Observed Atmospheric Profiles in the Arctic Seasonal Ice Zone and the Role of Synoptic Conditions

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Introduction

Unique features of the atmospheric profiles in the Arctic

- temperature and moisture inversion, low-level jet (LLJ)
- static stability, mixed-phase cloud, surface energy budget, Arctic amplification
- data-sparse Arctic over sea ice

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Seasonal Ice Zone Reconnaissance Survey

- USCG Arctic Domain Awareness flights in the Beaufort Sea
- Atmospheric and oceanic measurements: dropsonde, visible/IR imaging, Lidar, AXCTD, AXCP, UpTempO buoy, AXIB buoy

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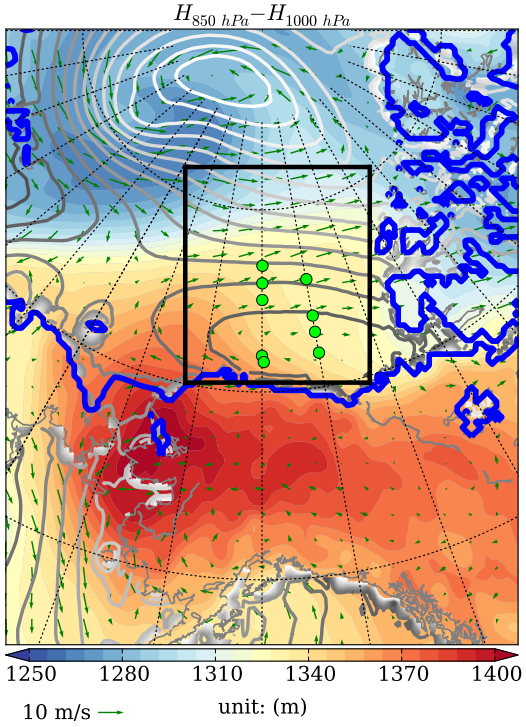
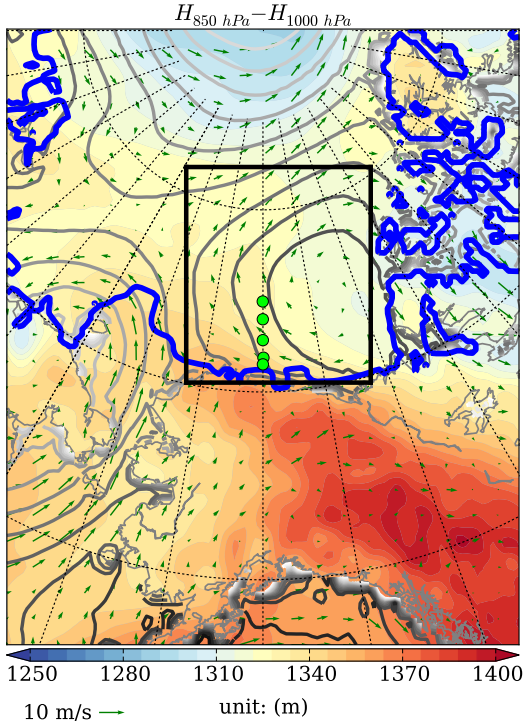
Approach

- Polar WRF simulations forced by reanalysis/analysis
- examine the performance of analyses and Polar WRF

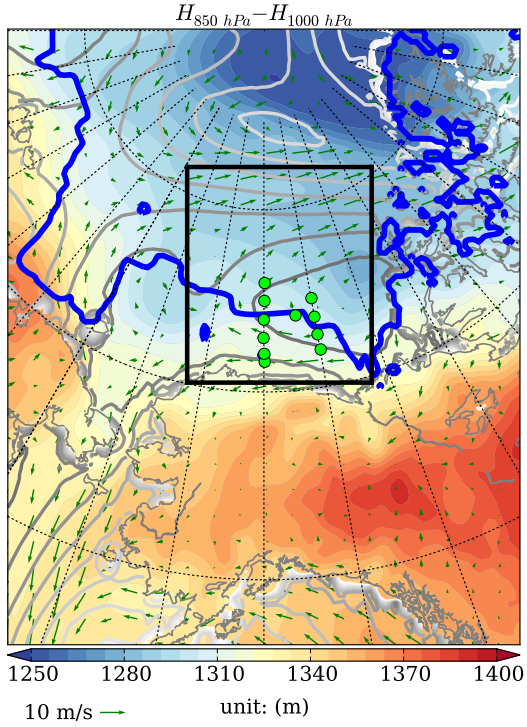
SIZRS transects and Polar WRF setting



(a) June 19



(b) July 16



(c) August 16

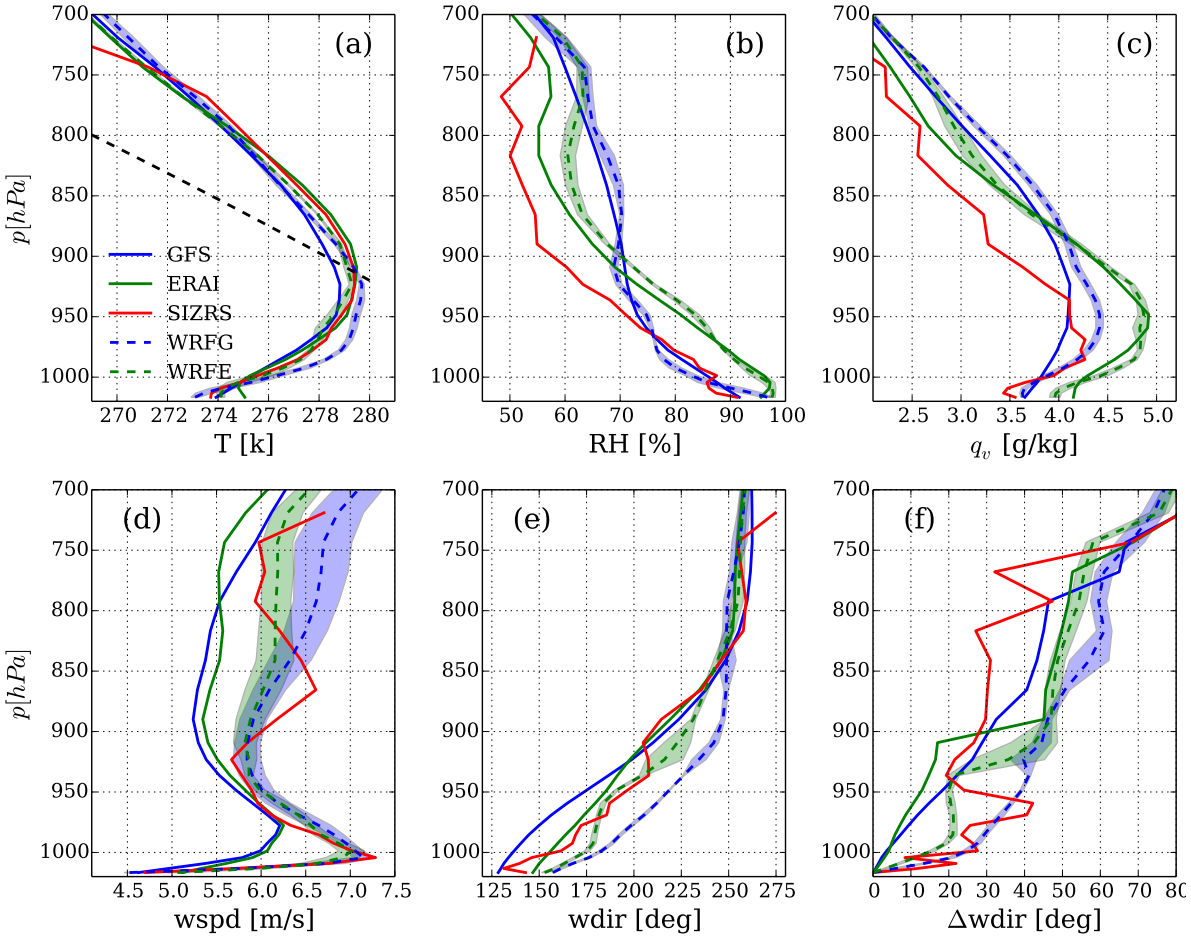
Polar WRF setting:

- $\Delta x = 30/10$ km
- 54 vertical levels
- forcing: GFS/ERAI
- baseline+7-member ensemble

Baseline physics:

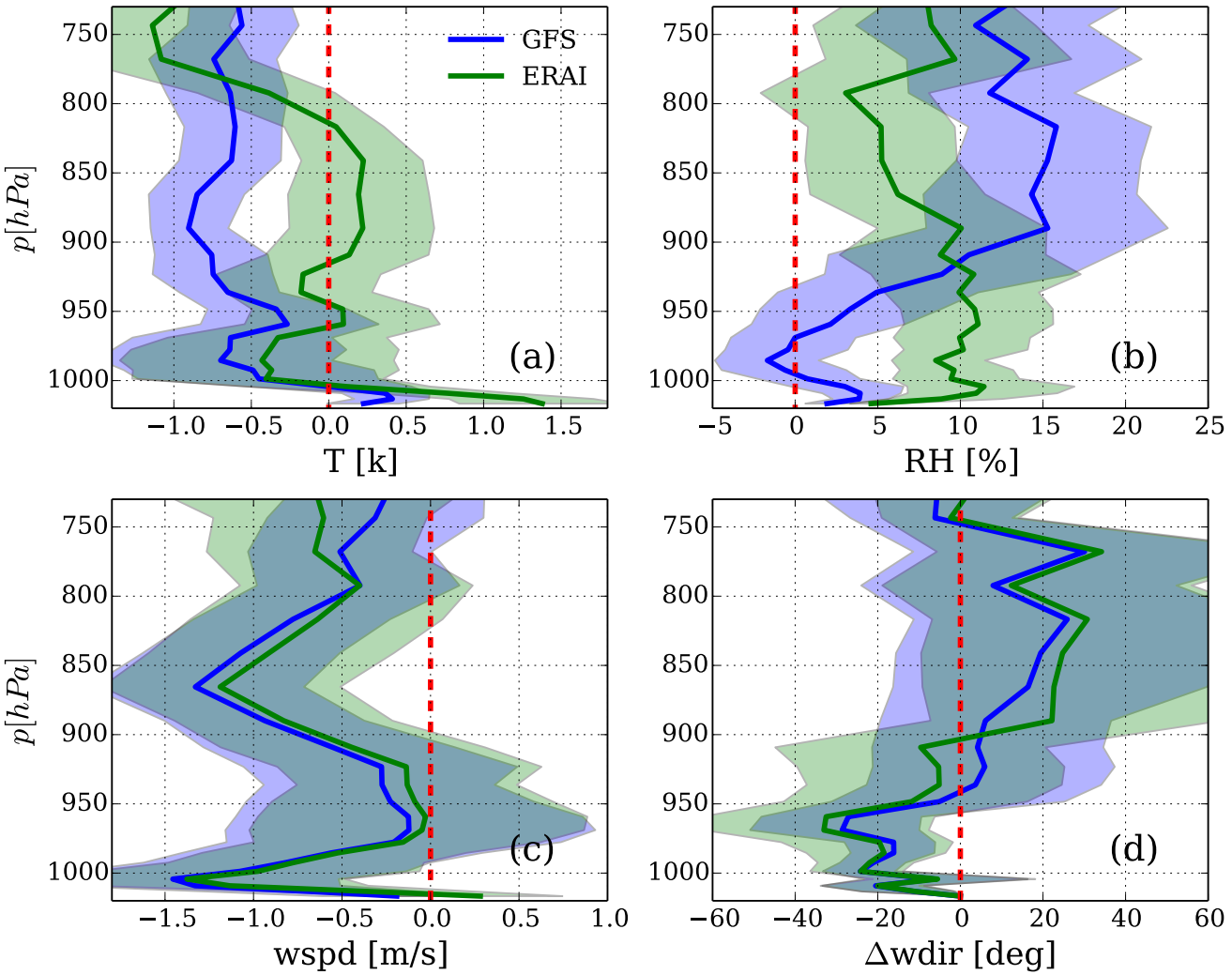
- MYJ PBL+surface
- Goddard microphysics
- RRTMG radiation
- Grell-Deveny cumulus
- nudging above 168 hPa

Observed and simulated mean profiles (22 total)



- General features reproduced
- Small ensemble spread
- Polar WRF $\sim$ forcing
- large differences between analyses and observations
- Low-level warm bias in ERAI, moist bias in ERAI and GFS
- Weaker LLJ and smaller wind turning angle in the analyses compared to the Polar-WRF and observations

Statistical significance of analyses biases (bootstrap)



Analysis

Significantly improved LLJ in Polar WRF

- vertical resolution: improvement in low resolution runs too
- mixing: artificially enhanced mixing in GFS/ERAI
- LLJ weakens with enhanced mixing in Polar WRF

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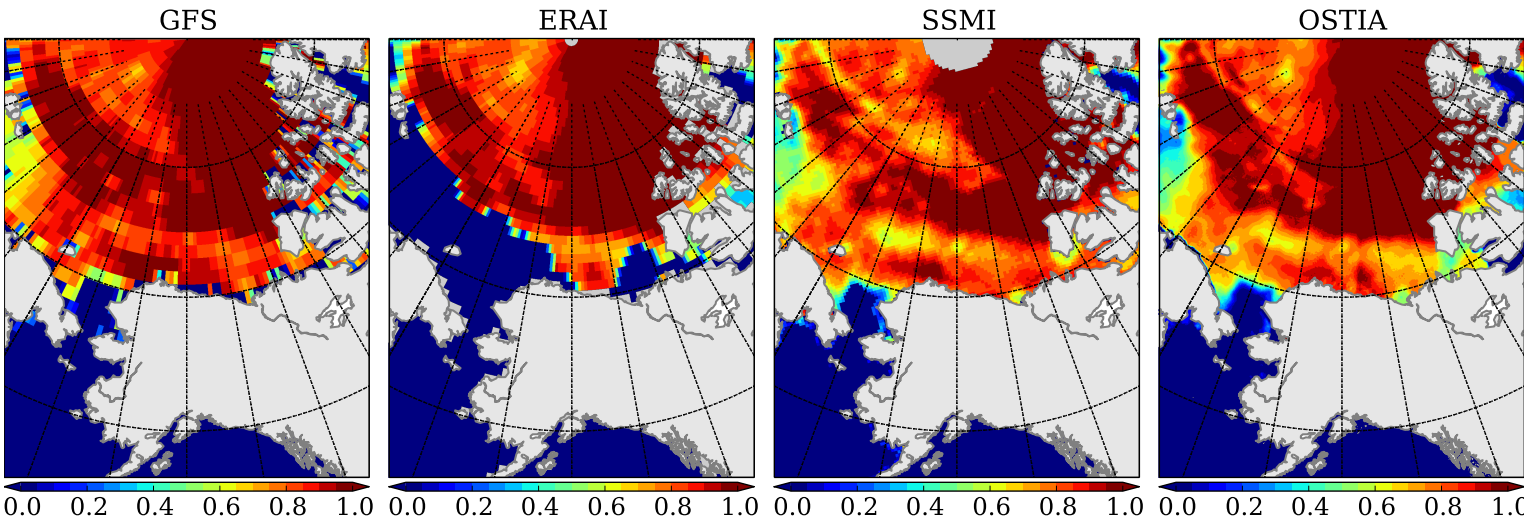
Low-level warm bias in ERAI (consistent with previous obs.)

- ERAI Sea ice issue: set SIC to 0 when T>274.26K



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- mixing: artificially enhanced mixing in GFS/ERAI
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Low-level warm bias in ERAI (consistent with previous obs.)

- ERAI Sea ice issue: set SIC to 0 when T>274.26K
- ERAI lateral + ERAI SST + GFS SIC: not sensitive
- ERAI lateral + GFS SST/SIC: like WRFG→SST or melt pond?
- warm bias over packed ice as well: ice model?

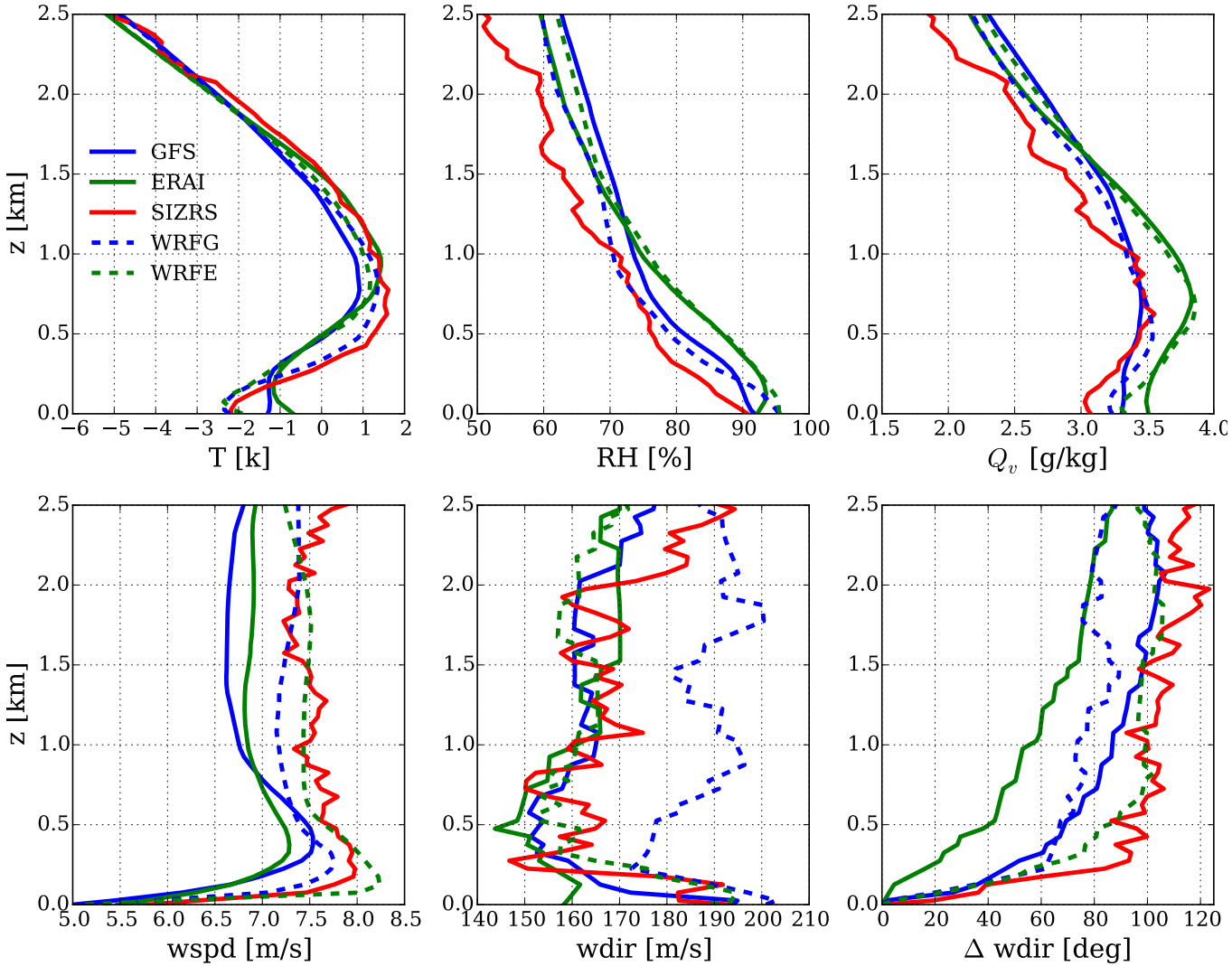
Conclusion so far

- General features reproduced in analyses and Polar WRF
- biases in both ERAI and GFS
  - weak LLJ and smaller turning angle due to too strong mixing
  - low-level warm bias in ERAI: SST/melt pond/ice model?
  - moist bias in ERAI and GFS
- Significantly improved LLJ in Polar WRF
- Polar WRF T/q follows forcing
- large inter-model discrepancies as well as model biases $\rightarrow$ need more observations like SIZRS

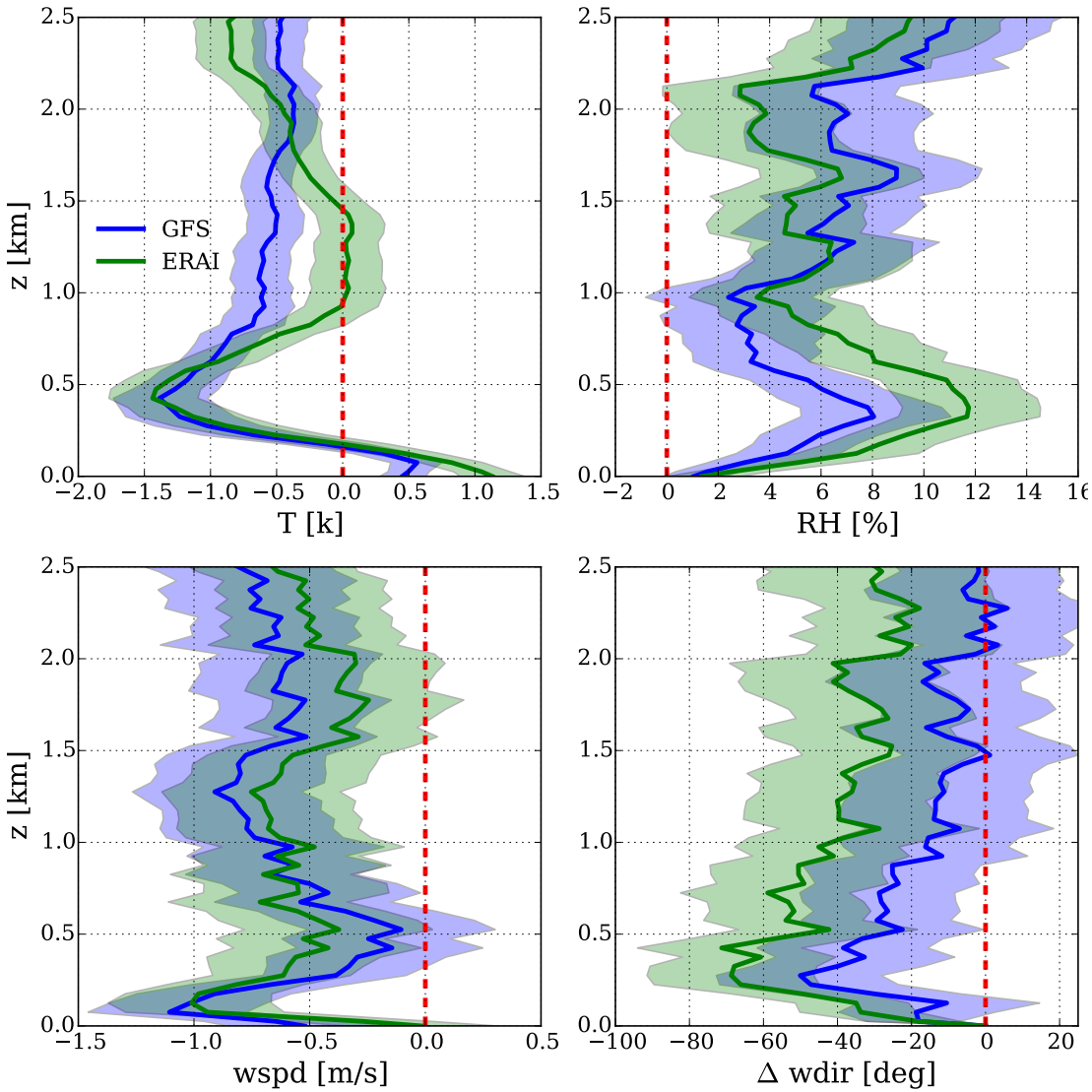
Reference:

Zheng Liu, Axel Schweiger, and Ron Lindsay, 2015: Observations and Modeling of Atmospheric Profiles in the Arctic Seasonal Ice Zone. *Mon. Wea. Rev.*, 143, 39−53.

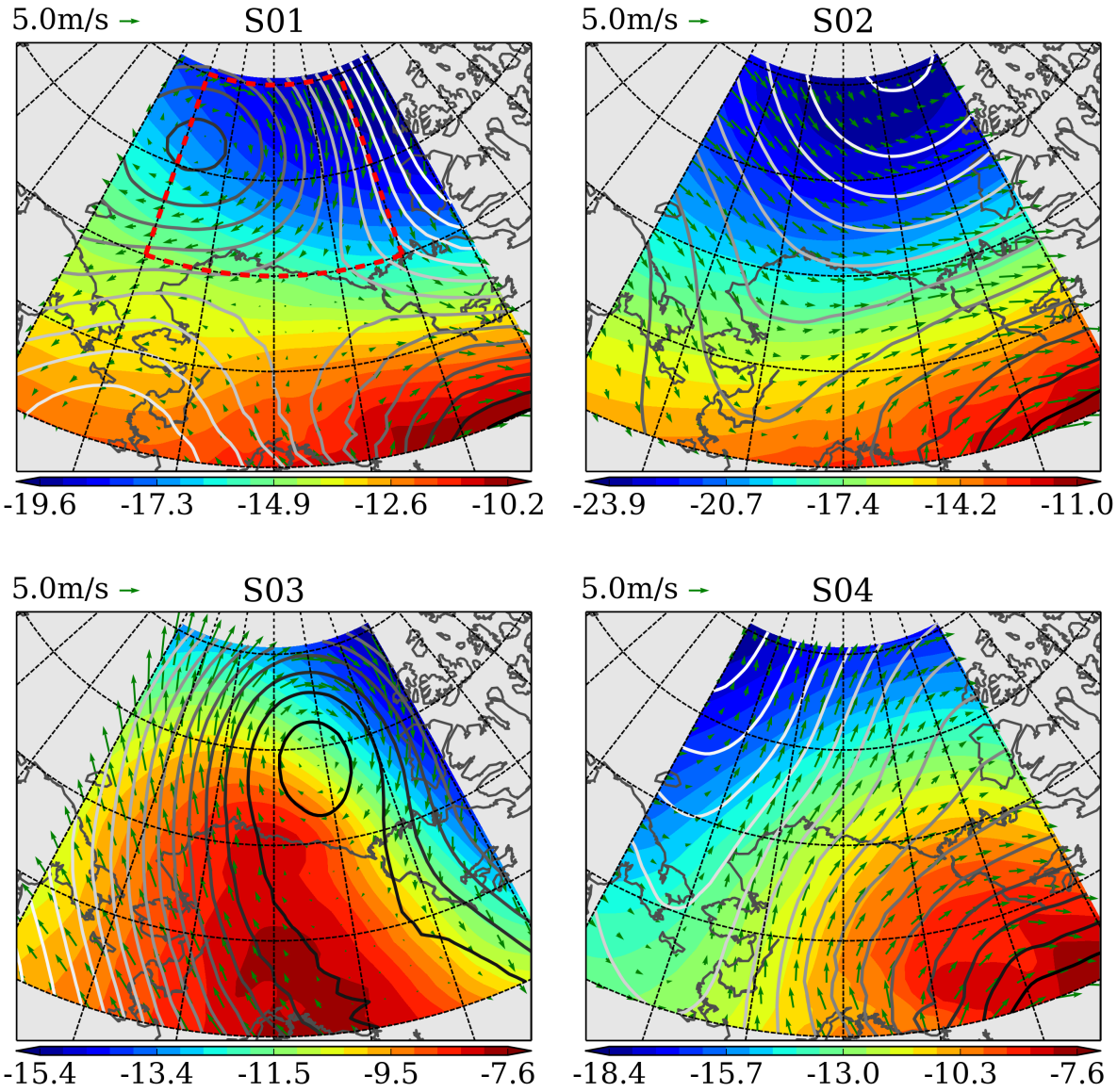
Mean profiles: 2013–2015 (89+22)



Statistical significance of analyses biases



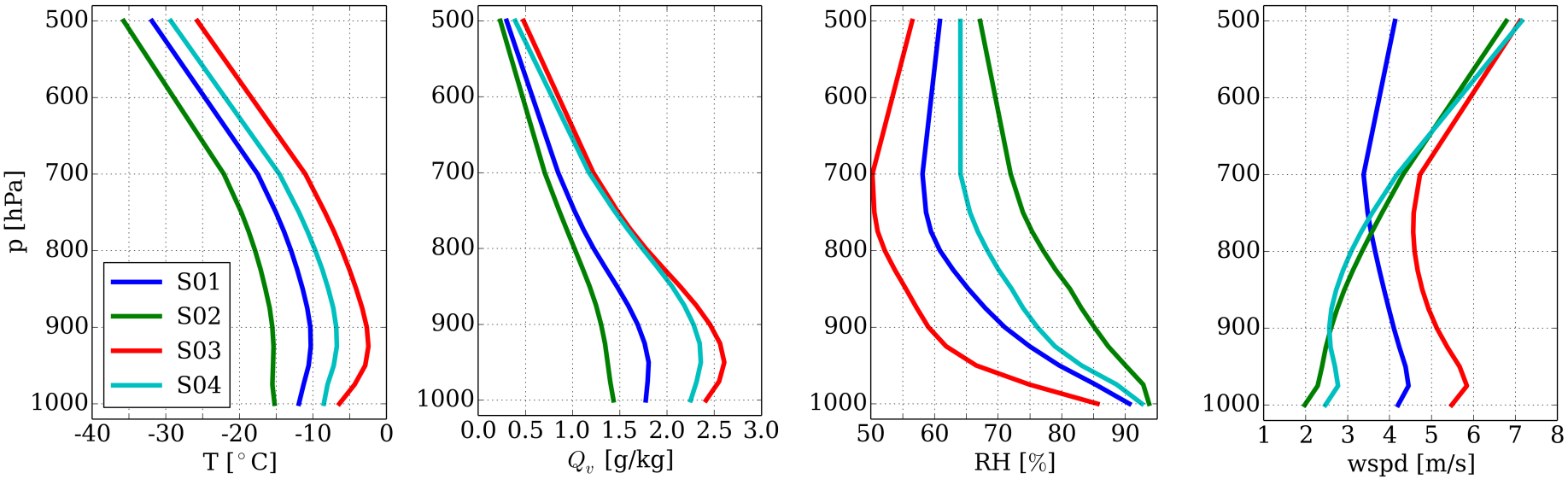
Synoptic classification using *k*-mean clustering



SIZRS observations show significantly different profiles: warm and dry, cold and moist

- Data: 6-hourly ERAI data at 6 levels from 1000 to 500 hPa
- Domain: 70°N to 80°N, 170°W to 130°W (red box).
- Variables: T, q_v, U, V, Z

Atmsopheric profiles in different synoptic coditions



Baroclinicity and temperature advection ⇒ inversions & LLJ

- State 1 (S01): high pressure, strong baroclinicity, strong cold advection from the Arctic Ocean
- S02: low pressure, weak baroclinicity, and weak cold advection from west.
- S03: high pressure, strong baroclinicity, and strong warm advection from Alaska
- S04: moderate baroclinicity and warm advection

Next ...

- examine model performance under different conditions
- atmospheric profile ↔ cloud ↔ sea ice

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  - low-level warm bias in ERAI: SST/melt pond/ice model?
  - moist bias in ERAI and GFS
- Significantly improved LLJ in Polar WRF
- Polar WRF T/q follows forcing
- large inter-model discrepancies as well as model biases $\rightarrow$ need more observations like SIZRS
- synoptic conditions have significant influence on the structure of the profile

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