# Atmospheric cold pools in the Bay of Bengal

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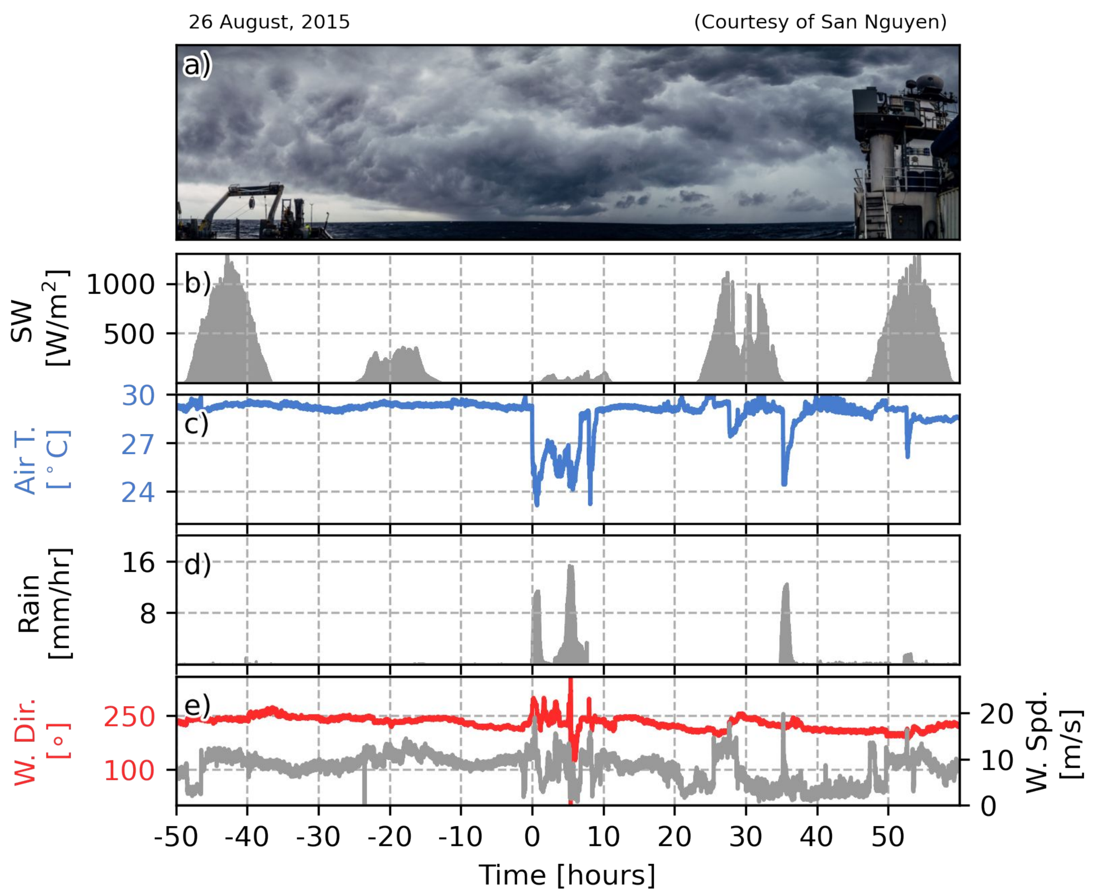
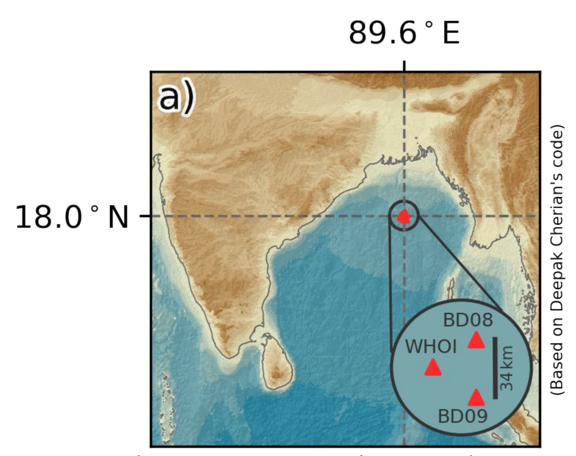
MISOBoB Project

## What are cold pools?

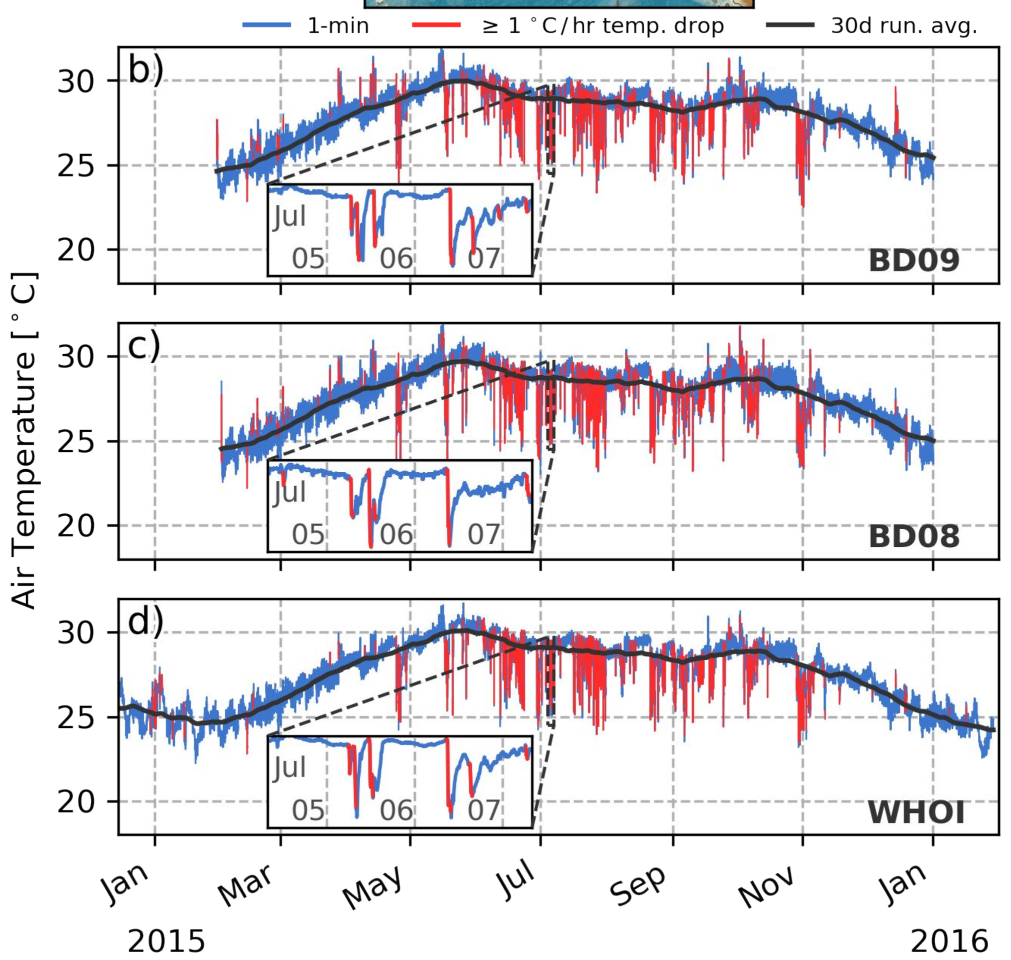
Atmospheric cold pools form over the ocean when falling rain evaporates, leading to a dense cold air mass spreading over the surface. They impact air-sea heat exchanges over tropical regions and give rise to new rainstorms.




## Study area and datasets




- North Bay of Bengal
- NIOT (BD08 and BD09)
- WHOI mooring



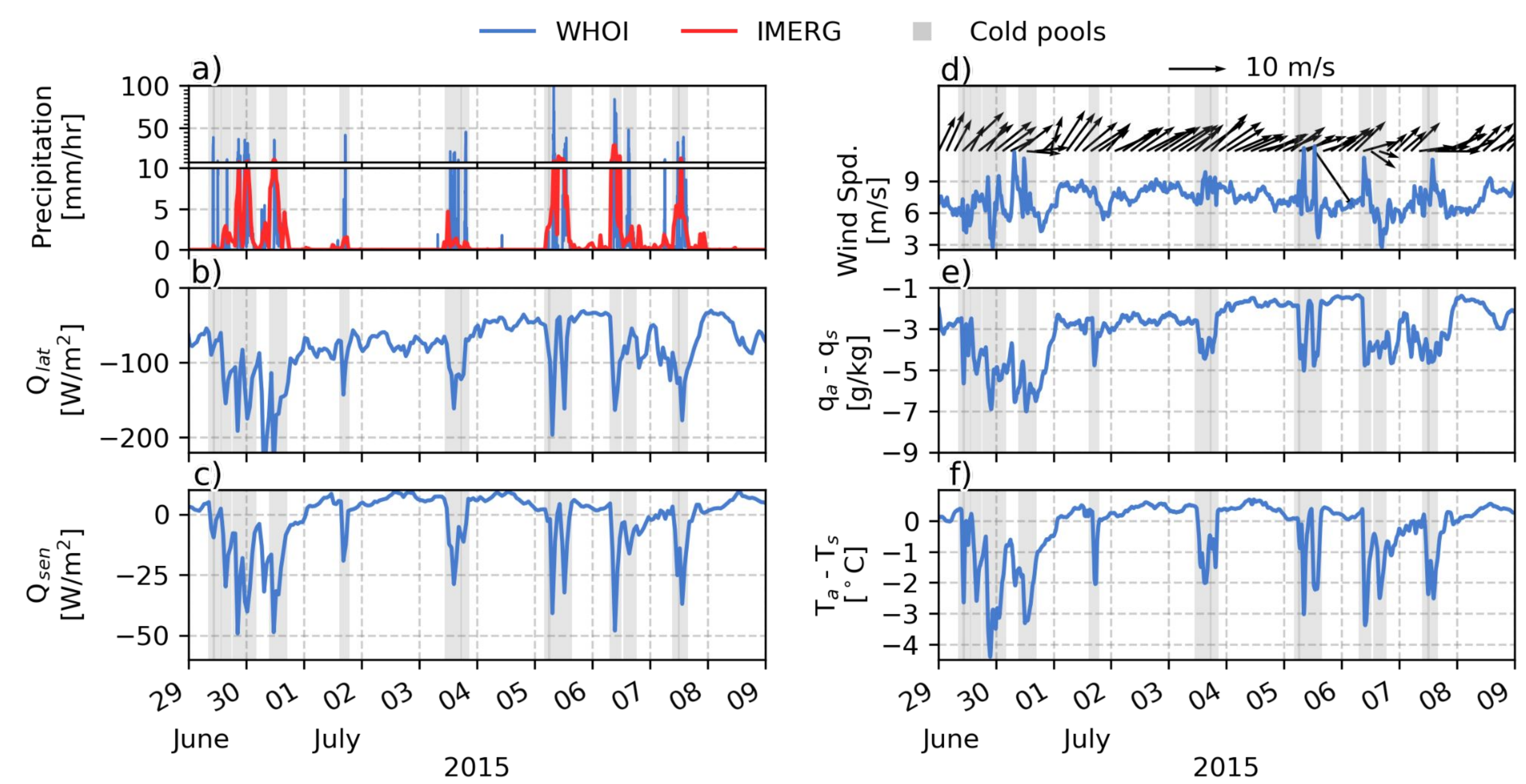

## Air-sea fluxes and rain during cold pools

Most of the striking peaks in the rain rate occur within cold pools, supporting the strong relationship between cold pools and rain events. In fact, this pattern occurs even beyond the selected time range, and ~80% of the total rain in the whole time series occurs within cold pools.

In addition to the remarkable signature in the rain-rate patterns, the cold pools also strongly influence the latent and sensible heat fluxes. For the chosen time range, cold pools can enhance the sensible sea-surface heat loss by 25-50 W/m2, and latent flux due to evaporation by 50-100 W/m2. In July, the average enhancement in latent flux due to evaporation by cold pools is 32 W/m2 above the monthly mean and cold pools occur during ~21% of the time.

The latent and sensible fluxes are enhanced mainly due to the anomalous thermodynamic interfacial differences of humidity (q_a-q_s) and temperature (T_a-T_s). Some cold pools even reached 4ºC colder than the T_s and 7 g/kg drier than the saturated specific humidity at q_s. We also investigate how much of the heat flux enhancement is driven by wind anomalies. The cold pools clearly intensify the wind direction and speed variability, but, after the front, do not necessarily increase the mean wind speed.

$$Q_{sen} = \rho_a c_{pa} C_h S (T_a - T_s) \qquad Q_{lat} = \rho_a L_e C_e S (q_a - q_s)$$

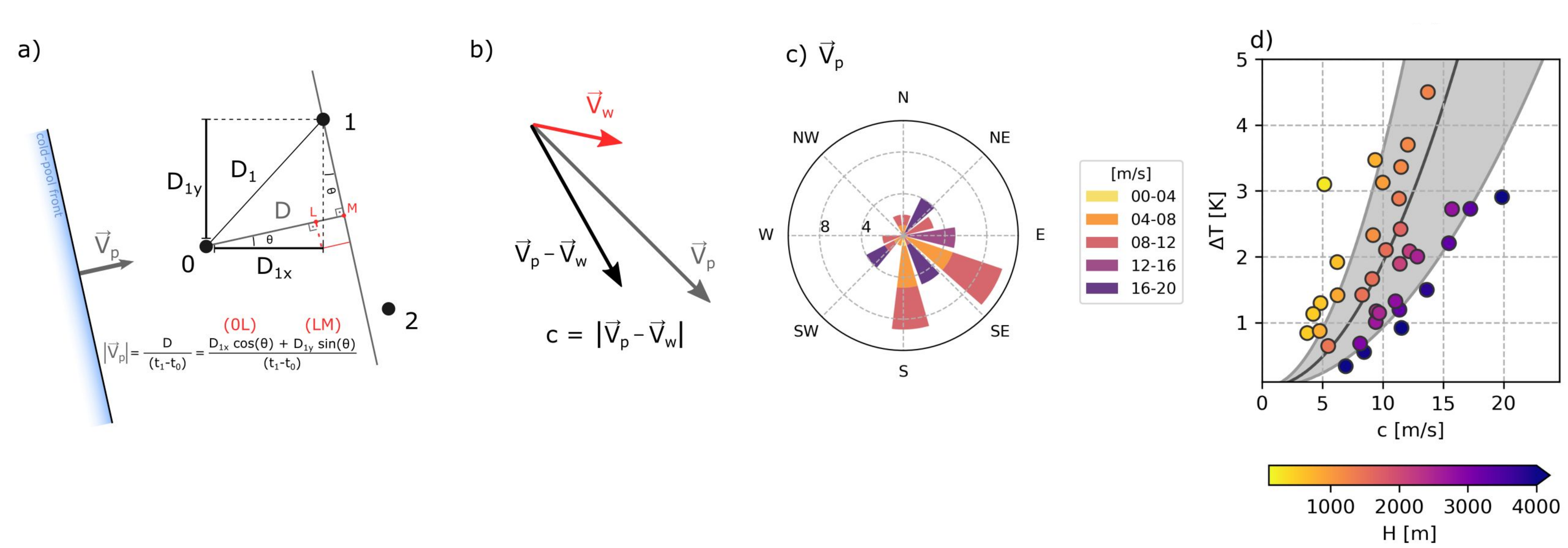



## The propagation and height of cold pools

The sharp fronts where the temperature drops associated with cold pools occur in quick succession at the three different moorings. We match the fronts of cold pools observed at all three moorings to estimate their propagation. After matching the temperature drops at different moorings, we estimate the depth H of each cold pool just behind the front. We assume that the front propagates in the cross-front direction taking the frozen-field assumption, i.e., the propagation speed does not vary through the mooring array. We here define propagation as the combination of advection and phase components. For a gravity current,

$$c = \sqrt{\frac{\Delta T}{T} g H}$$

, of which g is the acceleration due to gravity (9.82 m/s2), ΔT is the maximum temperature drop among the moorings, T is the reference temperature (before the front), and H is the height of the gravity plume. From the phase speed c we thus estimate H. The predicted height of the cold pools predominantly spans from 850 to 3200 m. Taller cold pools are more likely to develop during June to September's summer monsoon season.




## Answering the scientific questions

**What are the characteristics of the cold pools?**

- 465 cold pools (~150/yr, 3 moorings)
- Cold (2ºC drop) and dry (1 g/kg)
- Stronger and less windy than equatorial
- ~1.5 - 3.5h (10h)
- Mostly SE (SW)
- 4-20 m/s (5-13 m/s)

**What is their temporal variability?**

- Summer Monsoon (April-November)
- Mostly by late morning

**What is their contribution to the air-sea fluxes?**

- Peaking 2-3x the base level (July)
- Wind -- 10% (SHF) 9%(LHF)
- ↑ wind contribution towards equator

**What is their association to the total rain?**

- About 80% of yearly total rain

**What is their height distribution?**

- 850– 3200 m tall
- Taller cold pools (summer)

*How important are cold pools to improve coupled **climate models** for **air-sea fluxes** and monsoon **rainfall**?*

## Acknowledgments

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