Role of the SST coupling frequency and « intra-daily » SST variability on ENSO and monsoon-ENSO relationship in a global coupled model

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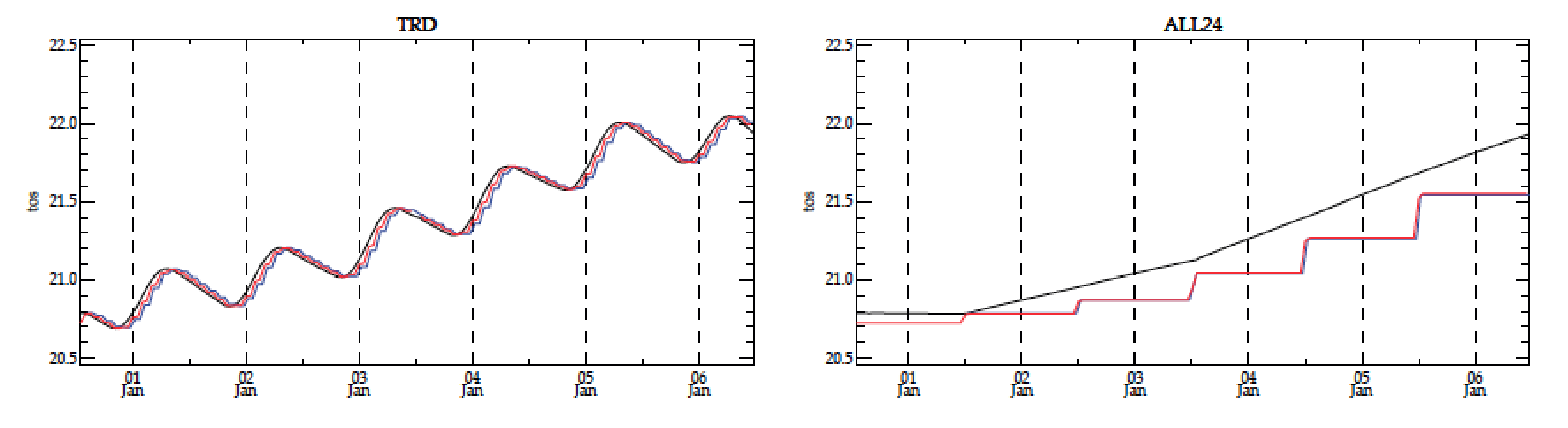
Past coupled studies on diurnal variability

Danabasoglu et al. (2006), Bernie et al. (2008), Ham et al. (2010) have contrasted 1-day air-sea coupling to 1-3 h coupling experiments:



Typical time steps in models: atmosphere 360 s; ocean 2400s; coupling 7200s

➔With 1-day air-sea coupling diurnal variations of oceanic quantities are not simulated

➔Coupling steps of 1 to 3-h lead to:

1)an increase of tropical SSTs caused by diurnal rectifications of daily mean SST (shoaling of the mixed layer and more warming during day-time; deepening of the mixed layer and less cooling during night-time)

2)Weakening of ENSO magnitude due to a cloud shading effect

3)Improvement in MJO

GOAL AND QUESTIONS

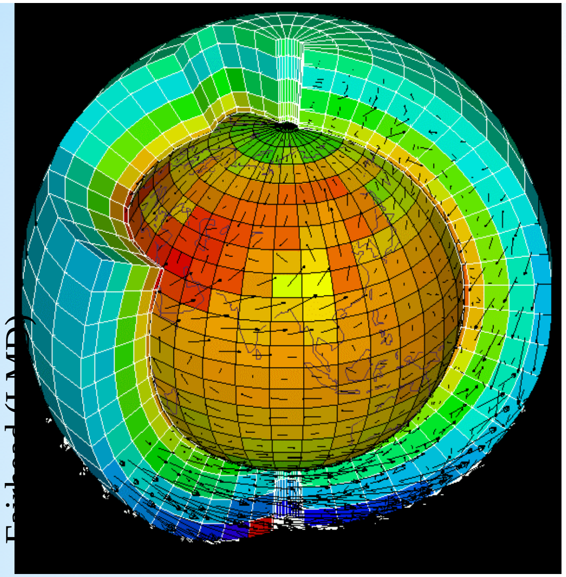
Our Goal:

Explore the impact of «intra-daily» SST variability and coupling on the development of large scale coupled phenomena such as ISM and ENSO through scale interactions and ocean-atmosphere coupling.

Open questions about the impact of the diurnal cycle on the tropical climate and its variability:

- Mainly through the rectification of the mean state by the presence of the solar cycle and its role on the air-sea coupling (Danabasoglu et al., 2006; Bernie et al., 2008; Ham et al., 2010) ?
- What is the contribution of the SST « intra-daily » variability ?
- How to separate the contributions of the solar cycle and the high frequency SST variability ?

The SINTEX-F2 coupled model

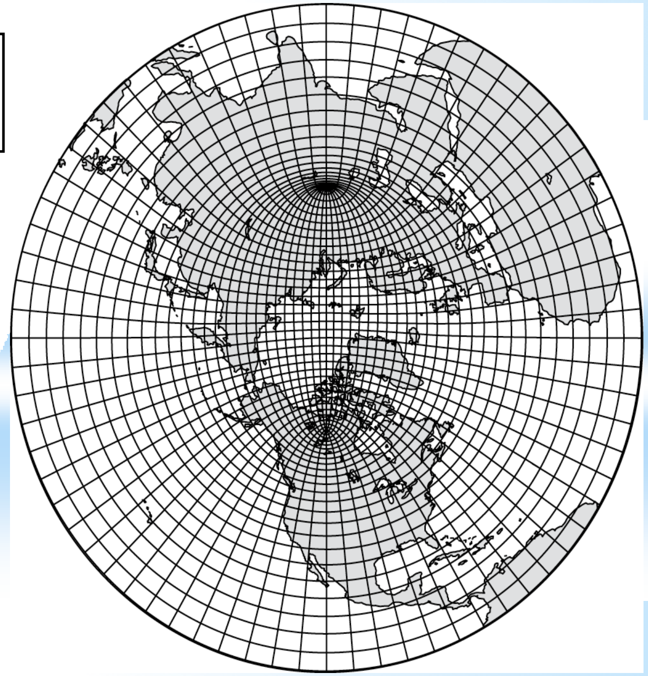


atmosphere:
ECHAM5.3
T106 L31
320×160×31

OASIS 3

ocean/sea ice:
NEMO v3.2
ORCA05-LIM2
722×511×31
722×511×301

Use of a high resolution ocean-atmosphere coupled model



ORCA05 mesh (1 point over 10)

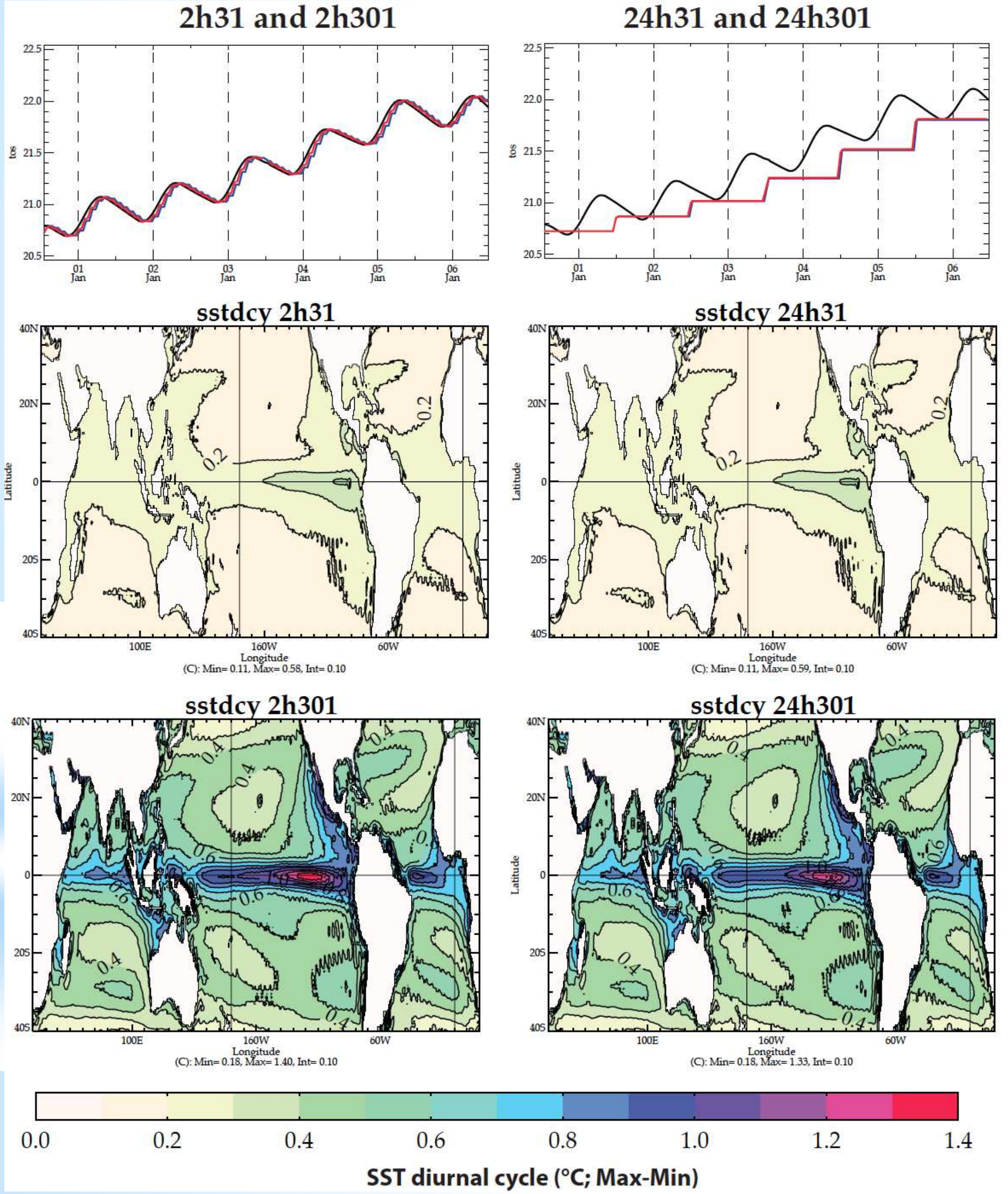
Method: coupled experiments

- A realistic diurnal cycle in the ocean needs 1 m resolution near the surface
➔301 levels instead of 31 in the ocean in 2h301 and 24h301

- Impact of the SST « intra-daily » variability without interfering with the solar diurnal cycle and its impact on the mean state
➔Coupling frequency of 2h excepted for the SST which is sent daily in 24h31 and 24h301

Experience name	2h31	24h31	2h301	24h301
Oceanic vertical resolution	31 (10m)	31 (10m)	301 (1m)	301 (1m)
SST coupling frequency	2h	24h	2h	24h
Other data coupling frequency	2h	2h	2h	2h
Experience length (in years)	110	110	75	75

Impact on SST diurnal cycle

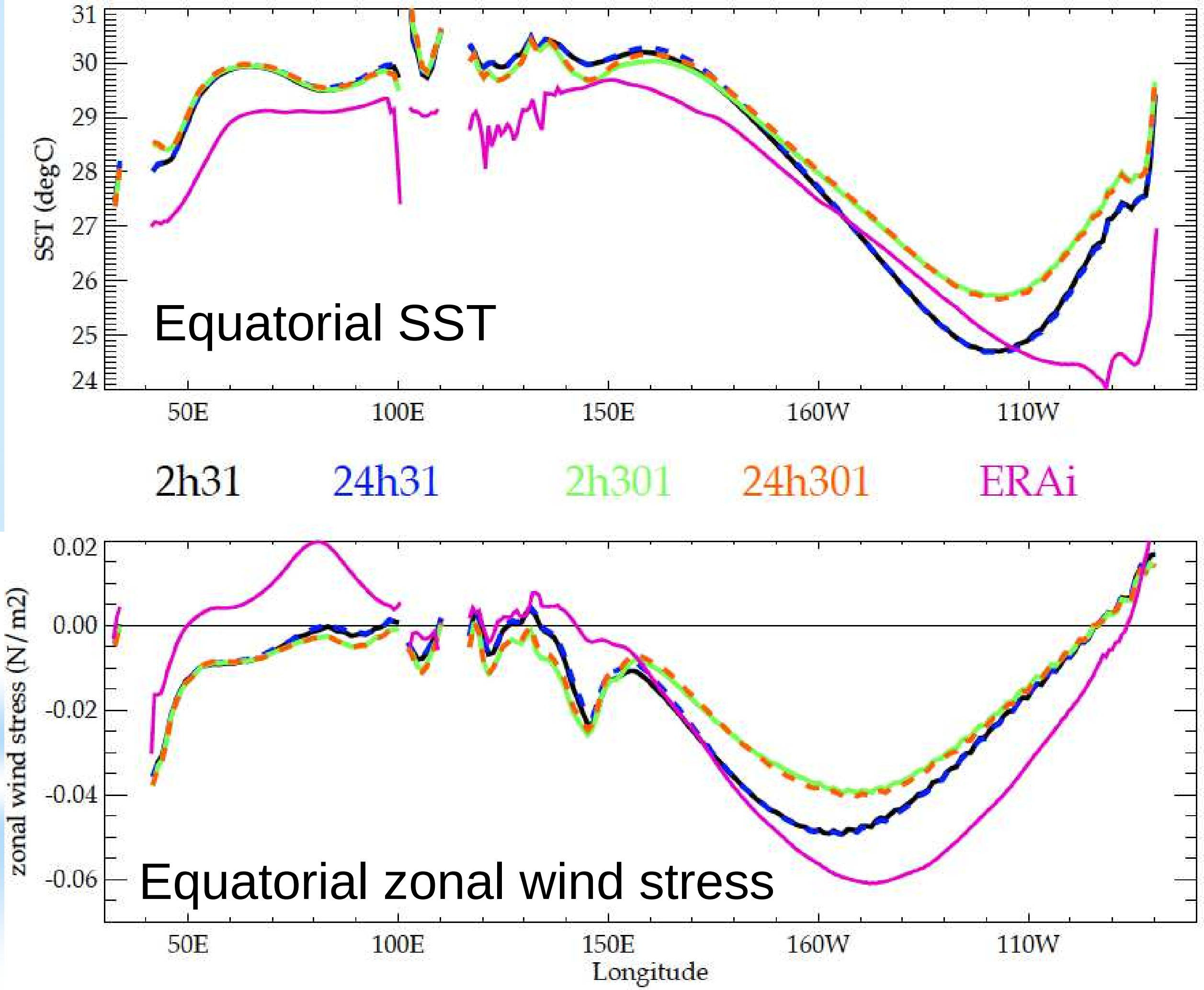


➔High vertical oceanic resolution (eg 1 m near the surface in 2h301 and 24h301) gives a realistic SST diurnal cycle

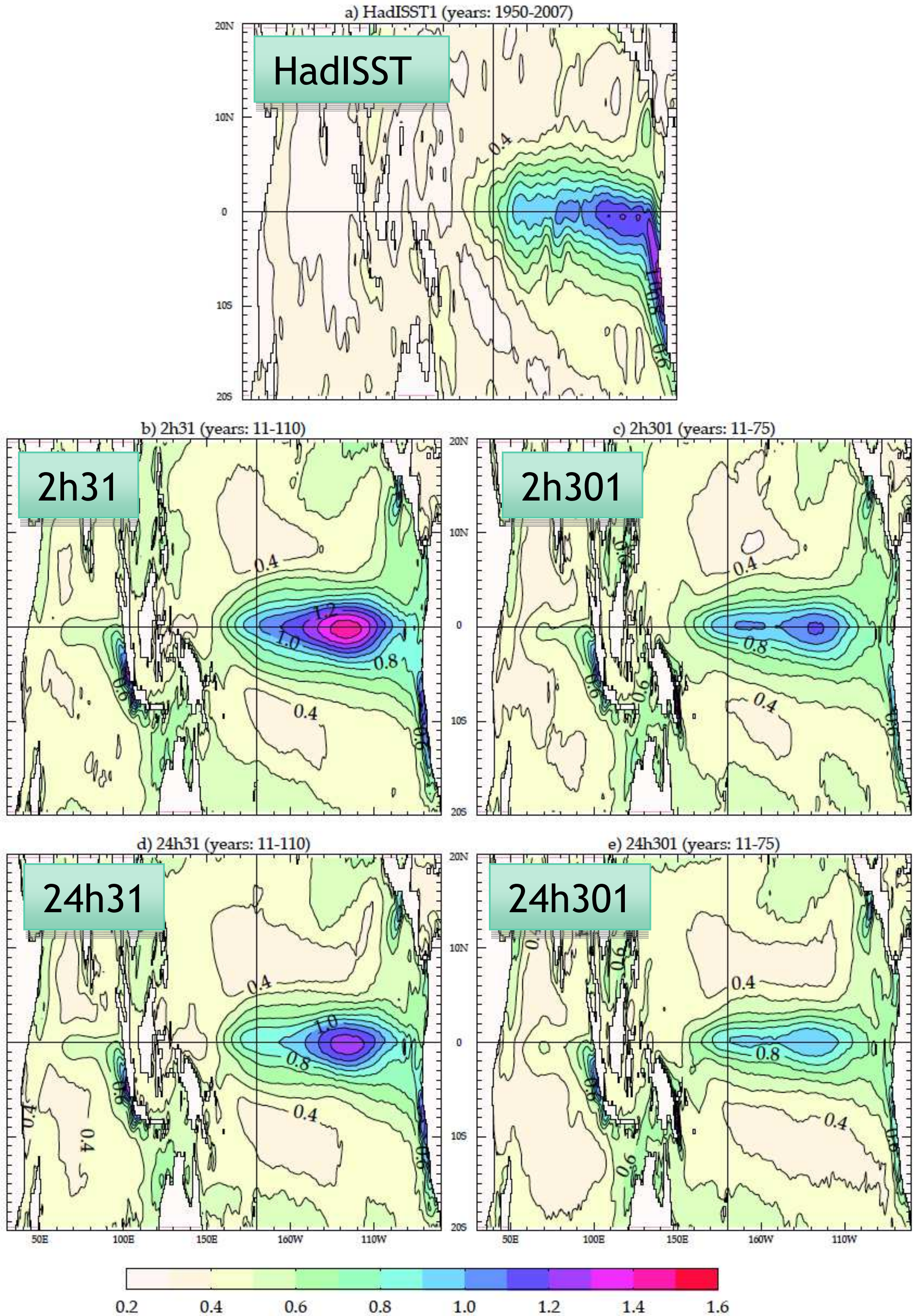
➔No changes from 2 hours to daily SST coupling

➔But the atmosphere does not see the high frequency SST variability in 24h31 and 24h301 !

Impact on the mean state



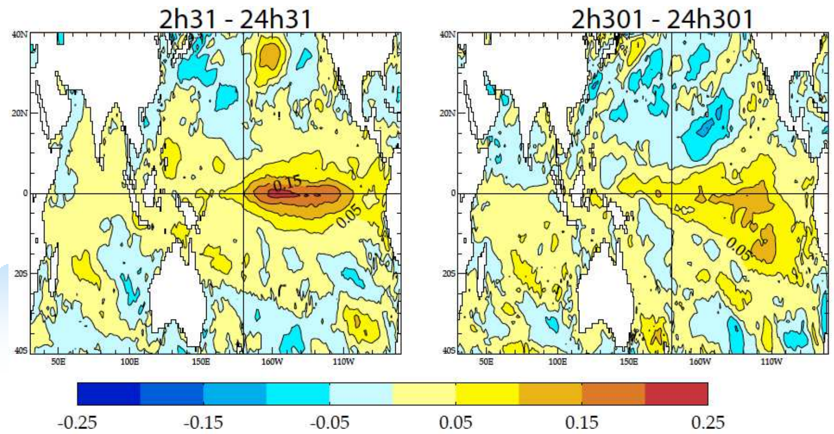
➔Contrary to changes of the vertical oceanic resolution, 2 hours SST coupling has no significant impact on the mean state, even with 1 meter resolution near the surface



Impact on ENSO amplitude

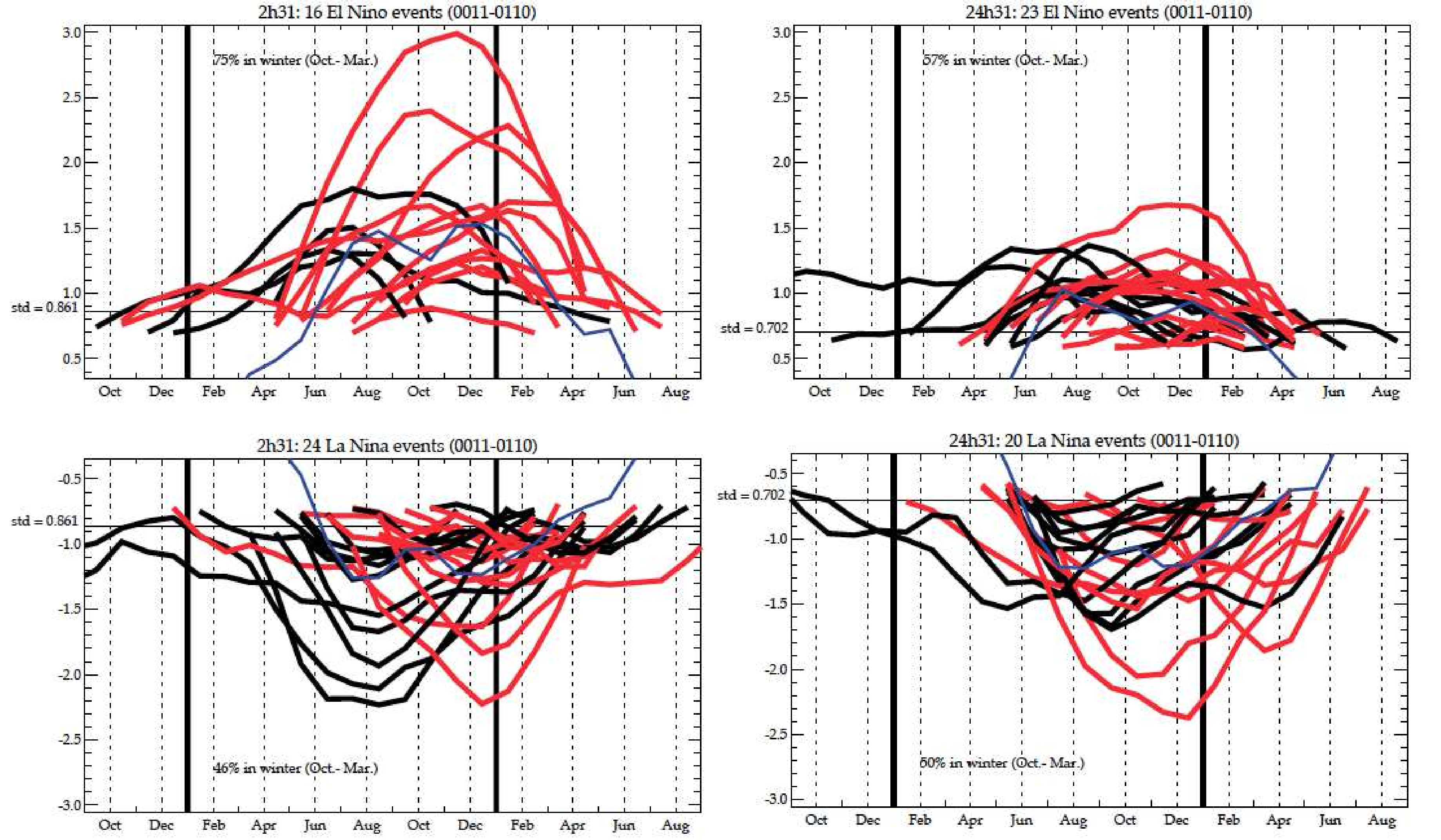
→ Significant decrease of SST interannual variability with high vertical oceanic resolution (-15-20%)

→ Significant increase of SST interannual variability with 2 hours SST coupling (+15%) !



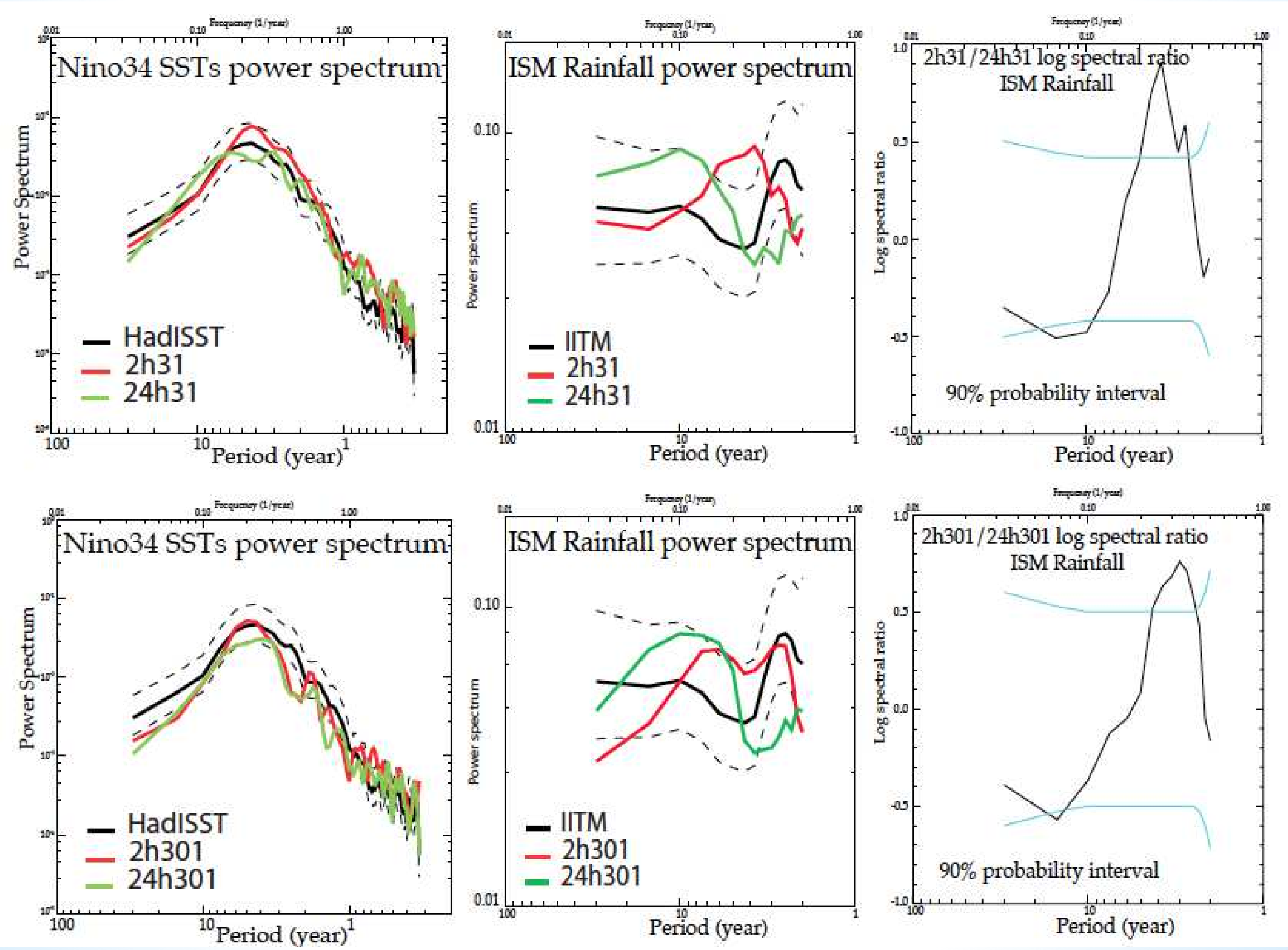
Impact on seasonal phase-locking of climate variability

➔ 2 hours SST coupling experiments (2h31 and 2h301) correct some of the biases in SINTEX-F2 and have more realistic seasonal phase-locking of key climate indices both in the Pacific and Indian Ocean !

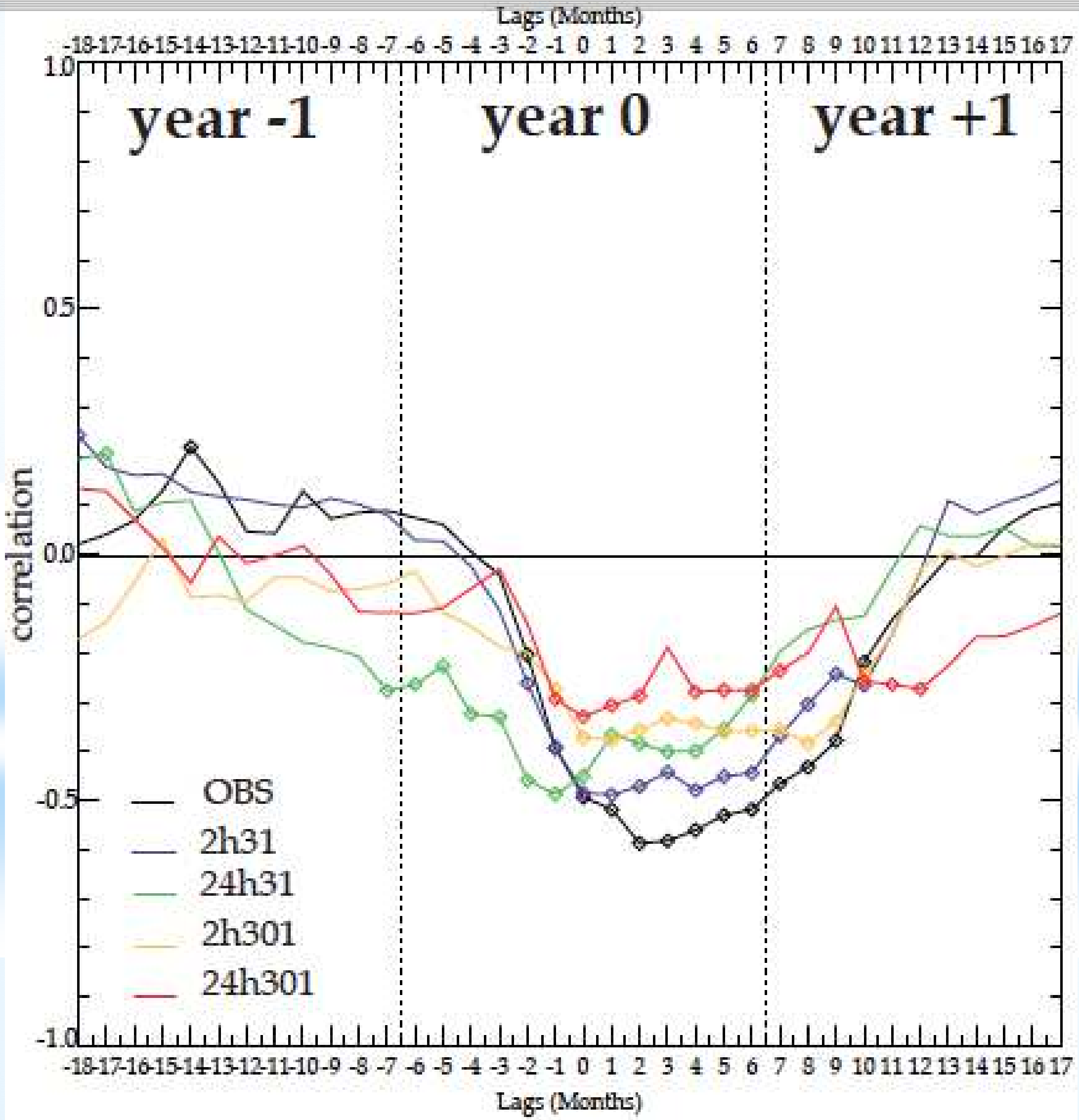


Impact on Nino34 SST and ISM rainfall power spectra

➔ 2 hours SST coupling experiments (2h31 and 2h301) have much more realistic power spectra both for ENSO and ISM rainfall, more energy at almost all periods from a few months to six years !



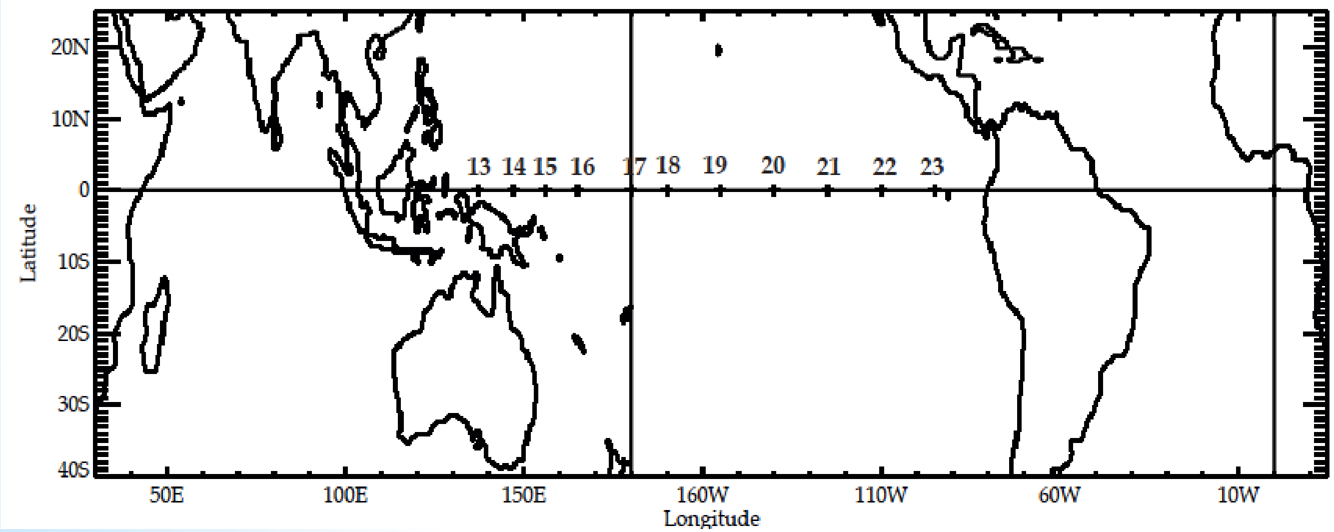
«Intra-daily» SST variability corrects much of the ISM-ENSO relationship problem in SINTEX-F2 !



Why is ENSO stronger and better with 2 hours SST coupling and SST diurnal cycle ?

Stronger ocean-atmosphere coupling
and
time scale interactions between submonthly (2-30 days) and interannual variabilities !

High frequency (2 h frequency) oceanic data from a moored buoy array in the coupled simulations



Data:
temperature,
water flux,
wind stress, …

	Pt013	Pt014	Pt015	Pt016	Pt017	Pt018	Pt019	Pt020	Pt021	Pt022	Pt023
2h31	4.25	2.89	2.40	*2.03*	**1.44**	**0.98**	**0.49**	0.31	0.30	0.36	1.11
24h31	4.19	2.84	2.45	*2.00*	**1.32**	**0.76**	**0.28**	0.20	0.22	0.33	0.97

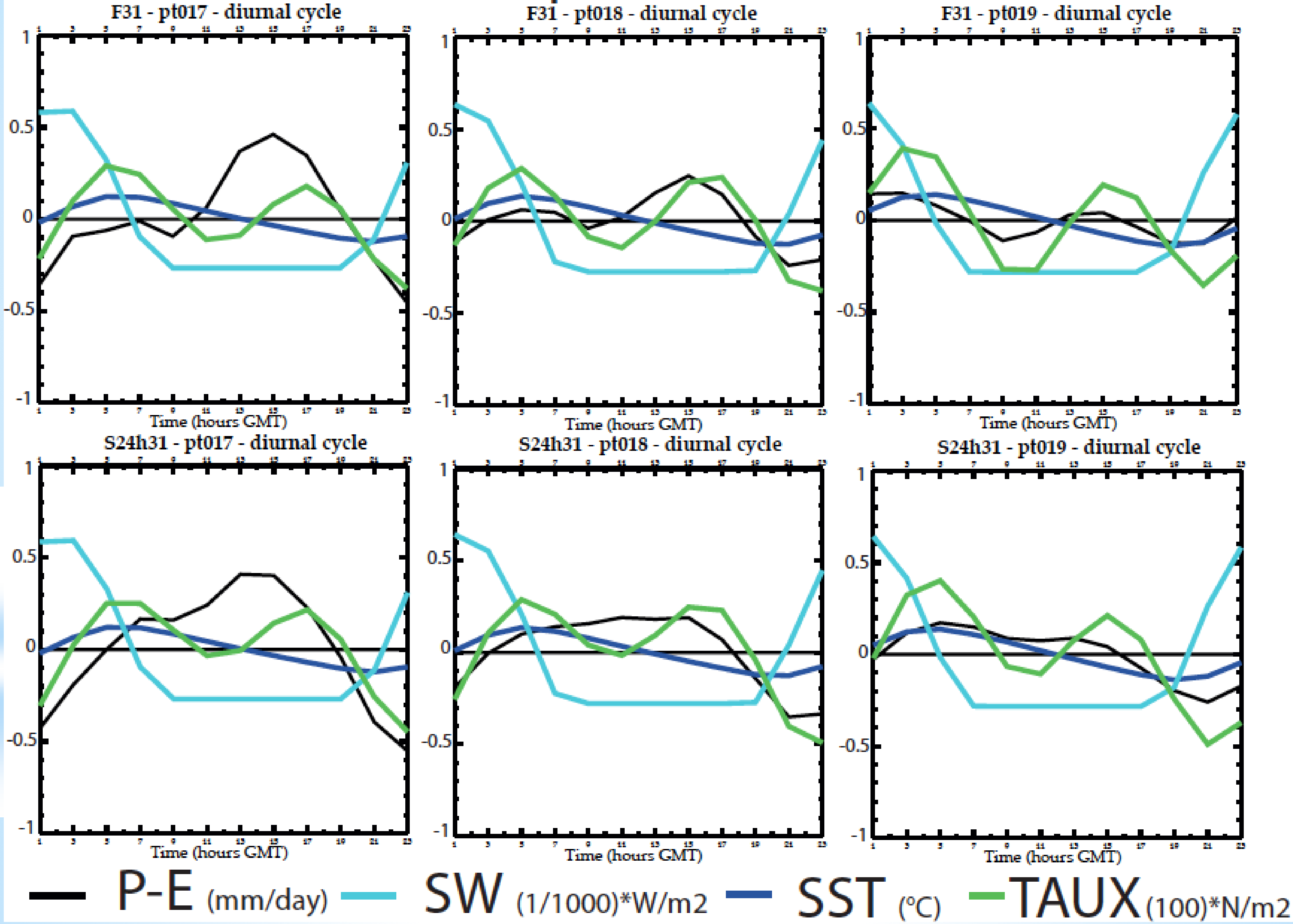
	Pt013	Pt014	Pt015	Pt016	Pt017	Pt018	Pt019	Pt020	Pt021	Pt022	Pt023
2h301	4.36	2.77	2.39	*2.03*	1.52	1.18	0.63	**0.54**	**0.55**	**0.65**	1.40
24h301	4.03	2.65	2.34	*2.03*	1.47	1.11	0.57	**0.43**	**0.43**	**0.53**	1.33

Amplitude (std) of diurnal cycle of

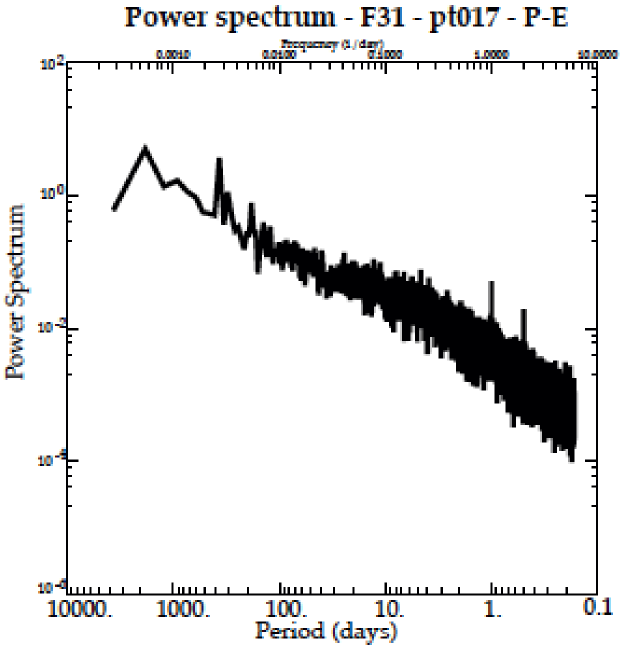
P-E = PRECIPITATION –EVAPORATION

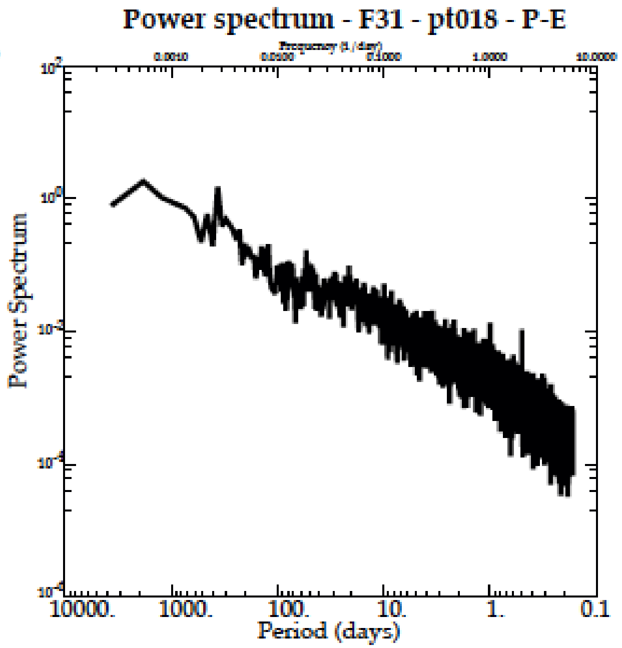
(mm/day) from 2 hourly data

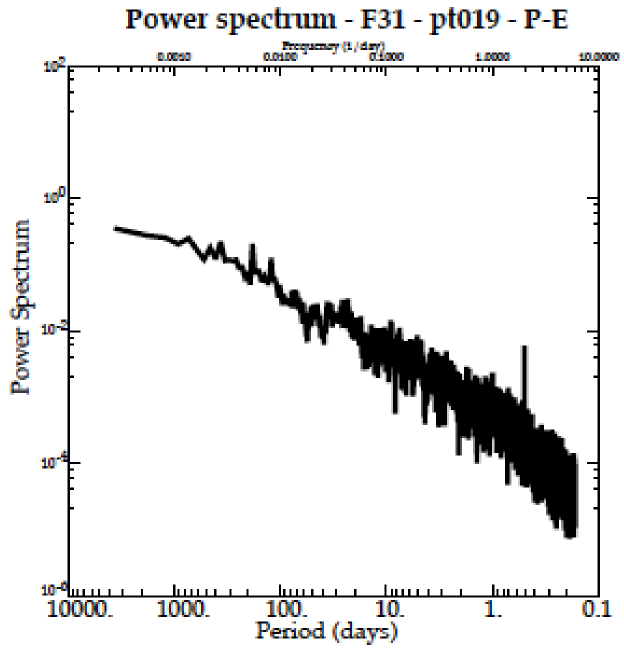
Central equatorial Pacific

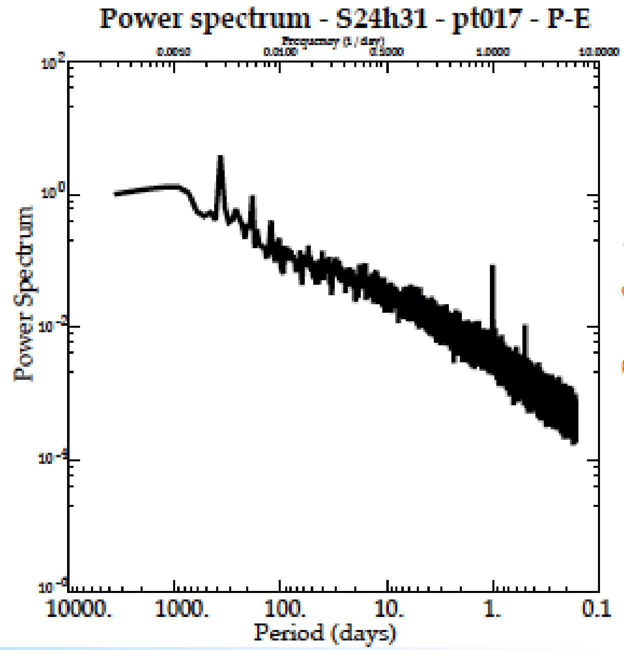


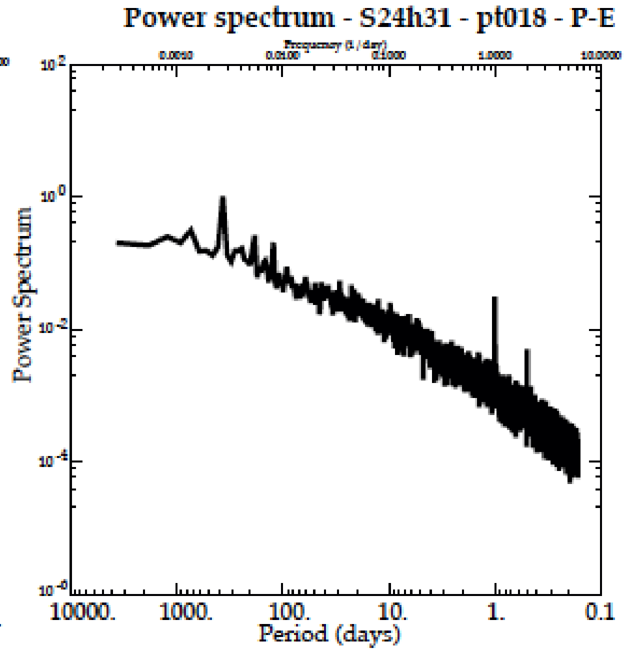
Central equatorial Pacific

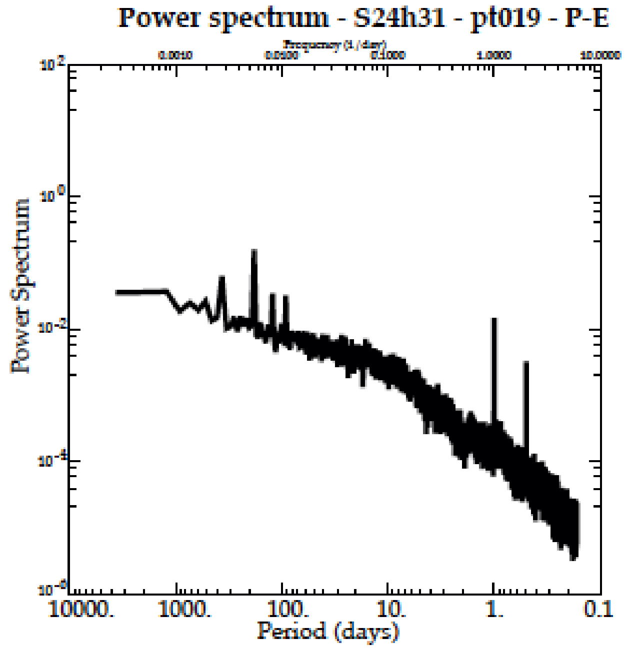




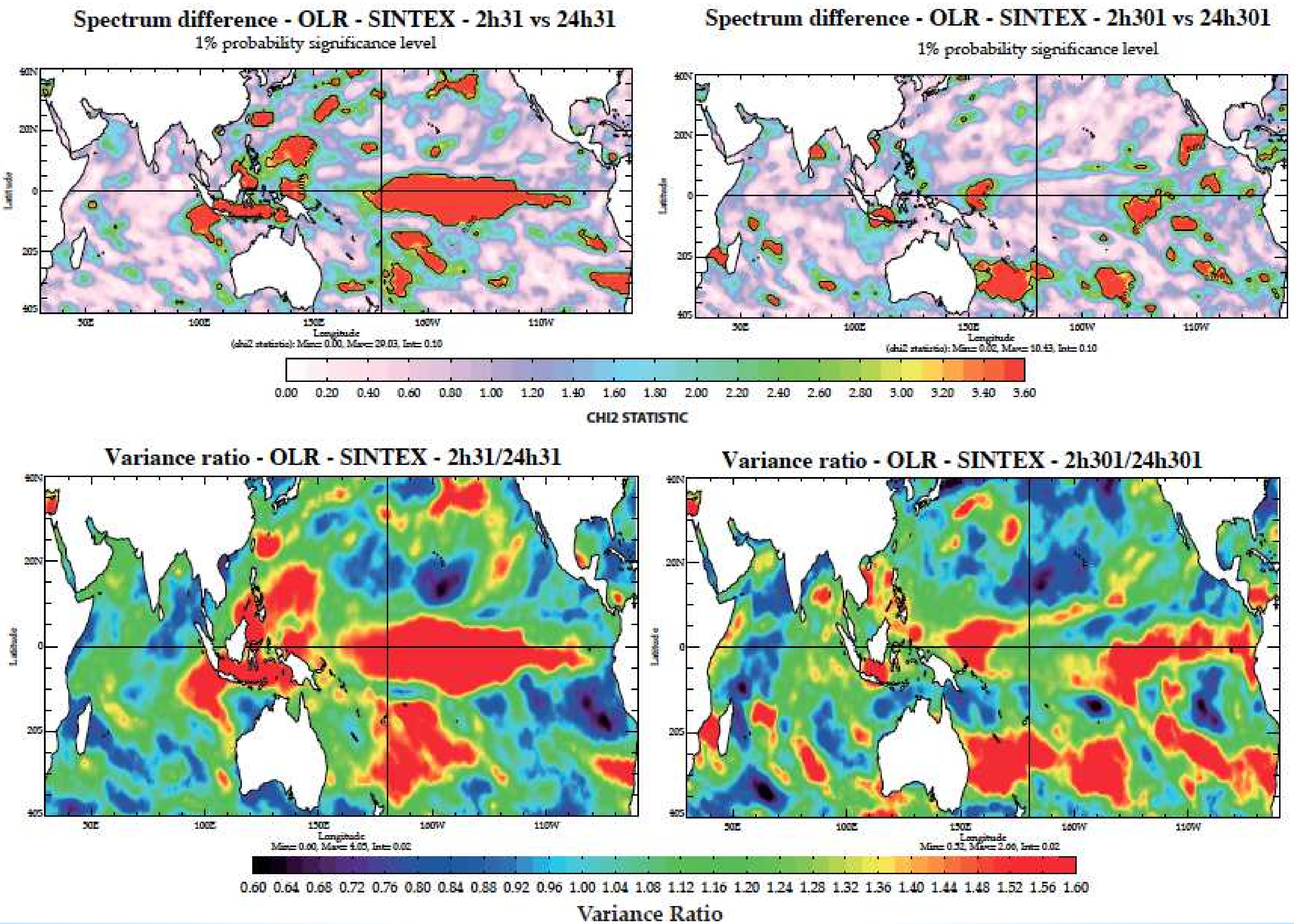






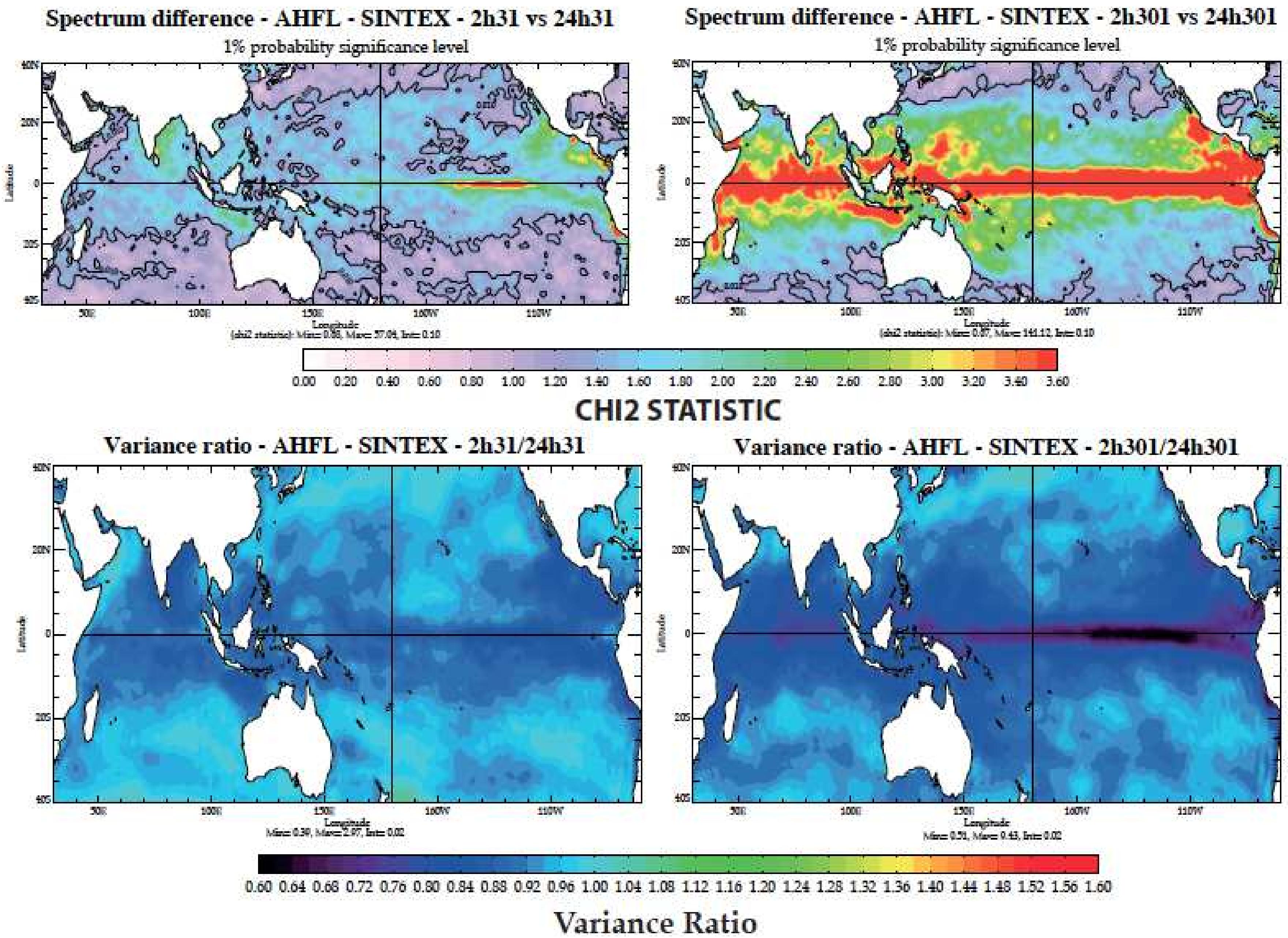


PERIOD : 365-2048 DAYS

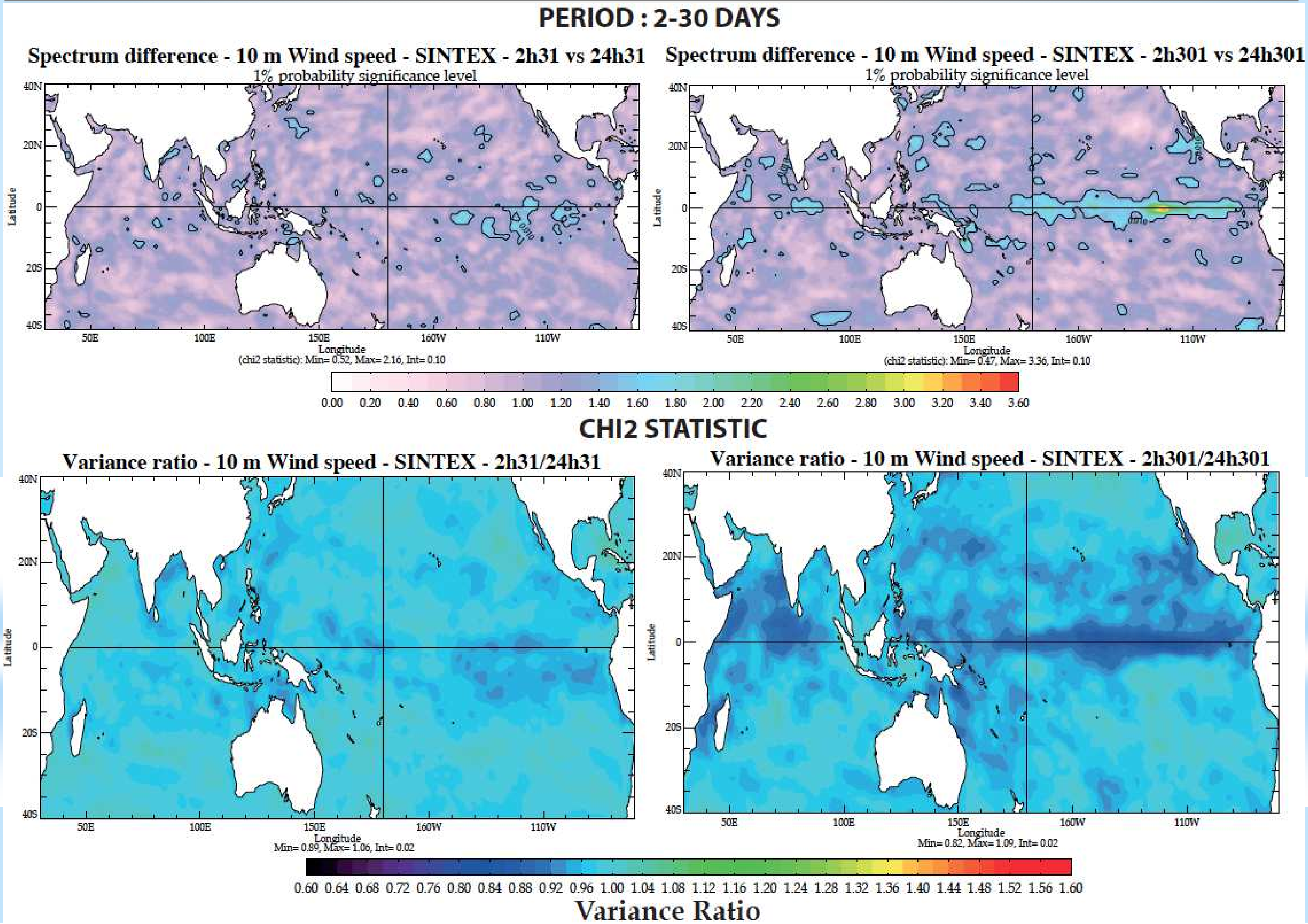


Submonthly time scale : decreased latent heat flux variability with 2-h SST coupling

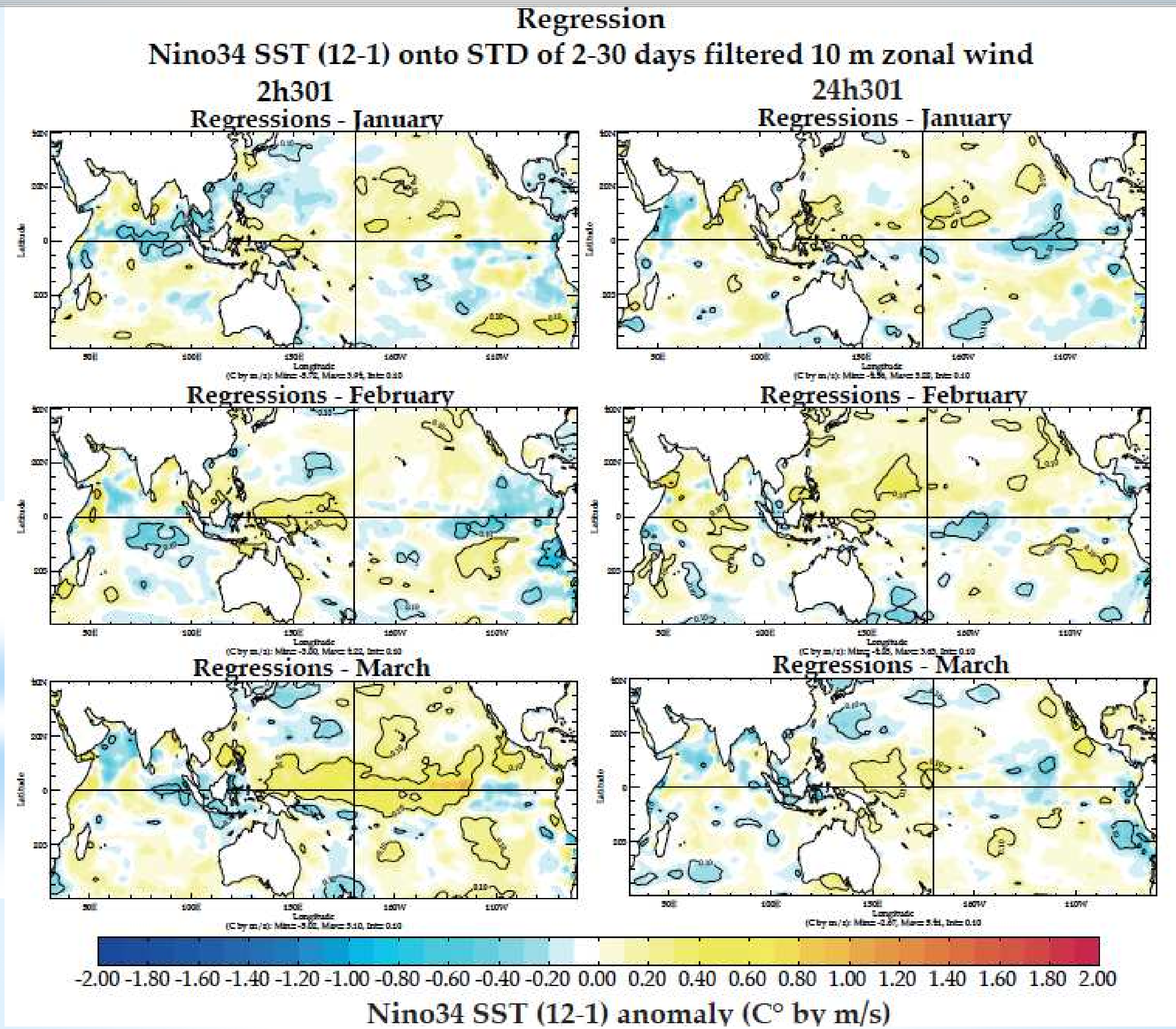
PERIOD : 2-30 DAYS



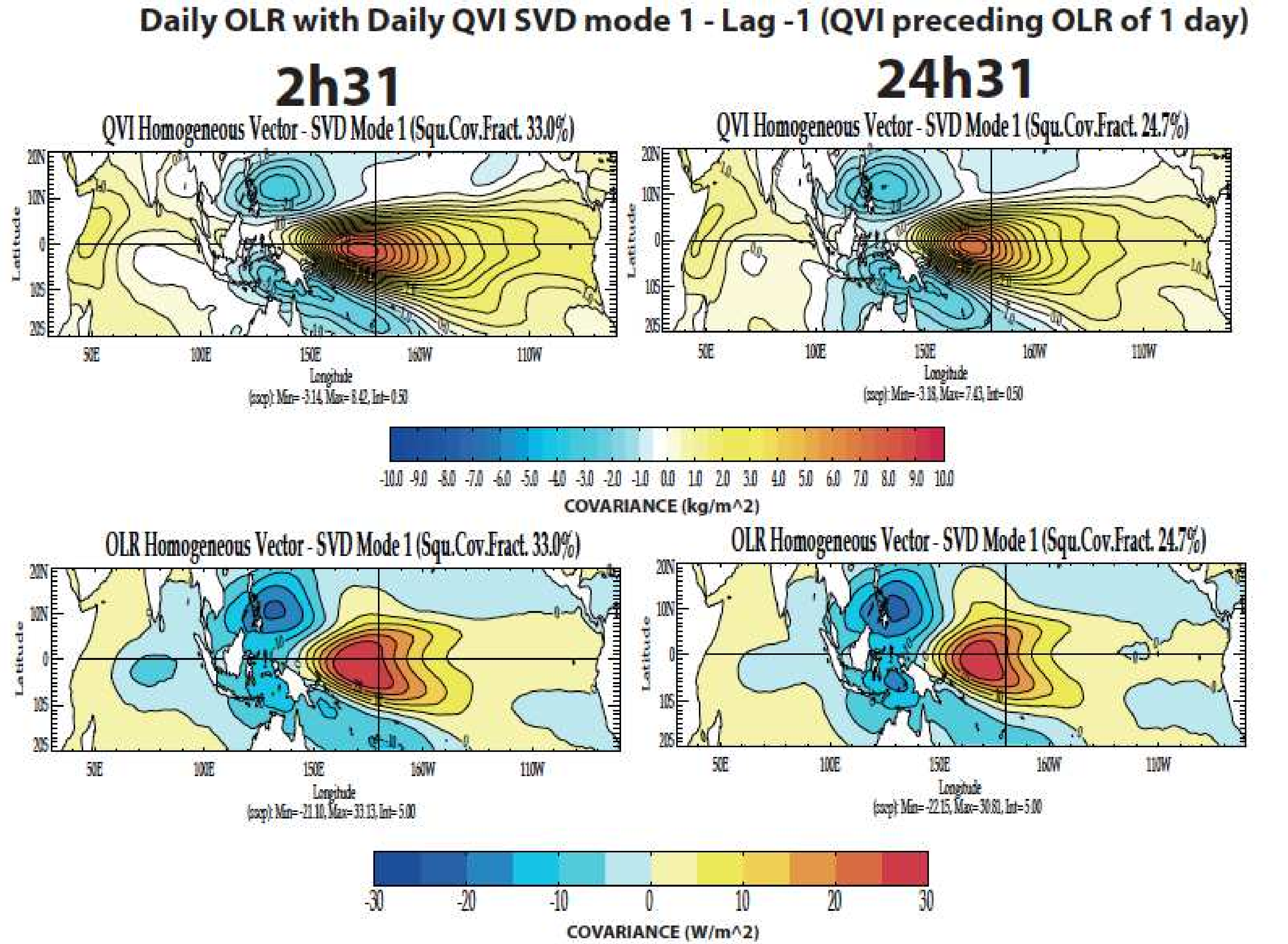
Submonthly time scale : decreased wind speed variability with 2-h SST coupling



Stronger impact of high frequency zonal wind variability (WWBs) on ENSO !



Stronger QVI and OLR relationships at the daily time scale !



CONCLUSIONS
related to 2 vs 24 hours SST coupling frequency in SINTEX-F2

- No significant impact on mean state and seasonal cycle
- Enhancement of SST interannual variability (+15%)
- Changes in the the physionomy of ENSO events, improvement of the space-time evolution of ENSO SST anomalies and the phase-locking to the seasonal cycle
- Much more realistic ENSO and ISM rainfall power spectra
- Significant improvement of the lead-lag ENSO-ISM relationships due only to better ENSO simulation
- Intensification of the ocean-atmosphere coupling strength and time scale interactions between high frequency and interannual variabilities with 2 hours SST coupling
- Stronger QVI and OLR lead and lag relationships at the daily time scale

➔ **Evidence for the importance of the diurnal cycle, scale interactions and coupling strategy for improving the coupled simulation of climate variability !**