High Latitude PBL Winds Sites & Field Observations in preparation for ADM-*Aeolus* Mission

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Motivation

Winds in polar regions frame several physical processes in the PBL with wide implications in weather, climate, energy resources and public health and safety

Anticyclone Conditions

- **Quiescent flows in the polar PBLs** are a key ingredient promoting the formation of **surface based temperature inversions (SBI).** SBIs are known to slow down surface radiative cooling during the long winter nights and drive Air Pollution episodes in urban areas (*Malingowski et al, 2014*).
- **Occurrence of Shallow Cold Flows in polar basins** impact the PBL thermodynamics and surface turbulence as well as the surface energy balance of the snowpack and permafrost regime (*Fochesatto et al, 2014*).
- Large scale synoptic flows introduces **elevated temperature inversion layers** promoting radiative interaction with the local PBL altering the surface energy balance (*Mayfield and Fochesatto, 2013*).

➢ Such restricted conditions in the PBL flow challenge mesoscale modelling to reproduce thermodynamic and flux exchanges at the land-surface interface.

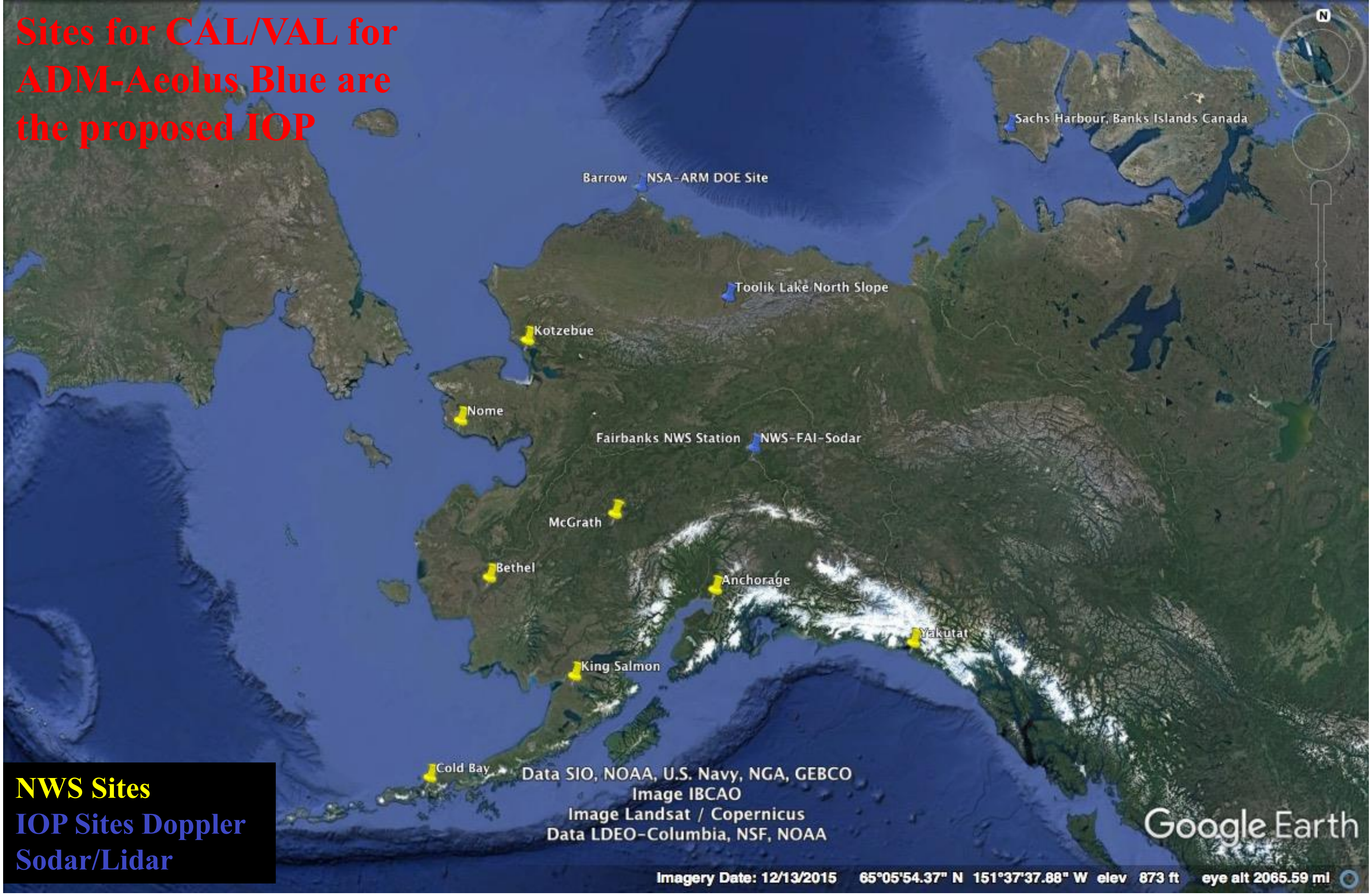
ADM-*Aeolus* wind profile mesoscale assimilation is critical to improve weather and climate processes across time and spatial scales from local to regional levels.

Cyclone Conditions

- The **Gulf of Alaska is the "graveyard" of storms** tracking northward in the western Pacific. During storms episodes **surface winds can rise and be higher than 100 mi/hr near shoreline**.
- Transition to winters (end of August/September) in Arctic Tundra (north of Brooks Range) normally comes after storms developed in the Beaufort Sea propagating inland.
- **Sediment venting and methane fluxes** in the East-Siberian Arctic Shelf (a shallow ocean with sub-sea permafrost) **are exacerbated by extreme storms reaching east Siberia** (*Shakhova et al, 2010*).
- **Strong winter winds in the PBL (>13 m/s) on Arctic plains** causes poor visibility conditions due to blizzards; glaciating the surface and giving origin to snow dunes formations (*Filhol and Sturm, 2015*).
- Northward migration of the Arctic front drives Chinooks events causing warming episodes in Interior Alaska.
- Information on offshore winds above sea level ~ 20 m ASL are important for energy extraction and future development of Alaska's natural resources.
- Some Alaskan villages in the northwest are being relocated due to permafrost subsiding and coastal erosion caused by storms in the North-West Pacific (e.g., Kivalina, Shismaref) .
- Increasing arrivals of Low pressure systems and their dynamical development in high latitudes possess threats to life and marine and coastal assets.

ADM-Aeolus wind profile would help undergoing efforts to develop accurate tools to assess weather and climate hazards and cope with climate change.

Sites for CAL/VAL for ADM-Aeolus Blue are the proposed IOP



NWS Sites
IOP Sites Doppler Sodar/Lidar

CAL/VAL Sites & Instruments

Soundings 00 & 12 UTC
http://weather.uwyo.edu/upperair/sounding.html

Station Code	Name	Lat.	Lon.	Elev.	City	Instruments
70026	**PABR**	**71.28**	**-156.79**	**19.0**	**Barrow**	**Lidar, Backscatter, Doppler, Soundings**
70133	PAOT	66.86	-162.63	5.0	Kotzebue	Soundings
70200	PAOM	64.50	-165.43	7.0	Nome	Soundings
70219	PABE	60.78	-161.84	33.0	Bethel	Soundings
70231	PAMC	62.96	-155.61	103.0	McGrath	Soundings
70261	**PAFA**	**64.81**	**-147.89**	**134.0**	**Fairbanks**	**Backscatter Lidar, Doppler Sodar, Soundings**
70326	PAKN	58.68	-156.67	8.0	King Salmon	Soundings
70316	PACD	55.20	-162.71	31.0	Cold Bay	Soundings
70273	PANC	61.16	-150.01	40.0	Anchorage	Soundings
70361	PAYA	59.51	-139.62	12.0	Yakutat	Soundings
--	**--**	**68.63**	**-149.60**		**Toolik Lake**	**Doppler Sodar**
--	**--**	**71.98**	**-125.24**		**Sachs Harbour**	**Doppler Sodar Collaboration with U. Victoria, Victoria & UQAM-Montreal.**

IOP s in support of ADM-Aeolus CAL/VAL Field Campaign

IOPs will be developed three months after ADM-launch

1. RAOBS across Alaska – Continuous 00 and 12 UTC.
1. Barrow ARM-NSA-DOE Backscatter HSRL lidar, Doppler lidar (Continuous)
2. Fairbanks (Lidar NASA-MPL) continuous and Doppler Sodar (during IOP, need funding)
3. Toolik Lake: Doppler sodar (during IOP need funding)
4. Sachs Harbour Banks Islands Doppler sodar and surface meteorology and turbulence observations (pending funding, submitted proposal in collaboration with University of Victoria and Universite de Quebec a Montreal).

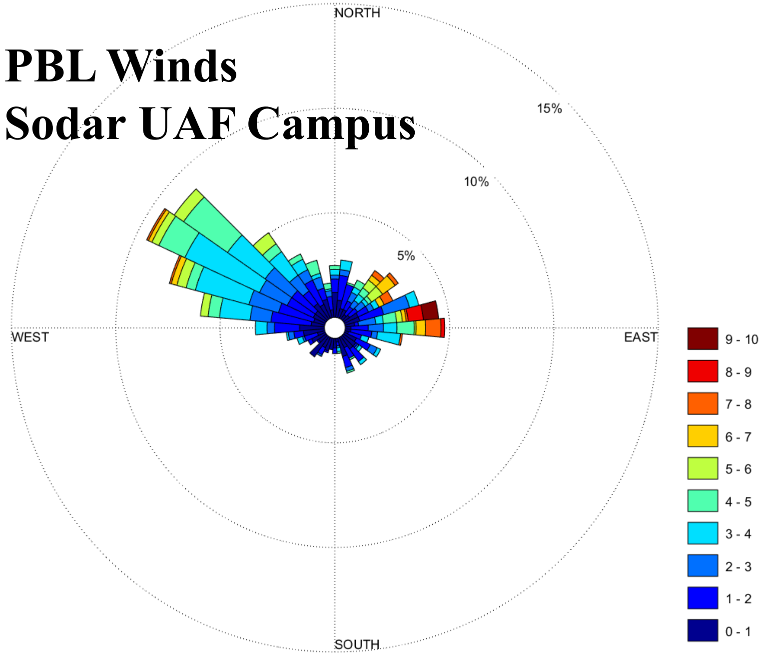
<u>Comparison exercises</u>: PBL winds Doppler Sodar-RAOBS collocated (table) and wind roses between UAF campus & NWS-Fairbank

Jan-Feb 2010 Statistical values of WS & WD difference

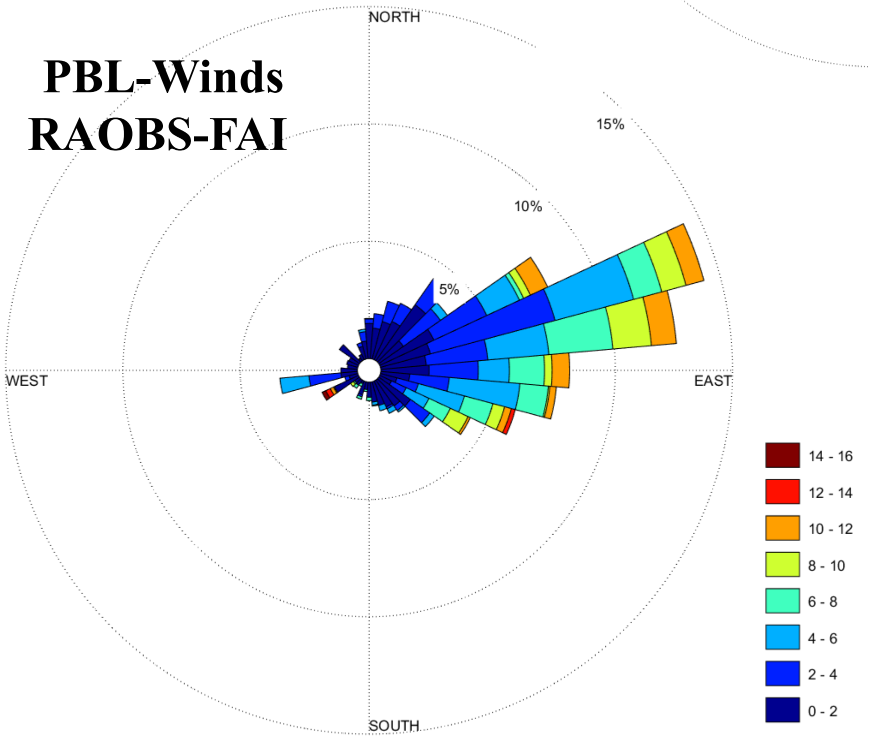
Wind Speed	Mean	Median	Std	Max	Min	0.10	0.90
50 m - 100 m	0.13	0.08	0.89	2.12	-1.62	-1.09	1.37
100 m - 200m	-0.29	-0.31	1.04	2.35	-2.70	-1.65	1.06
200 m - 300 m	-0.43	-0.38	1.01	2.12	-3.55	-1.81	0.77
300 m - 400 m	-0.97	-0.92	1.24	1.43	-6.42	-2.24	0.51
400 m - 500m	-1.32	-1.23	1.61	3.22	-7.23	-3.31	0.74
Wind Direction	Mean	Median	Std Dev	Max	Min	0.10	0.90
50 m - 100 m	-5.30	-5.27	54.06	164.83	-165.86	-57.04	61.10
100 m - 200m	-3.73	0.96	46.95	178.41	-163.79	-61.44	42.92
200 m - 300 m	-5.91	-0.13	59.09	173.01	-176.75	-81.35	61.42
300 m - 400 m	3.20	-0.18	53.73	179.91	-178.89	-46.08	64.73
400 m - 500m	-5.48	-6.57	27.28	76.83	-108.01	-30.19	20.78

- ✓ **Differences in Wind Speed range from 0.13 m/s to -1.32 m/s**
- ✓ **Difference in Wind Direction range from -5.3 – 3.2 degrees**

PBL Winds
Doppler Sodar UAF Campus



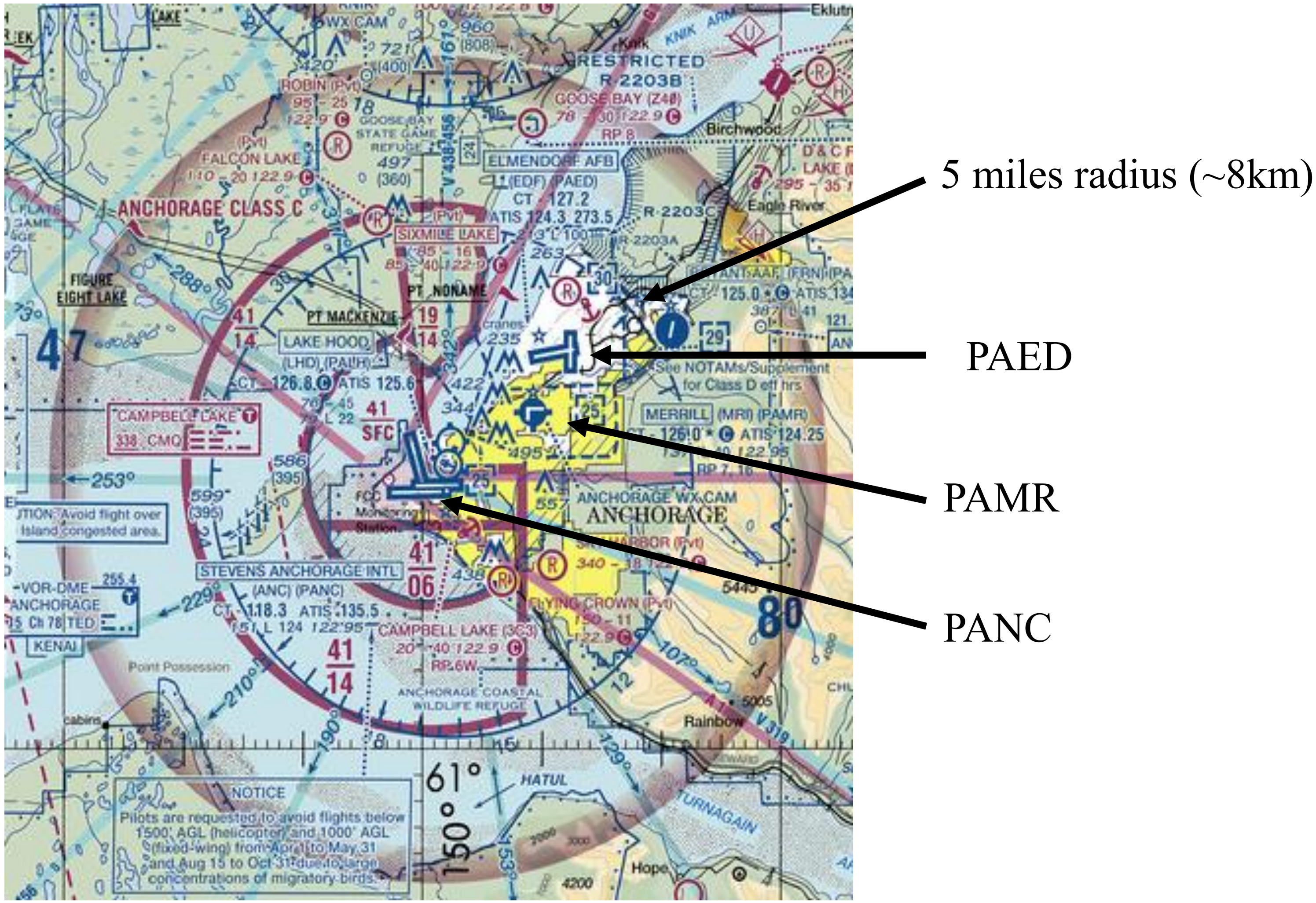
PBL-Winds
RAOBS-FAI



Surface Winds Statistics within a pixel of ADM-*Aeolus*

	Wind Speed[m/s]		Wind Direction	
	Mean	Std	Mean	Std
PANC	3.44	1.89	16.03	76.30
PAMR	2.70	1.32	344.47	68.49
PAED	5.23	3.04	236.13	70.46

- ✓ Wind statistics for PAED differ from PAMR and PANC due the topography of the Cook Inlet.
- ✓ PANC and PAMR winds falls in the light category and predominant from the north quadrant.
- ✓ Cook Inlet (PAED) winds are from the southwest versus the rest of the stations in a 8 km radius have winds generally calm (PANC and PAMR).



Winds in the Cook Inlet (area bounded by active volcanos) are extremely important for dispersion of Volcanic Ashes (Anchorage population is more than 300,000). Coastal hazards and marine operations related to high winds (more than 100 mi/hr) developing in the Gulf of Alaska.

Surface Wind Regime across Alaskan Climate Regions

West Coast

	Wind Speed		Wind Direction	
	Mean	Std	Mean	Std
PABE	5.27	2.69	6.31	75.31
PAKV	3.33	1.81	58.31	76.20
PAOM	5.04	2.89	47.67	73.18
PAOT	5.55	3.60	58.41	73.98
PASN	7.22	3.60	25.12	75.31
PAVL	5.86	5.52	50.16	68.68

Interior

	Wind Speed		Wind Direction	
	Mean	Std	Mean	Std
PABI	4.88	3.39	171.89	71.08
PAEG	3.20	1.57	119.13	66.62
PAFA	5.27	2.69	6.31	75.31
PAEI	2.82	1.75	270.30	77.73
PABT	2.78	1.15	352.55	65.69
PAMC	2.97	1.70	297.70	75.05
PANN	3.39	1.76	10.07	75.28
PATA	3.09	2.18	65.78	68.36
PAOR	4.88	3.39	294.74	73.50

Panhandle

	Wind Speed		Wind Direction	
	Mean	Std	Mean	Std
PAGY	5.90	2.50	198.79	79.74
PAHN	4.62	1.79	15.67	74.21
PAJN	4.32	2.41	98.36	57.04
PAKW	3.16	1.5	165.45	73.74
PANT	4.14	4.44	135.22	66.61

North Slope

	Wind Speed		Wind Direction	
	Mean	Std	Mean	Std
PABR	5.80	2.81	79.57	69.29
PASC	5.77	3.84	82.65	76.92
PAWI	5.81	3.13	72.55	67.59

Aleutians

	Wind Speed		Wind Direction	
	Mean	Std	Mean	Std
PACD	7.30	3.98	269.94	74.91
PAVC	6.46	3.55	260.06	70.94

- Winds in the west coasts are generally from the North-East
- Winds in the Interior region are influenced by topography and are generally within the light wind category in some locations
- Aleutians region have winds generally from the southeast within the category of strong.
- North Slope of Alaska generally ranges above 5 m/s winds with an easterly wind component
- Calm winds are not included in the statistical analysis because ~0 knot wind measures in the 360^{o} (0^{o}) degree direction and therefore biases the calculations.

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