A parameterisation for sea-breeze enhancement of convective rainfall in a global model

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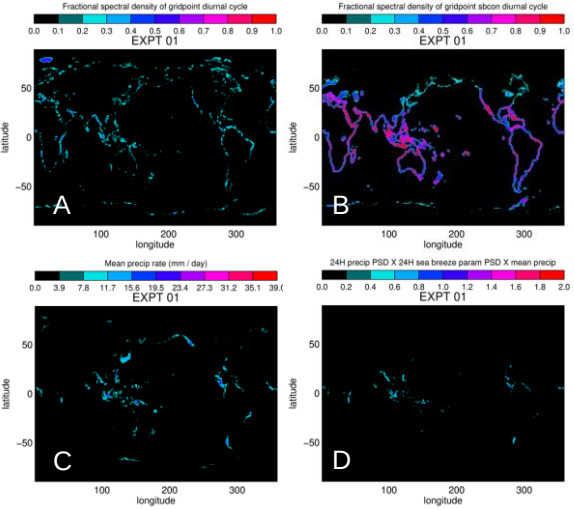
Background

Tropical rainfall variability is strongly dominated by the diurnal and seasonal cycle, and in coastal regions (such as the Maritime Continent) diurnal precipitation variability is thought to be dominated by land-sea breeze circulations. However most global models are too coarse to resolve such small-scale circulations and therefore their associated impacts on rainfall.

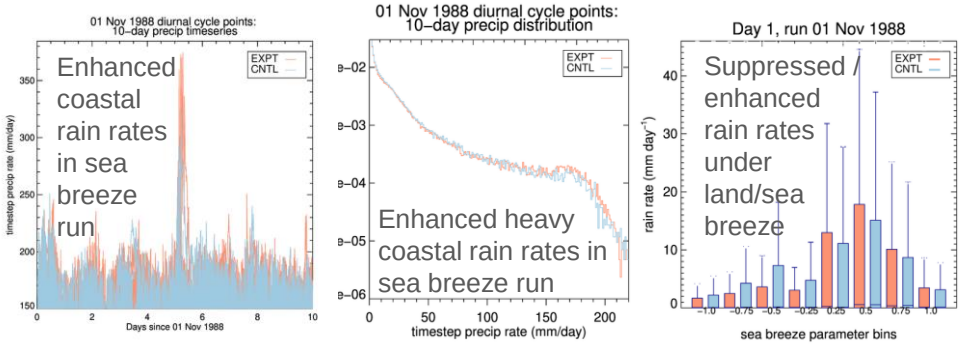
Parameterisation description: GA6 N96, 10-day initial timesteps and 3-month DJF ensemble runs

Coastal tiling used to determine average land vs average ocean thermal contrast at each coastal grid point. If ocean-land thermal contrast exceeds +/-0.75 K, sea/land breeze conditions are diagnosed. Sea breeze parameter defined at each grid point as thermal contrast above 0.75K threshold, scaled between [-1,1] (+sea/-land breeze). Modify surface parcel in convection scheme by +1K (sea breeze) or -1K (land breeze) whilst keeping parcel relative humidity constant.

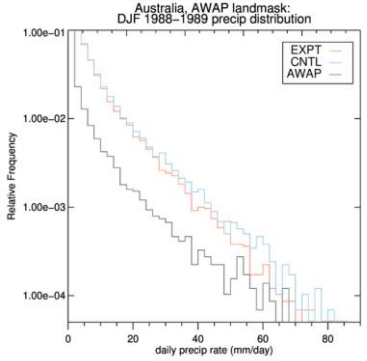


1. Calculate power spectra of sea breeze parameter and of coast-masked precipitation at each grid point. Extract fractional power spectral density of both fields at the 24-hour mode to identify coastal grid points with and strong diurnal precip cycle (Fig A) and a sea breeze (Fig B).
2. Multiply 24h precip fractional power by the 24h sea breeze fractional power (AxB) to suppress points where diurnal precip signal is strong but sea breeze signal is weak.
3. Multiply by mean rain rate (Fig C) at grid point to enhance regions with strong precip and suppress points with weak precip (Fig D, AxBxC).

Global effects,10-day run: rainy diurnal cycle sea breeze coastal points



Australian seasonal effects (DJF)

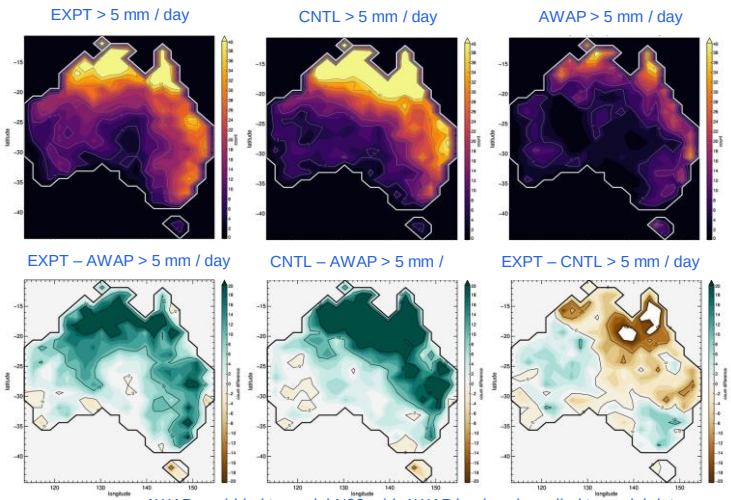


Note: NOT rainy diurnal coastal points as in 10-day analysis of timestep rain. Here we show daily mean rain distribution over entire AWAP land region.

Seasonal daily mean rain distribution across all of Australia shows ***reduced*** overprediction of high intensity rainfall in sea breeze run compared to AWAP observations.

Recall: short timescale timestep rain analysis of only rainy diurnal sea breeze coastal points showed ***increased*** heavy rain in sea breeze run.

Australian seasonal effects (DJF 3-member ensemble means & gridded obs)



Both global model configurations overdo the moderate-to-heavy rain, but the sea breeze version reduces the bias in north Australia and improves the frequency and spatial distribution along the east coast.

The reduction in the wet mainly comes from a reduced frequency of the +5mm/day wet days in the north and northeast, with an increase in the southeast.

AWAP regridded to model N96 grid. AWAP landmask applied to model data.