

Stratospheric Influence on Tropical Convection: Insights from SNAPSI Experiment

Shunsuke Noguchi* and SNAPSI Working Group 6 Members

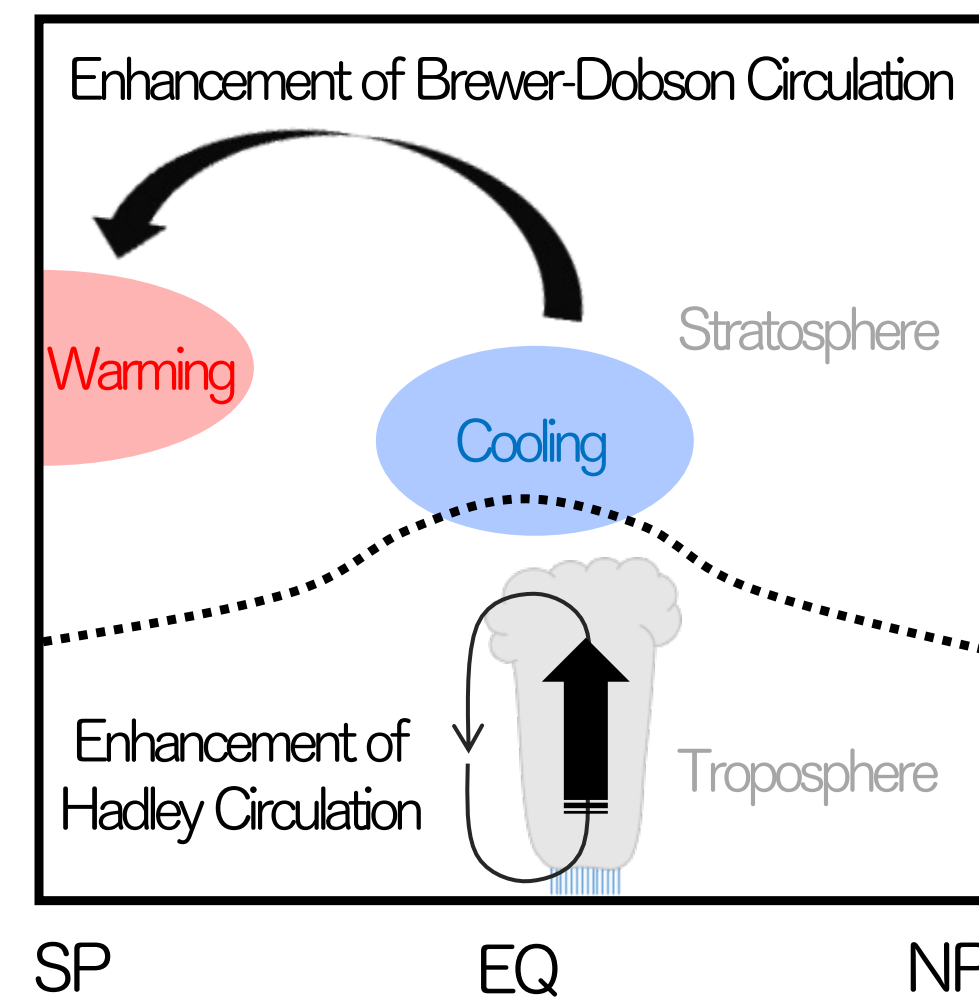
* : Kyushu University, Faculty of Science, E-mail→ noguchis@geo.kyushu-u.ac.jp

1. Introduction

◆ Stratospheric downward influence in low-latitude regions

- ✓ The impact of SSW on tropical convective systems e.g., Koder (2006) has the potential to be one of attractive process in S2S forecasting
- ✓ The lower stratospheric cooling caused by the enhanced BDC would act to deepen the tropical convective clouds
- ✓ If this process is proven to be as robust as the downward influence in high-latitudes, we can expect the stratospheric contribution to enhance the predictability of low-latitude phenomena, such as the genesis and intensification of tropical cyclones

(, which are of great social interest)



◆ A bottleneck for further understanding of this coupling process

- ✓ The representation of clouds in NWP models still involves large uncertainties
- ✓ Tropical responses to SSW depend on convective (cumulus) parameterizations

2. Experimental Data and Methods

◆ SNAPSI (Stratospheric Nudging And Predictable Surface Impacts) project data

- ✓ A multi-model (system) intercomparison with the “perfect stratosphere” settings allows us to infer the diversity of tropospheric responses to SSW
- ✓ Target: Recent three SSWs (actively diagnosed cases since the availability of S2S forecast data)

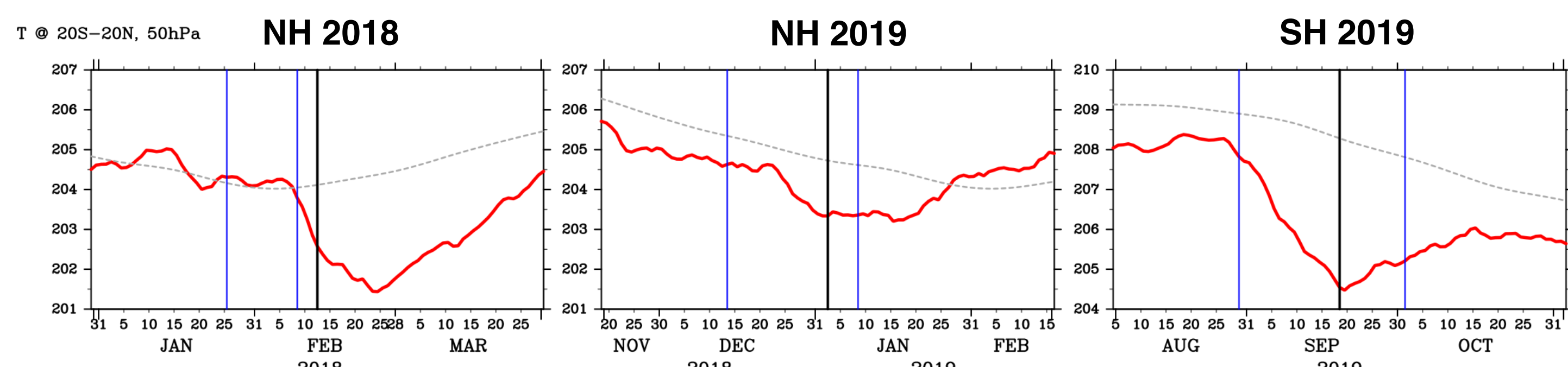
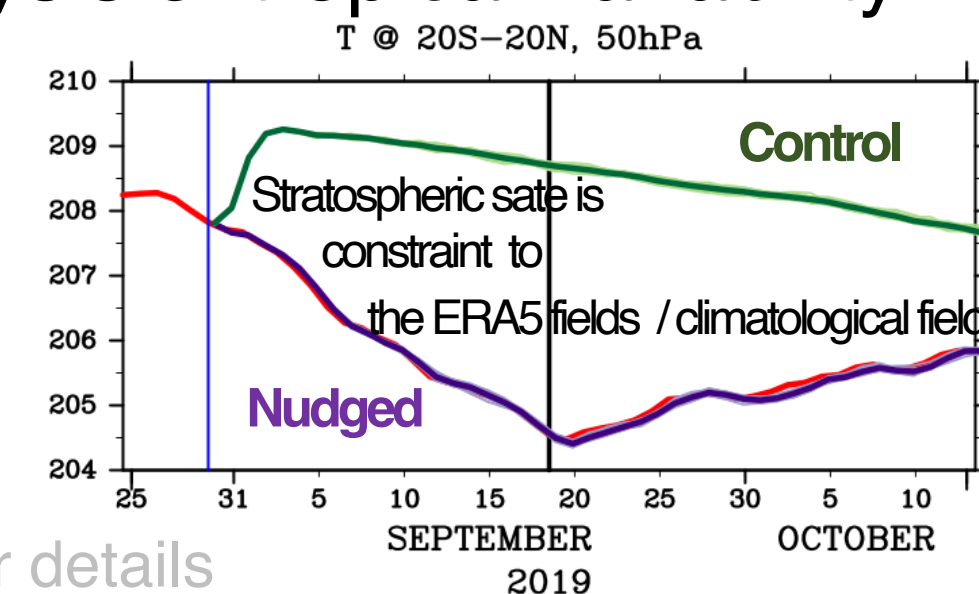


Figure 1. Time series of lower stratospheric temperature (50 hPa, 20°S–20°N) during the three target events of SNAPSI project. The red line and gray dashed line indicate ERA5 and its climatology, respectively. The black vertical line represents the central date of the event, and the blue vertical lines indicate the forecast initial dates.

- ✓ Among the outputs (from about a dozen models*), we analyzed the pre-onset initialization runs for each SSW that allowed for a valid analysis of tropical variability

*though only about half were actually usable

- ✓ The differences between the Nudged and Control runs can be used to quantify the SSW-induced impacts on the freely evolving tropospheric circulation



See Hitchcock et al. (2022) for details

4. Northern Hemisphere Cases

◆ Similar responses, but reflecting event-specific characteristics

- ✓ Clear convective enhancement in response to distinct post-event cooling

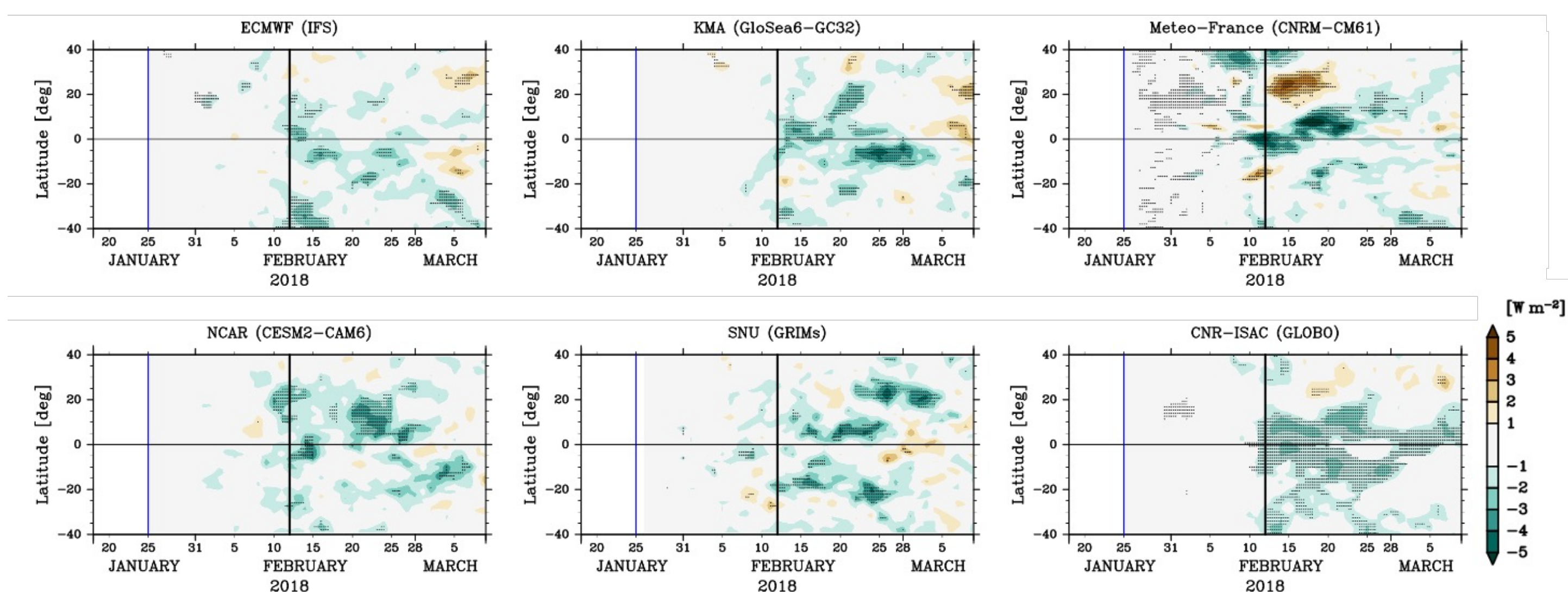


Figure 5. Same as Figure 3, but for the NH 2018 case.

- ✓ Gradual pre-event impacts associated with broad circulation changes

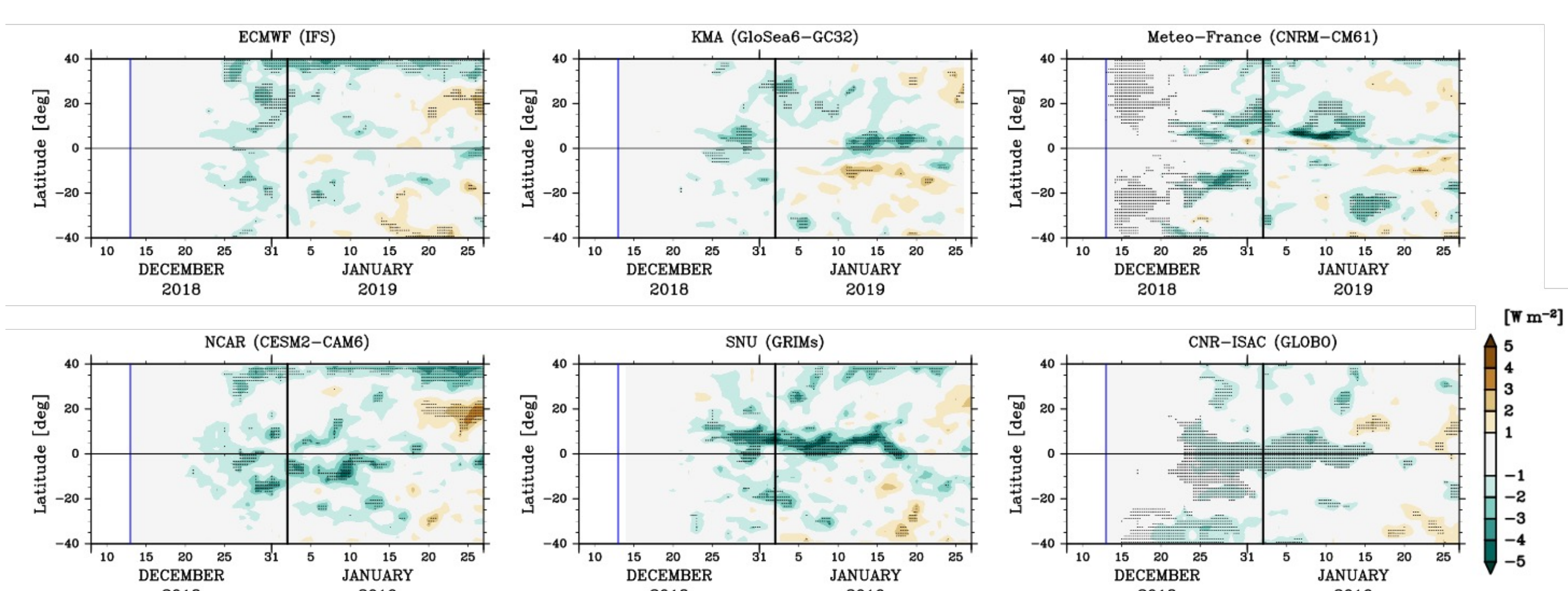


Figure 6. Same as Figure 3, but for the NH 2019 case.

5. Summary and Discussion

◆ Overview of Tropical Convective Responses to SSWs in SNAPSI

- ✓ **General Convective Enhancement:** Confirmed across all examined models, consistent with previous single-model nudging experiments.
- ✓ **Inter-Model Diversity:** Response intensity and spatial patterns vary, broadly reflecting each model's climatological representation.
- ✓ **Majority Response:** (for the SH 2019 case)

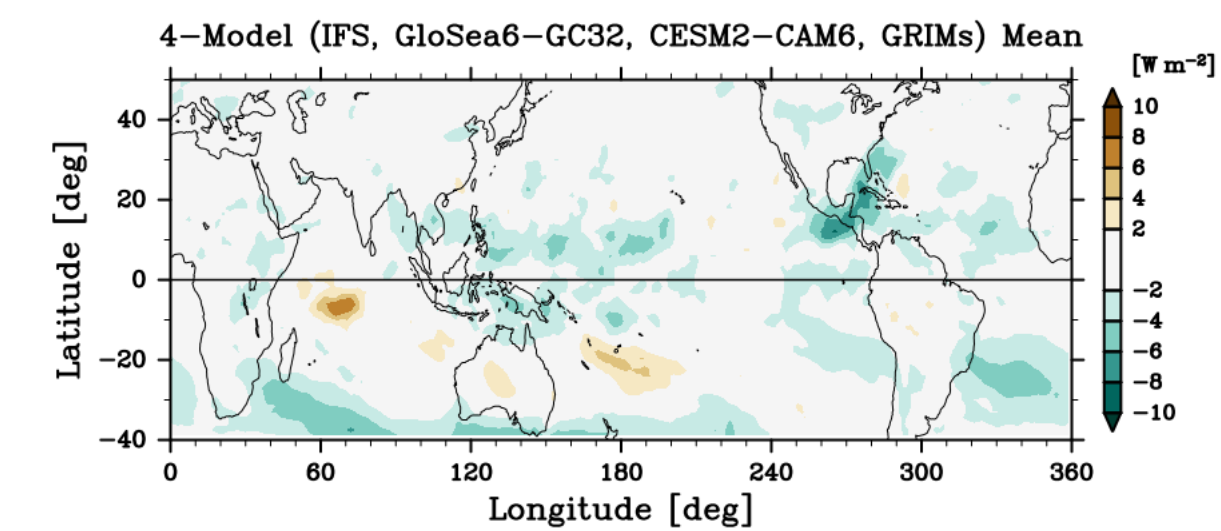


Figure S1. Same as Figure 3, but for the mean of four models that show convective enhancement with similar timing.

◆ Importance of Further Phenomenon-Specific Evaluations

- ✓ **Role of Transient Disturbances:** Variations from low to mid-latitudes appear to reflect the development of specific phenomena (e.g., TC-like vortices). Do individual model responses depend on their ability to sustain well-developed convective systems from the early forecast leads?

3. Southern Hemisphere Case

◆ General enhancement, with variations in its timing and intensity

- ✓ Most models show an enhancement of convective activity (in their convective hot spots) around the mature phase of the LS cooling, consistent with [previous results](#) Noguchi et al. (2020)
- ✓ However, exceptions (e.g., CNRM-CM61) exist where organized responses are less apparent, instead suggesting the contribution of advective processes
- ✓ The interplay between convective triggering and upper-level temperature/stability changes (inferred from the limited model outputs) remains complex

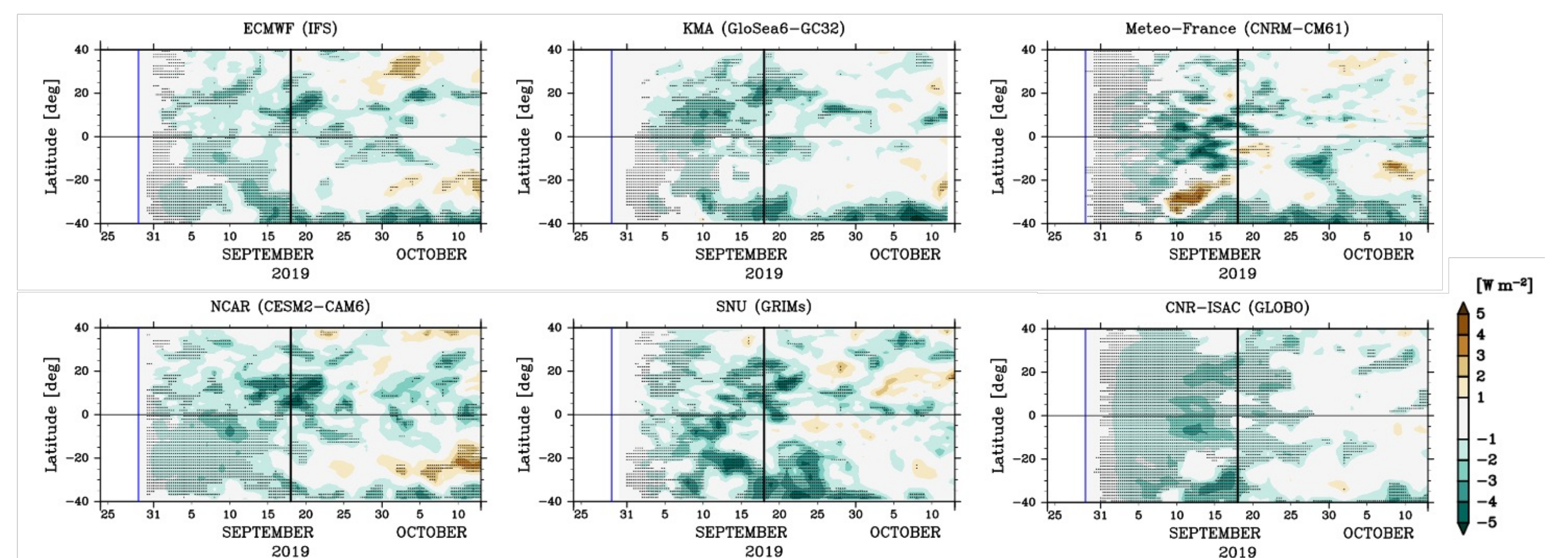


Figure 2. Time-latitude cross sections of SSW impacts on tropical convective activity for the SH 2019 case. Ensemble mean differences (Nudged minus Control) of the zonal-mean OLR are shown for each model. Regions where the difference is significant at the 90% confidence level (estimated by Welch's *t*-test) are stippled.

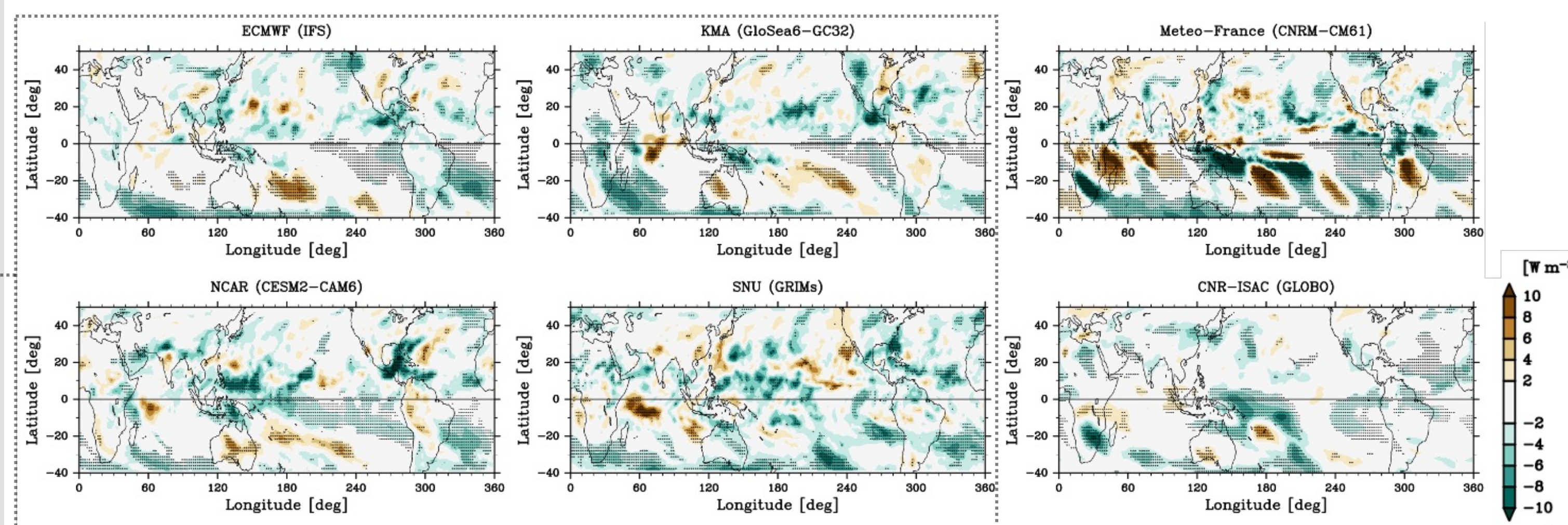


Figure 3. Longitude-latitude cross sections of SSW impacts on tropical convective activity for the SH 2019 case. Ensemble mean differences (Nudged minus Control) of the OLR averaged over the last half of September are shown for each model. Regions where the difference is significant at the 90% confidence level (estimated by Welch's *t*-test) are stippled.

◆ Different contributions of parameterized convection to precipitation

- ✓ Convective precipitation is generally the dominant contributor, but non-convective precipitation contributes significantly in some models

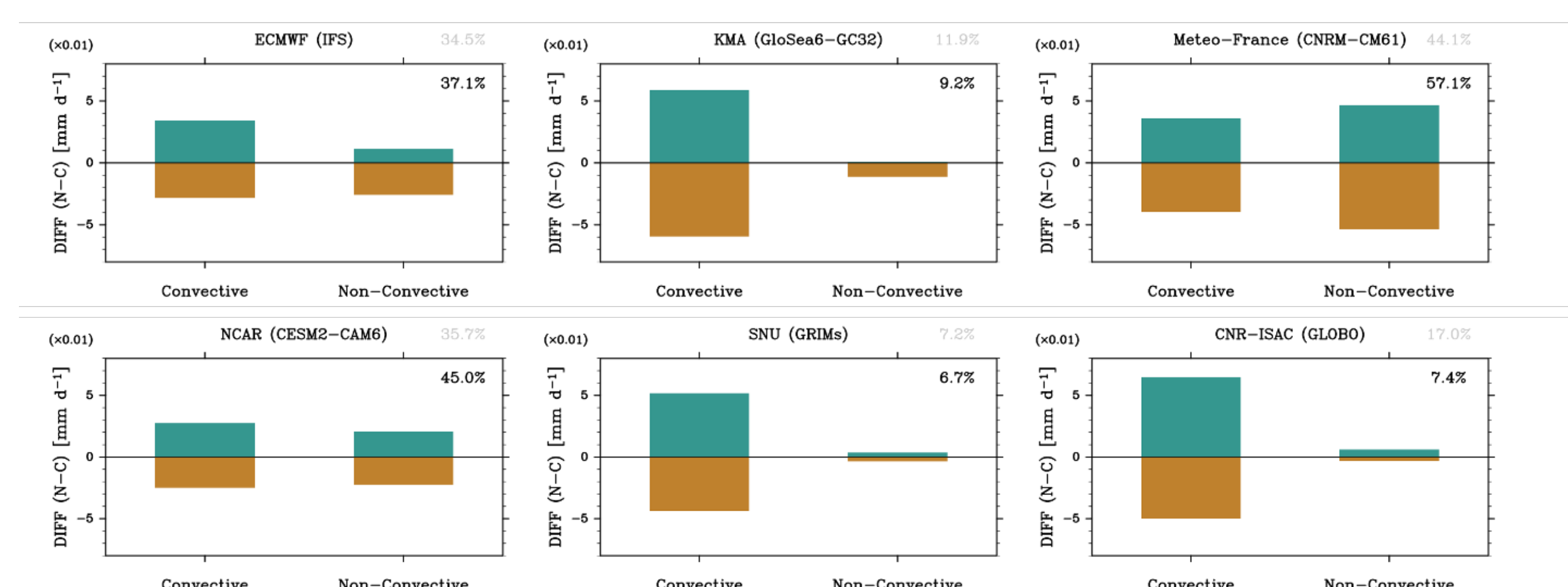


Figure 4. Contributions of parameterized processes for each model. Ensemble mean differences (Nudged minus Control) of zonal-mean convective and non-convective precipitation for September, averaged over 30°S–30°N. Numbers inside (outside) the panels represent the percentage of non-convective precipitation to total precipitation for the difference between Nudged and Control (the Free run).