4.2: Characterizing Summertime Wind Systems in the Complex Terrain of the Columbia River Basin during WFIP2, and Validating HRRR Model Skill in Simulating These Flows

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19th Conference on Mountain Meteorology, *virtual presentation*: 13 July 2019

Oregon – Washington WFIP-2** Study Area

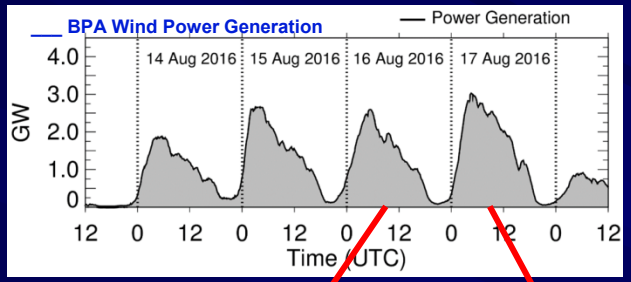
3 Doppler lidar sites: at Wasco, Arlington, and Boardman OR

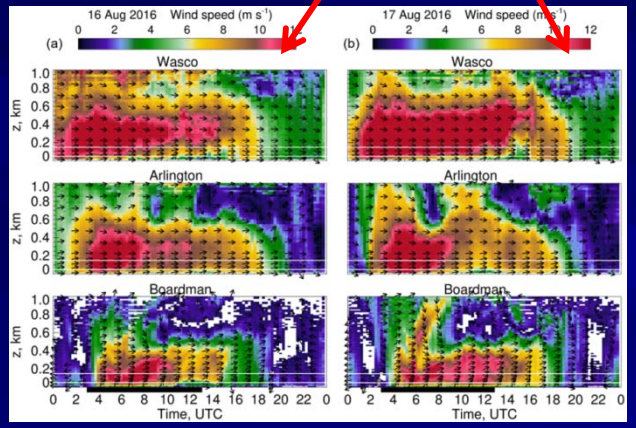
WFIP-2 Goals, include

- "Improve understanding of physical phenomena, processes, and atmospheric properties that occur in these regions and [that] impact wind speeds and direction at turbine hub height" (FOA 2014)
- Validate, improve RAP and HRRR NWP forecast models

WFIP-2 = 2nd **Wind **F**orecast **I**mprovement **P**roject

Recap: *Marine Intrusion*



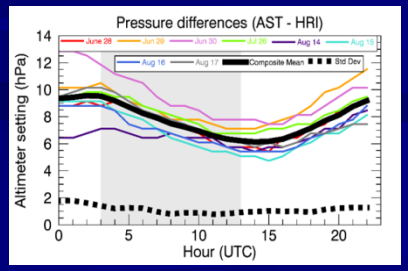


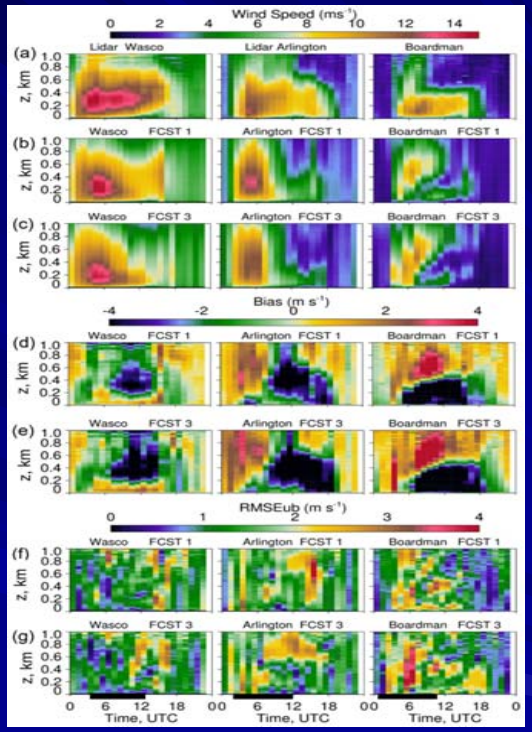
8-day composite

Marine intrusion occurs in HRRR -

- Shut down too fast
- Happens each time
- Onset timing errors

8 cases





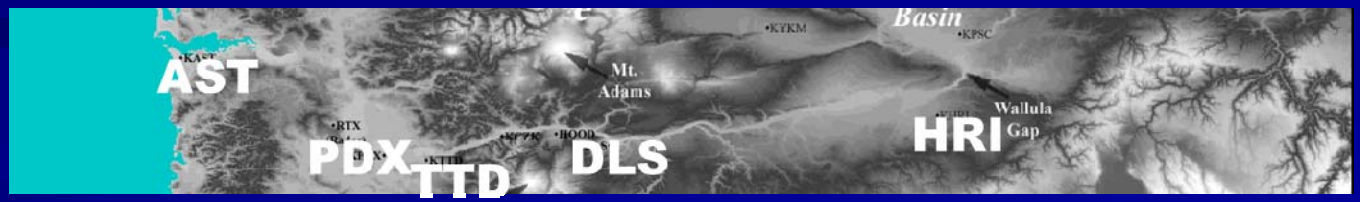
Lidar

1-h HRRR fcst

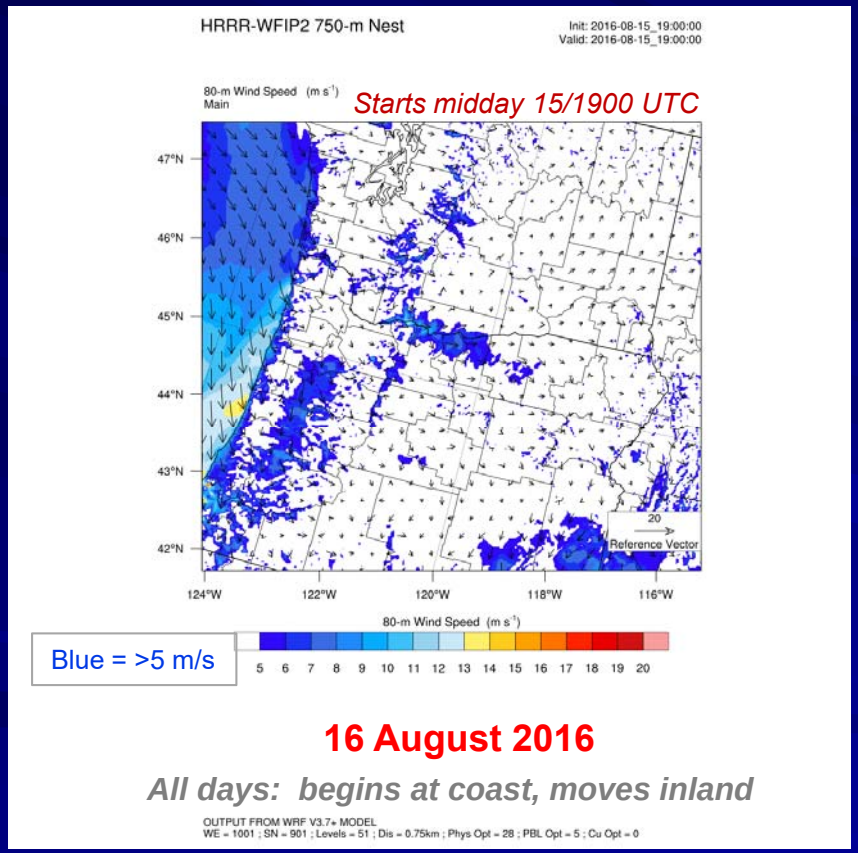
3-h HRRR fcst

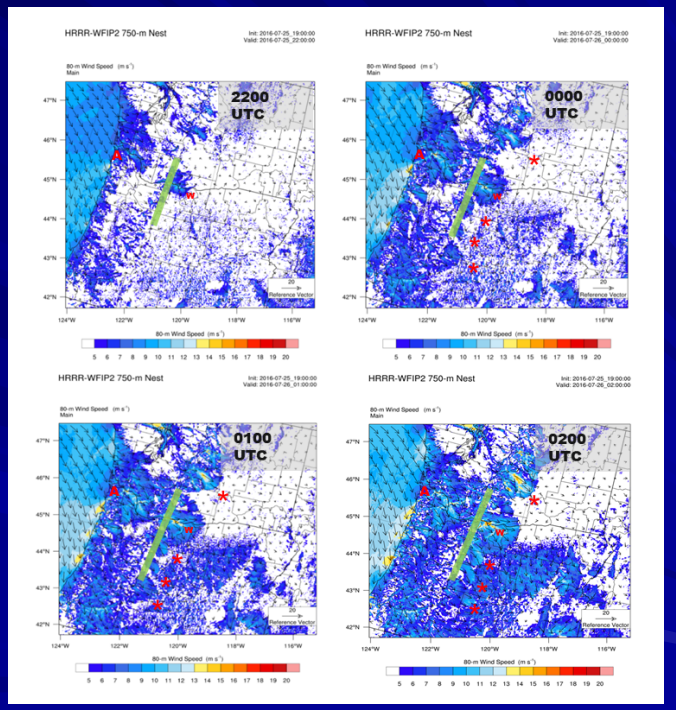
Bias

RMSE - unbiased



The marine intrusion – HRRR animation



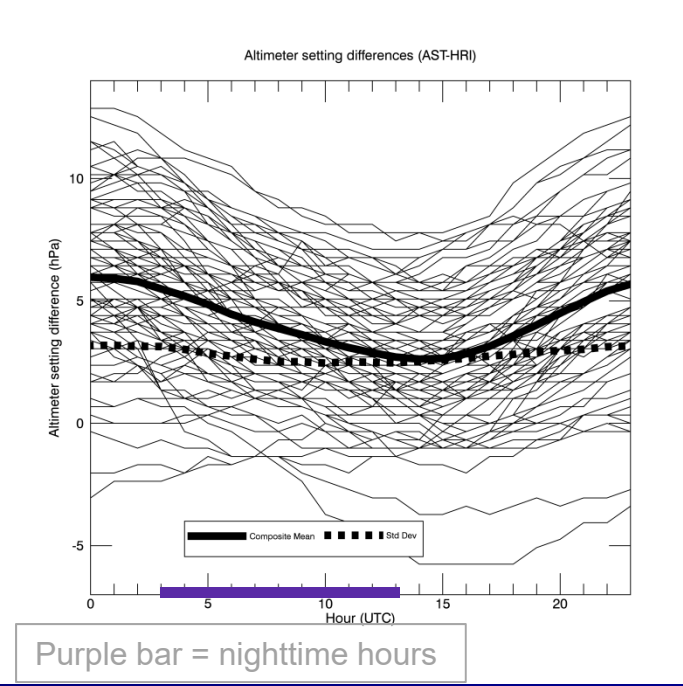


26 July 2016

Large-scale pressure gradient, favoring onshore flow, superimposed

What happened on the other days?

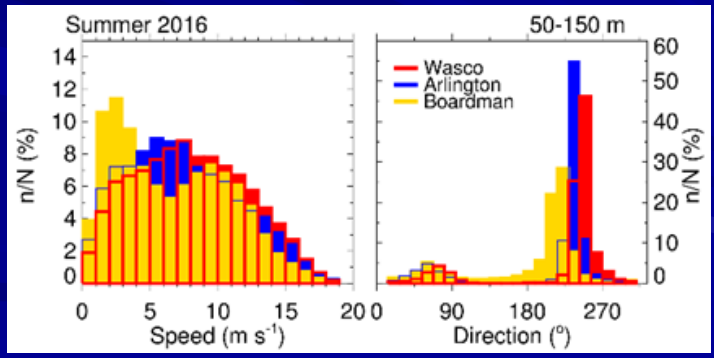
Summertime flow types



Purple bar = nighttime hours

Hourly surface Δ-pressure traces – all June-July-August days, 2016

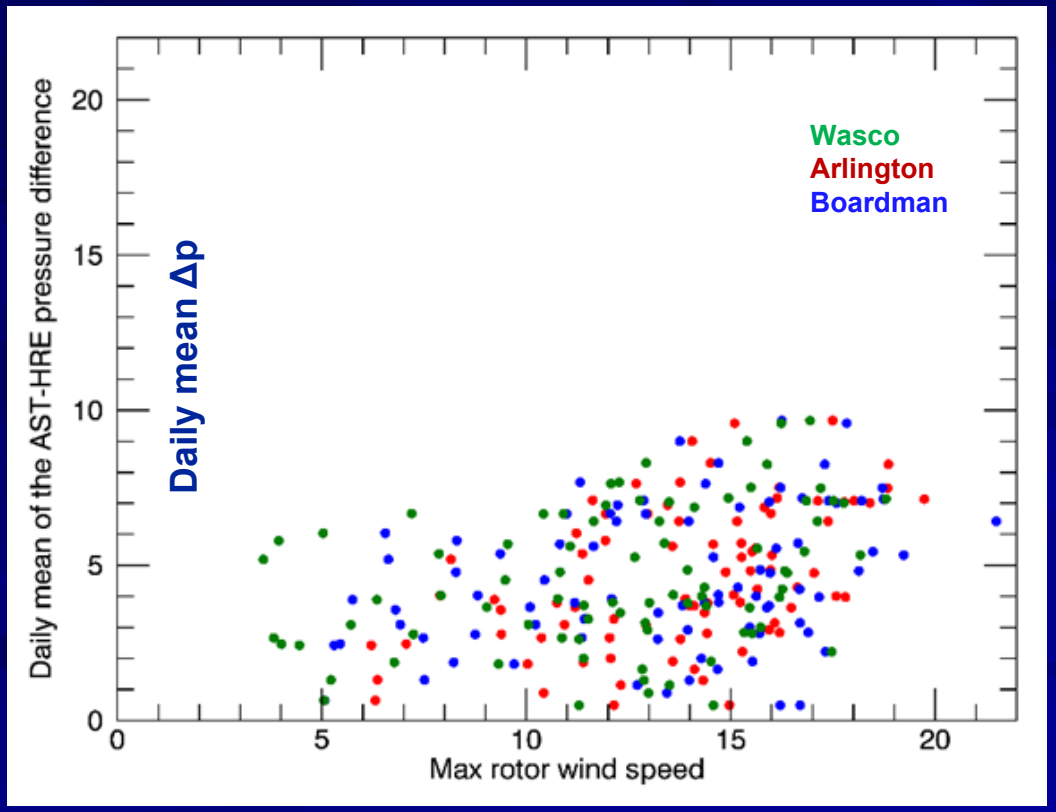
Near surface:
Wind speeds ~ Δ pressure across Cascades

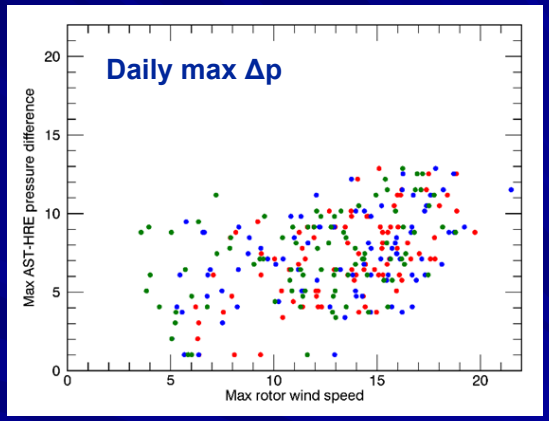


Bidirectional wind distribution

Relate wind speed to pressure difference

First attempt

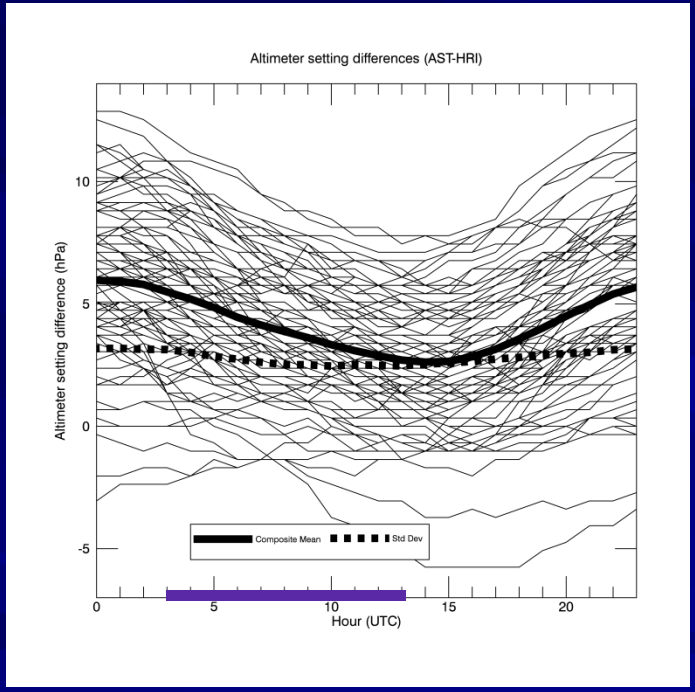




Not much correlation…

What happened on the other days?

7 Summertime flow types

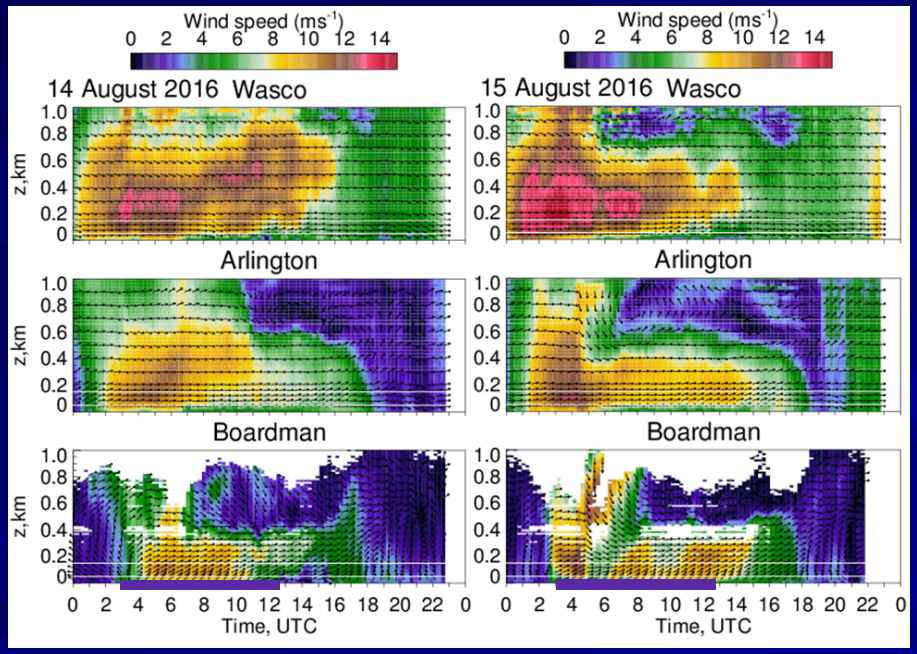


Hourly surface Δ-pressure traces – all June-July-August days, 2016

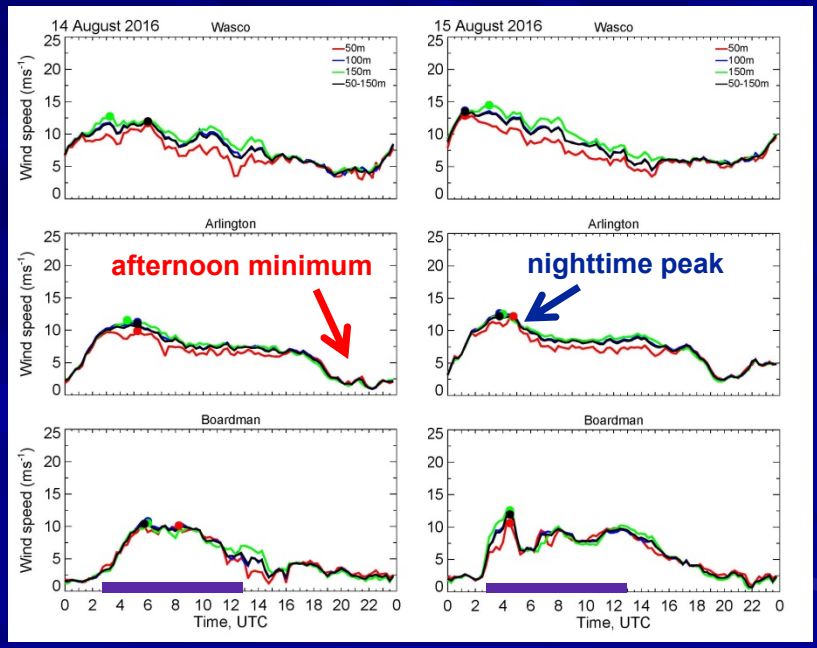
- Marine intrusion
- Weak intrusion (E-W-E)
- Up-ramping day
- Strong westerly flow all day
- Down-ramping day
- Synoptic + diurnal modulation (*trough, "cool diel"*)
- No diurnal pattern (*'misc.'*)

→ and …many unclassifiable

Marine intrusion - example

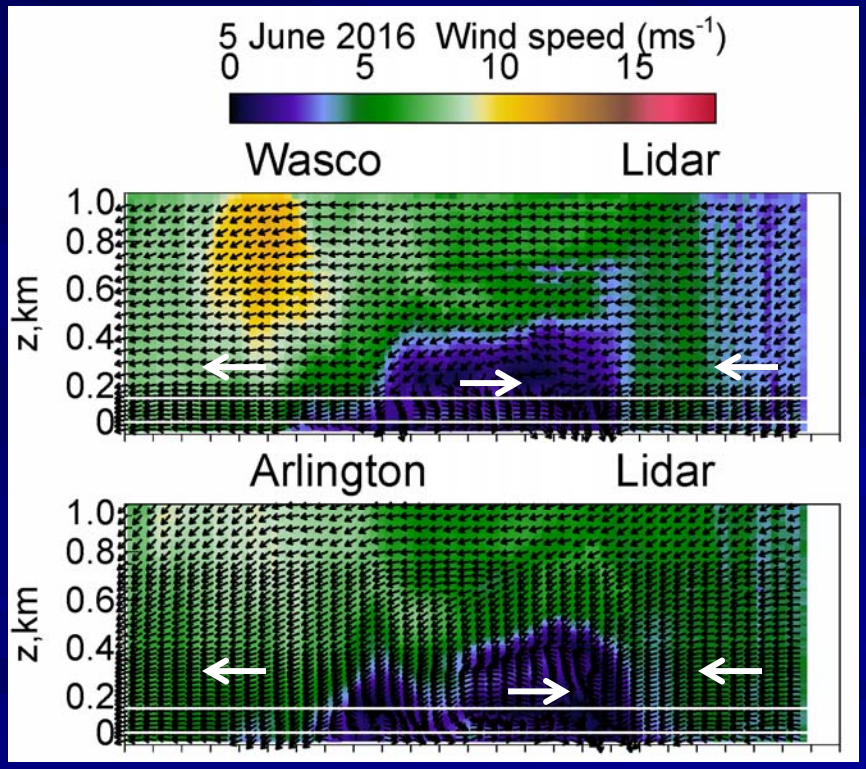


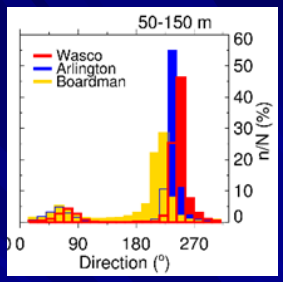
Time-height cross section – wind speed

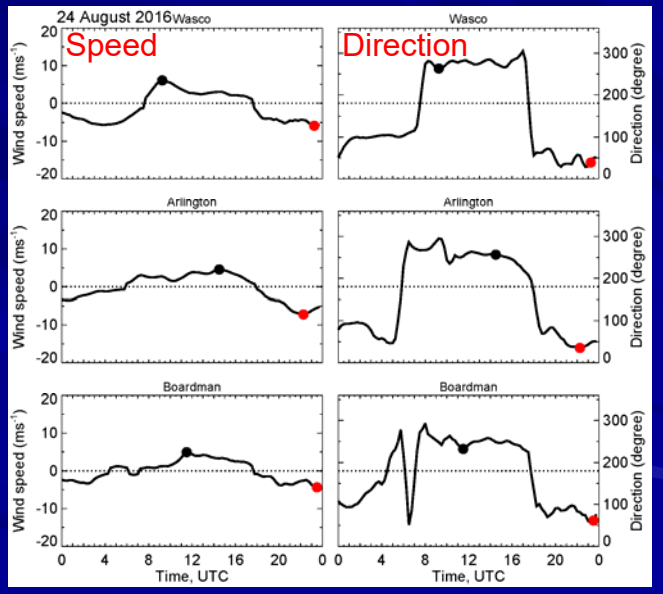


Time- series – rotor-layer wind speed

‘East-west-east’ (*ewe*) days: weak intrusions?

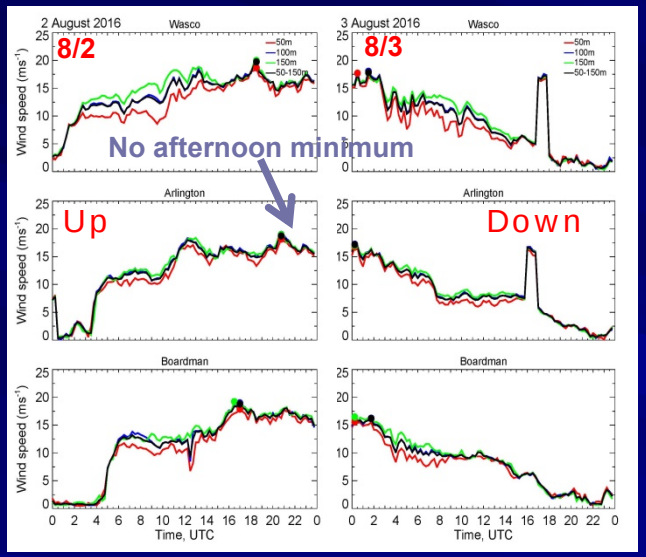






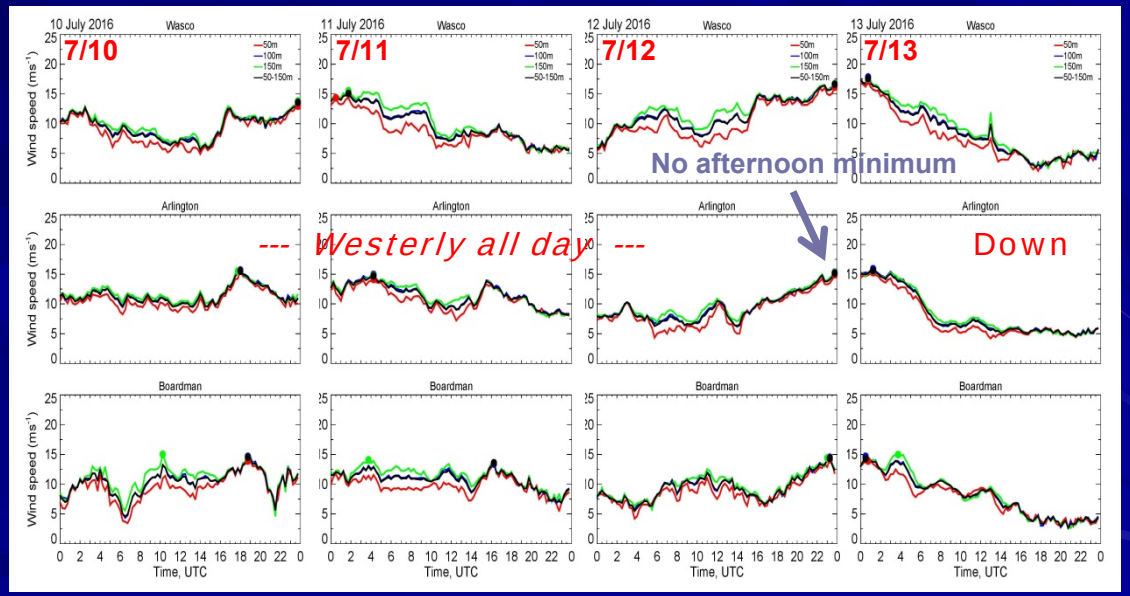
Easterly winds – plotted negative

Other types – synoptic: Up; Strong-West; Down



Up-ramping Down-ramping

Rotor-layer wind speeds (0-25 m/s) vs. hour (UTC)

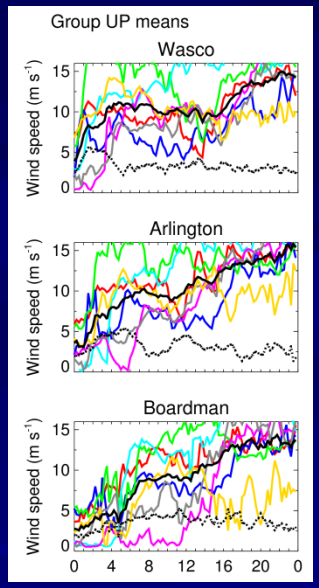


Westerly all day: no afternoon minimum

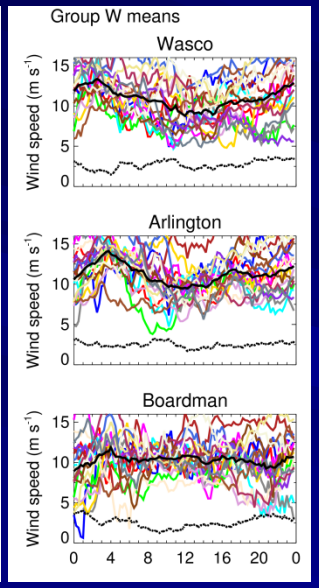
Minimum daily speed >5 m/s at Arlington or Boardman (or both)

Down-ramping

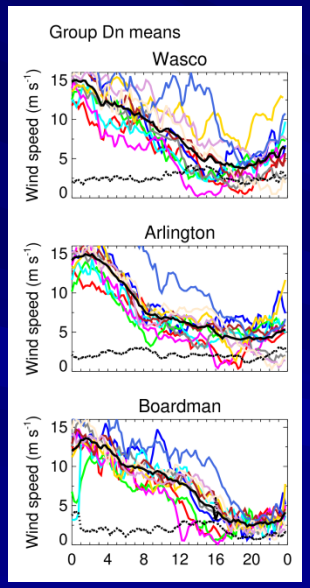
Composited wind speed for each category (5 shown here)



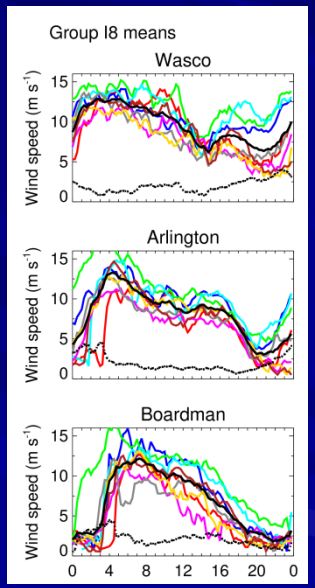
Up-ramping



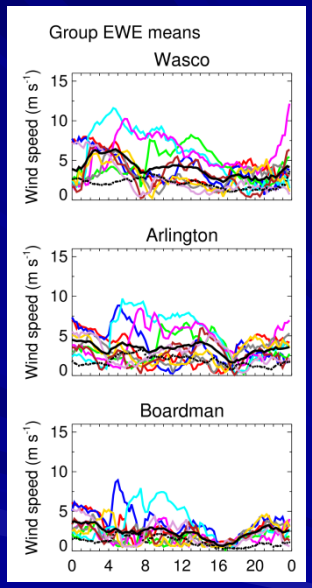
Westerly!



Down-ramping



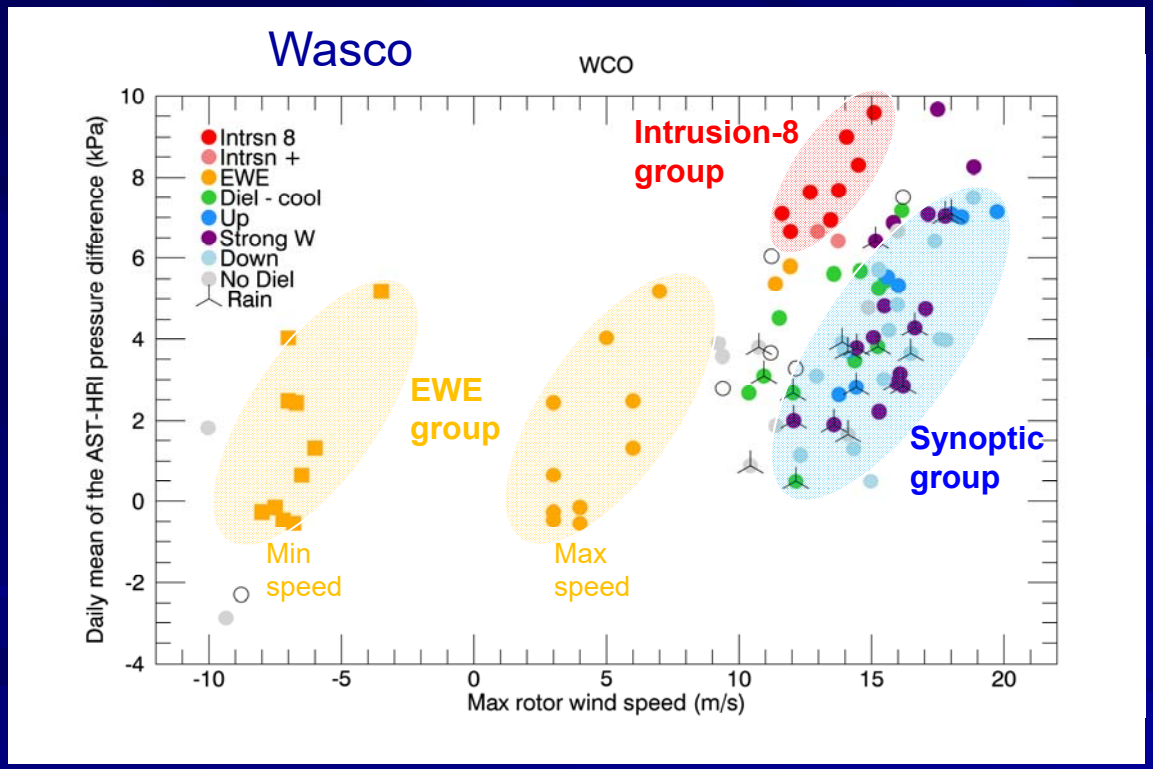
Intrusion-8

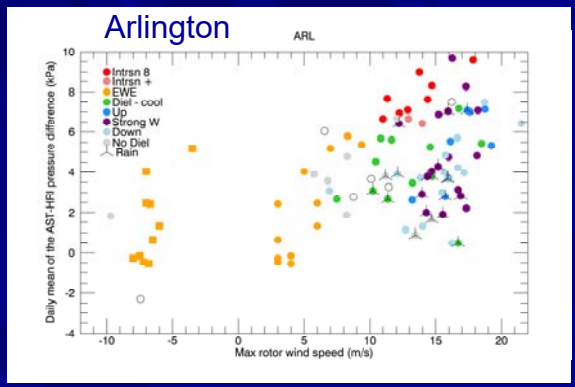


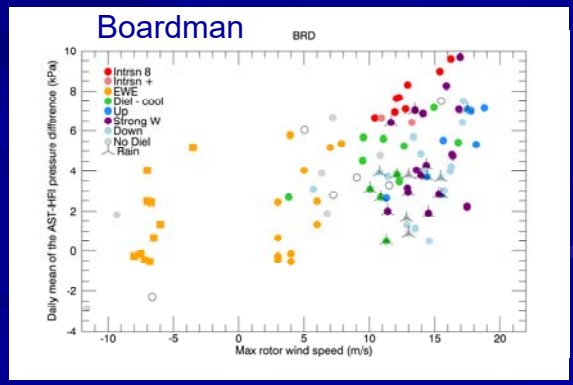
E-W-E

Stay Tuned … !

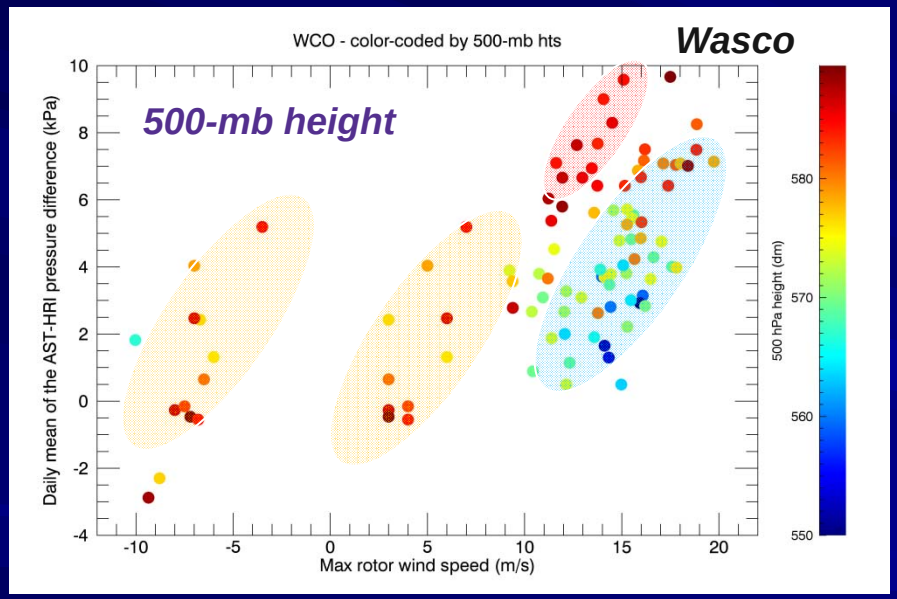
Wind speed vs. coast-inland pressure diff's

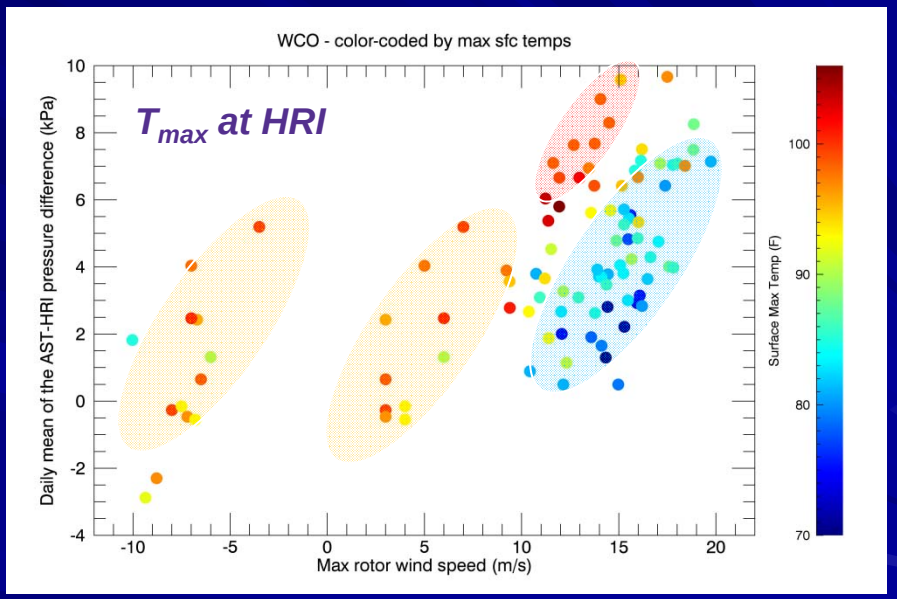




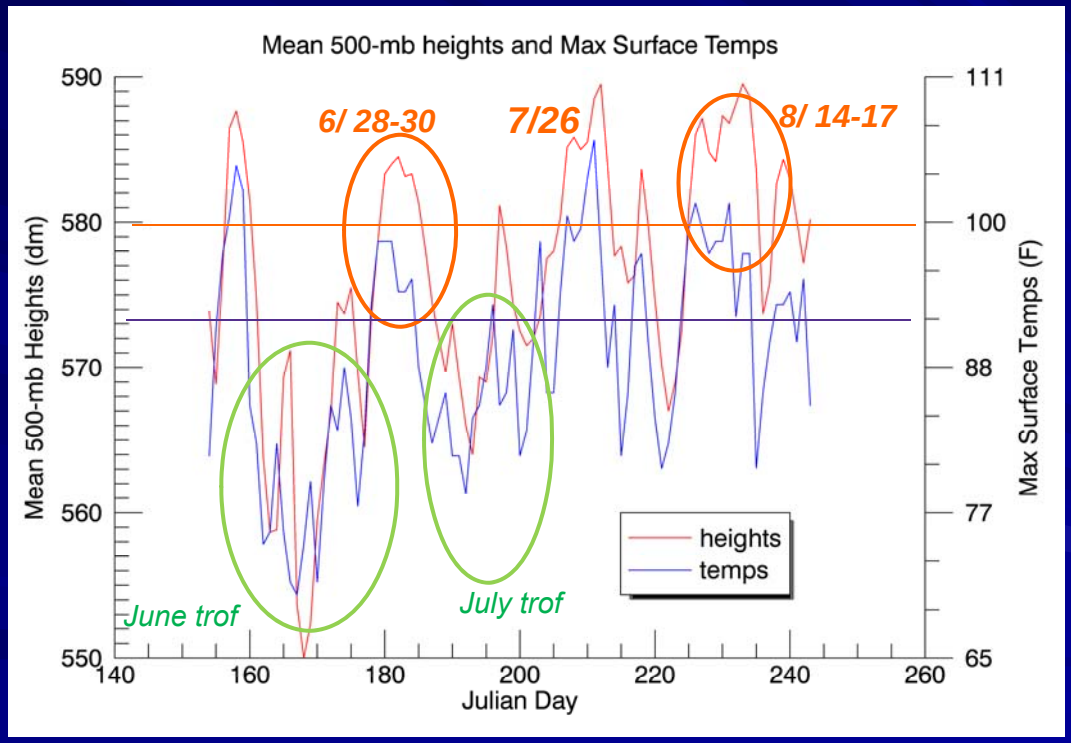


Relationships to met vrbls





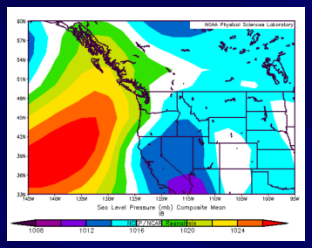
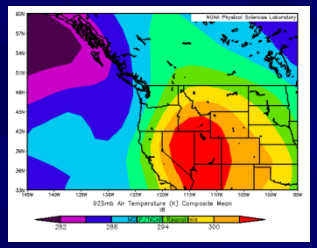
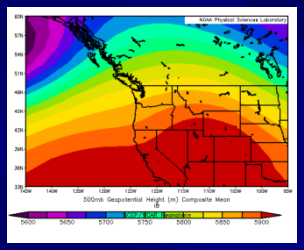
Relationships to met variables - 2



Composite NCEP/NCAR Reanalysis Charts

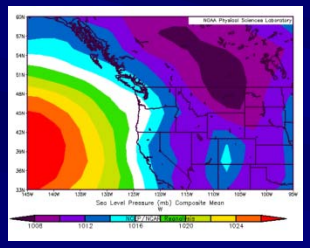
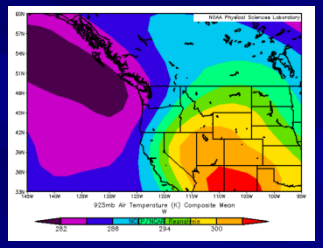
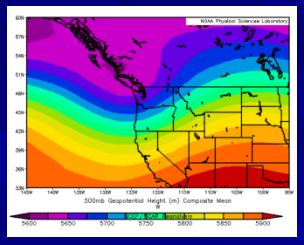
Diel flows – Intrusions: original 8

Intrsn-8

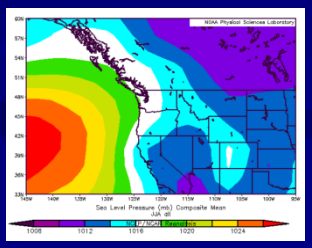
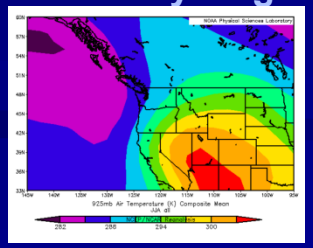
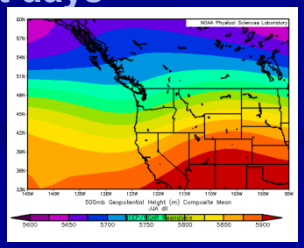
***vs.* synoptic: strong westerly all day**

Strong W

***vs.* all 92 June-July-August days**

All JJA

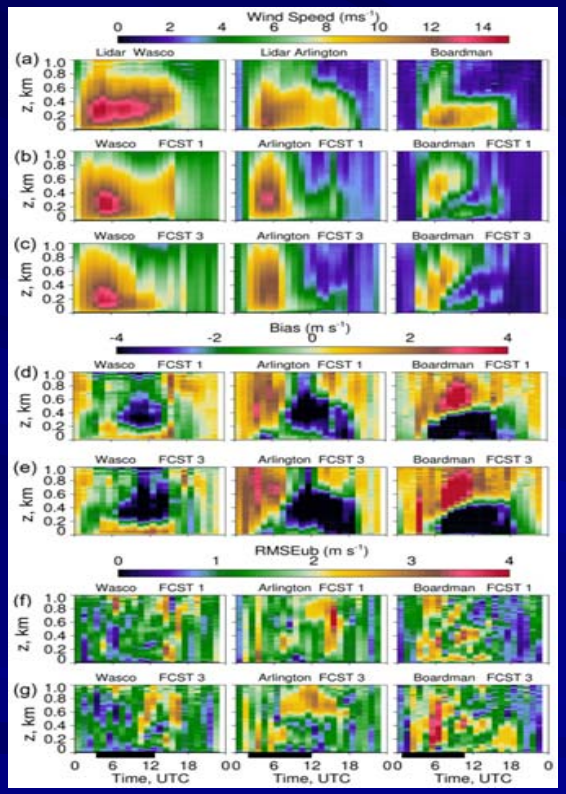




Sea-level press **925-mb T** **500-mb height**

- Intrusion
  - Ridge – 500 mb
  - Hot into Idaho ($\mathbf{T_{925}}$)
  - Sfc ridge into BC; thermal trough – SE OR
- Strong westerlies
  - Trough at 500 mb
  - Cold to Vancouver Is; else $\mathbf{T_{925}}$ ~ 3-mo mean
  - Broad sfc LO inland; strong W-E ▼P across OR

HRRR validation – example

Marine Intrusion: *8-day composite*



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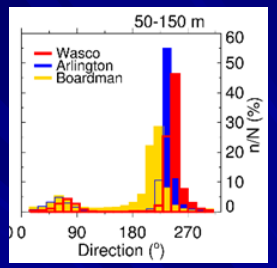
Summary

Flows through the complex terrain of the Columbia-River wind-energy corridor are highly controlled by topography (*e.g., bidirectional wind distribution***)**



Ridging conditions in summer, including hot daytime temperatures inland:

- Heating-cooling cycle inland
  - Sea breeze near coast
- Impressed large-scale pressure gradient
- When strong, this combination can produce a regional-scale sea breeze (marine intrusion) intense enough to push through the Cascades and into the Oregon-Washington interior
  - Good for wind energy!
- Challenging forecast for models and forecasters

Trough conditions:

- Gap winds controlled by traveling mesoscale trough-ridge systems moving through
- Also a challenging forecast

Major categories of summertime flow in this region provide insight into evolution, relevant controlling processes, and forecast model skill for each type.

Thank you,

and thanks to our sponsors:

This work was sponsored by the NOAA/CSL Air Quality Program,
the NOAA Atmospheric Science for Renewable Energy Program,
and the U.S. Department of Energy, Wind Energy Technologies Office