Observations of Dynamic Air-Ice-Ocean Interaction Events During MOSAiC

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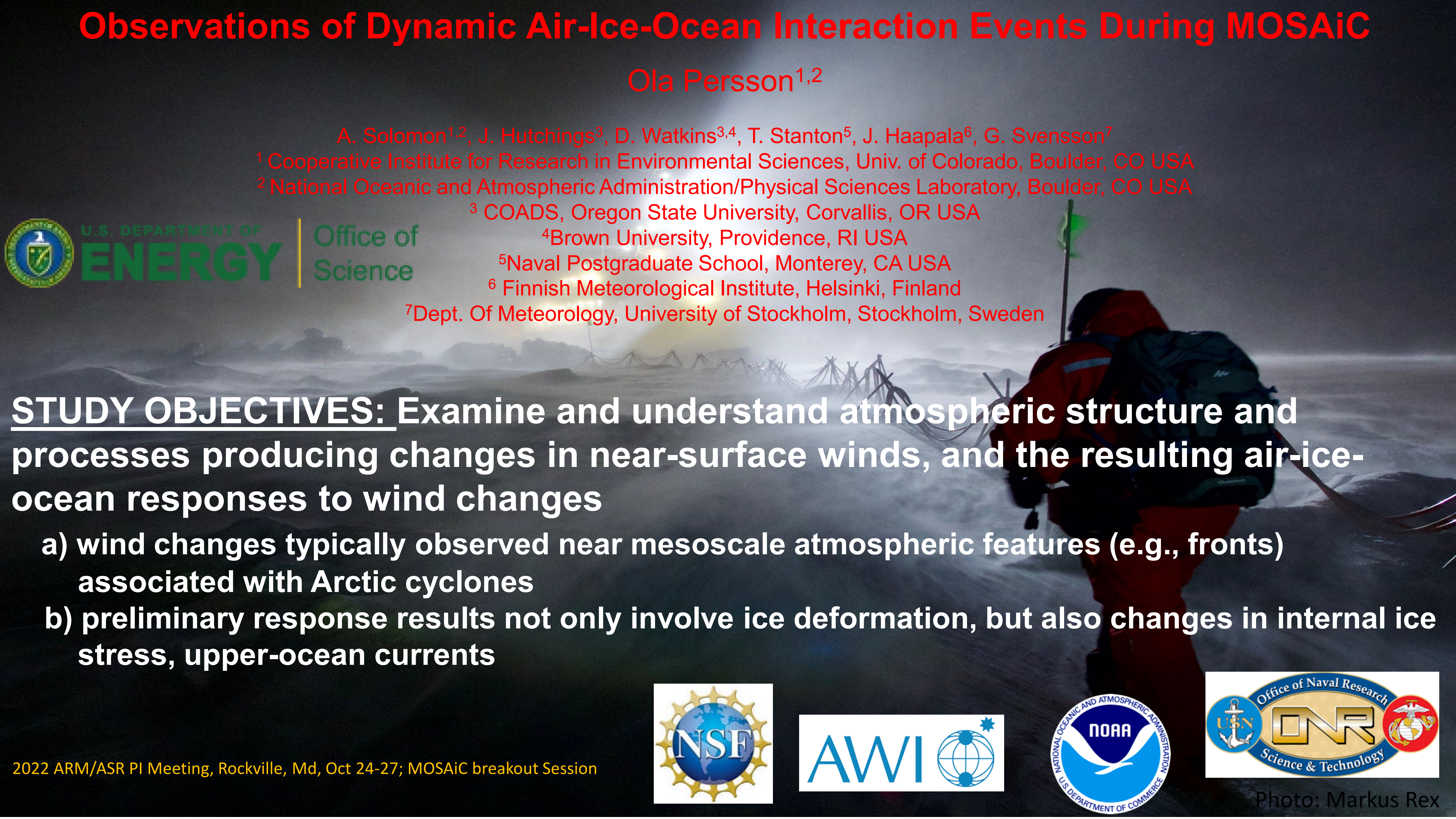

STUDY OBJECTIVES: Examine and understand atmospheric structure and processes producing changes in near-surface winds, and the resulting air-ice-ocean responses to wind changes

- a) wind changes typically observed near mesoscale atmospheric features (e.g., fronts) associated with Arctic cyclones
- b) preliminary response results not only involve ice deformation, but also changes in internal ice stress, upper-ocean currents

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Photo: Markus Rex

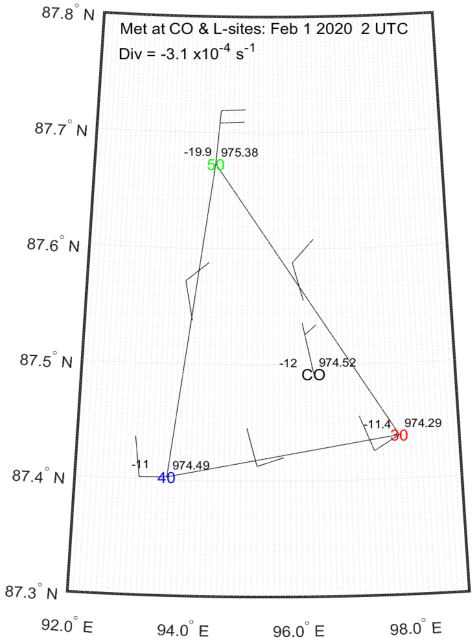
Key Premise: Atmospheric winds are primary forcing that moves and deforms sea ice, and influences upper-ocean currents. Results suggest modifications.

Changes in ice velocity · *Internal stress tensor* · *atmospheric stress* · *ocean stress* · *Coriolis forcing* · *large-scale ocean slope*

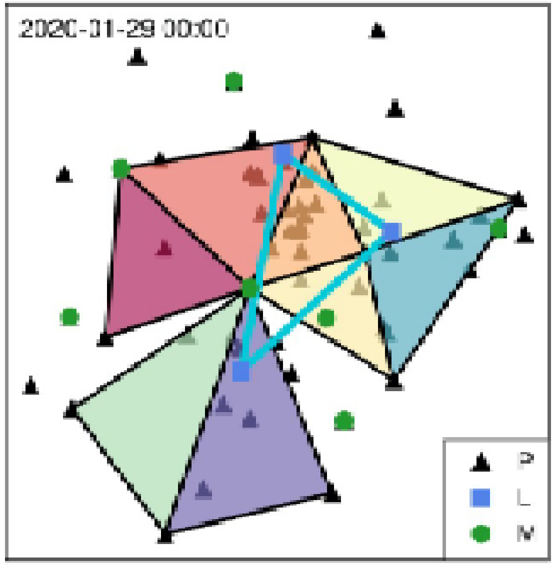
$$m\,\partial \mathbf{u}/\partial t = \nabla \bullet \boldsymbol{\sigma} + \boldsymbol{\tau}_a + \boldsymbol{\tau}_w - [\mathbf{k} \times (m\, f_C\, \mathbf{u})] - m\, g\, \nabla H_0$$

Method: Use air, ice, ocean <u>observations</u> from MOSAiC, and NOAA CAFS coupled model, to examine these terms and the processes associated with them

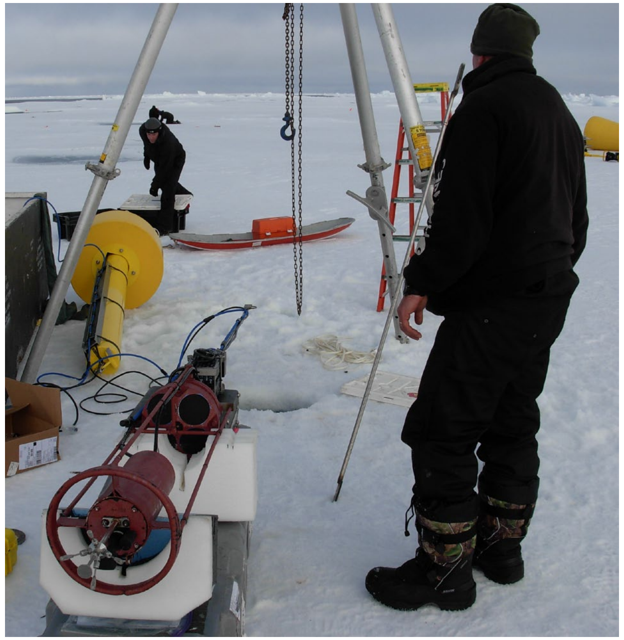
CO & ASFS, met obs, soundings, remote sensors; Atmospheric divergence



Ice GPS buoys; ice deformation triads



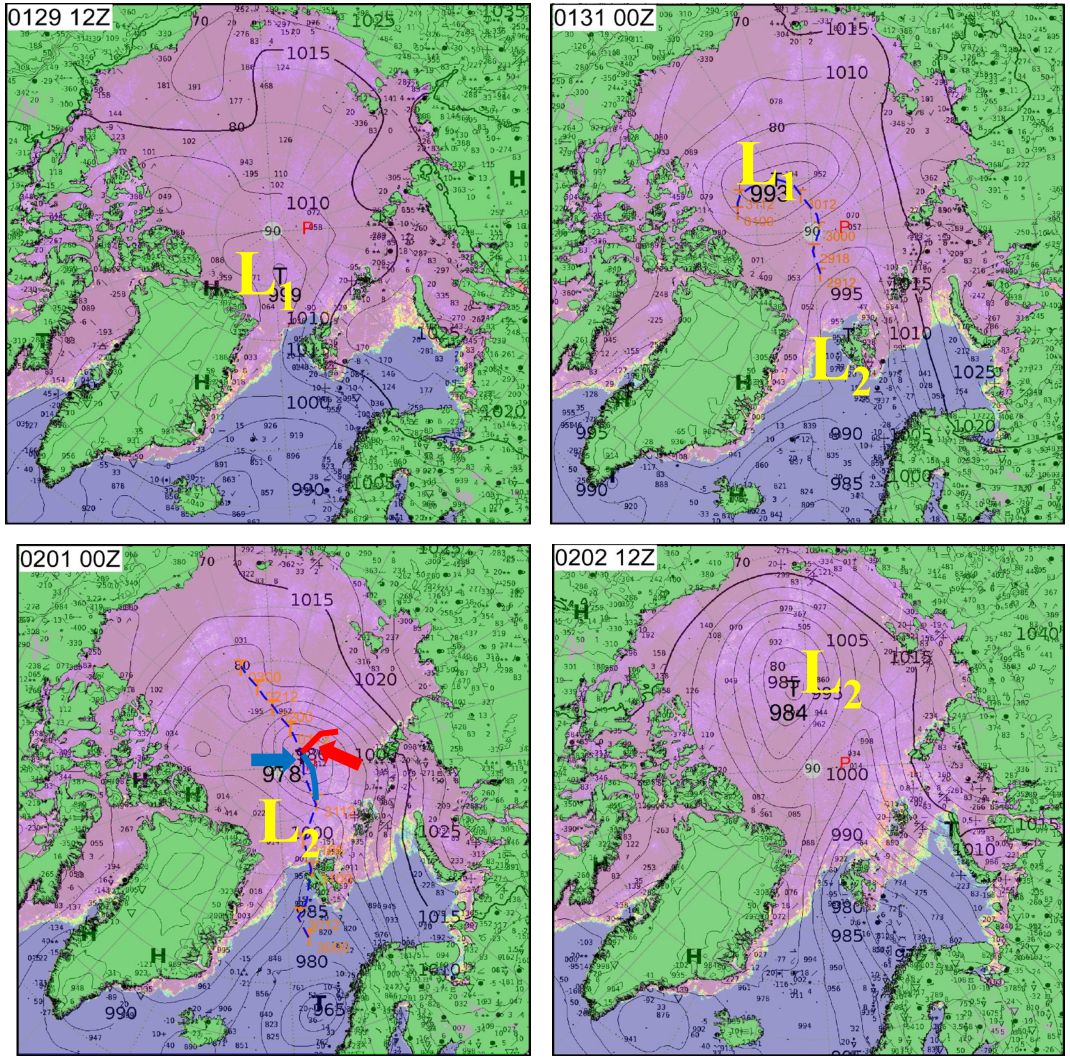
ADCP measurements of ocean currents



1) Strong changes in vector winds (speed/direction) produce or enhance ice deformation events

- atmospheric changes often linked to synoptic/ mesoscale features (LLJs, fronts)

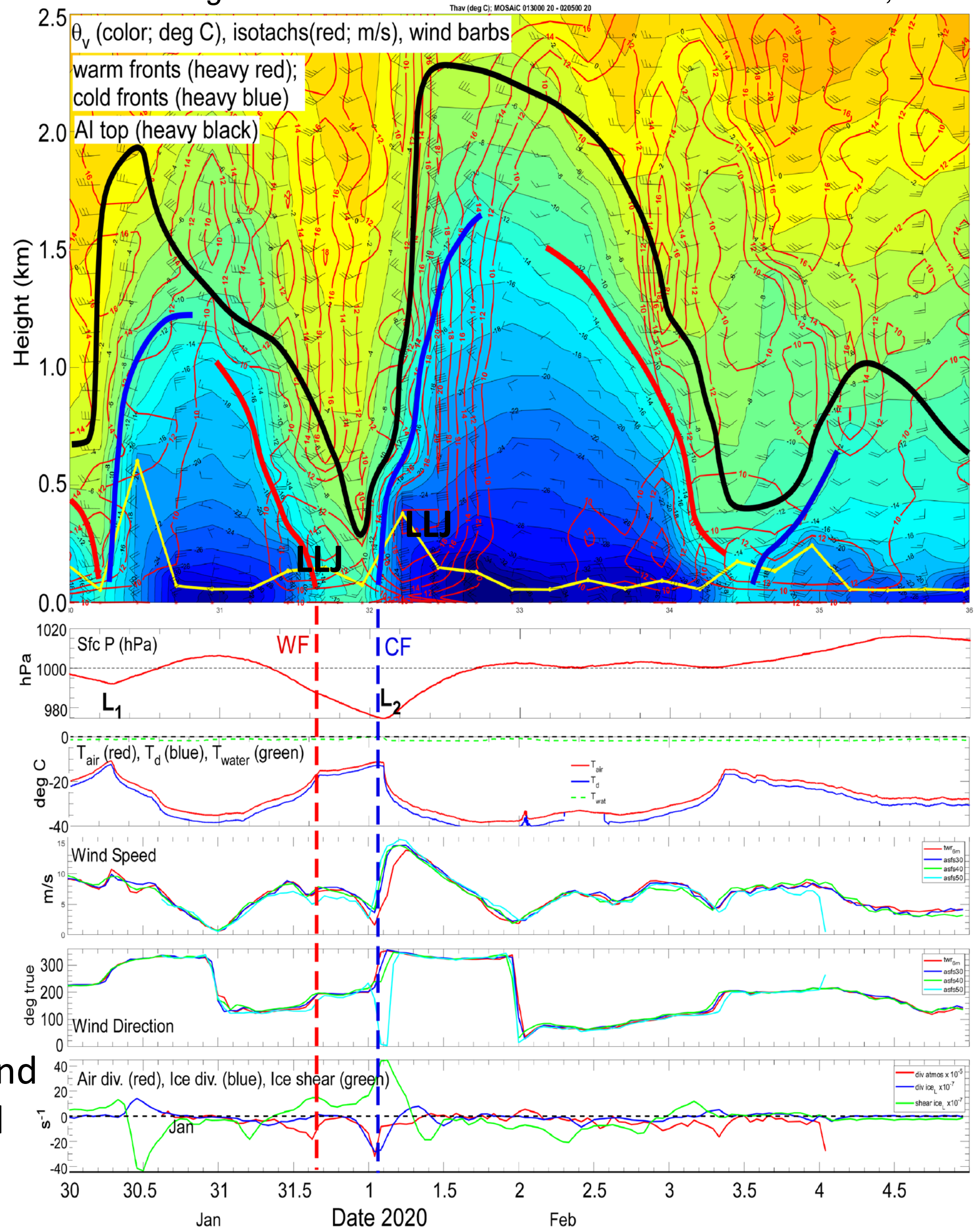
- quasi-axisymmetric LLJs for some cyclones esp. impactful



DWD MSLP analysis; AMSR2 ice conc

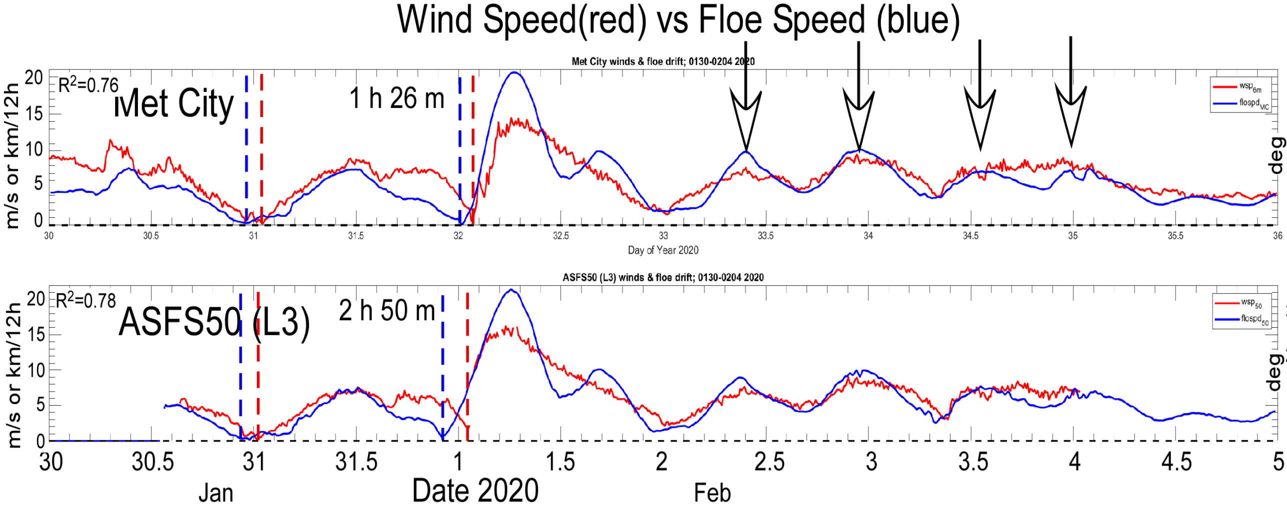
Axisymmetric LLJ produced large, surface wind speed and directional changes between 23 UTC Jan 31 and 04 UTC Feb 1.

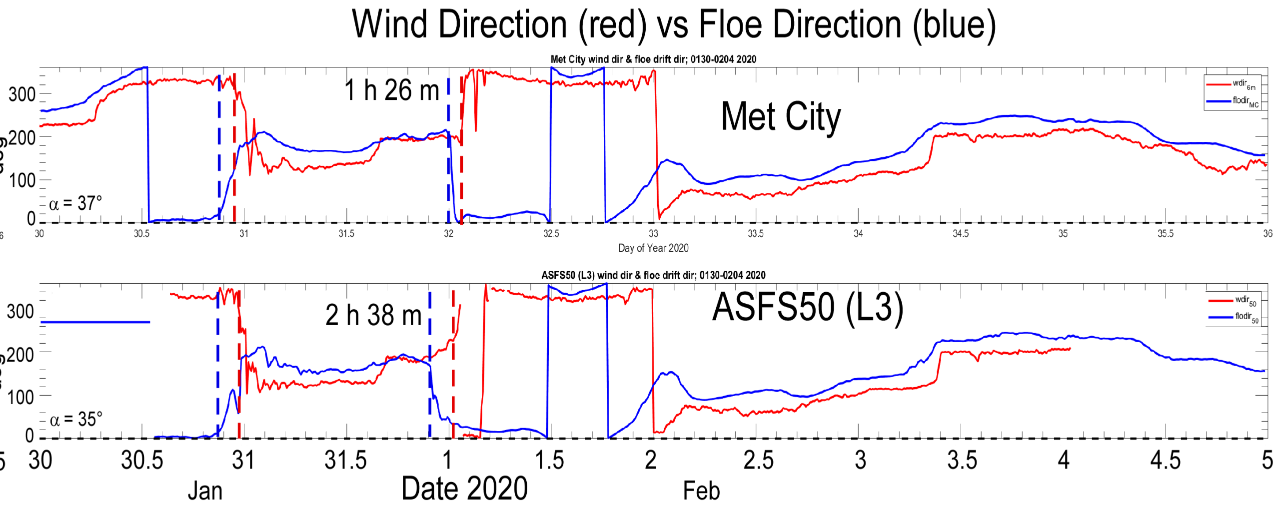
Observed time-height section and surface time series Jan 30- Feb 4, 2020



Atmos conv, ice conv, and ice shear max near cold front

2) Confirm high correlation between wind speed/direction & ice motion (speed/direction)


Wind Speed(red) vs Floe Speed (blue)

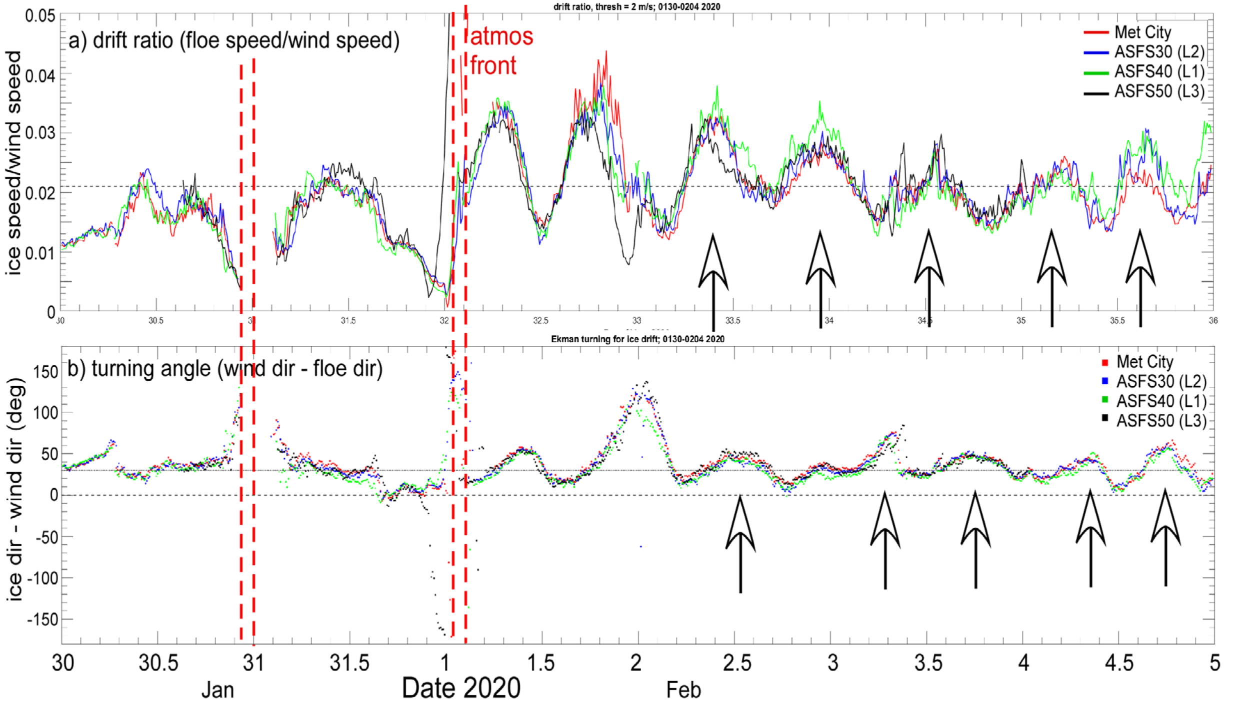

Wind Direction (red) vs Floe Direction (blue)

3) Timing of local ice events may be offset from local atmospheric forcing

- Feb 1: local ice reversal occurs 1.5 - 3 h prior to local wind reversal
- Jan 16: local ice event forced by fronts outside DN
- suggests importance of internal stress term for local ice forcing ("forcing at a distance")

4) Classic air-ice relationships (ice drift ratio ~0.02, Ekman turning angle 30°-35°) confirmed in the mean but have significant temporal variability

5) Strong atmospheric forcing events (e.g., 00-02 UTC Feb) can produce inertial "ringing" in ice and ocean motions (arrows)



6) Strong atmospheric forcing events not only impact ice motion/deformation, but subsequent ice motion can produce changes in upper-ocean currents

SUMMARY

a) atmosphere impacts ice motion (atm stress term)

b) changes in local ice motion may be forced by atm forcing at a distance (internal stress term)

c) changes in ice motion induces changes in upper ocean currents (ocean stress term)

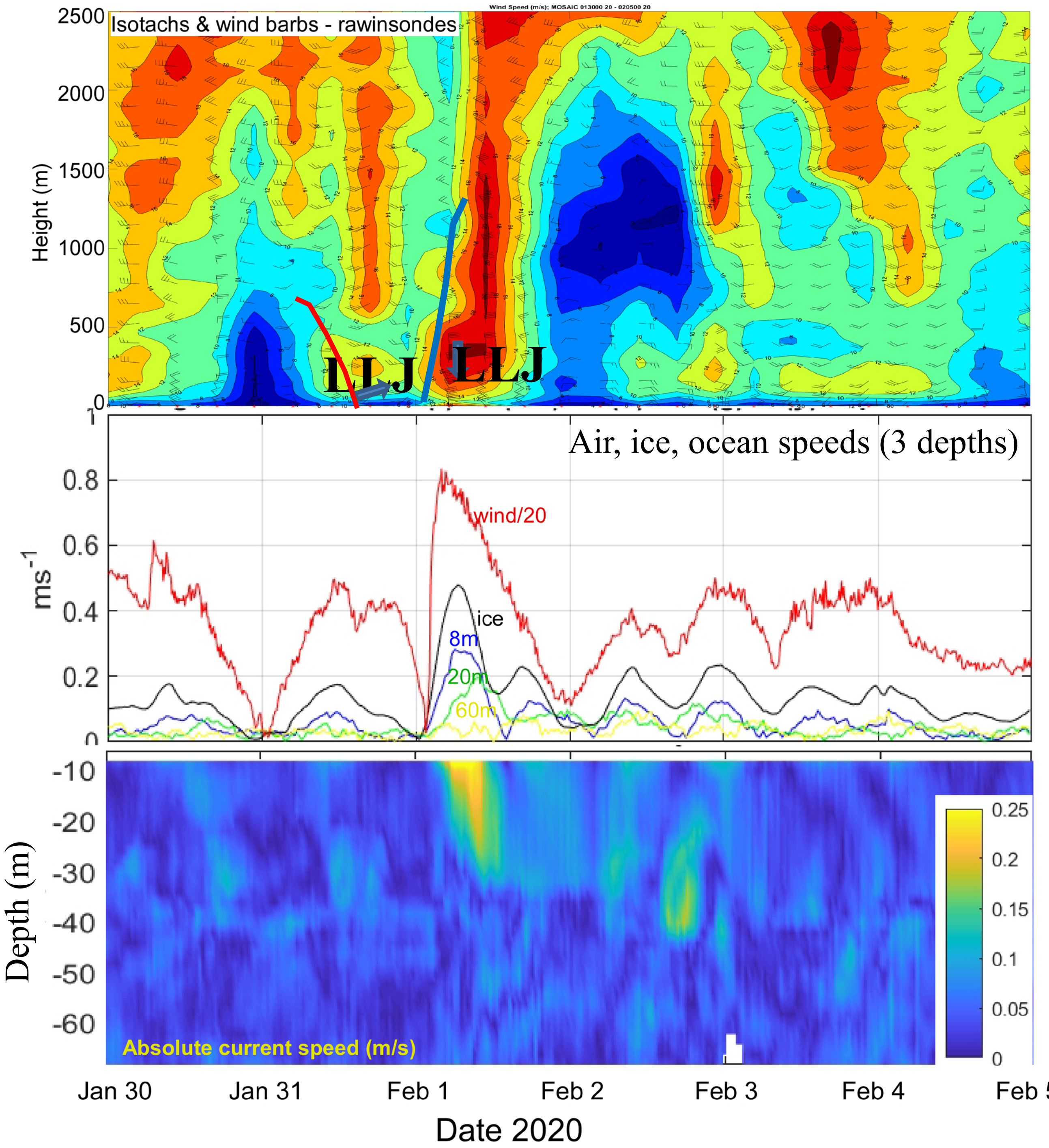
d) large ice dynamics events can produce inertial ice & ocean motion (Coriolis term)

ONGOING/FUTURE WORK

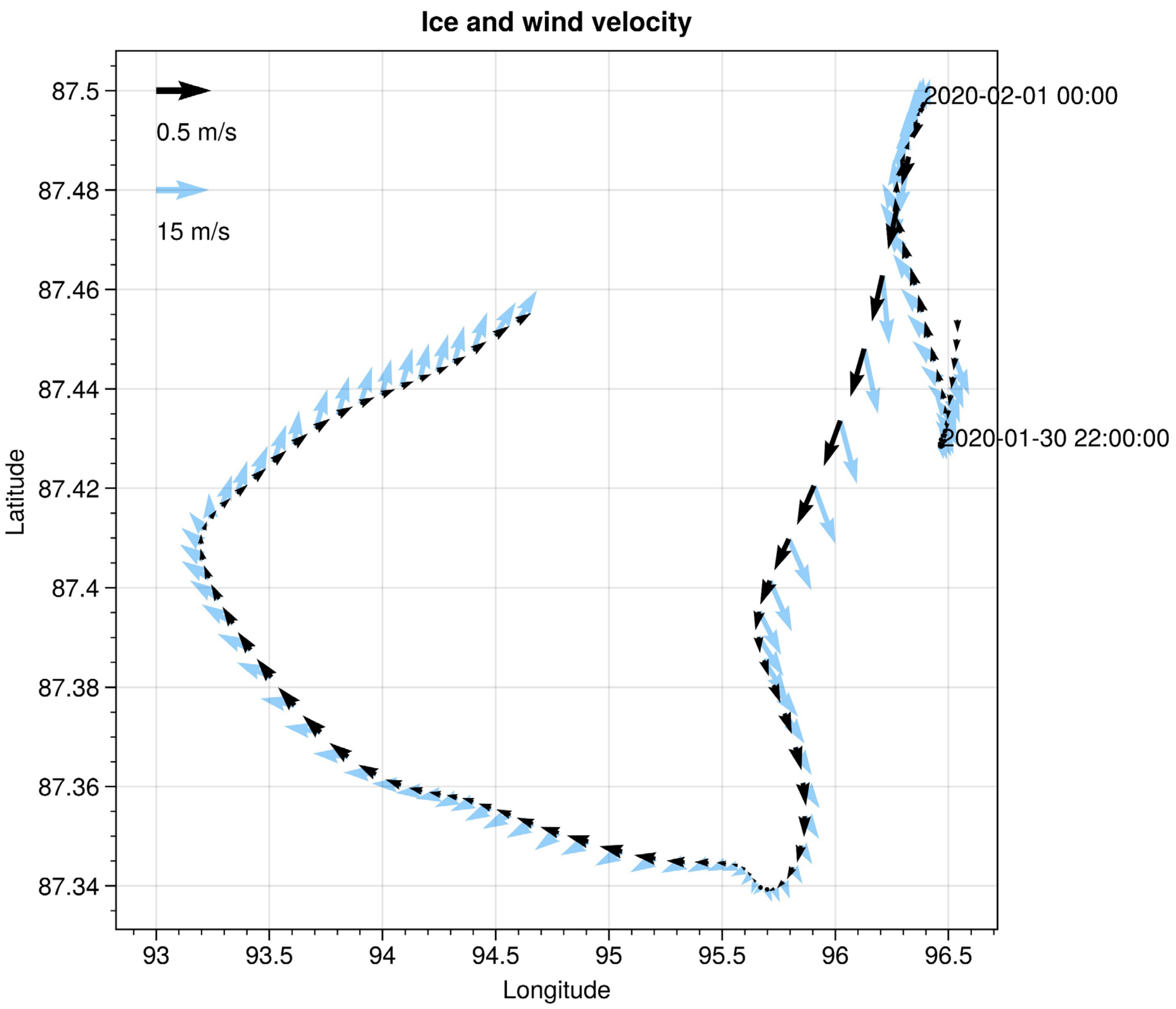
a) Sorting out details of atmospheric forcing features, esp. forcing of ice events without obvious local atmospheric forcing

b) b) Trying to quantify various terms of budget equation

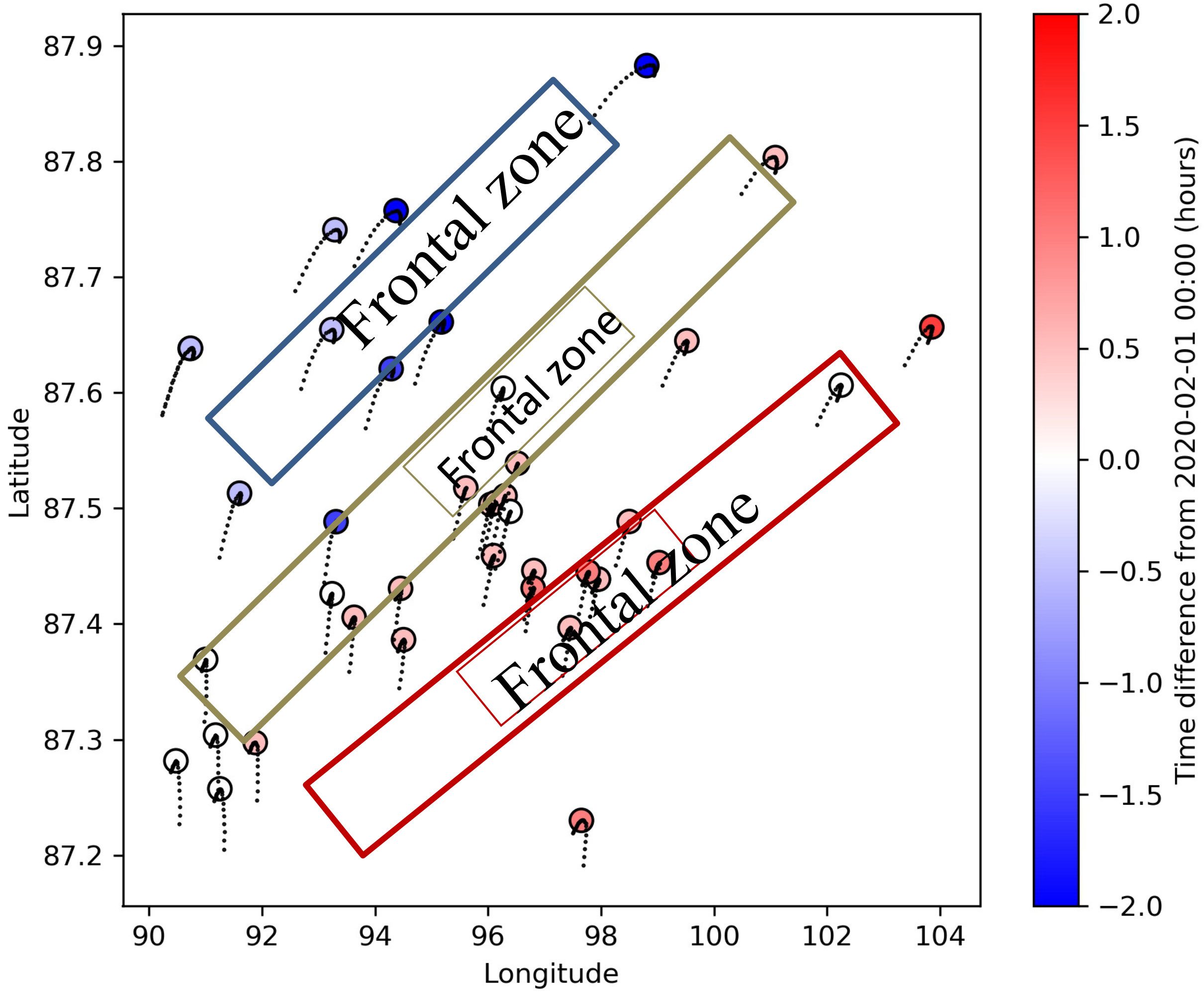
c) Validating processes in coupled CAFS model



CO Met City positions, wind vectors (blue) & ice motion vectors (black) (00Z Jan 30 – 00Z Feb 4 2020)
- ice track changes abruptly with wind changes
- ice track reverses near 00Z Feb 1, forming track cusp



DN buoy tracks (dots) and track cusp times (Jan 31 18Z – Feb 1 6Z; ½-hour intervals)
- track cusps mark times of floe direction change
- cusp timing progresses from NW to SE across DN in ~2-3 hours, with transition centered on 00Z Feb 1 in center of DN (at CO) 2 h BEFORE CO wind shift
- ice analysis also implies atmospheric forcing of ice north of front propagates ahead of atmospheric front



22 Cyclones during MOSAiC Drifts (vertical black lines; SLP<1000 hPa); Polarstern Mast Met data (Winds - 38.9 m; T - 28.9 m)

Cases discussed in this talk: blue boxes (4 events, 7 cyclones)