# Joint modulation of coastal rainfall in Northeast Australia by local and large-scale forcings

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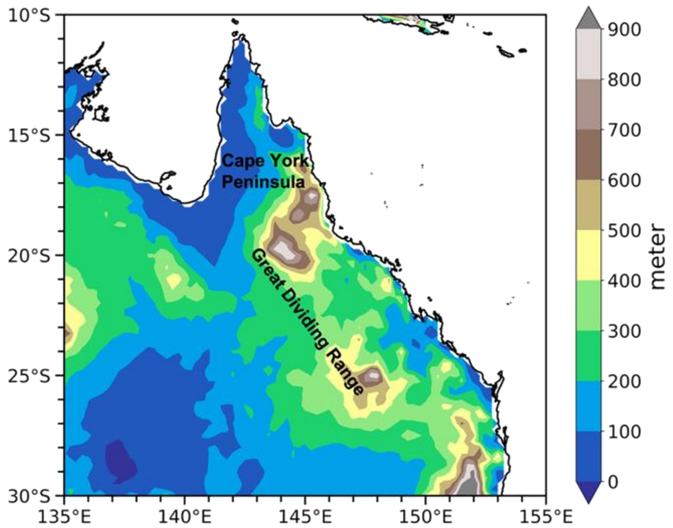
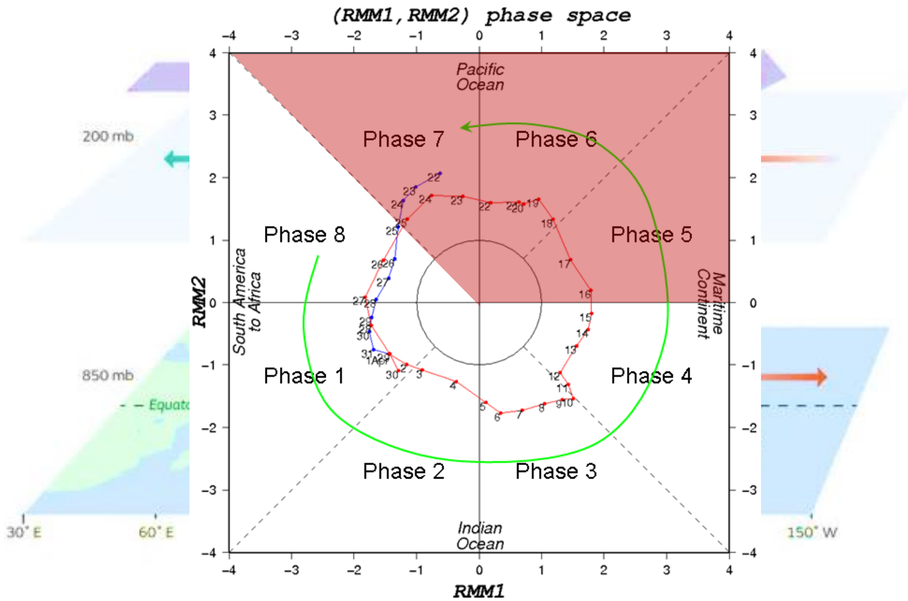
# Introduction

**Sub-daily** ⟶ **Intraseasonal** ⟶




(https://ds.data.jma.go.jp/tcc/tcc/products/clisys/mjo/explanation_mjo)

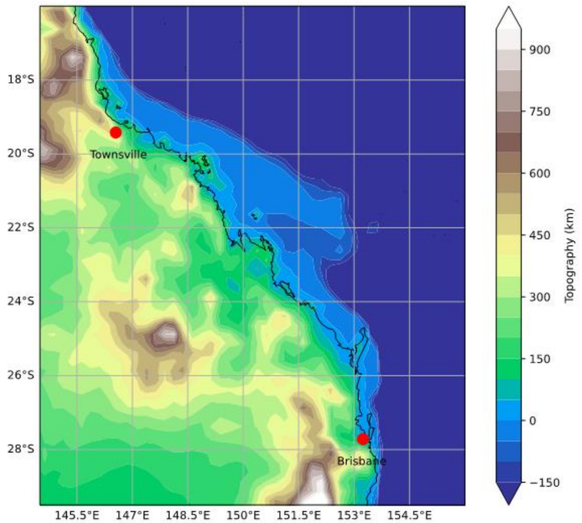
## Local Variability

- Land-sea breeze circulation
- Topography

## Madden Julian Oscillation (MJO)

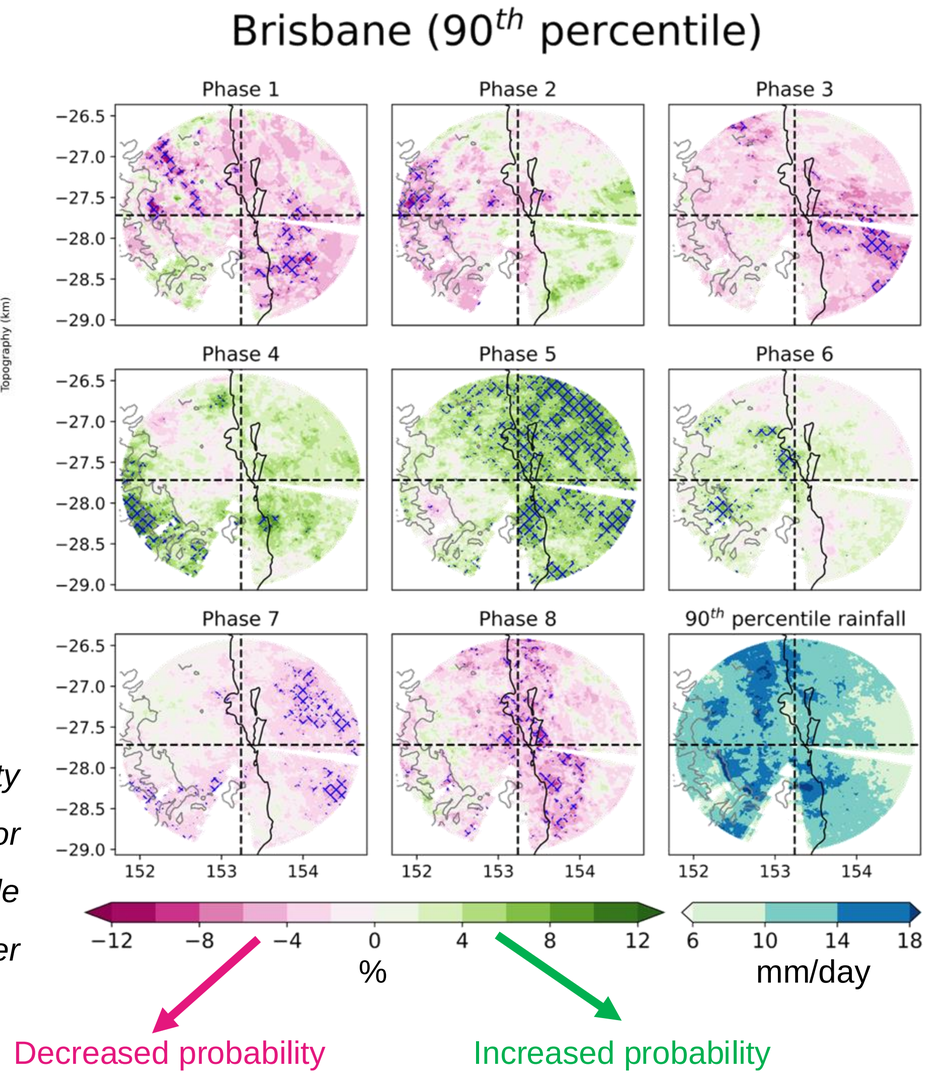
- Typical periods of 30-60 days
- Lifecycle is classified into 8 phases

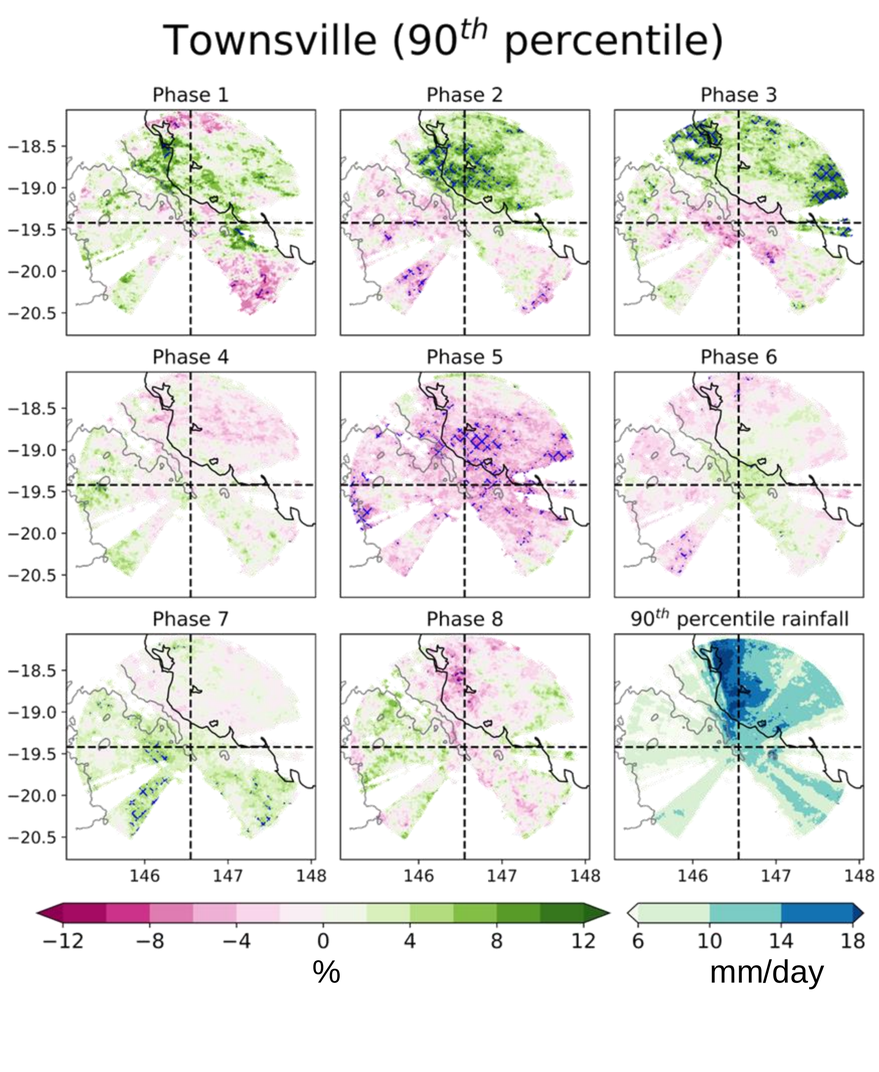
# Introduction




11 DJF seasons radar data

*The anomalies of daily rainfall probability exceeding the 90$^{th}$ percentile (%) for different MJO phases. 90$^{th}$ percentile rainfall (mm/day) is shown at the lower right corner of each radar plot*




=> Multi-scale interaction between local features and large-scale forcings in regulating rainfall over coastal areas of Northeast Australia

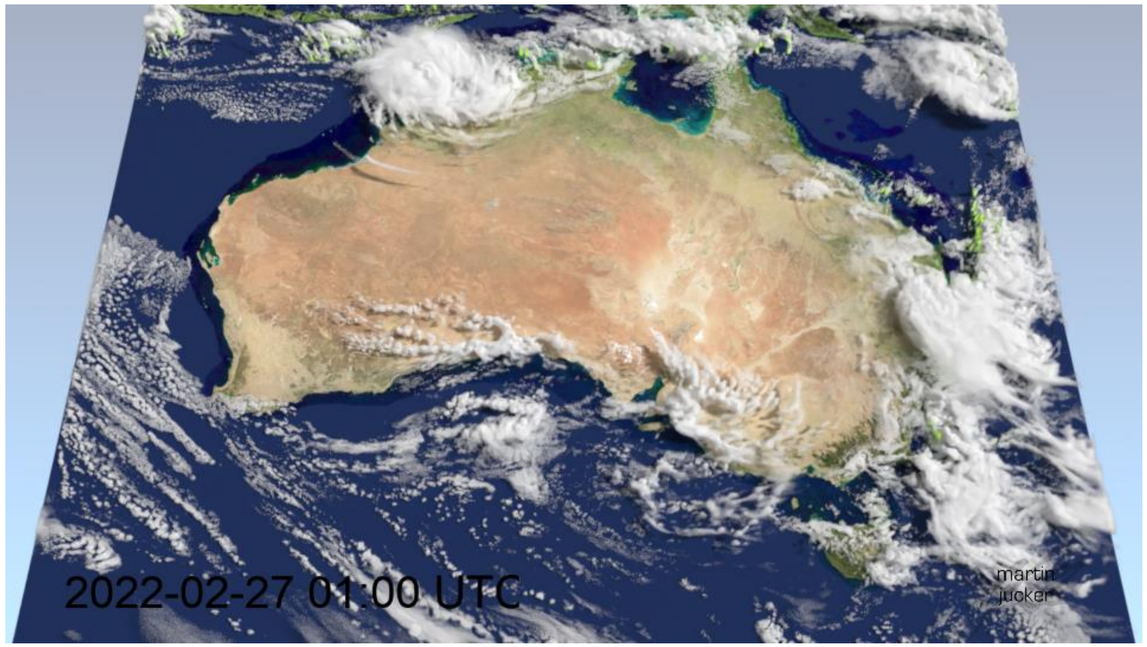
# Introduction

How do mesoscale processes interact with the large-scale forcings in modulating coastal rainfall?

## High-resolution Regional Atmospheric Modelling Project (AUS2200)

A community project that aims to develop high-resolution regional atmospheric modelling across Australia using the Australian Community Climate and Earth-System Simulator (ACCESS)

A common platform that helps facilitate research and model development that advance scientific understanding of important atmospheric processes across a wide range of scales.




An example of AUS2200 simulated cloud fields.

Image credit: Dr Martin Jucker, UNSW

# Model experiment

Total of 180 simulation days for three strong MJO events: 2016 (El Niño), 2013 (Neutral) and 2018 (La Niña)

## Current specifications of AUS2200 model

| Model Version | UM 12.2 |
|---|---|
| Configuration | Regional Atmosphere and Land Configuration 3 (RAL3) |
| Domain Size | Australia |
| Initial and Boundary Condition | ERA5 + BARRA2 soil moisture |
| Timeframe | 2013, 2016, 2018 (Jan-Feb) |
| Output frequency | Hourly |
| Horizontal Grid Spacing | 2.2 km (Convective permitting model) |
| Vertical levels | 70 |

## Experiment domain & model orography

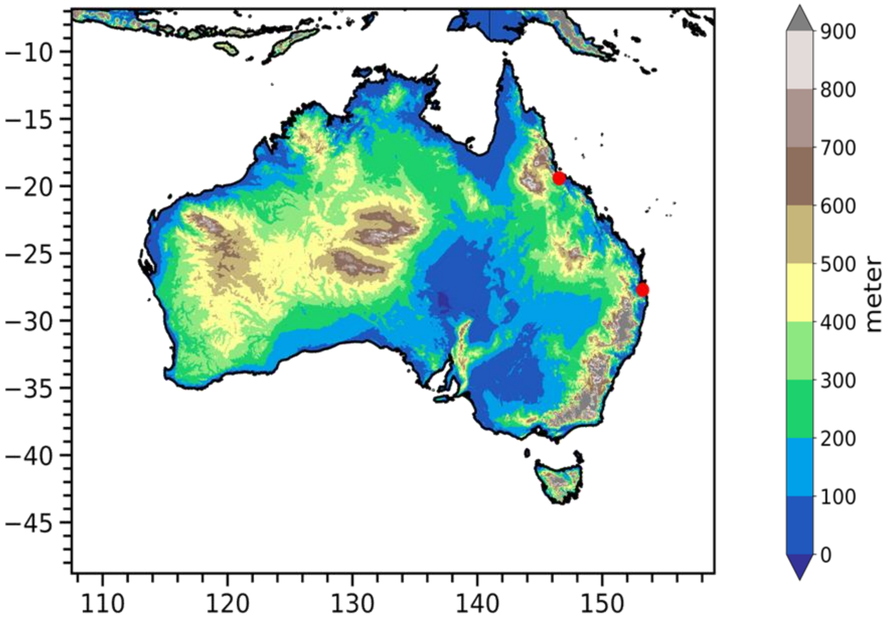
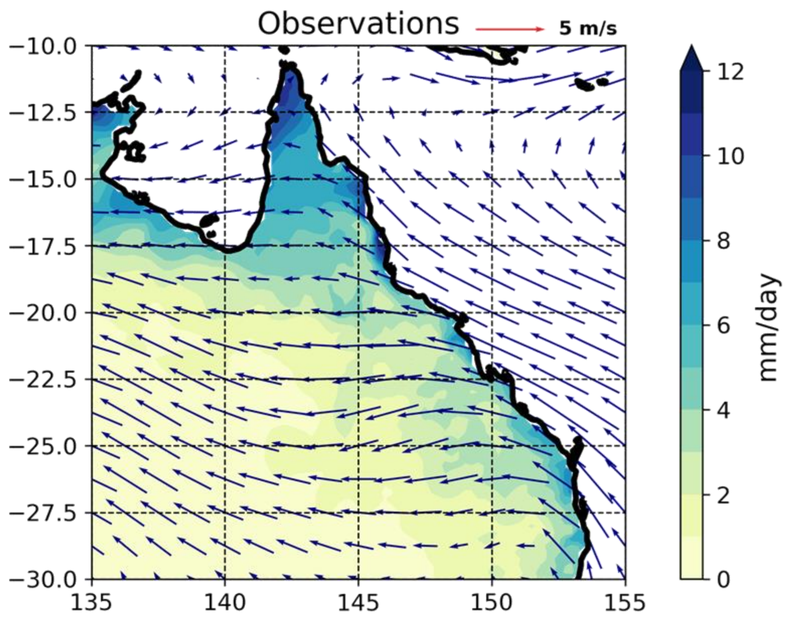


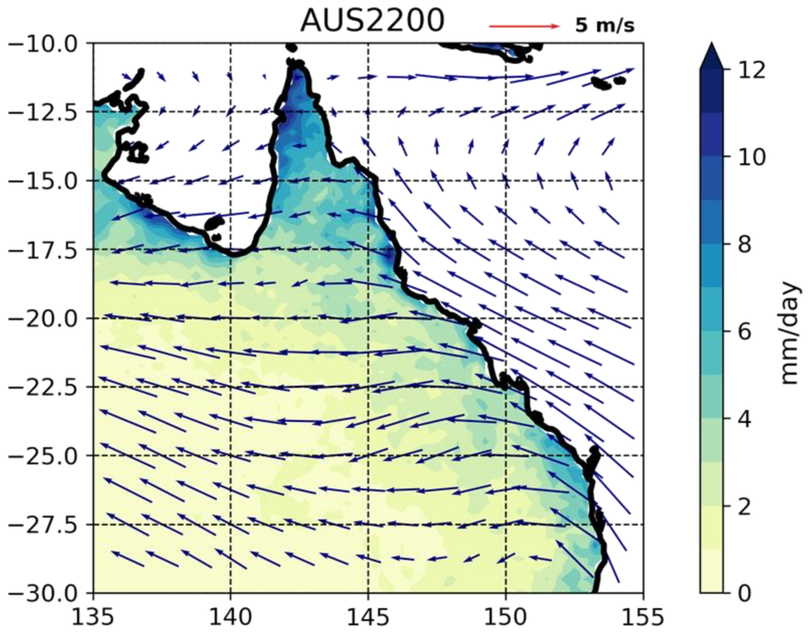

Table credit: Dr. Yi Huang

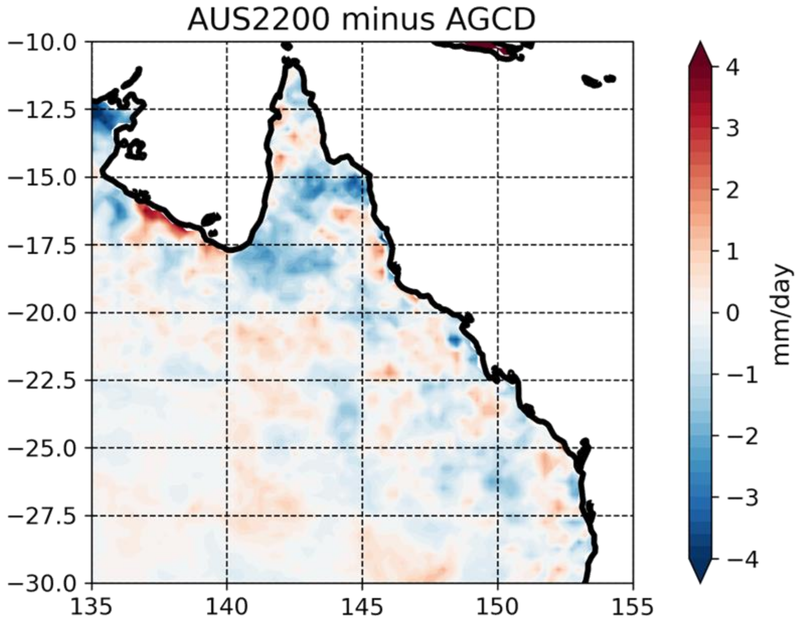
Simulations were run by the CMS team (Thanks Dale Roberts and Paola Petrelli)

# Coastal rainfall: Radar versus AUS2200

Excluding Tropical Cyclone Oswald: 22-29/2013



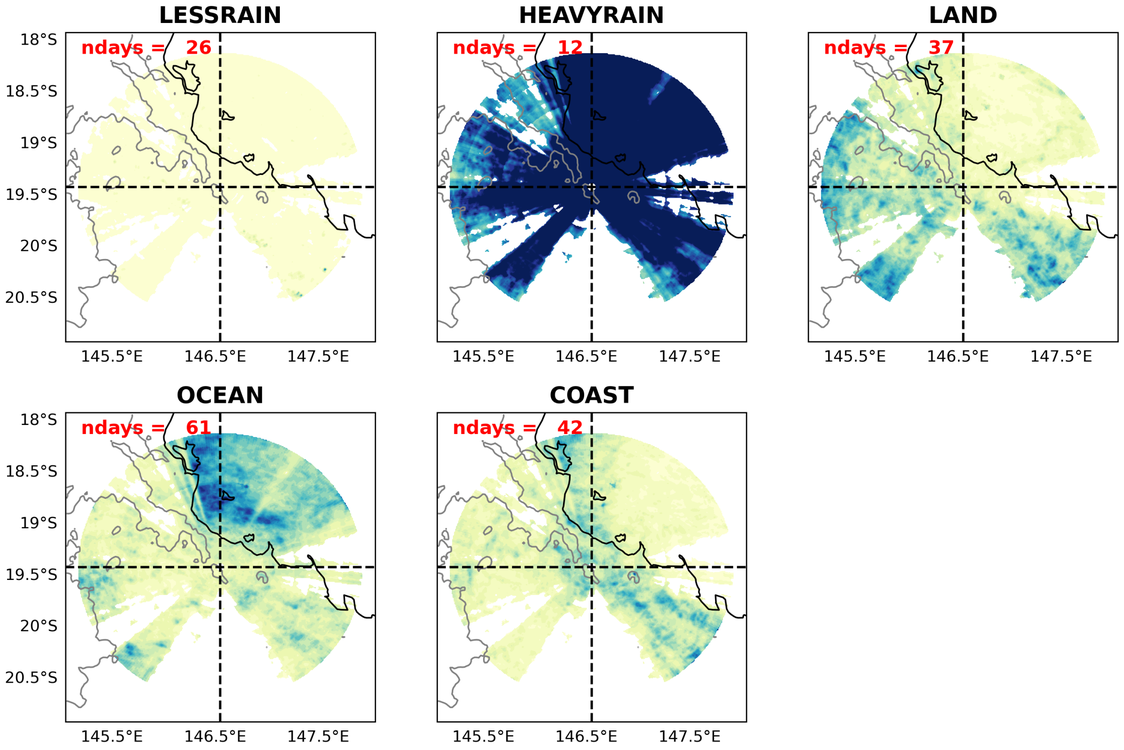




Correlation coefficient: 0.89

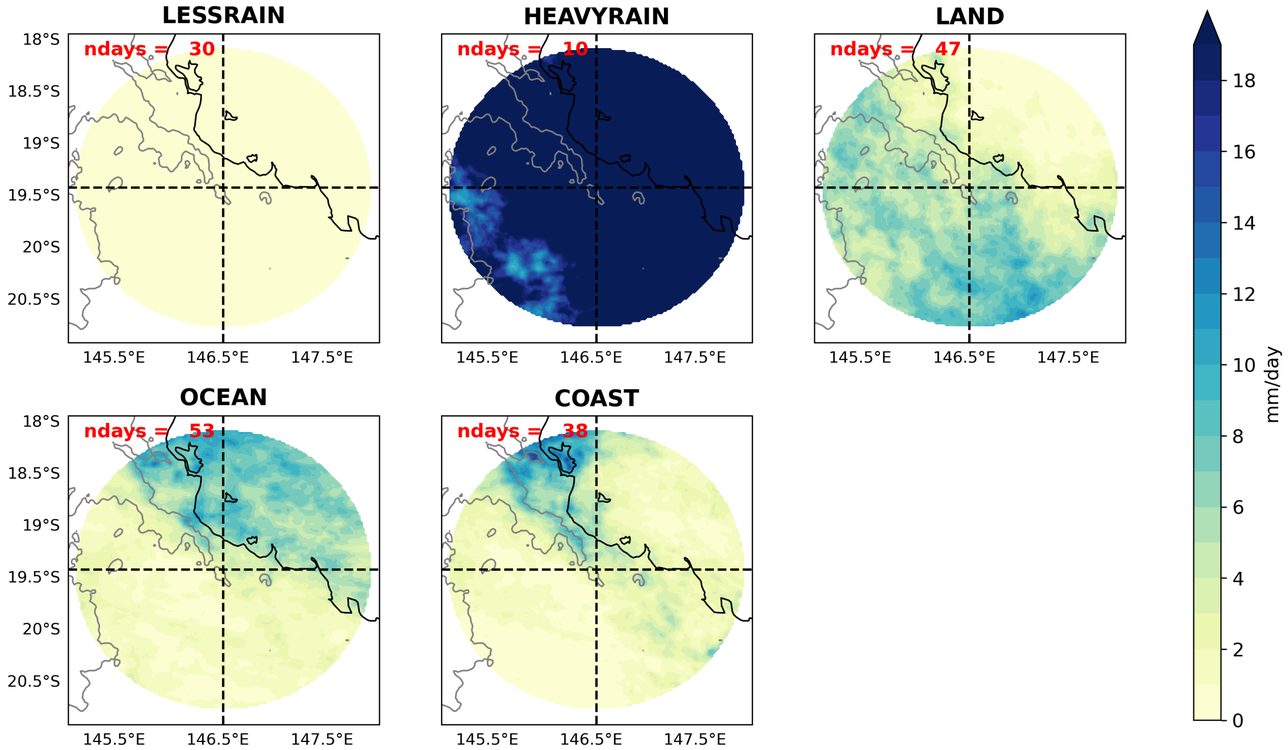
*AGCD: the Australia Water Availability Project from the Australian Gridded Climate Data

# Coastal rainfall distribution: Radar versus AUS2200

## Radar

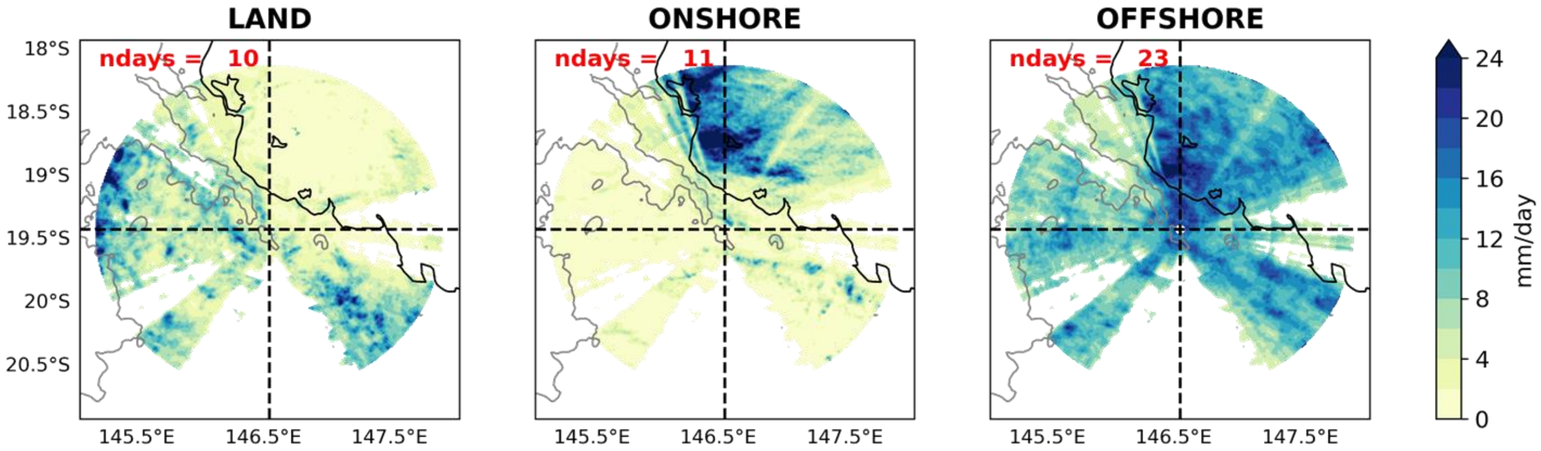



## AUS2200 simulations

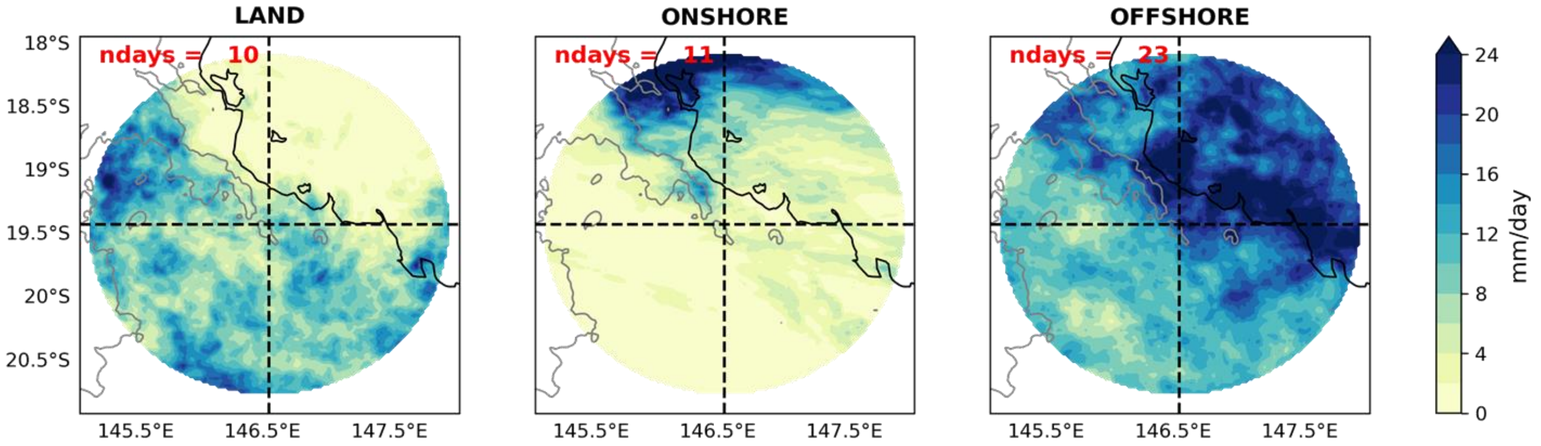


# Coastal rainfall distribution: Radar versus AUS2200

Radar

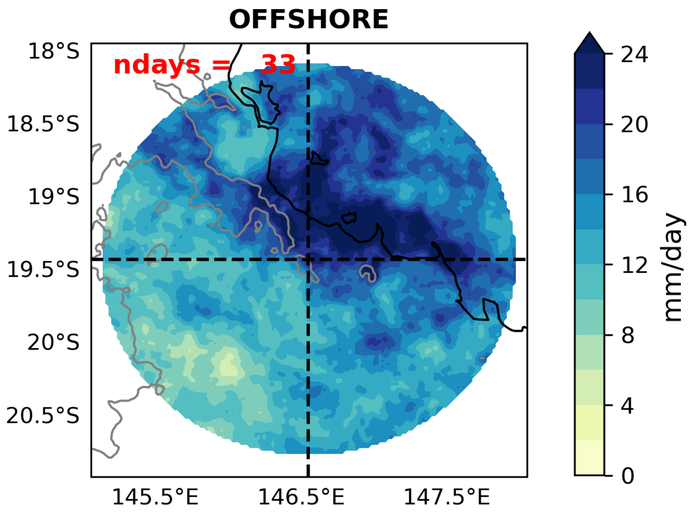


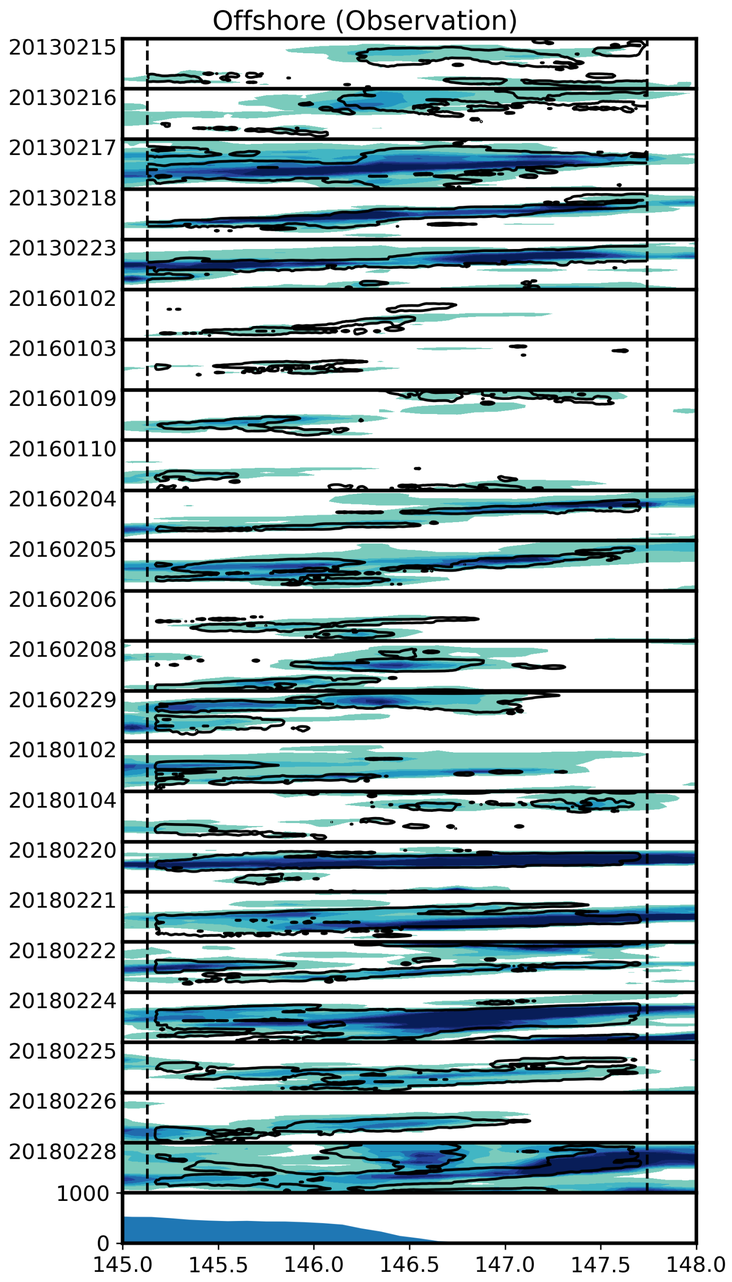

AUS2200 simulations

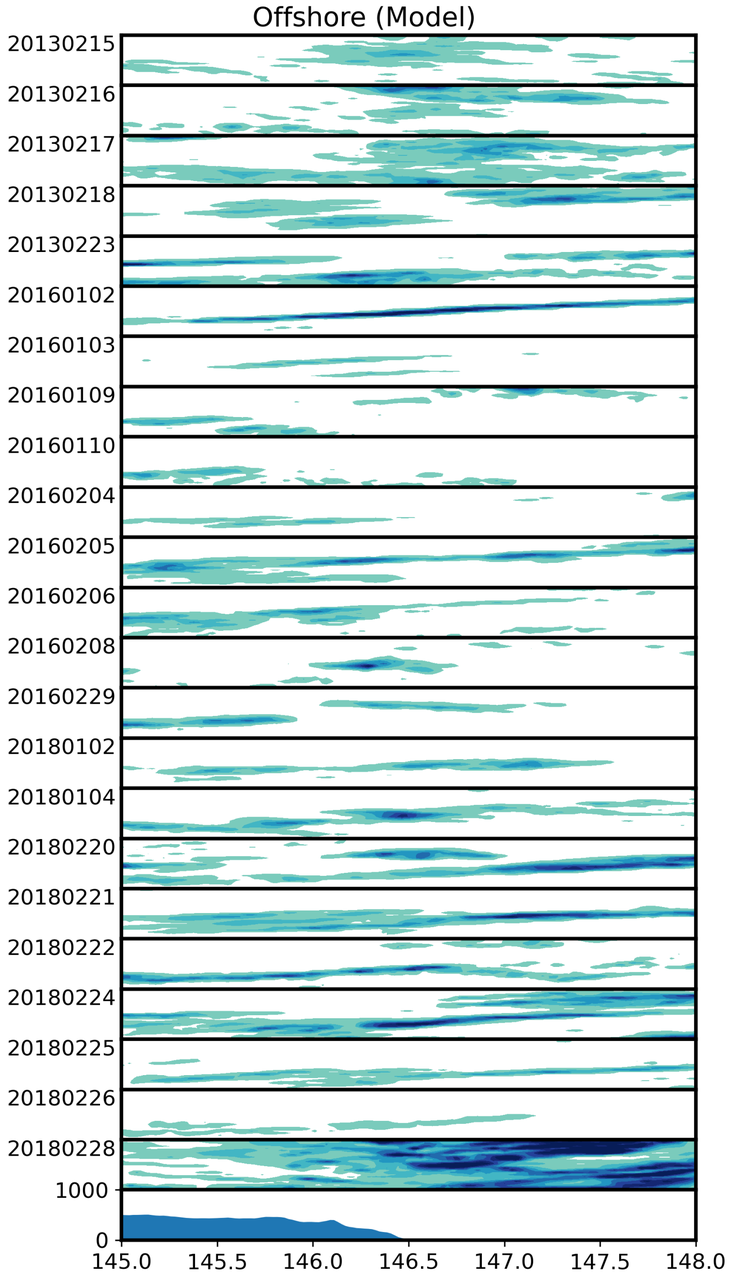


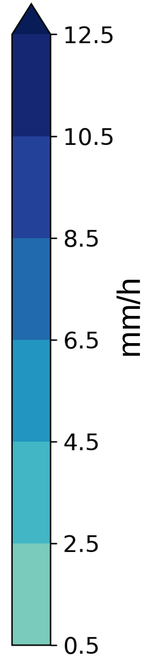

Rainfall propagation modulates the average rainfall patterns over coastal areas of NE Australia

# Offshore rainfall propagation



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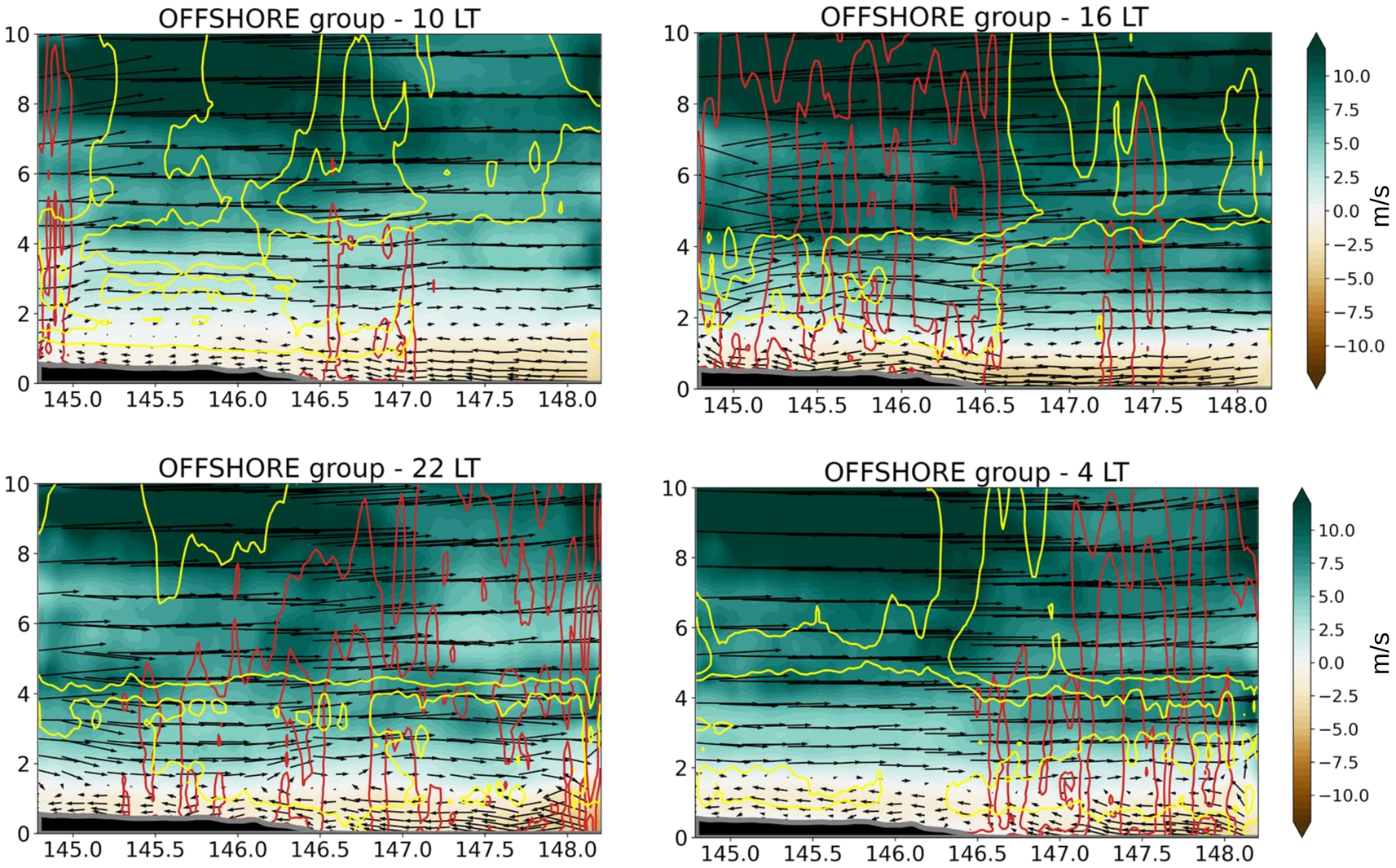
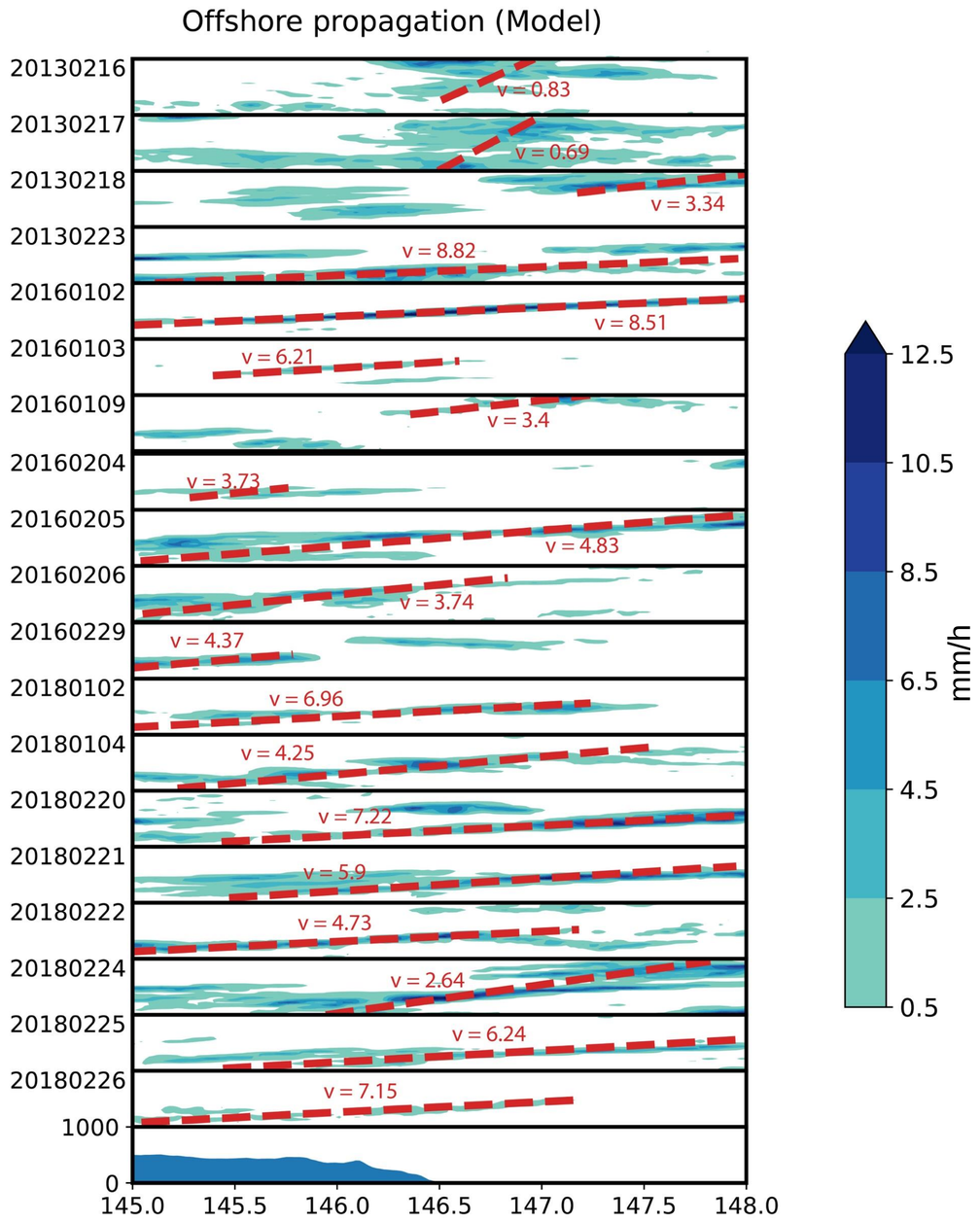



- Red contours: Rain + graupel
- Yellow contours: cloud liquid + snow

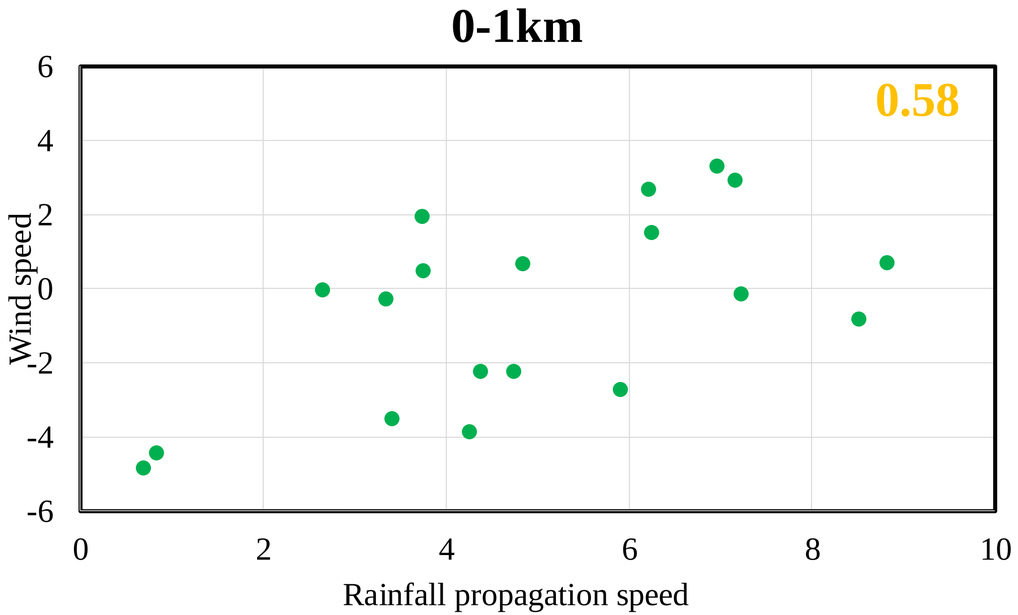
Rainfall is triggered during the afternoon by sea breezes, and then propagates offshore during the nighttime

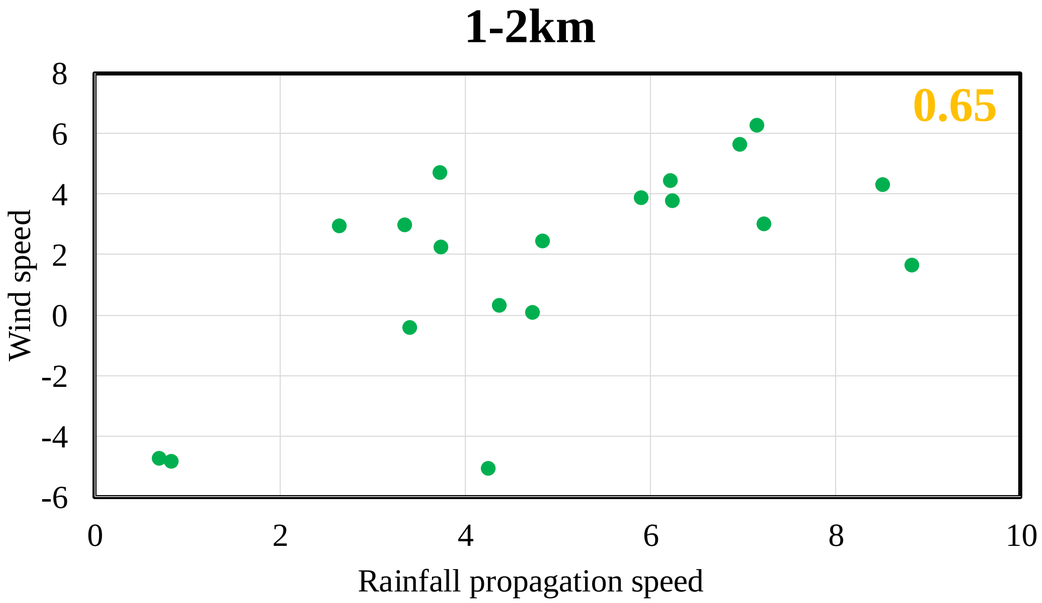
# Offshore rainfall propagation









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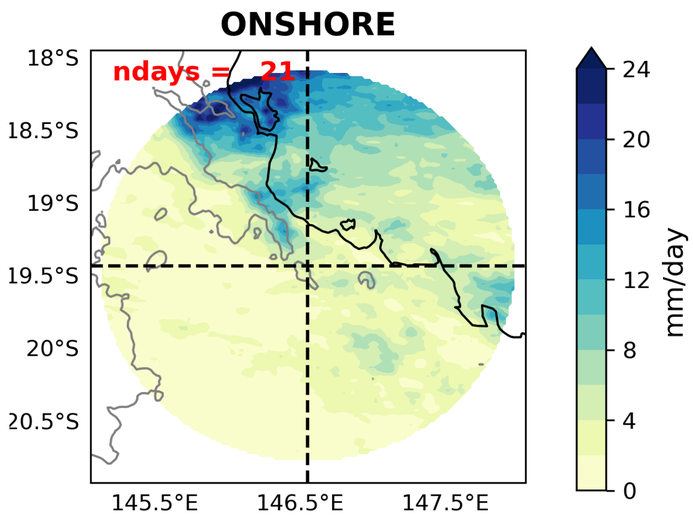





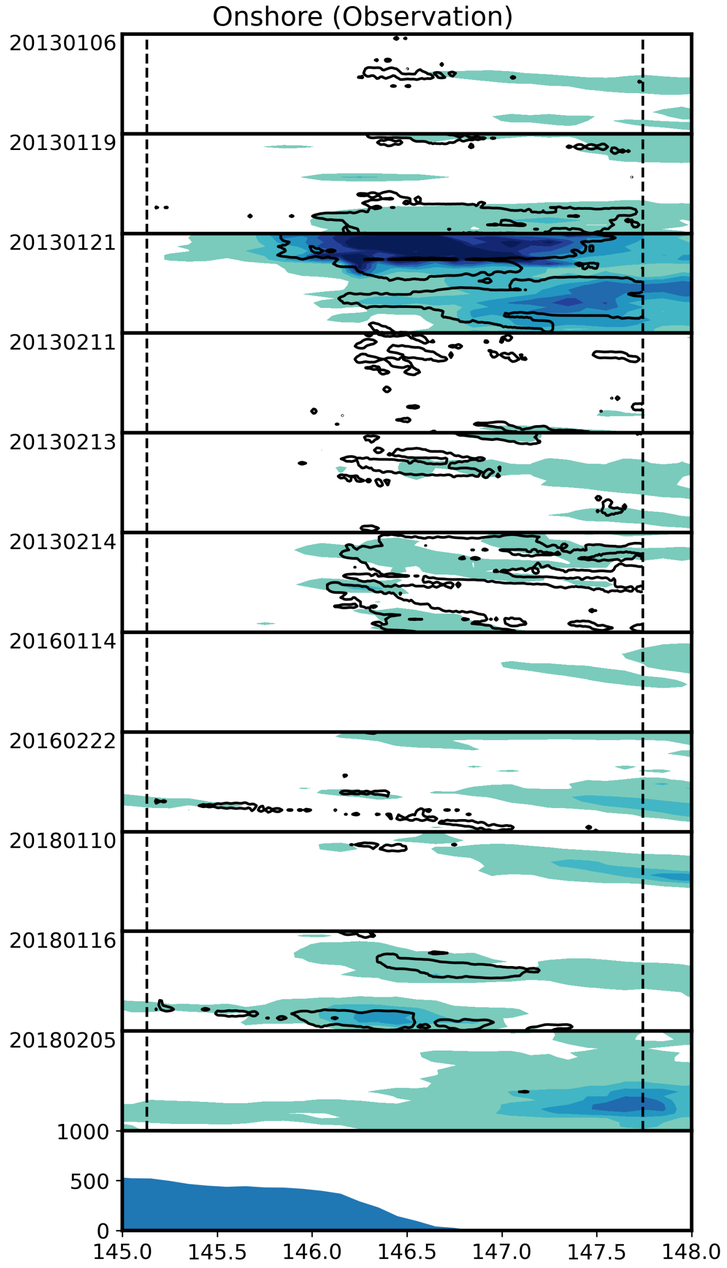


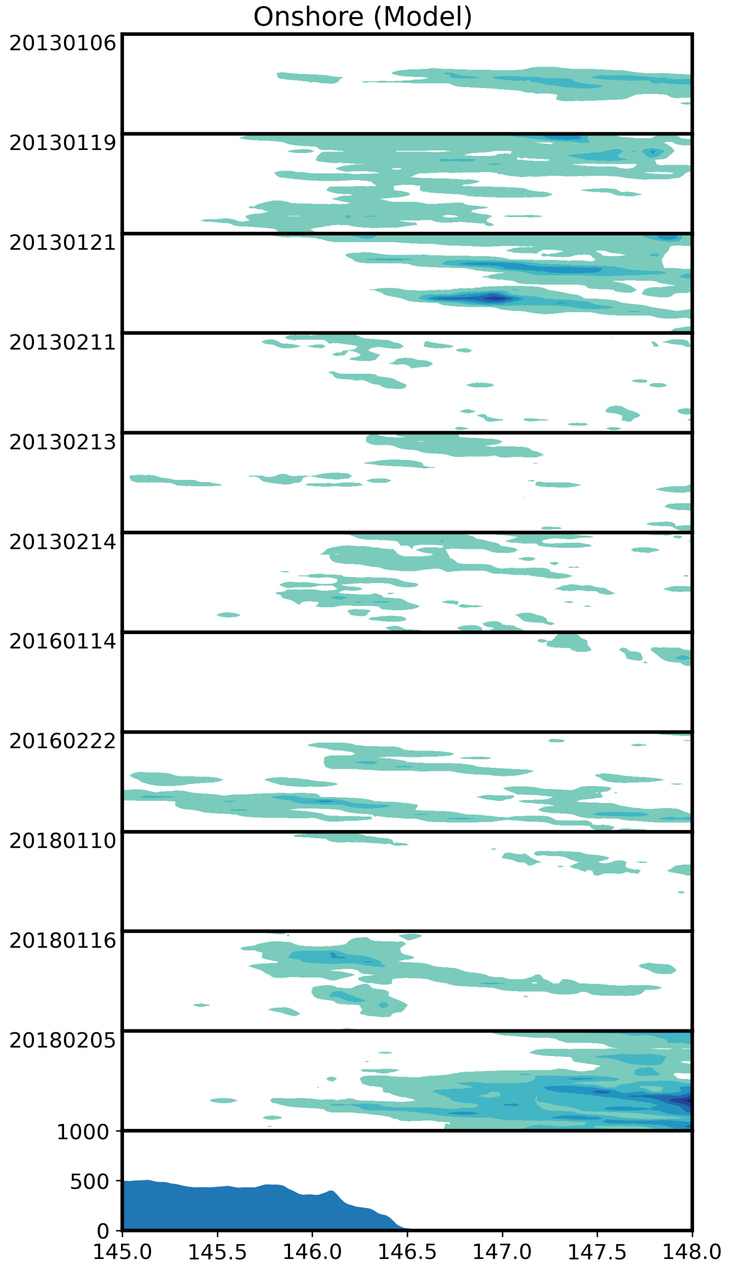


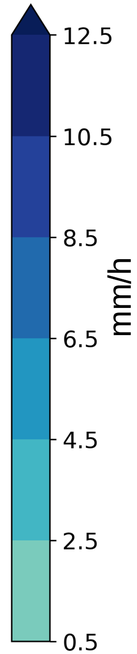

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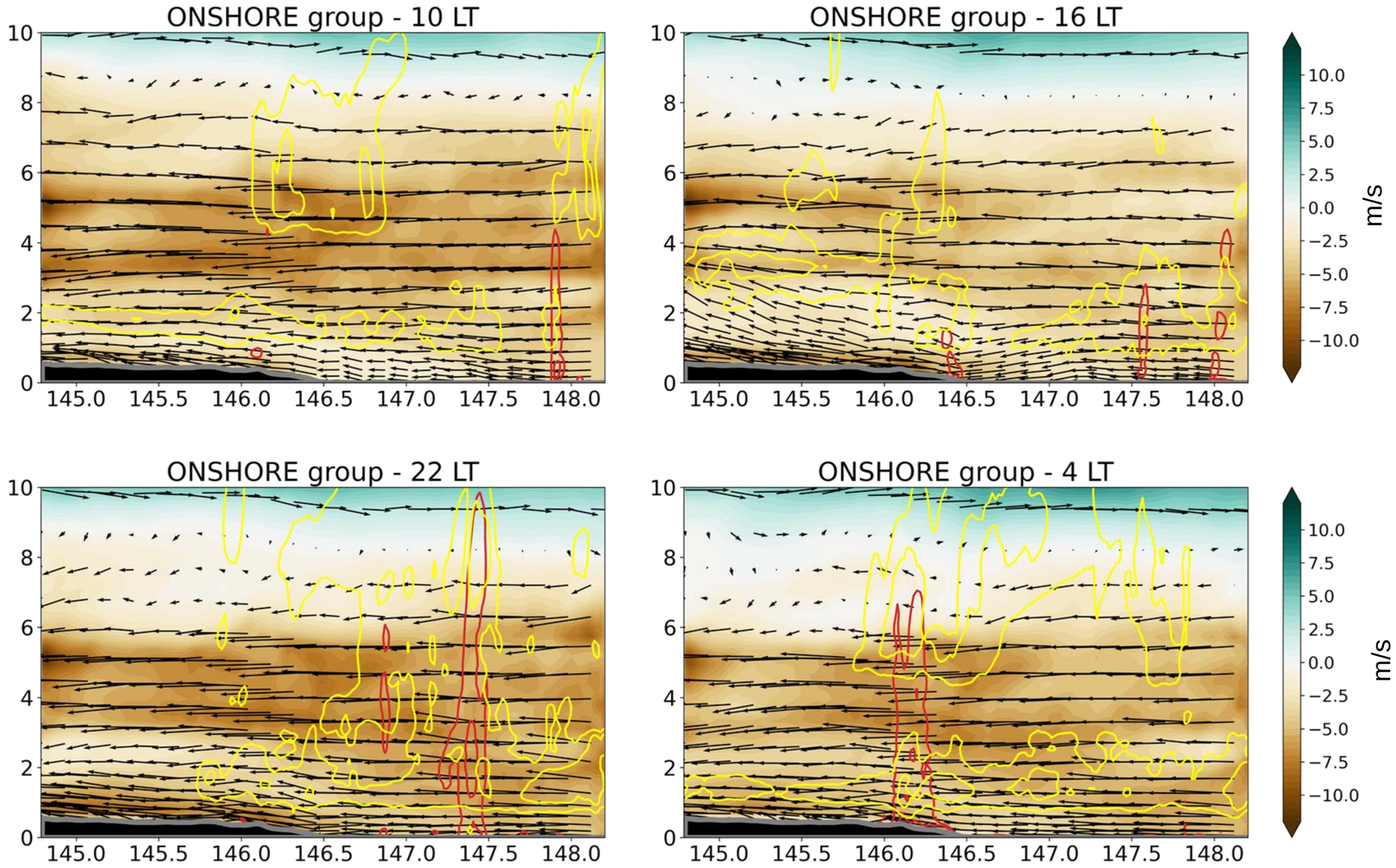
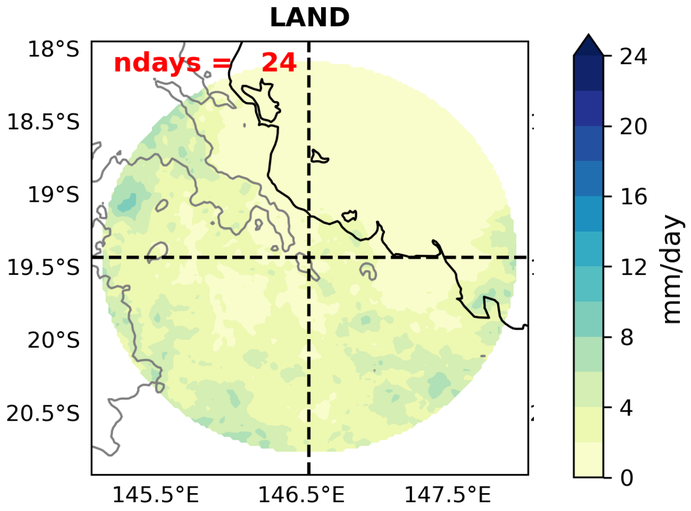
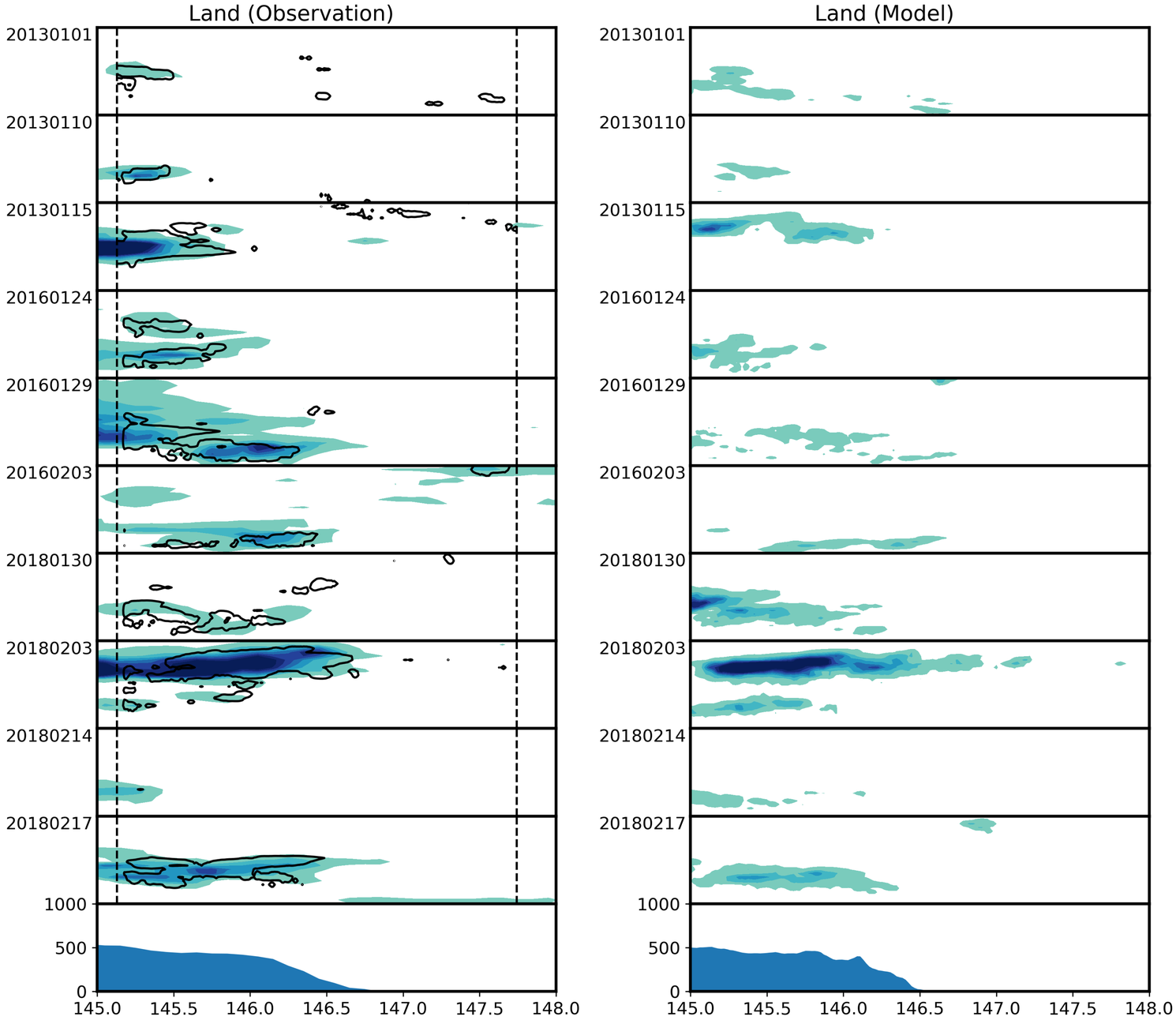



- Red contours: Rain + graupel
- Yellow contours: cloud liquid +snow

Onshore rainfall propagation occurs during days with strong background easterlies

# Rainfall over land



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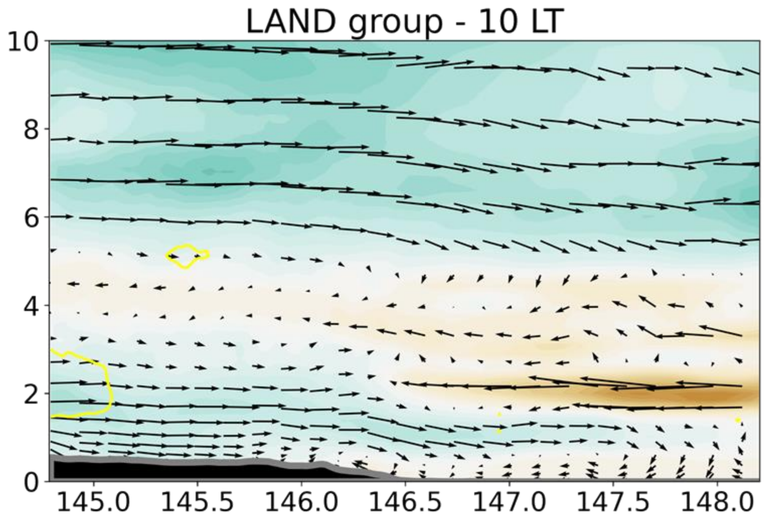


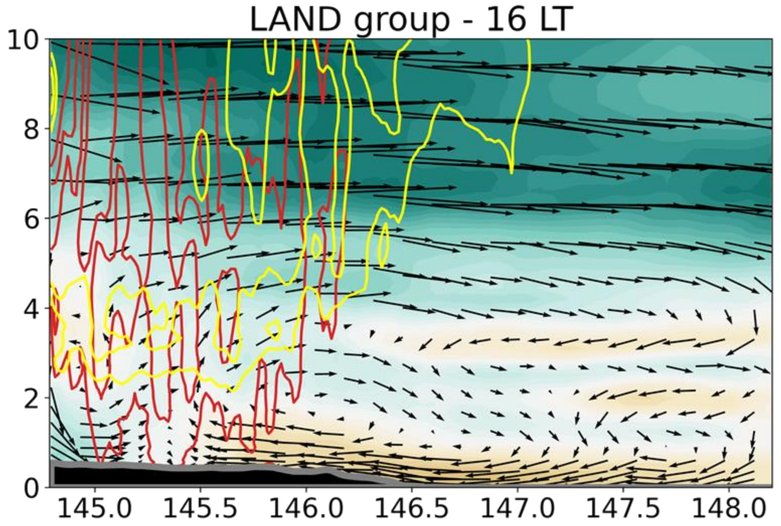


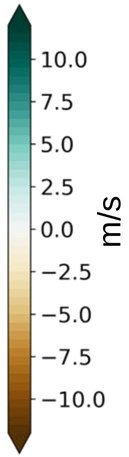


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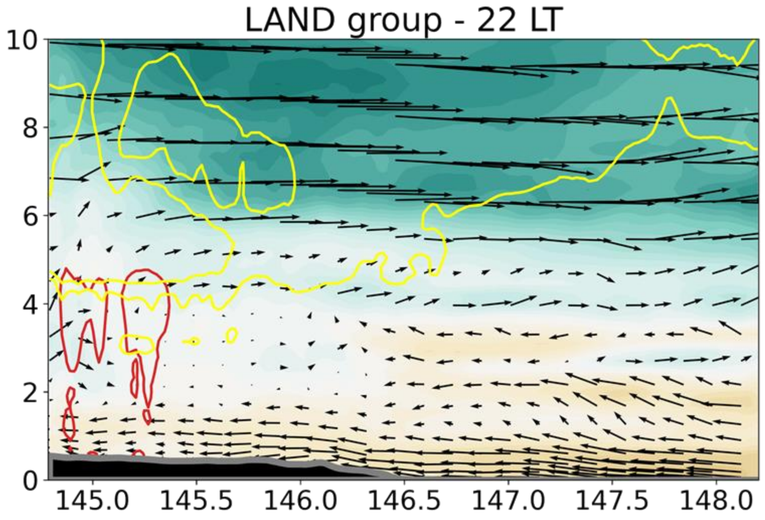
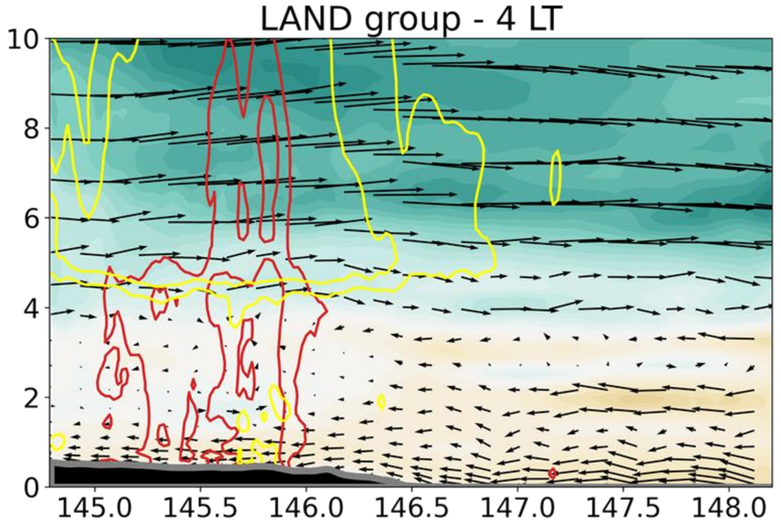
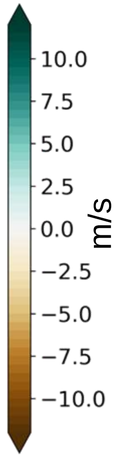


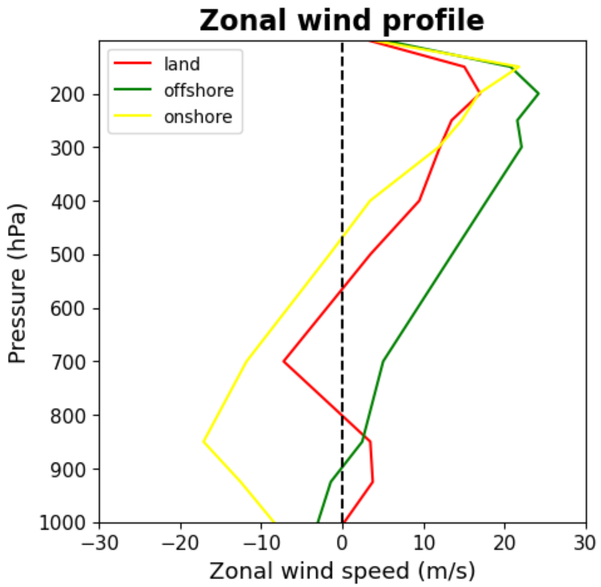



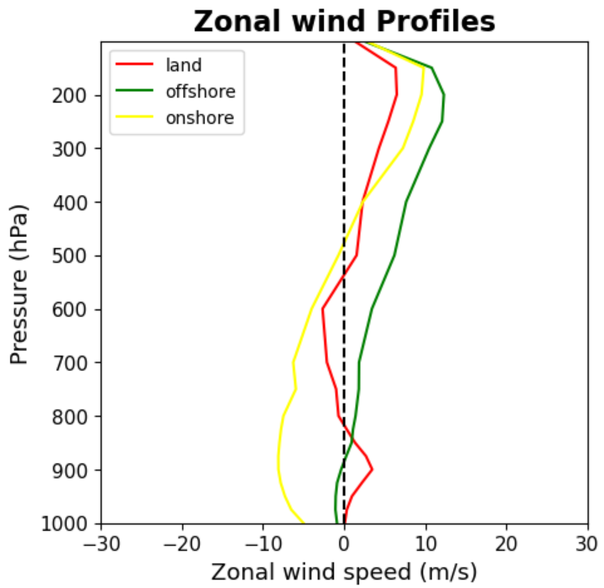

Rainfall tends to occur and stay over the land during days with strong sea breezes and middle-level easterlies

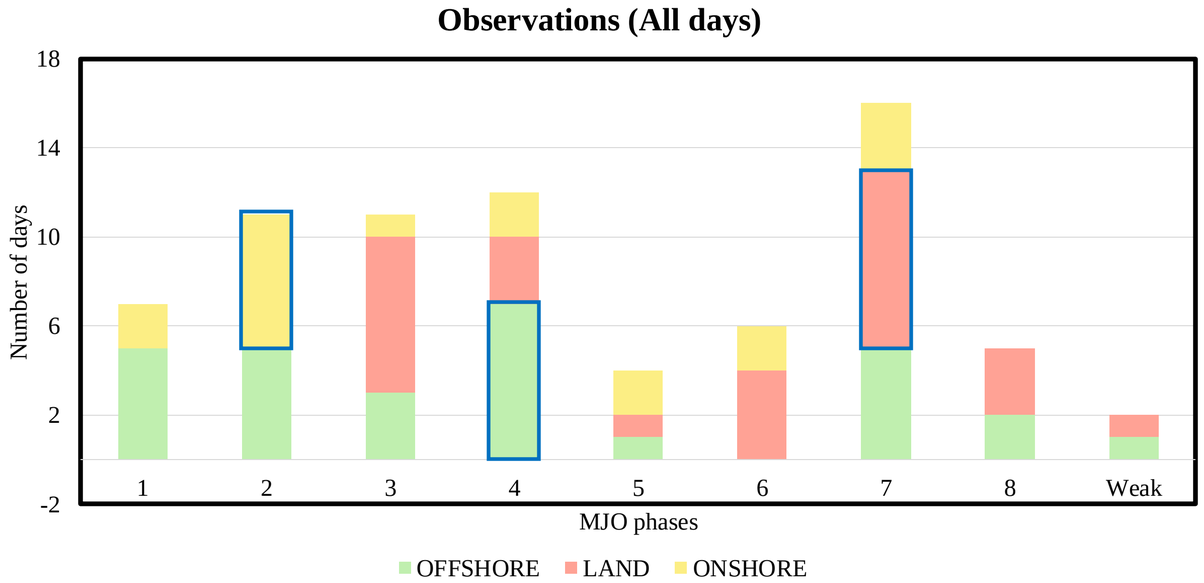
# MJO-rainfall propagation relationship

**Sounding**




**AUS2200 simulations**




=> Background wind regimes associated with different MJO phases may modulate the direction and strength of rainfall propagation

# Summary

- ✓ AUS2200 simulation can capture the inhomogeneous rainfall pattern over coastal areas of NE Australia
- ✓ Rainfall propagation modules the average coastal rainfall patterns
- ✓ The large-scale background wind and local-scale land-sea breeze circulation are two important factors driving rainfall propagation
- ✓ The background wind regimes associated with different phases of the MJO may modulate the direction and strength of rainfall propagation, leading to different coastal rainfall patterns.
- ✓ The limited number of samples is insufficient to fully resolve the scale interaction mechanisms driving observed coastal rainfall.

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