EGU2014-4637

Dynamics of near-surface wind response to Arctic sea ice

Hyodae Seo (hseo@whoi.edu) and J. Yang
Physical Oceanography Department
Woods Hole Oceanographic Institution

1. Summary

Goal: Examine the dynamics of two near-surface wind responses, 10-meter wind (W10) and SLP-based geostrophic wind (Wg), to various Arctic sea ice conditions.

Method: Use the Polar WRF weather model forced with multiple sea ice concentration (SIC) datasets.

Result: Variations in W10 and Wg involve distinctive dynamical mechanisms and reflect different spatial information of sea ice condition.

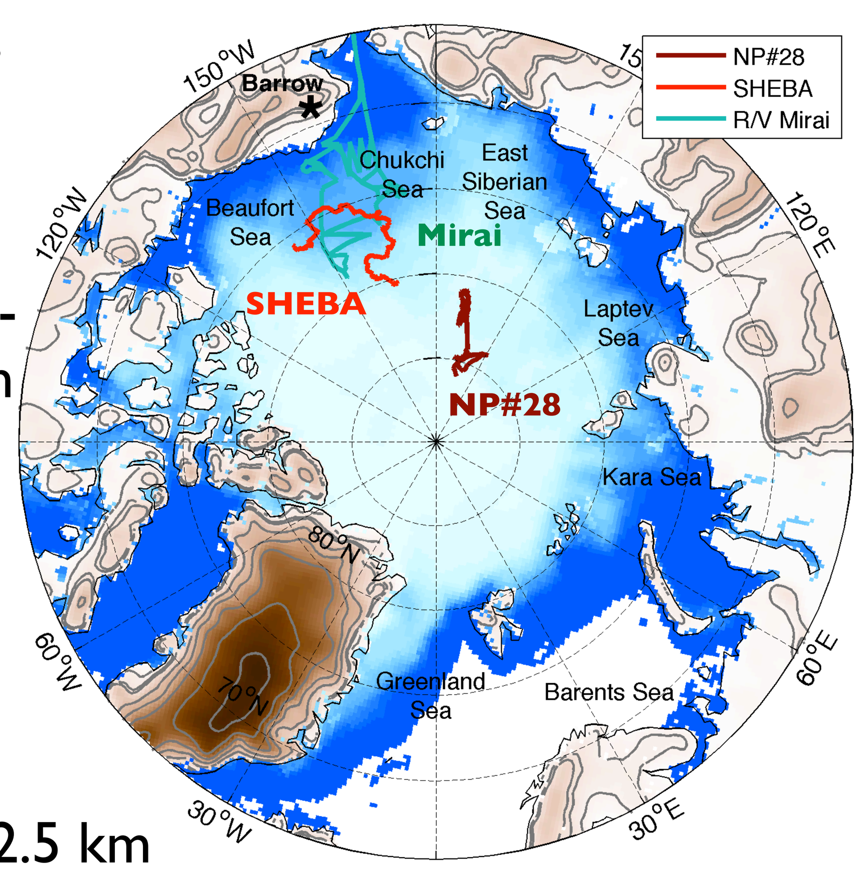
Implication: An accurate representation of the dynamical process for surface winds is important for the improved understanding of air-ice-ocean interactions.

SST-wind mechanisms	vertical mixing	pressure adjustment
key process	1D turbulent momentum transport	lateral pressure gradient and ageostrophic flows
phase relationship	$\nabla\cdot u \propto \nabla_d T$	$\nabla\cdot u \propto \nabla^2 P \propto \nabla^2 T$
time-scale	faster (<synoptic)	slower (>synoptic)
height-scale	shallower (below PBL)	deeper (beyond PBL)
horizontal-scale (Arctic)	broader (the whole Arctic basin)	narrower (the ice margins)

2. Model, experiment, and data

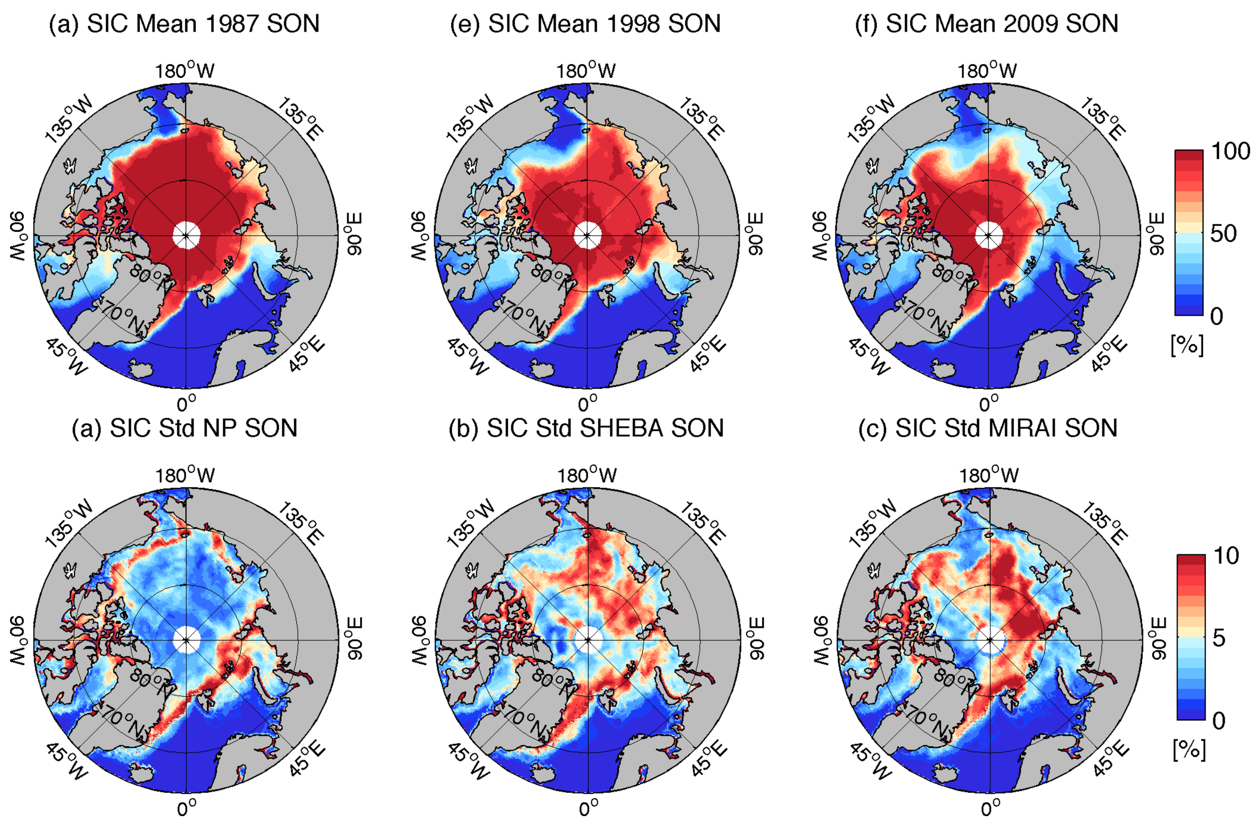
- Model: Polar WRF (Hines and Bromwich, 2008), 25 km resolution
- Experiment: A series of 1-year integration forced with 3 SICs

1) NT: NASA Team, 25 km (Cavalieri et al., 1996)
2) BT: Bootstrap, 25 km (Comiso, 2000)
3) EU: EUMETSAT hybrid, 12.5 km (Tonboe et al., 2011)



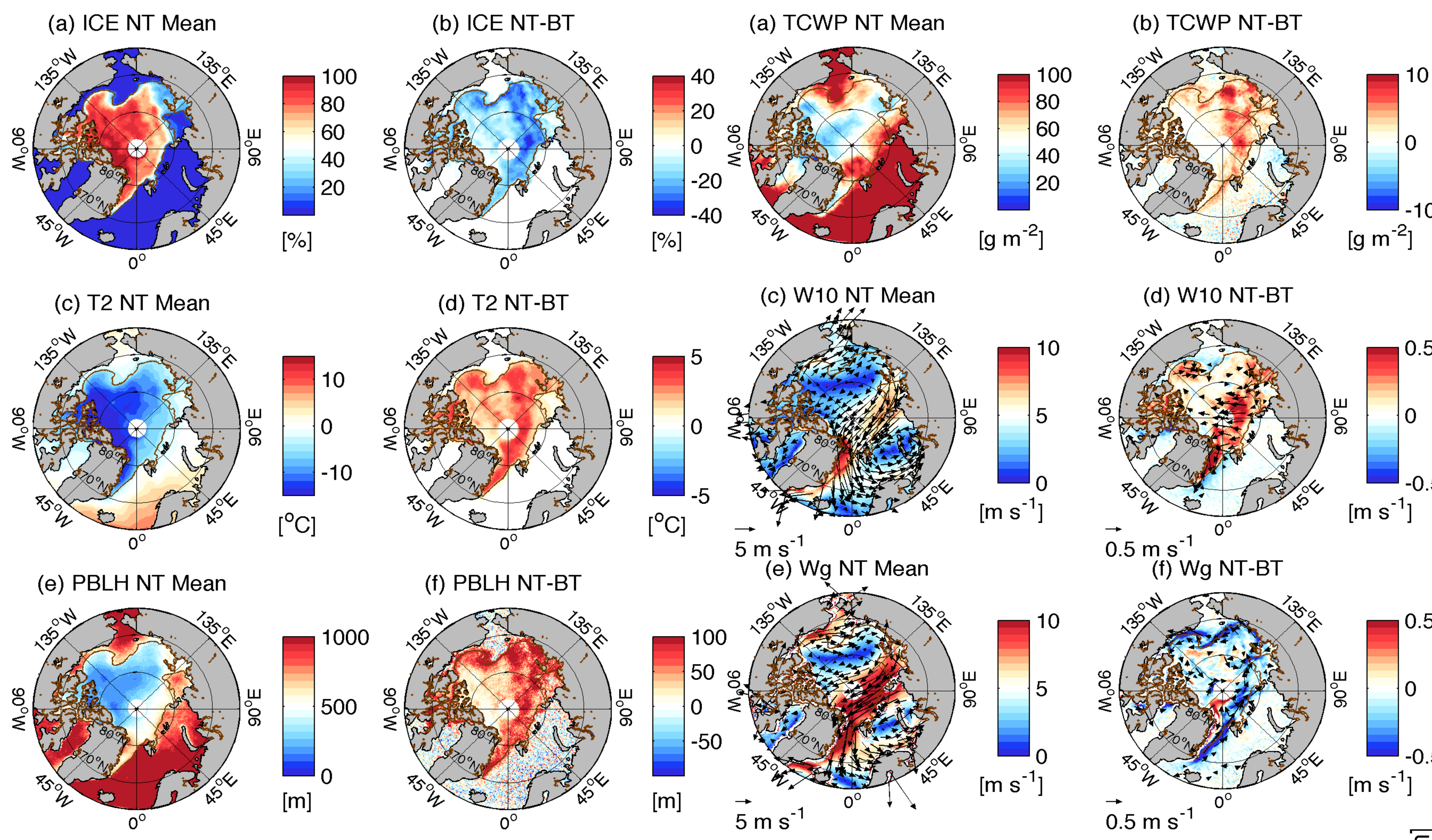
Polar WRF domain

3. Sea ice concentration estimates



- The autumn SICs show an Arctic-wide uncertainty pattern.
- We will look for ABL response to different SIC products.

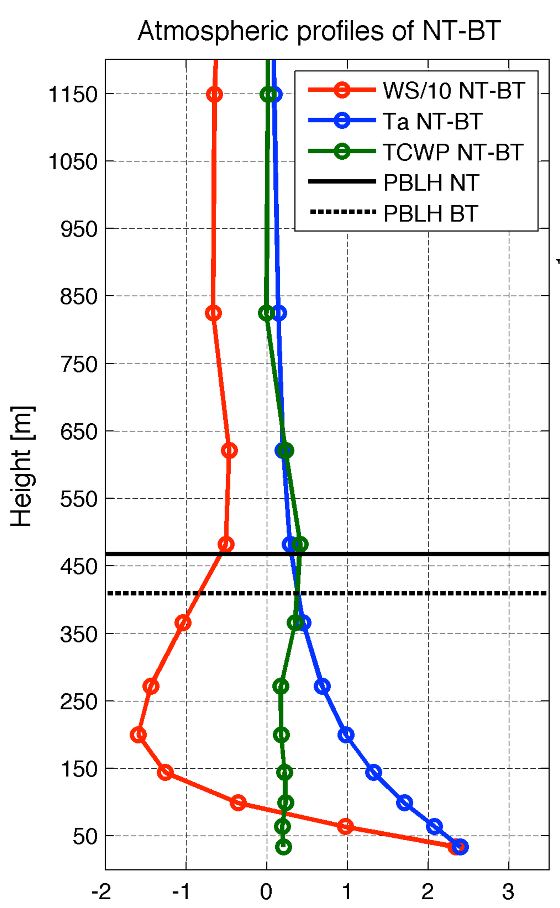
4. Pan-arctic ABL response: NT-BT



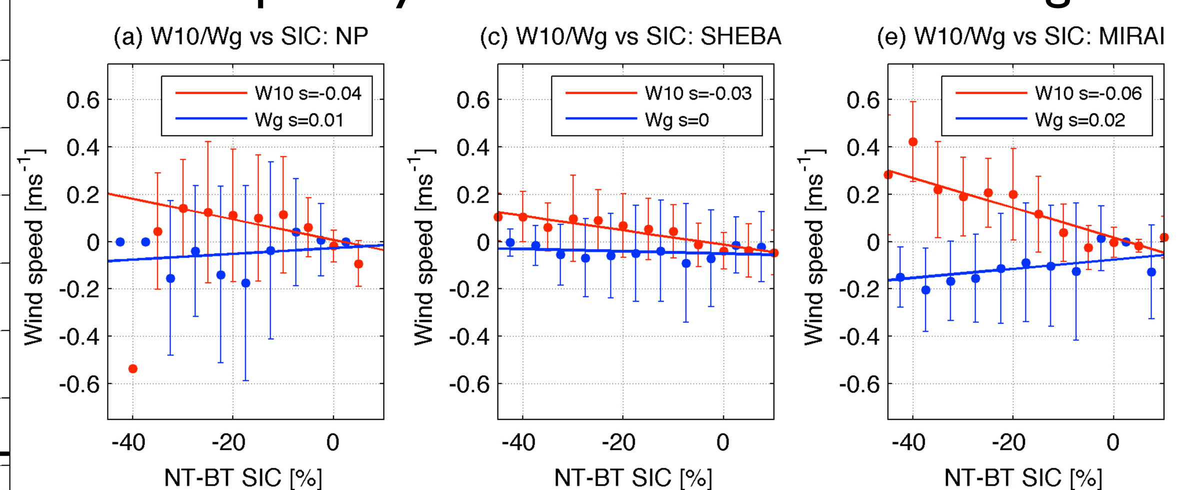
- Lower SIC produces higher T2, PBL and cloud water path, and W10, an indication of an unstable ABL.
- Comparable spatial scale of between wind and SIC

$T' \rightarrow u'$ via ABL stability

5. Modulation of the ABL static stability



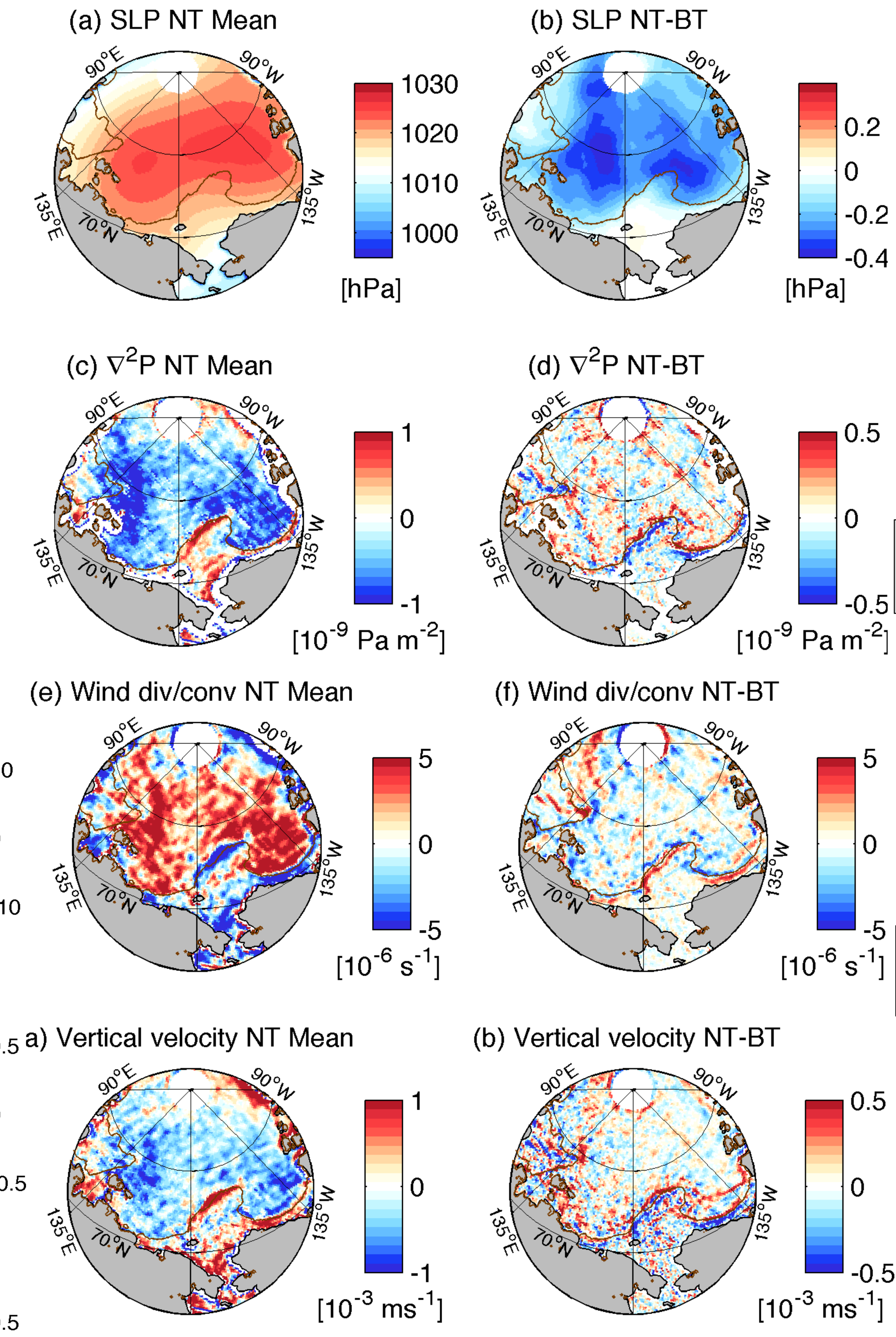
Statistical method (Chelton et al., 2004) to quantify the effect of vertical mixing



- W10: A quasi-linear relationship → W10 response is consistent with the vertical mixing mechanism.
- Wg: No significant relationship → a different mechanism is needed to explain Wg response.

- Unstable PBL with higher temperature and clouds below PBL.
- Increased surface wind at the expense of decreased wind aloft

6. Modulation of surface pressure



- A linear MABL model of Minobe et al. (2008)

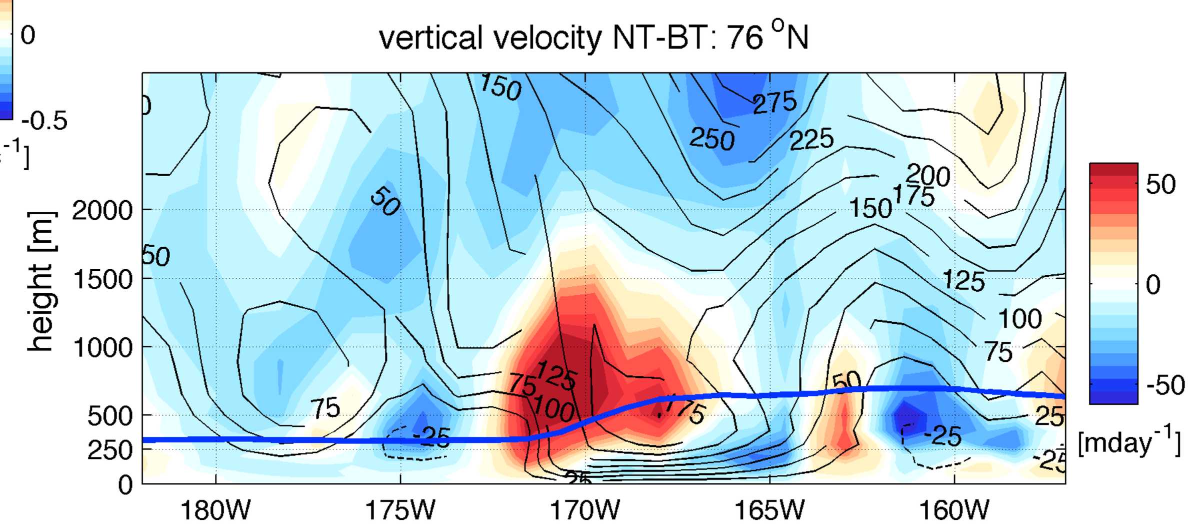
A steady flow, no advection, linear friction.

$$\rho_o(\nabla\cdot\vec{u}) = -(\nabla^2 P)\varepsilon/(\varepsilon^2+f^2)$$

- $\nabla\cdot u$ is proportional to $\nabla^2 T$ (via $\nabla^2 P$).

$$w(z) = \frac{1}{\rho_o}\left(\frac{\varepsilon z}{\varepsilon^2+f^2}\right)\nabla^2 P$$

- w is also proportional to $\nabla^2 P$



- A "deep" atmospheric response.

7. Implications

W10 and Wg, governed by different dynamics, reflect different spatial information of ice condition.

- In situ SLP-based Wg *underestimates* the effect of basin-scale SIC changes.
- W10 from coarse resolution reanalyses *underestimates* the wind variations across the ice margins.
- A more accurate representation of the surface wind variability reflecting the both effects is needed.

Seo, H. and J. Yang, 2013: Dynamical response of the Arctic atmospheric boundary layer process to uncertainties in sea ice concentration. *JGR-Atmos.*, 118, 12,383-12,402