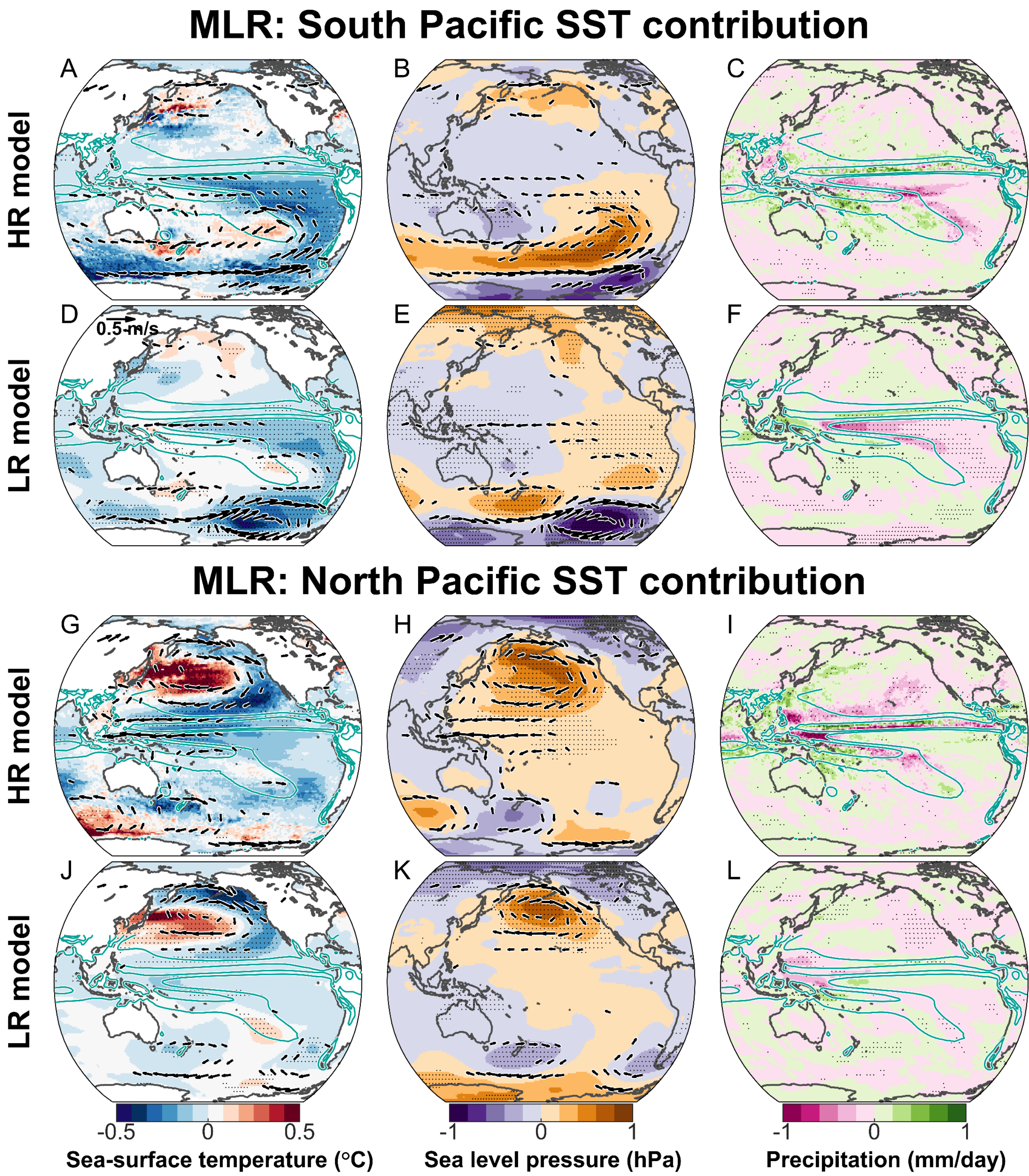
**Fig. 2** | Observed and simulated trends for six Pacific climate indices. Dots show individual members, diamonds show ensemble means, and horizontal lines show observations. **HR forced responses are consistently closer to the observed trends.**

### Seasonal ITCZ migration sustains subtropical–equatorial coupling



**Fig. 3** | Seasonal evolution of HR and LR forced trends. HR better captures the seasonally migrating rainbands and associated Pacific SST and circulation responses.

### Two-way tropical–extratropical coupling amplifies Pacific variability



**Fig. 4** | Multiple regression of member-to-member austral summer–autumn trends in SST, SLP, and precipitation onto South and North Pacific SST trend indices. HR shows stronger basin-wide atmospheric connections between extratropical and tropical Pacific changes.

### Key takeaways

- ✓ Anthropogenic forcing and internal variability contribute roughly equally to the observed Pacific trend amplitude.
- ✓ Realistic seasonal rainband migration and ocean mesoscale dynamics strengthen two-way tropical–extratropical coupling.
- ✓ High resolution therefore reconciles recent observations with an anthropogenically forced response.