Climatology of the Global Planetary Boundary Layer

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Goal: Develop an understanding of the global climatology and variability of the Planetary Boundary Layer (PBL) and its relation to other aspects of global climate

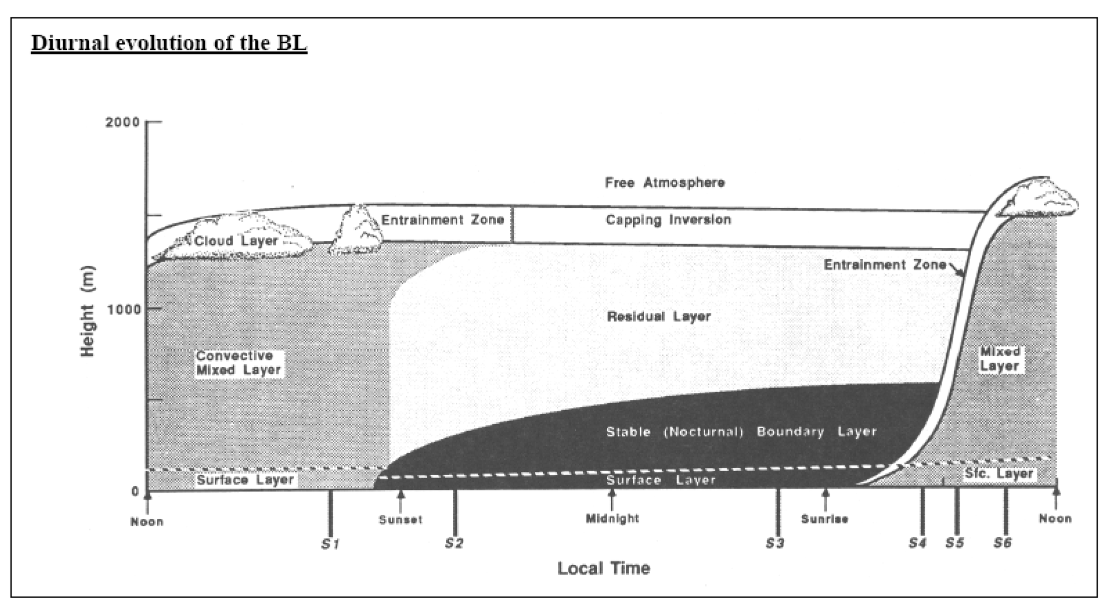
•Assess the suitability of various global datasets and methodologies for analysis of PBL climatology and variability

•Differentiate PBL analysis methods appropriate to different regions of the world and different scientific problems

•Analyze the climatology and variability of the PBL in relation to specific topics in climate, air quality, and carbon cycle science.

•Evaluate the simulation of the PBL in climate models.

Essentially, ARL seeks to bridge the boundary-layer meteorology and climate science communities by addressing problems of mutual interest.



The complex structure and diurnal variability of the PBL pose challenges for developing long-term global climatologies by applying automated algorithms to large datasets.

Figure taken from Stull (1988)

Approaches

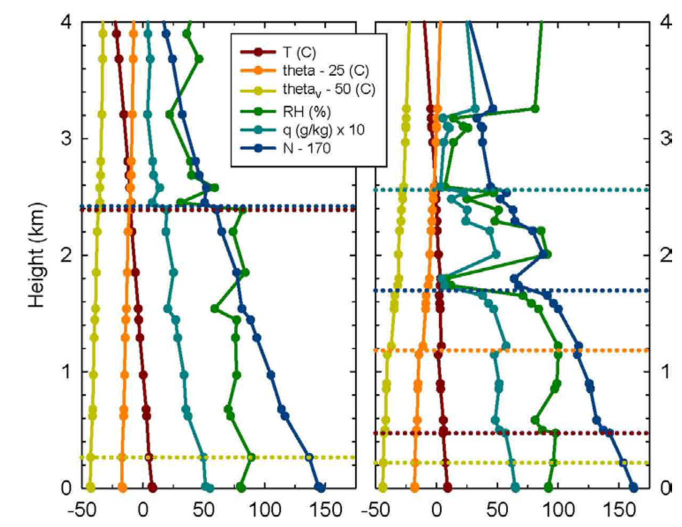
•Focus on analysis of radiosonde observations, a traditional strength of ARL

•Develop collaborative relationships with leading modeling groups, boundary-layer specialists, and experts in other relevant observational datasets.

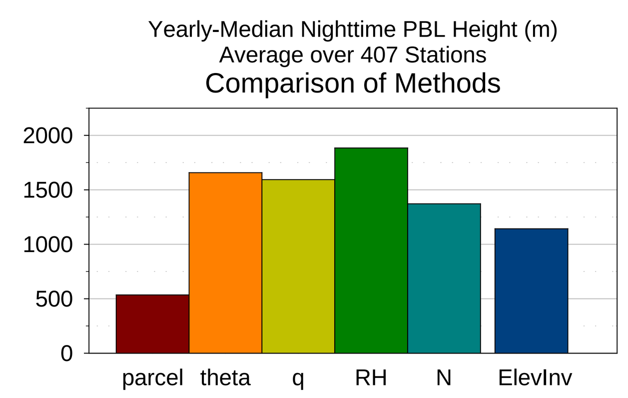
•Exploit opportunities for collaboration as our datasets describing the climatology of the PBL that we have developed become more widely known.

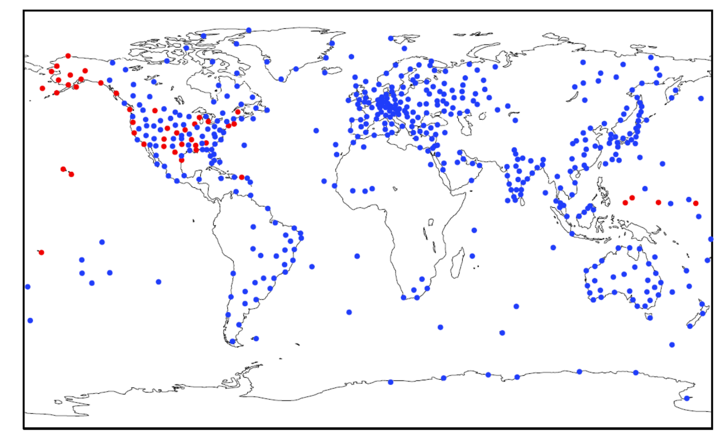
Accomplishments

I. Evaluation of methods for estimating PBL height



Different methods of identifying the top of the PBL may agree (as in the case on left) or disagree (right). Plots compare PBL heights evaluated with six methods. Soundings are from Lerwick, UK (17 Feb 2007 and 23 Dec 2006).

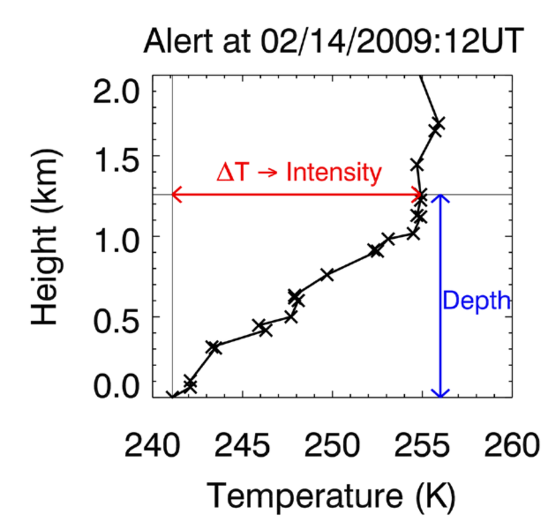


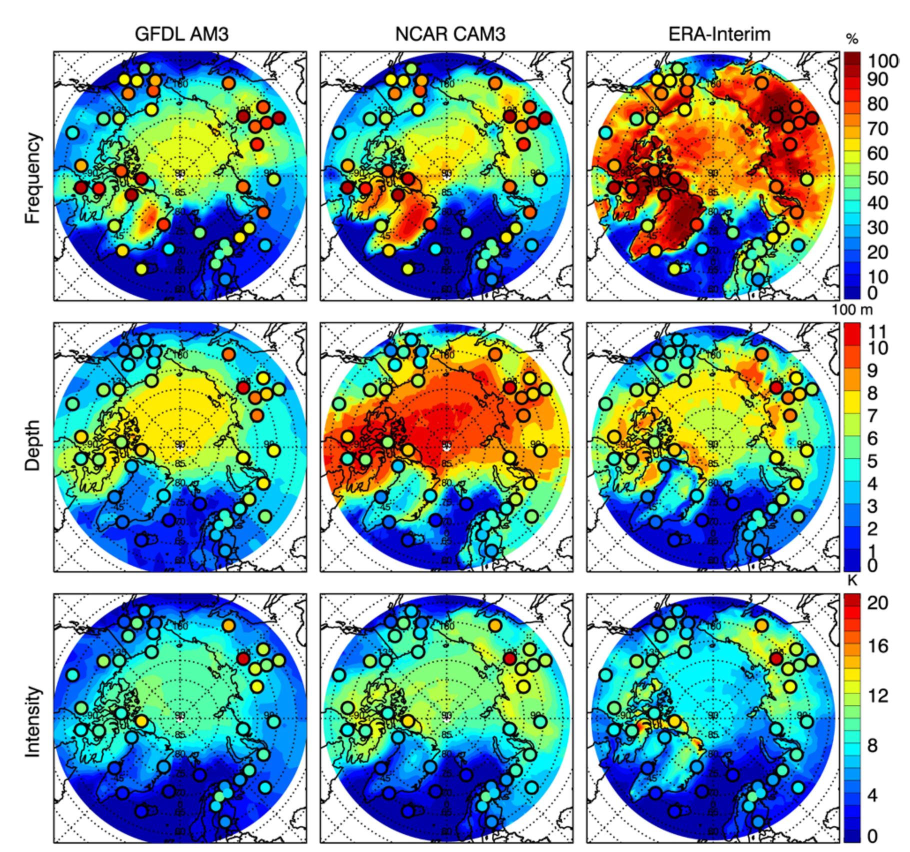


PBL height estimates from different methods have systematic biases. Using 10 years of global radiosonde data, we find average differences of several 100 m .

II. Analysis of Arctic and Antarctic surface-based inversion climatology

Surface-based inversions (SBI) are a relatively simple type of PBL structure that are common in the polar regions. The climatology of SBI can be described using three parameters:
- ➢Frequency of occurrence of SBIs
- ➢SBI depth (from surface to SBI top)
- ➢SBI intensity (temperature change from surface to SBI top)

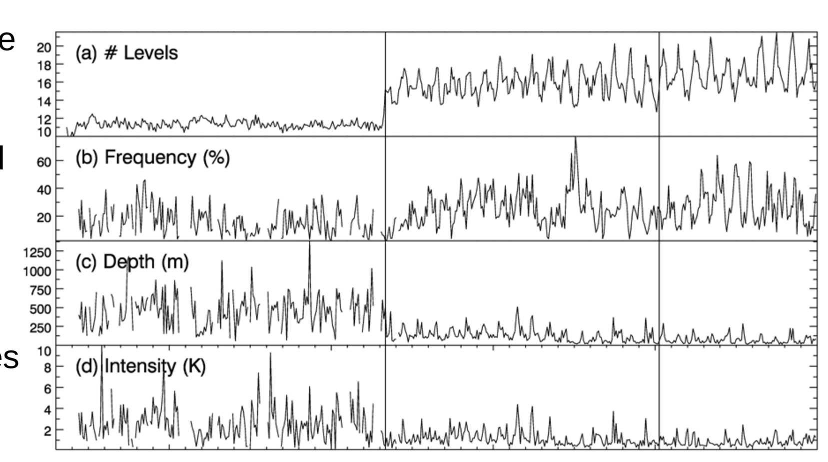




Comparison of radiosonde-based SBI climatology with two climate models (NCAR CAM3 and NOAA/GFDL AM3) and with ECMWF Reanalysis data. Figure shows climatological wintertime distributions of SBI frequency, depth, and intensity over the Arctic. Inaccurate representation of these PBL features in models may influence their simulation of important physical processes, such as vertical mixing and air-surface exchange of energy and moisture.

III. Analysis of trends in Arctic surface-based inversions

Changes in observational methods, particularly those affecting sounding vertical resolution, introduce artificial changes in radiosonde representations of SBIs that degrade trend estimates. SBI intensity and depth data are particularly sensitive to this problem, but frequency of SBI occurrence is more robust. Previous analyses of SBI trends have neglected or dismissed this issue. An example from Jan Mayen (an island station near Norway) shows how increases in the number of data levels affects estimates of climatological SBI properties.



Collaborators/Partners

Yehui Zhang (NRC Postdoctoral Associate)

NOAA Earth Systems Research Lab – Andy Jacobson

NOAA Geophysical Fluid Dynamics Laboratory - Chris Golaz

National Center for Atmospheric Research - Clara Deser, Brian Medeiros, Sungsu Park, Bob Tomas

Jet Propulsion Laboratory (CalTech) – Chi Ao

NOAA National Climatic Data Center – Imke Durre

Summer Interns

Kun Li – Montgomery Blair High School, University of Maryland

Angelica Betancourt-Negron – University of Puerto Rico (NOAA Educational Partnership Program)

Future Directions

•Analyze the climatology and variability of mixing height over continental regions and compare with climate, air quality, and carbon cycle models (in progress)

•Develop a global PBL climatology making use of atmospheric refractivity observations from the Global Navigation Satellite System in complement with radiosonde observations

•Analyze the role of PBL changes in explaining multi-decadal trends in the tropospheric temperature profile and water vapor content

Publications

Seidel, D.J., C.O. Ao, and K. Li, 2010: **Estimating climatological planetary boundary layer heights from radiosonde observations: Comparison of methods and uncertainty analysis**. *J. Geophys. Res.*, 115, D16113, doi:10.1029/2009JD013680.

Zhang, Y., D.J. Seidel, J.-C. Golaz, C. Deser, and R.A. Thomas, **Climatological characteristics of Arctic and Antarctic surface-based inversions**, in revision for *J. Climate*.

Zhang, Y., and D.J. Seidel, **Trends in Arctic surface-based inversions from radiosonde data**, submitted to *Geophys. Res. Lett.*