Wave-ice interactions and trends in the marginal ice zone

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with

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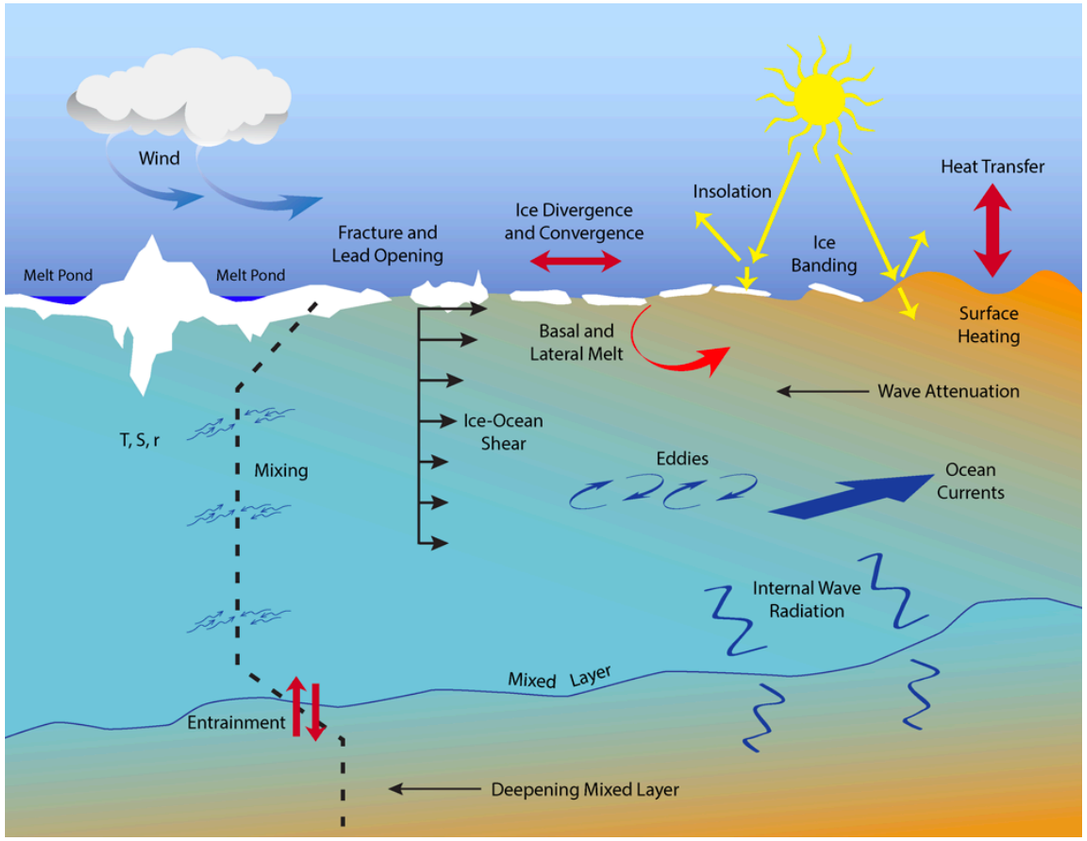
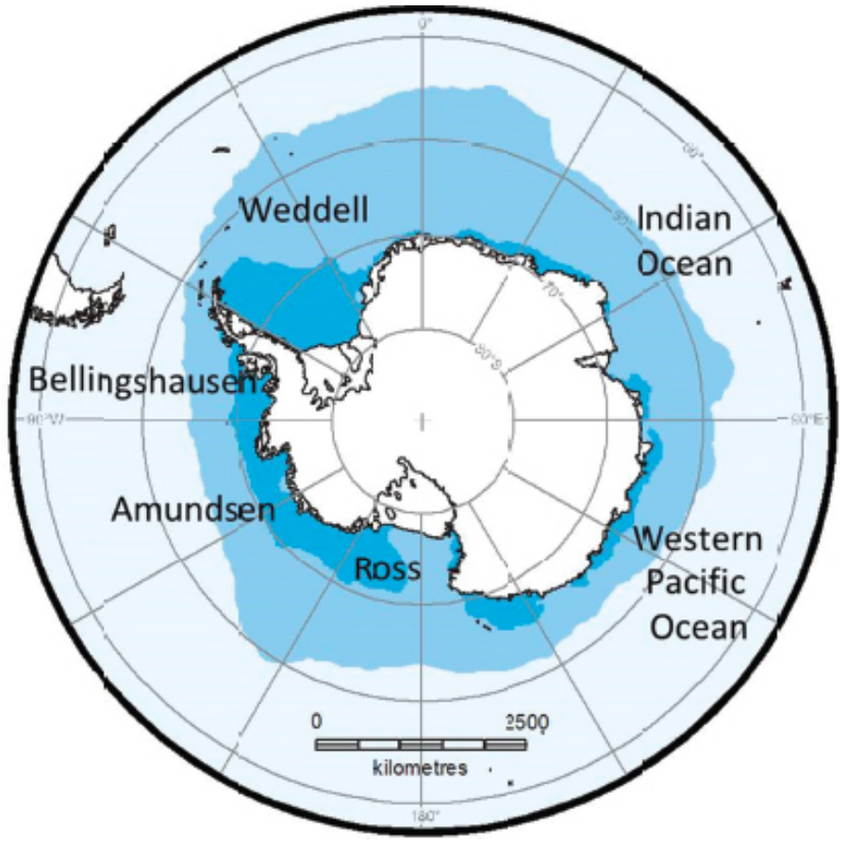
Antarctic marginal ice zone

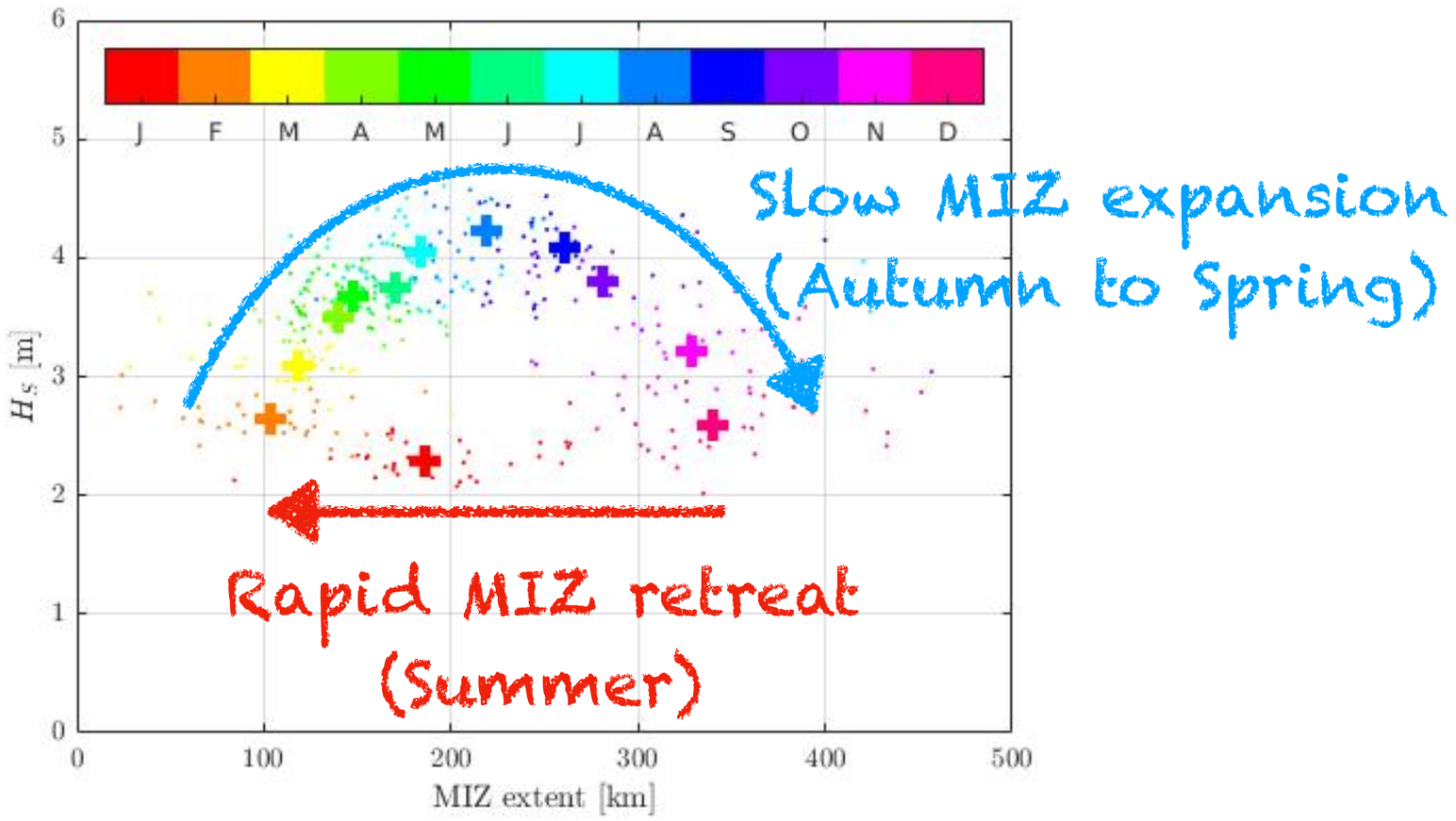




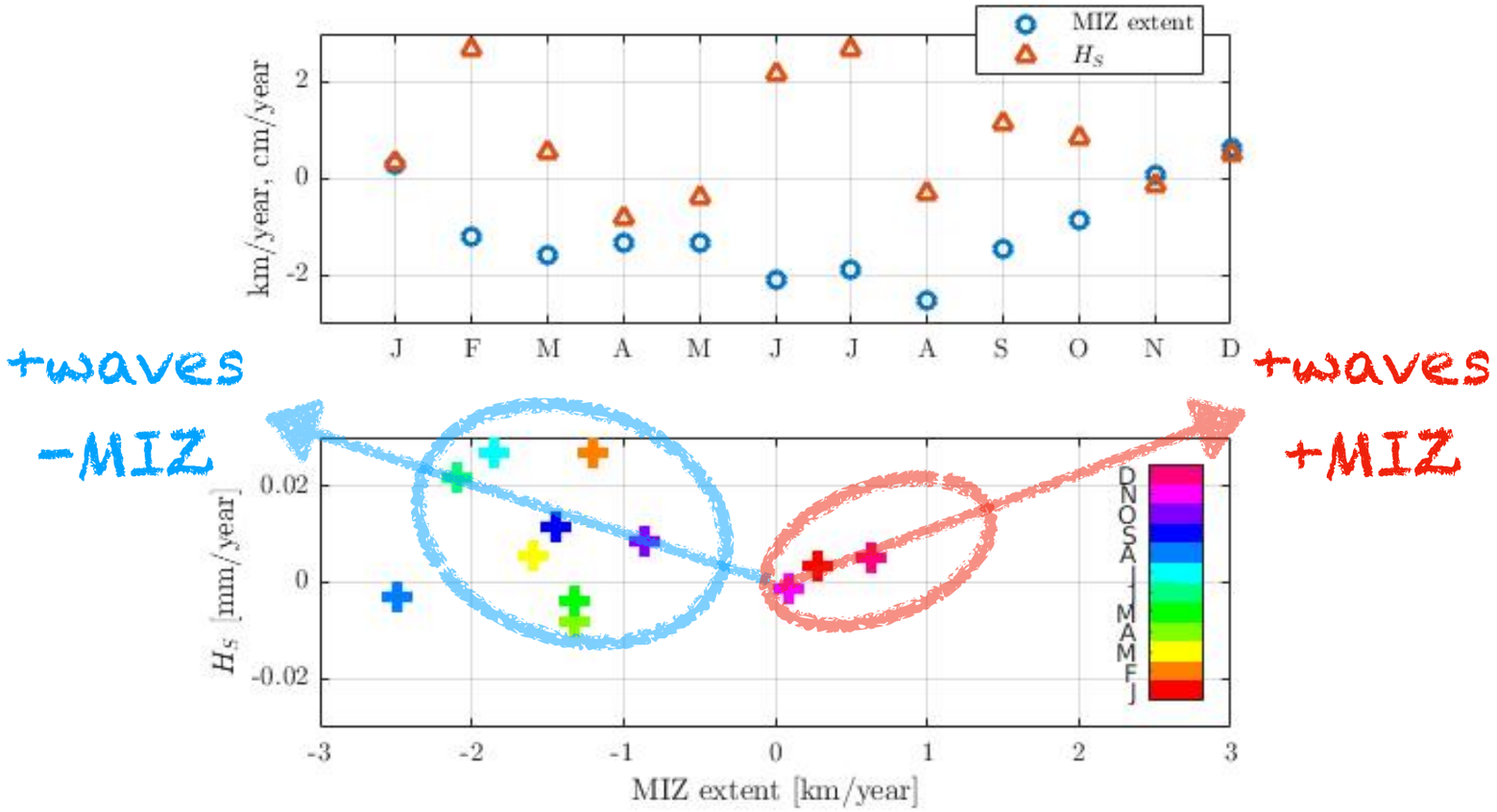
- **MIZ** is the area where there is significant contribution of open ocean **waves** to sea ice dynamics
- Antarctic MIZ ~5 millions km² at max (20–30% of total sea ice)
- Sea ice (and MIZ) play a substantial role on climate dynamics

MIZ and waves

- **Wave height:** altimeter missions (1985-2019) within 5 degrees of the ice edge (OSISAF/AMSR2)
- **Ice concentration:** OSISAF (1979-2015) and AMSR2 (2012-2019) at daily at 12.5km resolution
- **MIZ:** 0.15 < ice concentration < 0.80 (concentration based definition—implemented in coupled models)



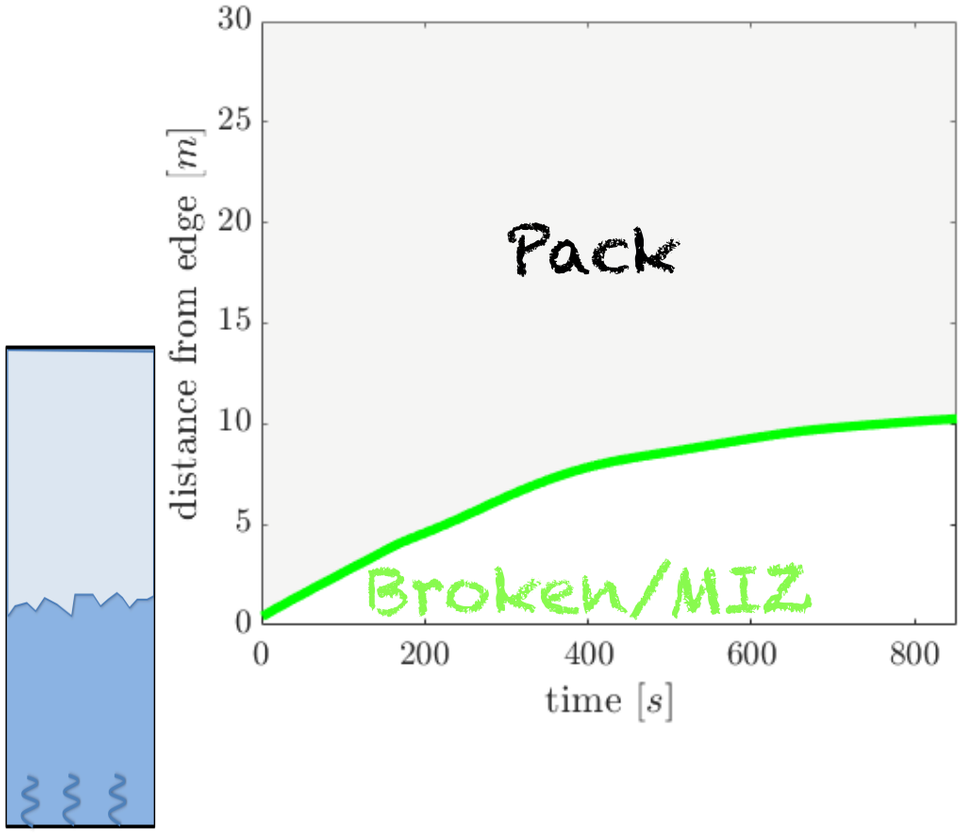
Trends in MIZ and waves

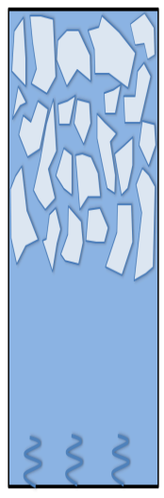


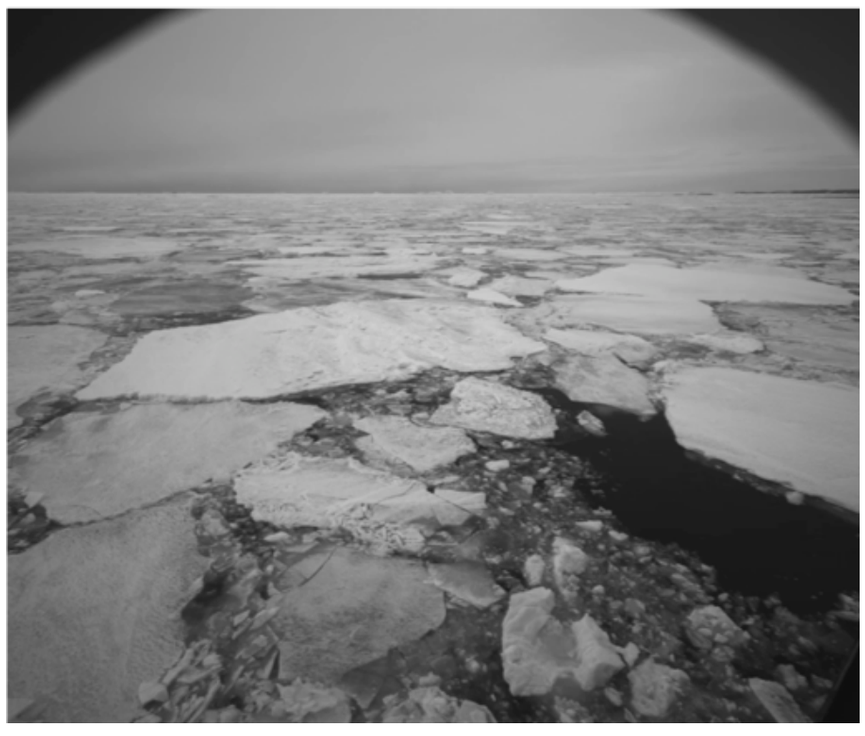
- **Wave height:** **+**10cm/decade on average, no clear seasonal trend
- **MIZ:** **+**5km/decade in NDJ (**MIZ maxima** and retreat), **-**15km/decade otherwise (**MIZ minima** and expansion).

MIZ retreat (+waves; +MIZ)

- **Nov—Jan:** MIZ retreat, total sea ice retreat







- Wave-induced-breakup (+waves; +MIZ)
- **Experimentally**: Dolatshah et al, PoF, 2018; Passerotti et al, ASME, 2020;
- **CICE (model)**: Bennetts et al, The Cryosphere, 2017

MIZ expansion (+waves; -MIZ)

- **Pancake floes** (most of the MIZ during expansion): small floes (0.1—10m) form in **wavy** conditions with interstitial frazil ice
- **Remote sensing** concentration 100% (pancake+frazil), but **in-situ** measurements of **wave** activity
- Alberello et al, The Cryosphere, 2019; Vichi et al, GRL, 2020; Alberello et al, JGR, 2020.

MIZ: waves contribution to sea ice dynamics

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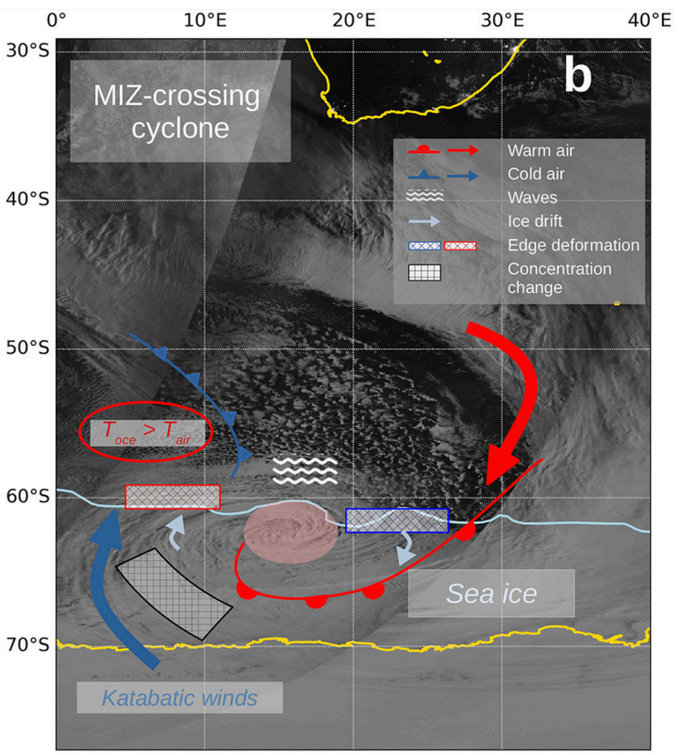
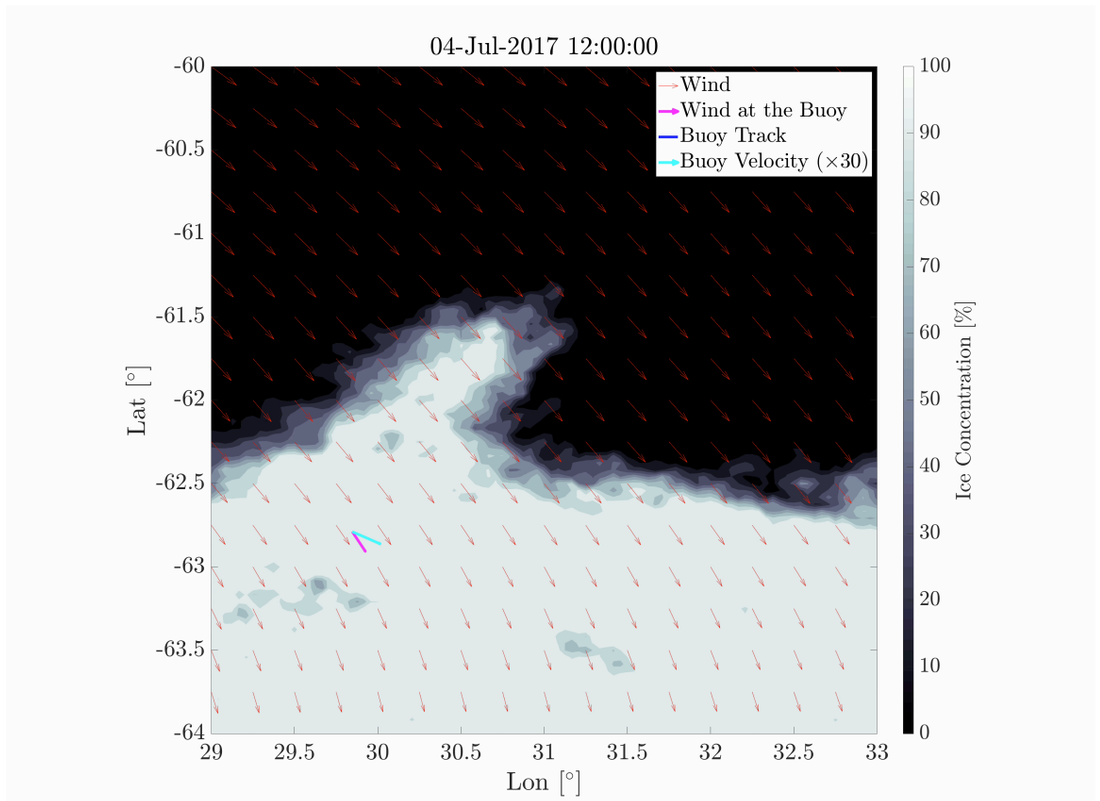
MIZ: 0.15<concentration<0.80

MIZ dynamics > MIZ concentration (models)

MIZ dynamics

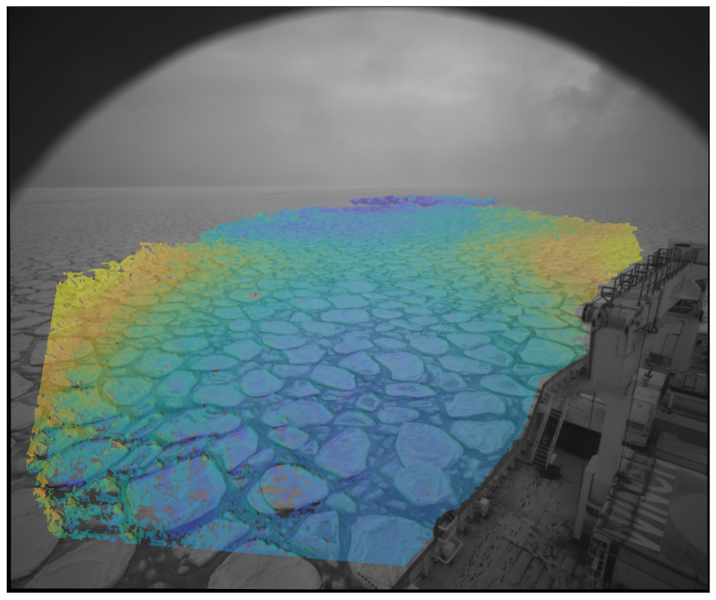
- Frequent **polar cyclones** reshape the **MIZ** at synoptic scales
- **Measured** fastest Lagrangian drift of the Antarctic MIZ (wind dominated) in 100% ice. Derived **model** to estimate sea ice drag.
- Alberello et al, The Cryosphere, 2019; Vichi et al, GRL, 2020; Alberello et al, JGR, 2020.

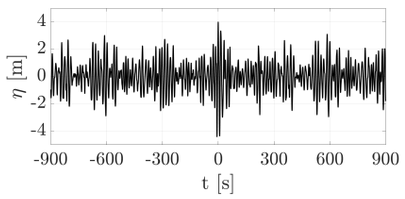


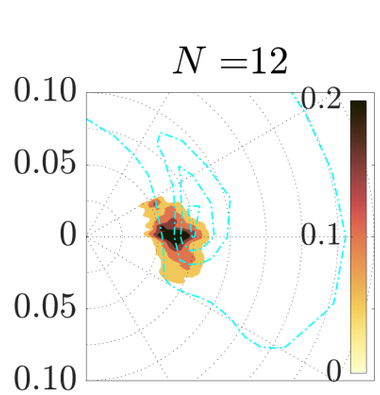


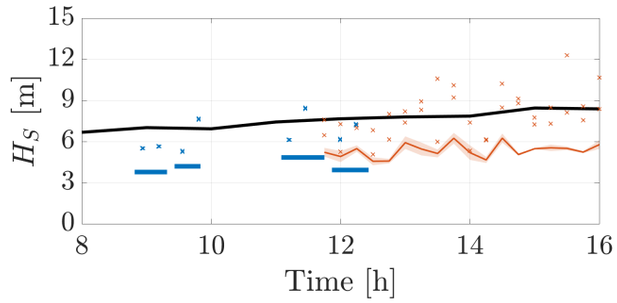
Wave-ice interactions

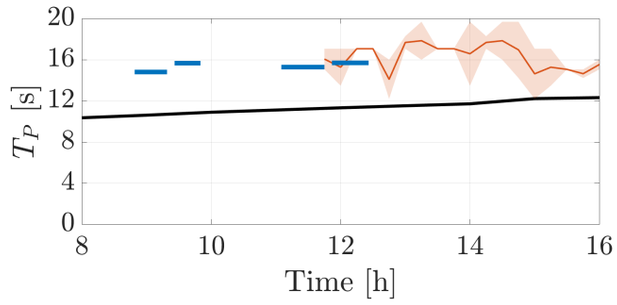
- **In-situ measurements** of waves (time-domain and spectral) and satellite observations
- **Model tests** of wave in ice propagation
- Alberello et al, ISOPE, 2019; Passerotti et al, ASME, 2020







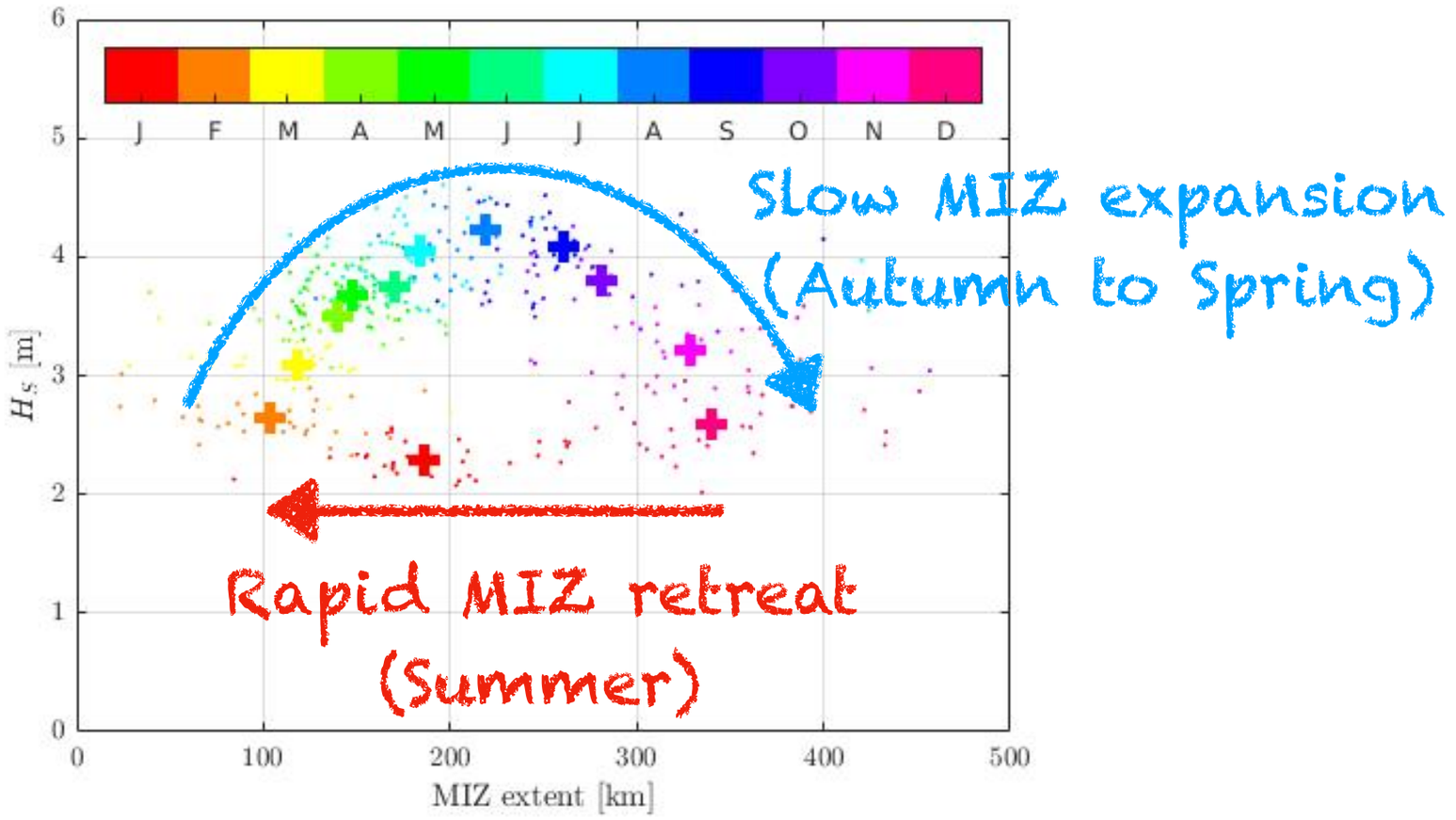




- Waves dissipates in ice, shorter waves dissipate faster
- **Wave dissipation rate** (needed for implementation in wave-ice coupled models) **depends on ice type and concentration**
- **High dissipation with compact ice and large floes** — waves dissipated in few kms
- **Low dissipation with broken ice/floes** — waves propagate hundred of kms

Summary

- MIZ evolves at seasonal scale and (rapidly) at synoptic scale



- MIZ concentration **vs** MIZ dynamics
- **Wave-ice** interactions depend on **ice concentration** and **ice type**