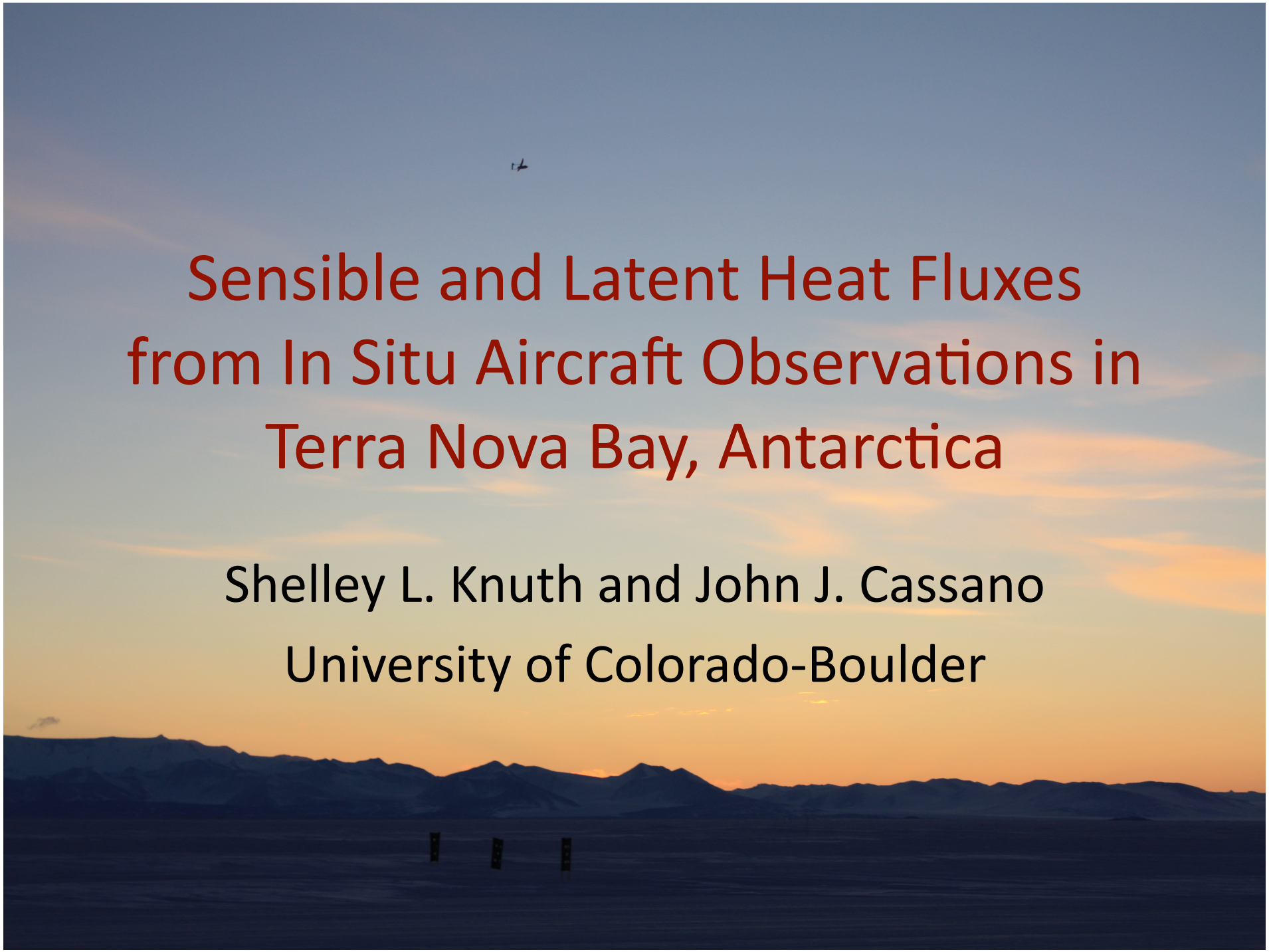

Sensible and Latent Heat Fluxes from In Situ Aircraft Observations in Terra Nova Bay, Antarctica

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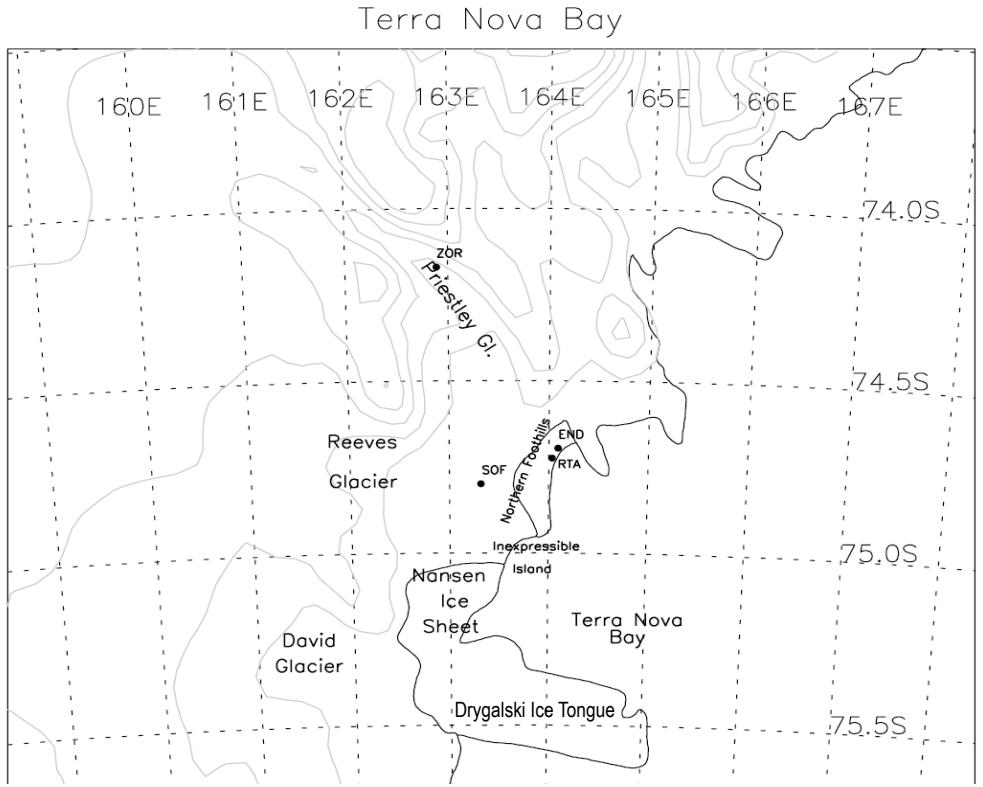
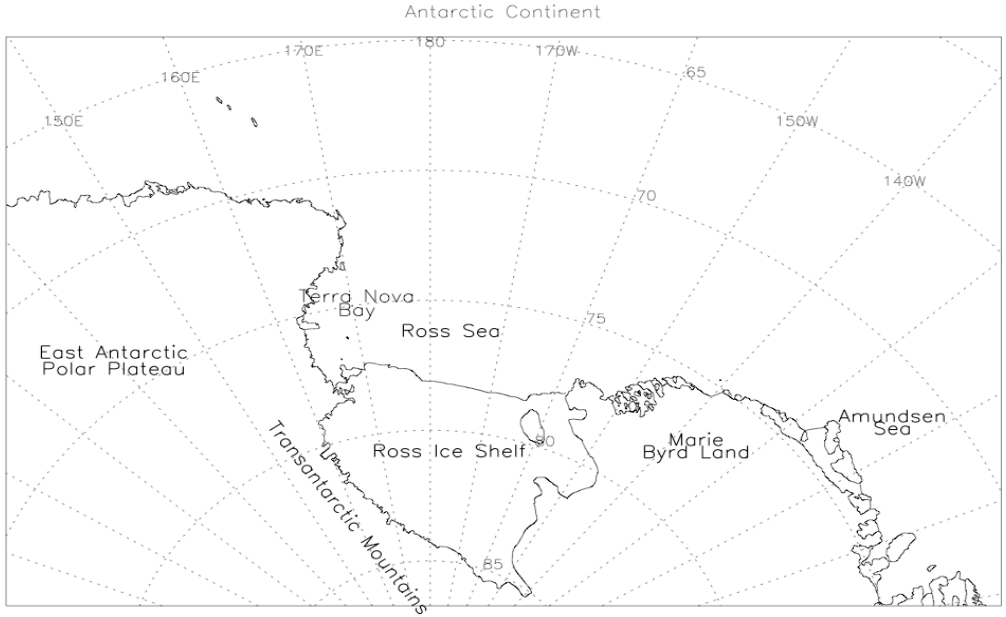
University of Colorado-Boulder

Terra Nova Bay, Antarctica

- Strong katabatic/ downslope winds
- Polynya
  - Open ocean water maintained throughout winter period
- Strong air-sea fluxes
- How is the air mass impacted by the polynya?
- UAV vertical profiles



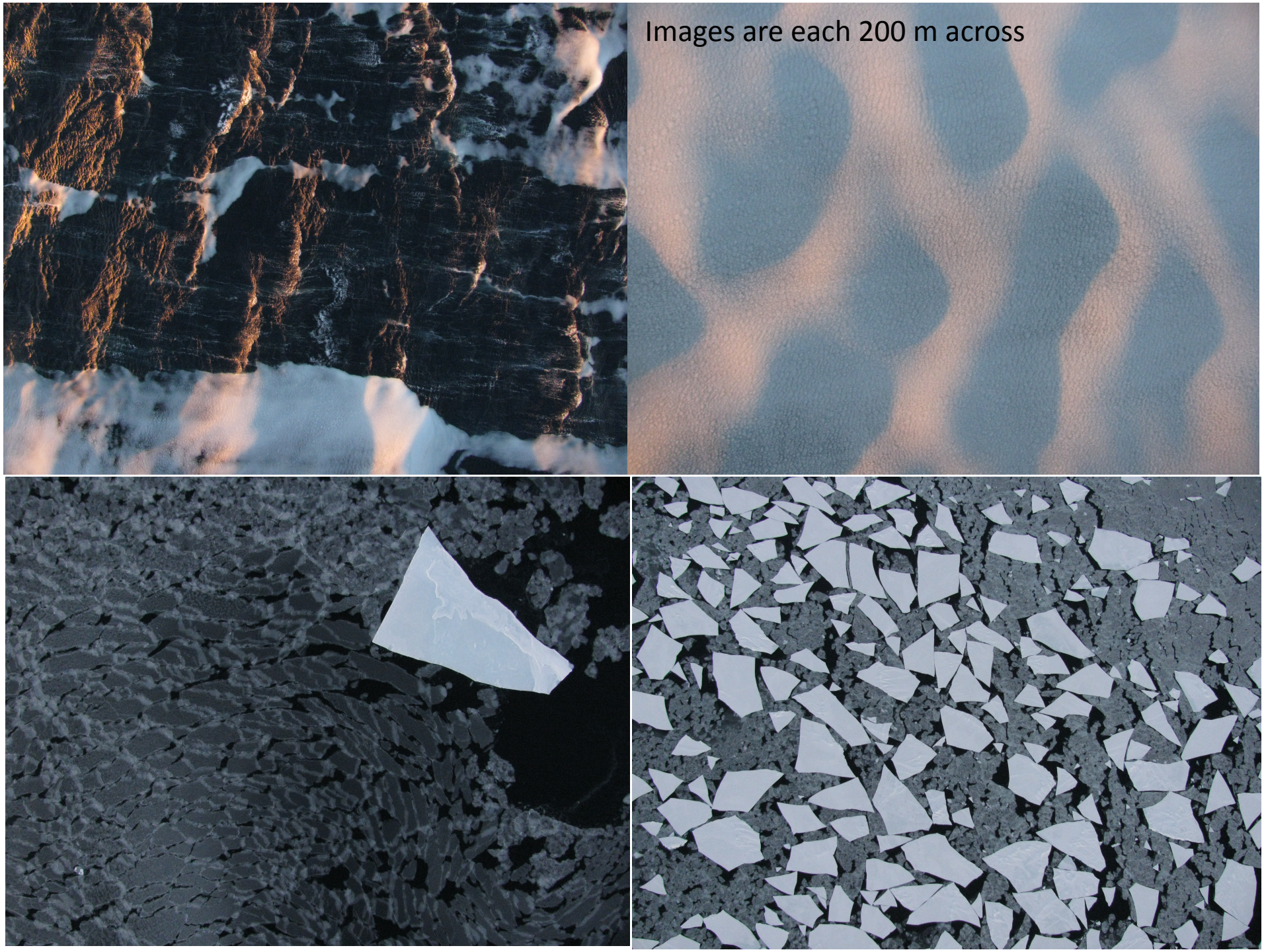


2009 UAV Flights over TNB

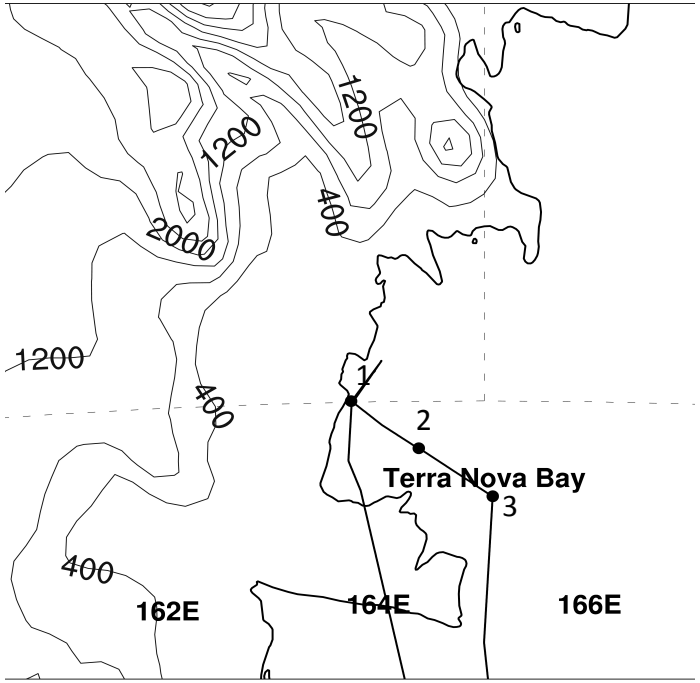
- Eight flights to TNB during September 2009
- Purpose to collect three dimensional measurements of air mass over TNB
- 11000 km
- 130 flight hours
- First ever wintertime measurements over polynya
- 2012 repeat

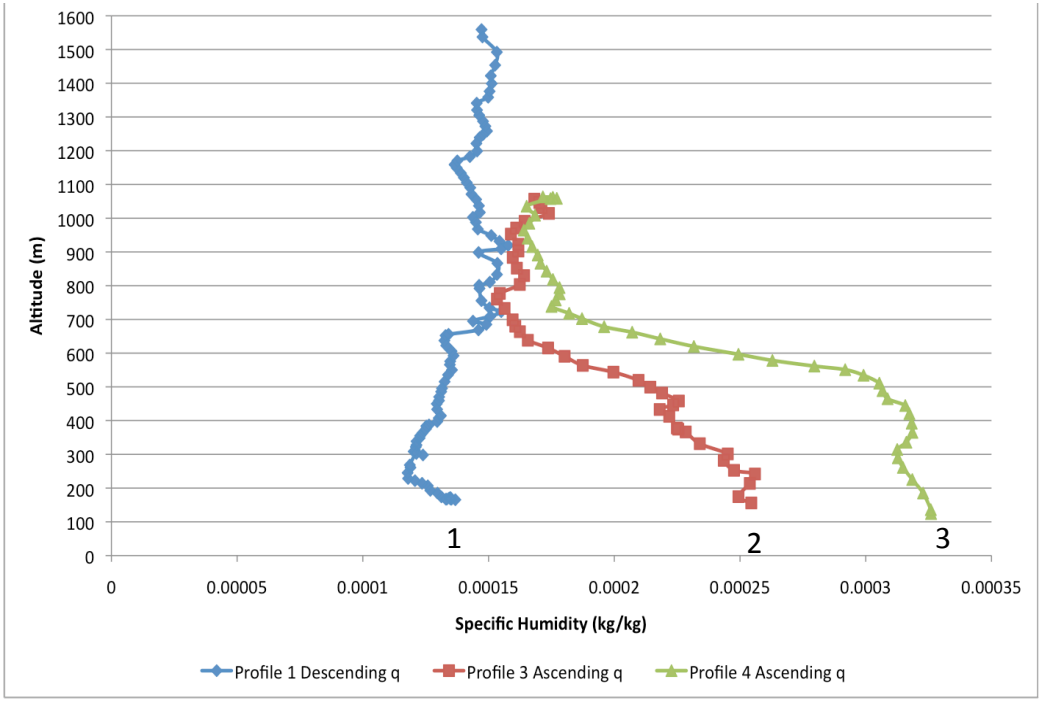
Knuth et al. 2013

Photo: John Cassano


Images are each 200 m across

23 September 2009

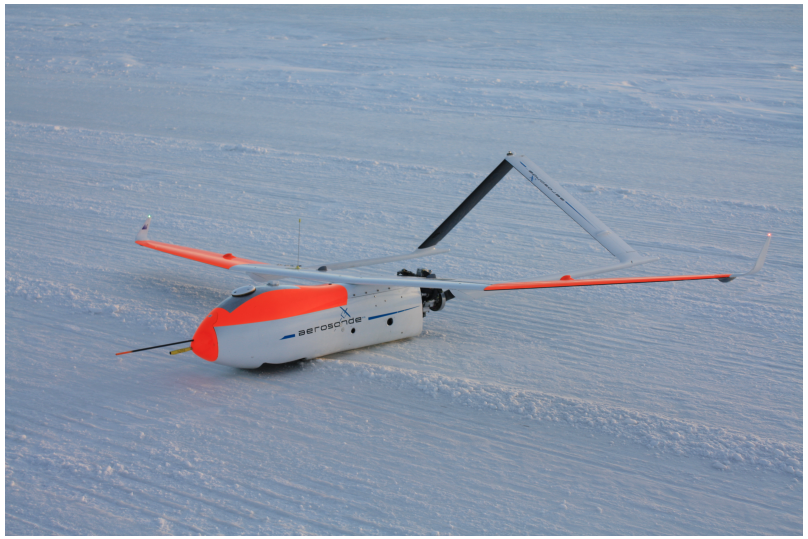


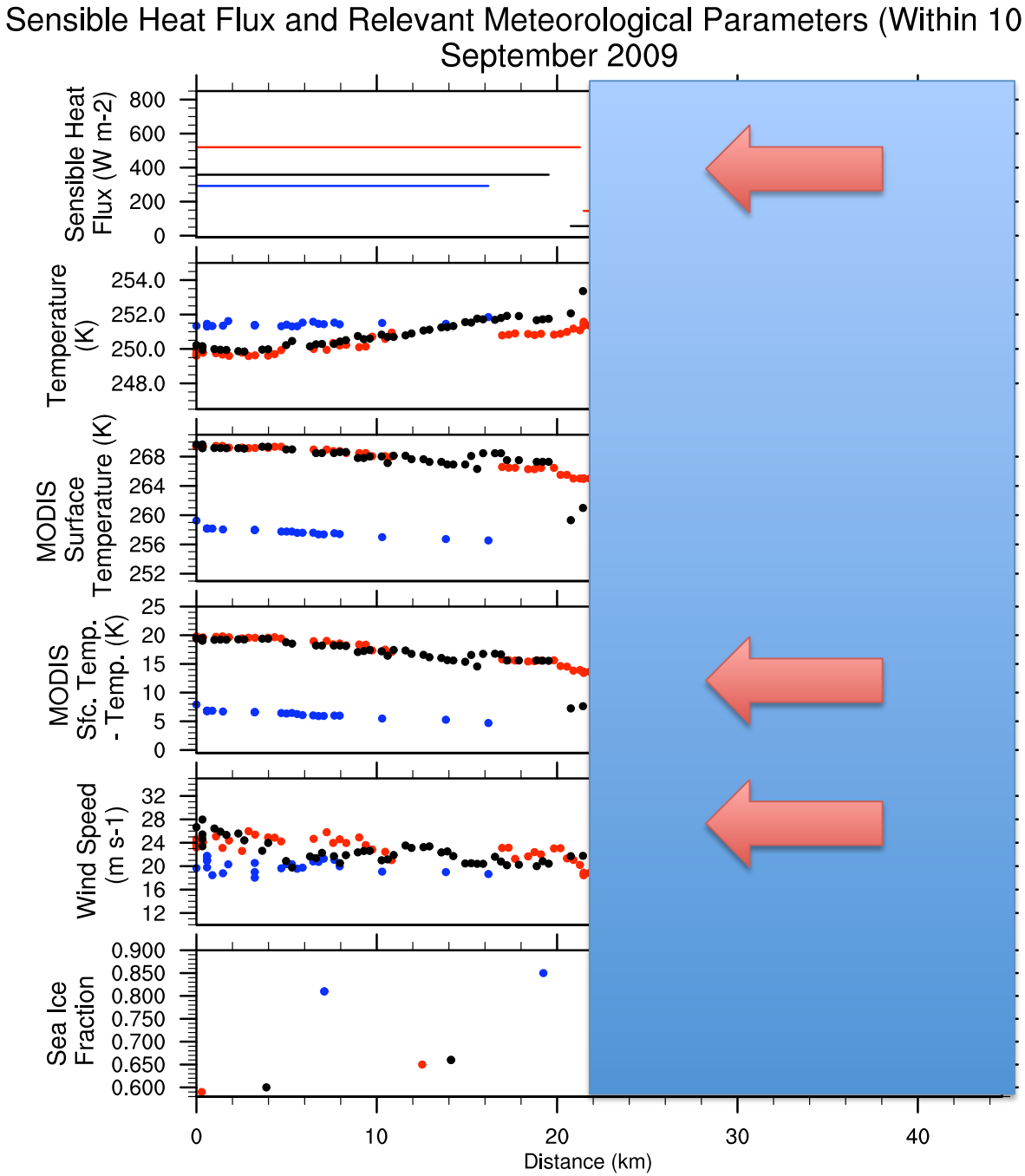


- Flight path along strongest winds
- Series of vertical profiles collected along tracks
- Examine how sensible, latent heat changed in the atmosphere between profiles
- Find flux between two vertical profile points

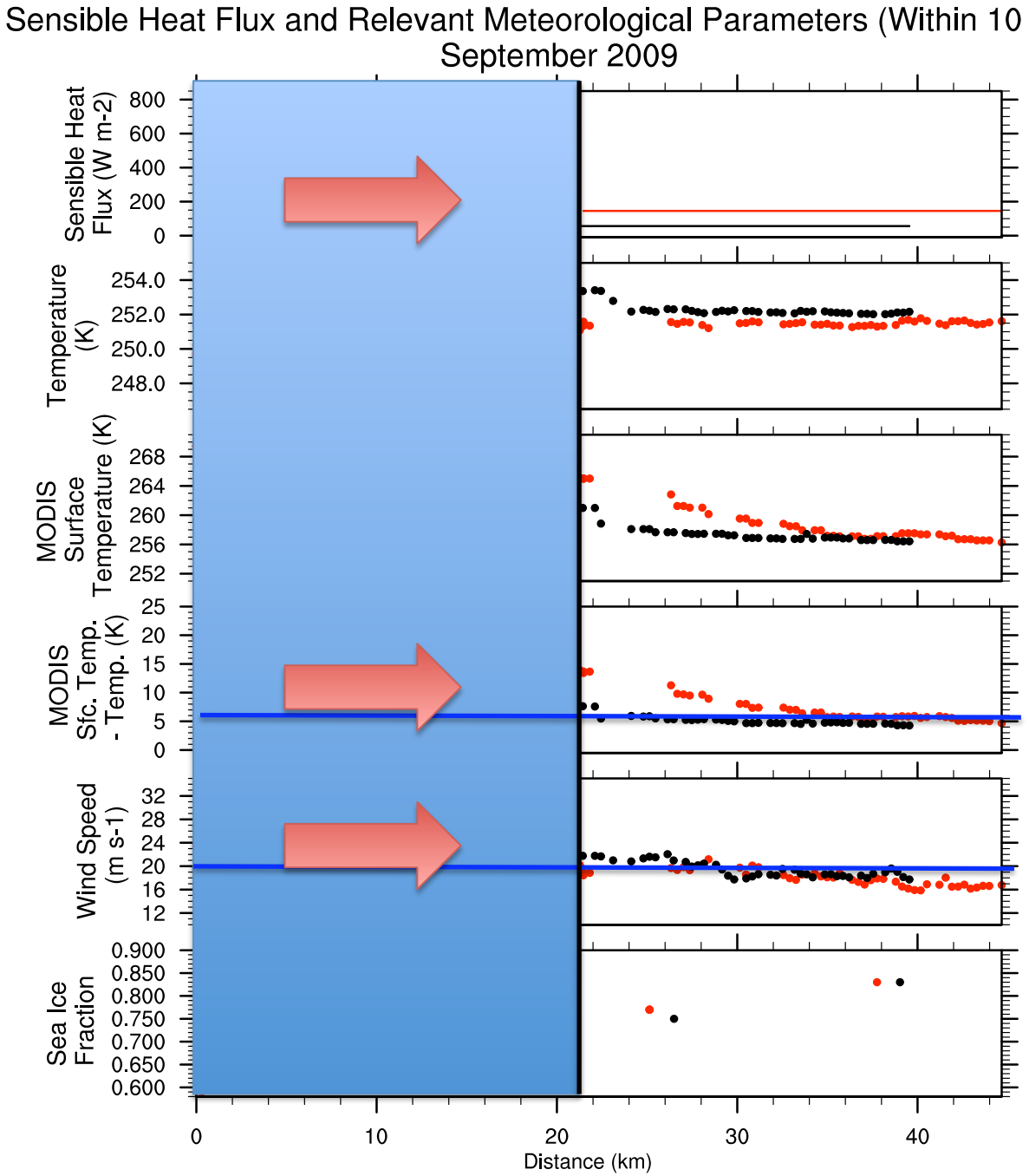
Fluxes Comparison

- Compare UAV flux days to assess differences
  - Three UAV flux days – 18, 23/24, and 25 September
- Compare observations to model output
  - Antarctic Mesoscale Prediction System (AMPS)
  - TOGA-COARE bulk flux algorithm (Chris Zappa)
  - Reanalysis data (Rich Cullather)
    - ERA-Interim
    - MERRA
    - CFSR





- Compare 18th, 23rd, 25th, Leg 1
  - 23rd had highest SH flux
  - 18th is lowest
  - Tsfc-Tair gradient is similar on 25th and 23rd
  - Winds are similar
  - 18th gradient much lower

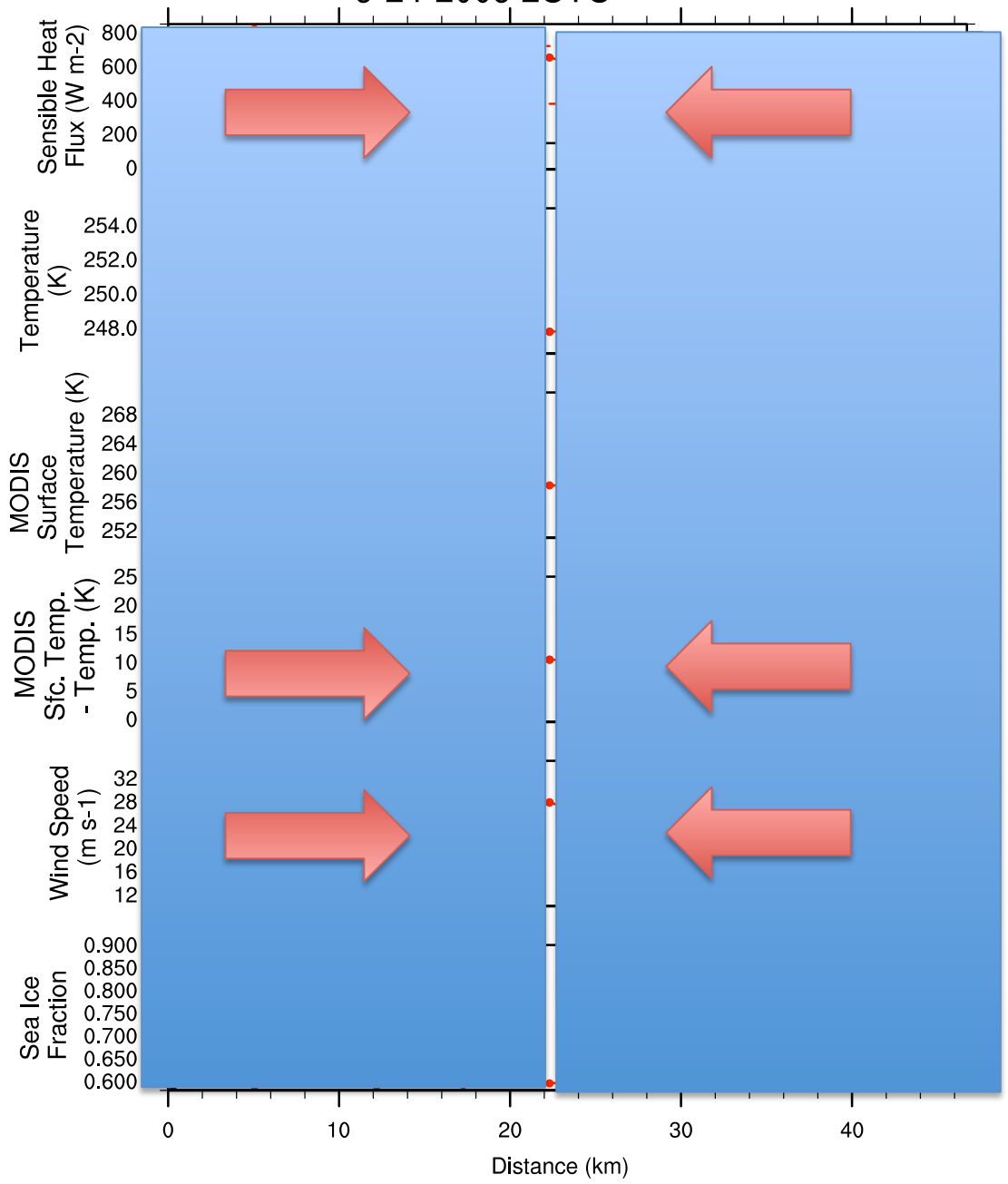


- Compare 23rd, 25th, Leg 2
- 23rd had highest SH flux
  - 23rd has a larger Tsfc-air temperature gradient than 25th
  - Winds are similar
  - 18th slightly higher gradient, winds slightly faster

Model Comparison

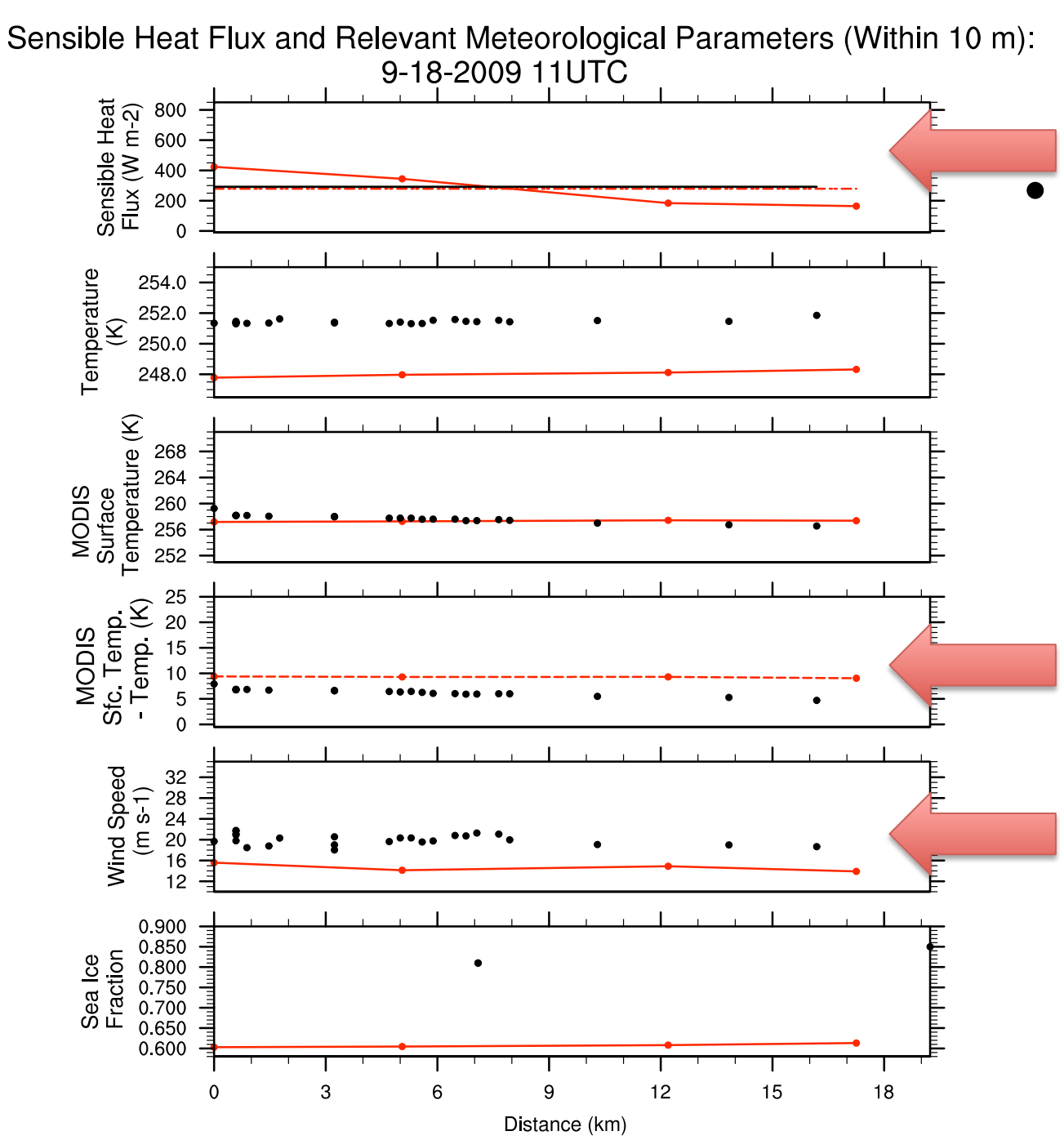
- Compare UAV calculations to AMPS calculations

Sensible Heat Flux and Relevant Meteorological Parameters (Within 10 m):
9-24-2009 2UTC



AMPS data
UAV/MODIS Observations

- AMPS SH flux greater than observed. Why?
  - Leg 1:
    - Over-forecasting winds
    - Smaller temperature gradient
  - Leg 2:
    - Similar winds
    - Larger temperature gradient
  - Need more analysis



AMPS data
UAV/MODIS Observations

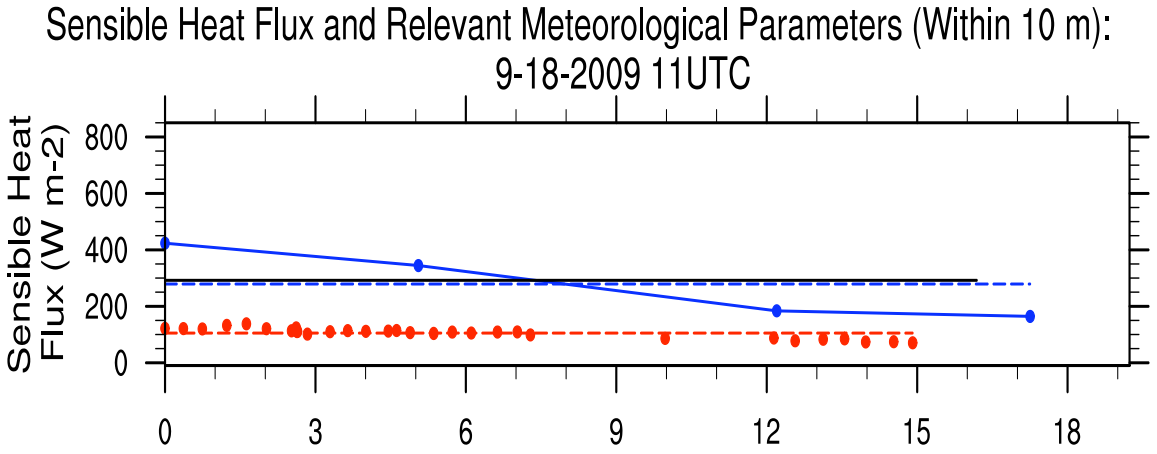
- AMPS SH flux similar to observed. Why?
  - Under-forecasting winds
  - Slightly larger temperature gradient
  - Perhaps temp/winds balance out?

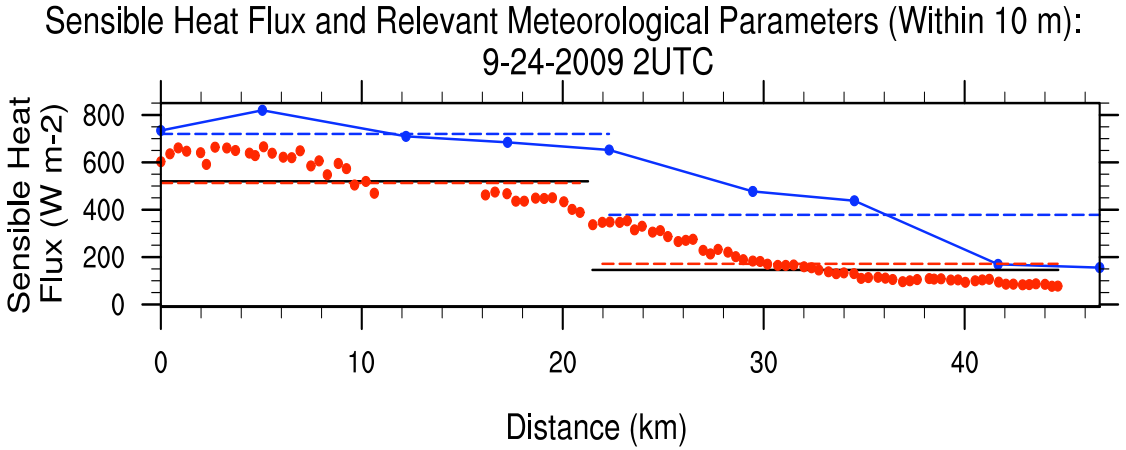
Model Comparison

- Compare AMPS and UAV calculations to other models

AMPS, Toga Coare, UAV Comparison

- Toga under-forecasting on 18th
- Toga nearly the same as UAV fluxes on 24th
- Toga meteorological input same as UAV
- Why is Toga parameterization better than AMPS on some days? Worse? The same?
- More analysis needed





Toga Coare output AMPS output UAV data

Dashed lines represent averages

Model and Reanalysis Comparison – 23 Sept.

Sensible Heat Flux (Wm^{-2})		
Type	Profiles 1-2	Profiles 2-3
UAV	**520**	**146**
AMPS	720	378
TOGA	513	172
MERRA	36	33
ERA-I	10	32
CFSR	55	39

- Large differences
  - Sea ice data assimilated weekly
  - Trouble with topography
- More analysis

Conclusions

- UAV calculated fluxes from three flight days in 2009 over Terra Nova Bay
- Sensible heat fluxes upwards of 500 W m^{-2}
- Compare flight days, assess meteorological variables
- Compare to model data, show mixed results
- Reanalysis far underestimates UAV fluxes

Questions?

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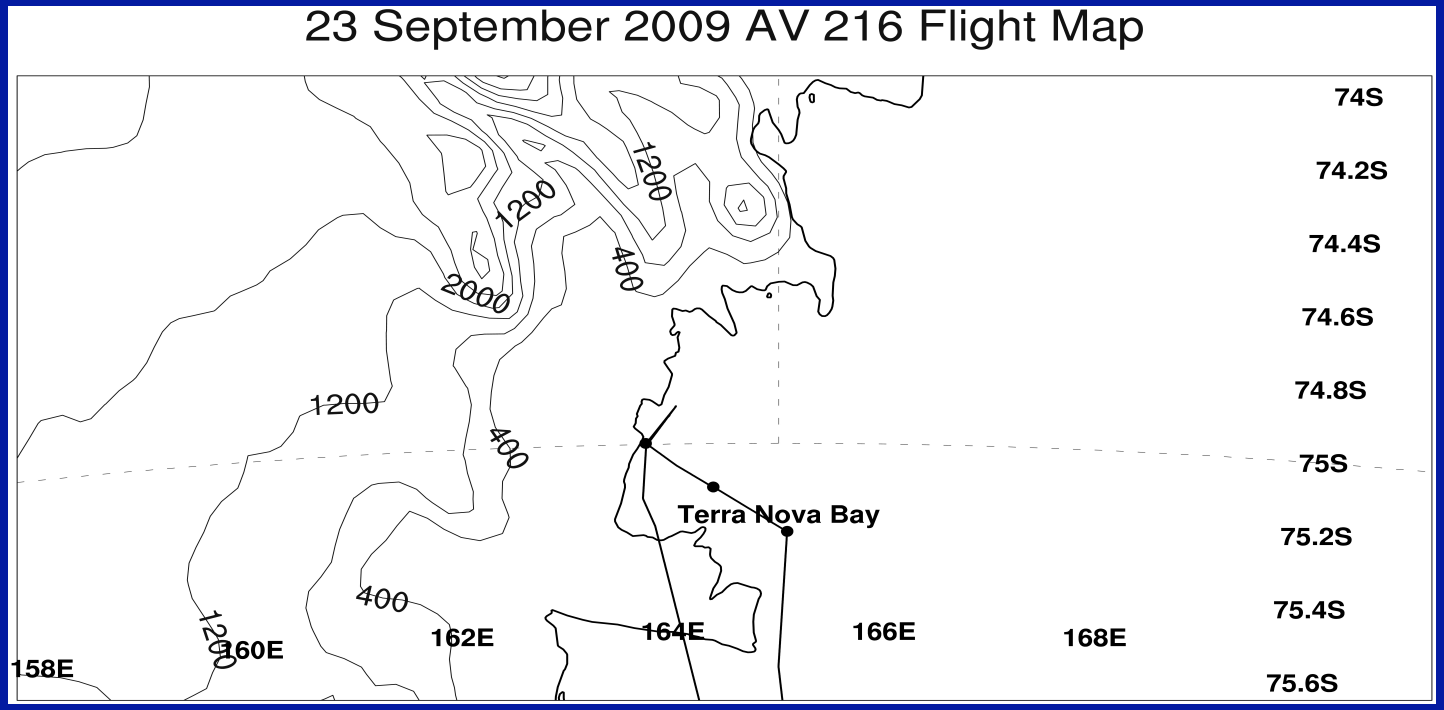
Reference: Knuth, S.L., Cassano, J.J., Maslanik, J.A., Herrmann, P.D., Kernebone, P.A., Crocker, R.I., and Logan, N.J., 2013: Unmanned aircraft system measurements of the atmospheric boundary layer over Terra Nova Bay, Antarctica, Earth Syst. Sci. Data, 5, 57-69, doi:10.5194/essd-5-57-2013.

Acknowledgments: MODIS Data – Jim Maslanik; Toga Coare data - Christopher Zappa; reanalysis data – Rich Cullather
NSF: ANT 0739464, ANT 1043657

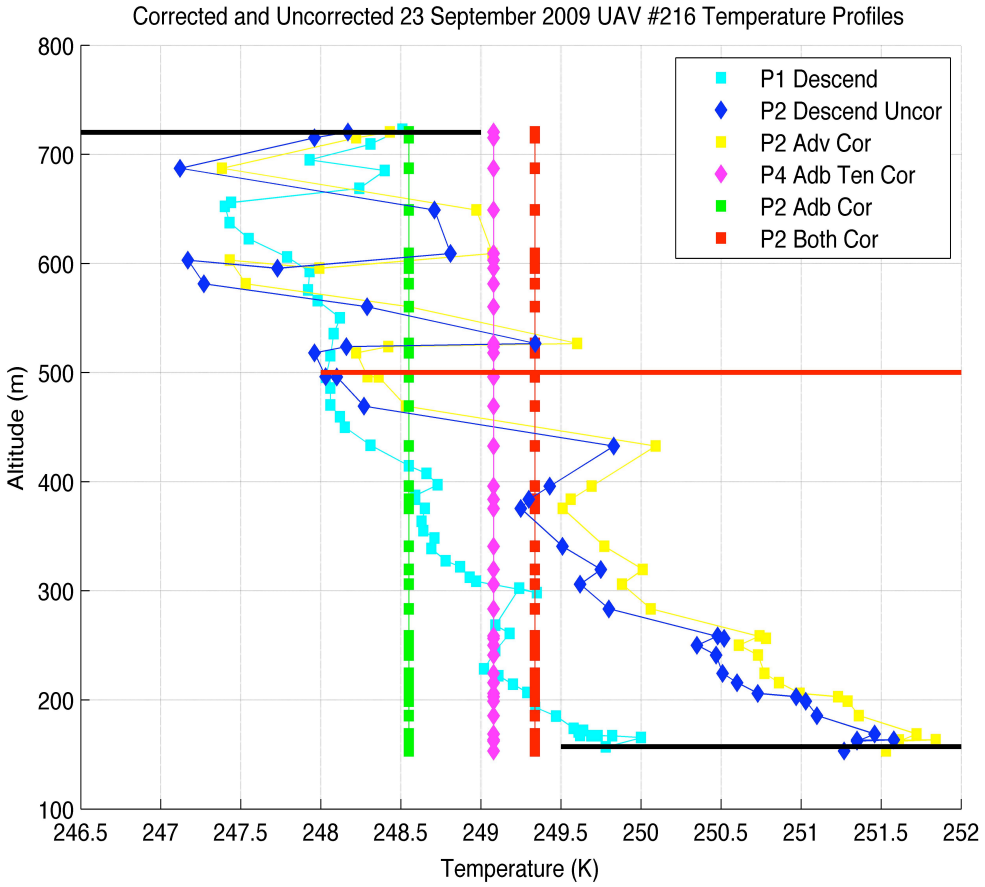
Purpose of Study



- To understand air-sea interactions in TNB
  - How do changes in the wind and temperature of the air mass impact air-sea interactions?
- Sensible heat and latent heat fluxes, and momentum fluxes
- UAV vertical profiles

Corrections to Flux Calculations

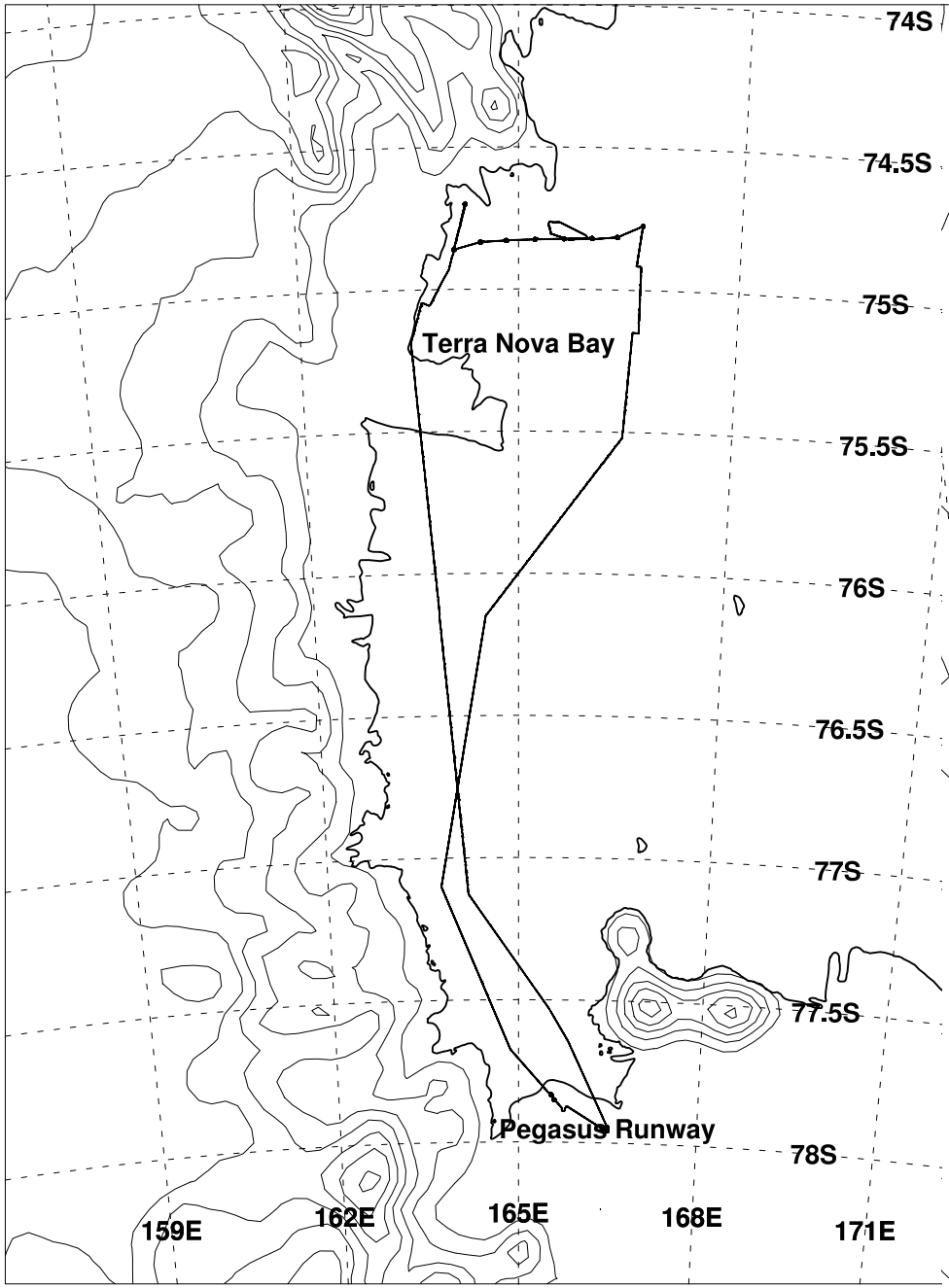
- Non-Lagrangian
  - Corrects calculation so that UAV is measuring the same air parcel in the downstream profile as it did in the upstream one
- Adiabatic processes (SH flux only)
- Winds rotated along the flight path
- Same mass in both profiles
- Sensor lag



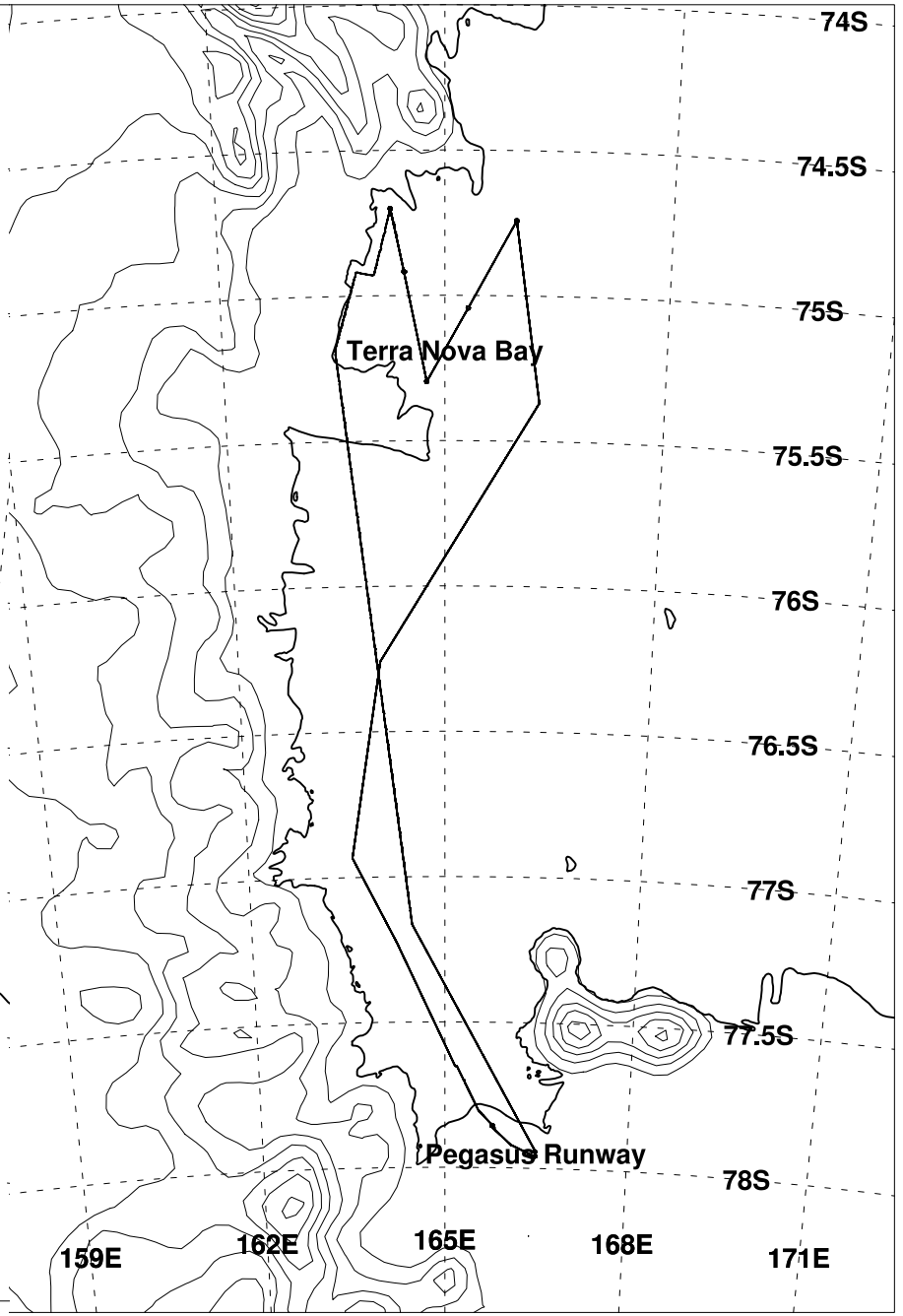
2009 vs. 2012

- 2009: initial campaign
  - 16 flights total, 8 local and 8 to TNB
- 2012: Improve upon measurements, collect additional
  - 13 flights total, 4 local and 9 to TNB
- Total flight hours in TNB
  - 2009: 31 hours
  - 2012: 58 hours
- Losses
  - 1 in 2009 – fuel pump failure
  - 2 in 2012 – pitot tube icing and generator belt

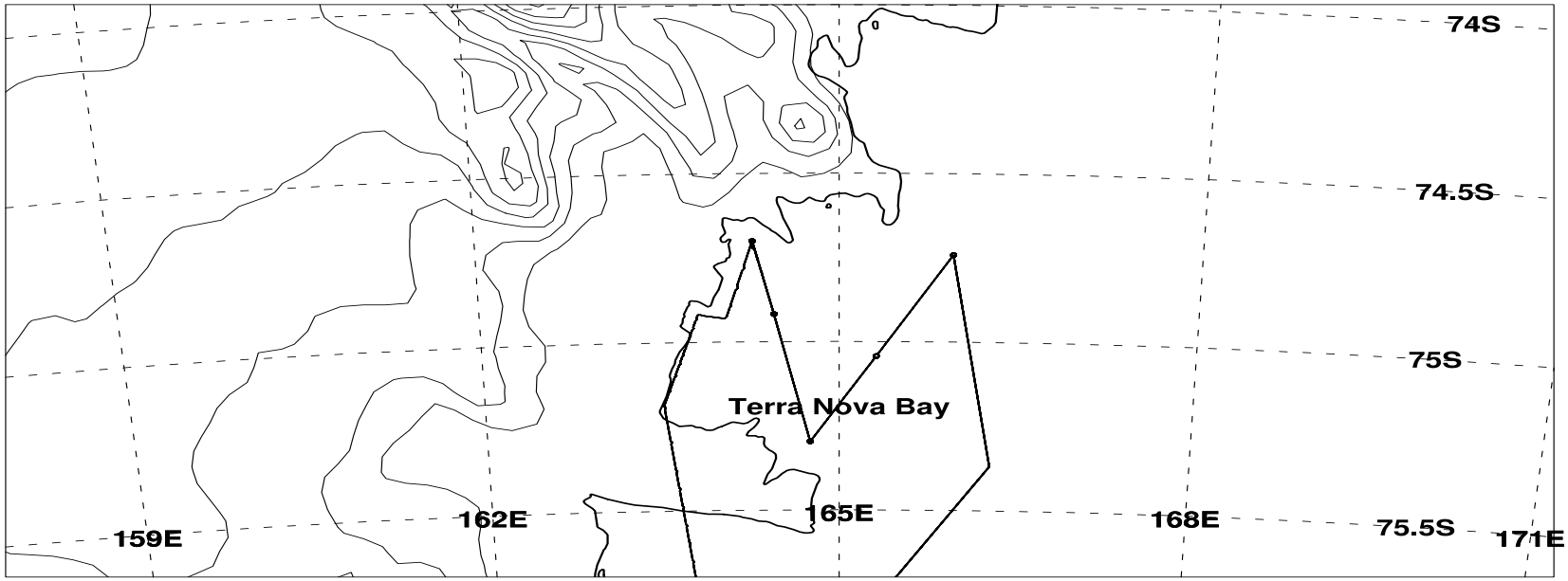
25 September 2012 AV 242 Flight Map

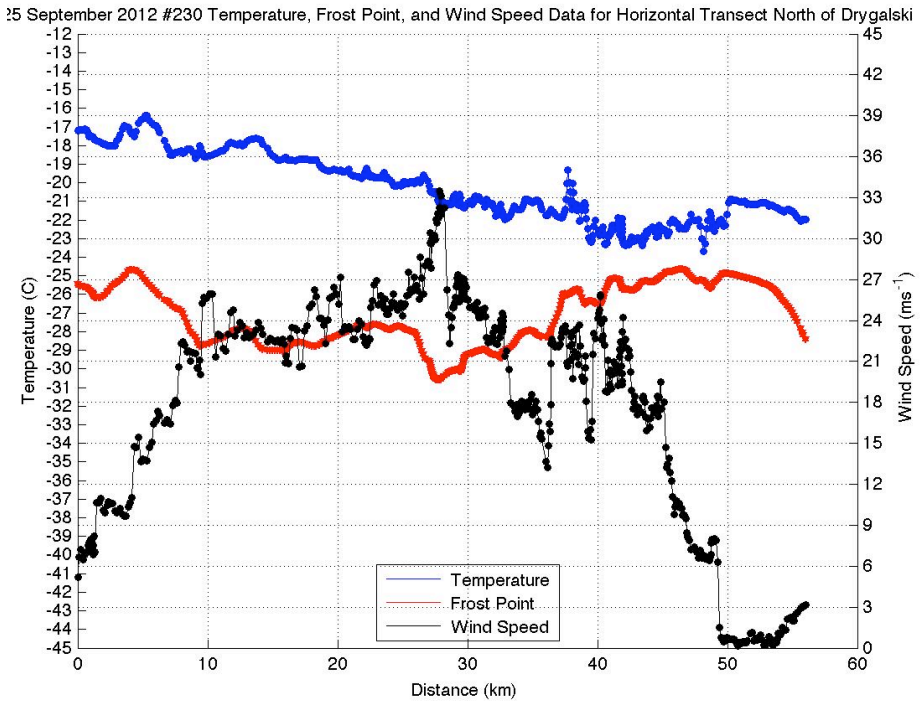


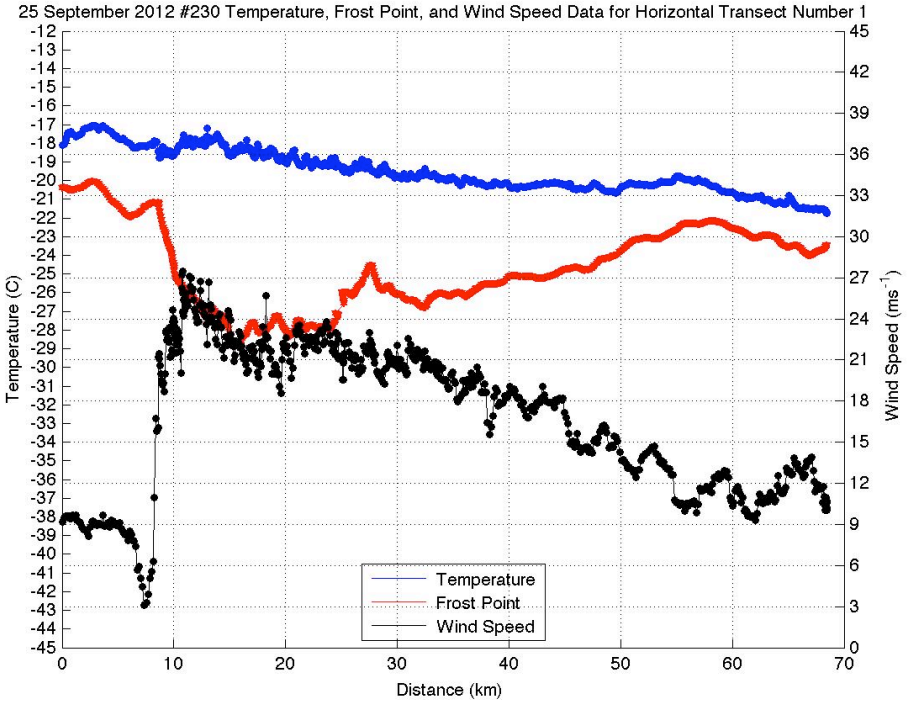
25 September 2012 AV 230 Flight Map



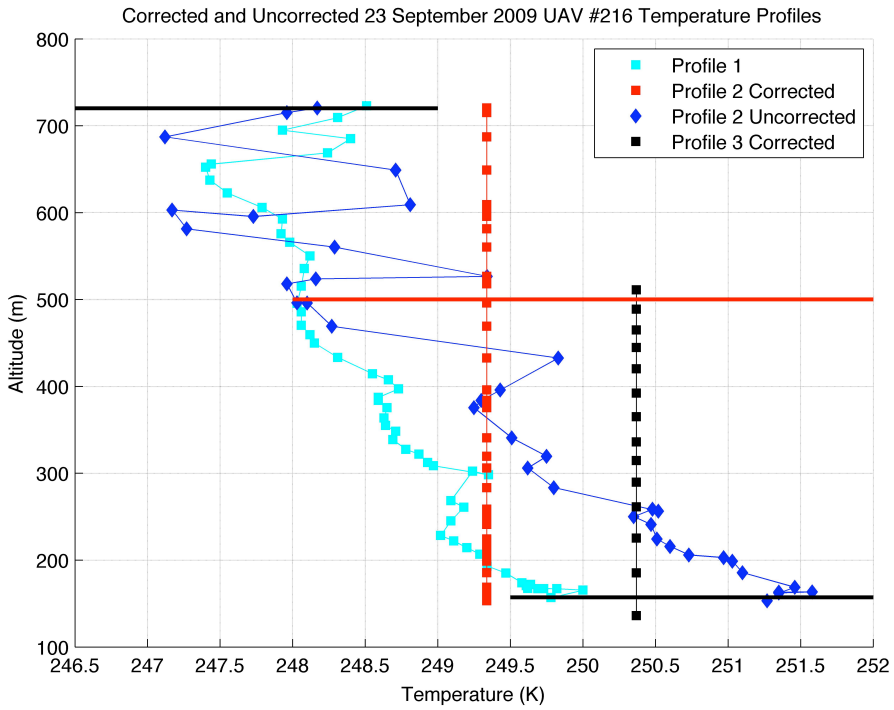
25 September 2012 AV 230 Flight Map

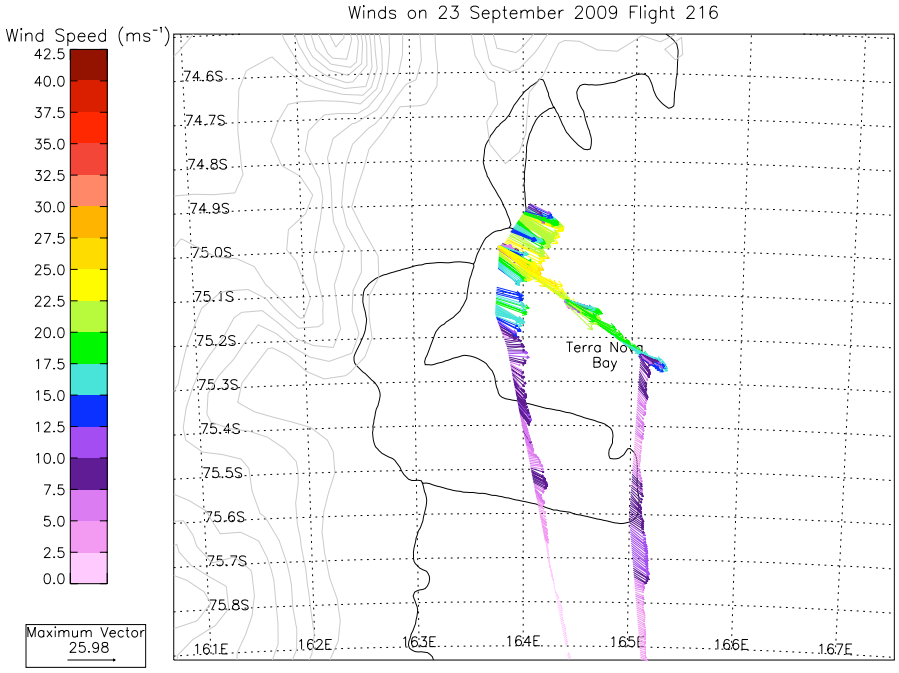




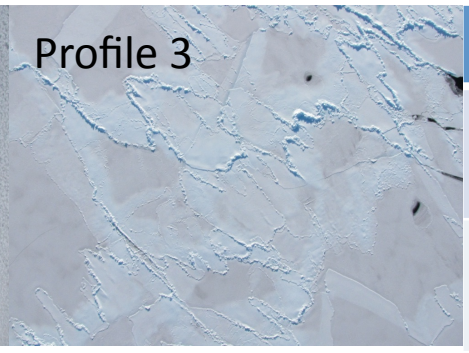


Temperature Profiles, Wind Speed, and Sensible Heat Fluxes for 23 September





↘ Wind Direction



	SH Flux
Profile 1 to 2	519 W m^{-2}
Profile 2 to 3	146 W m^{-2}