UNIVERSITY OF CANTERBURY

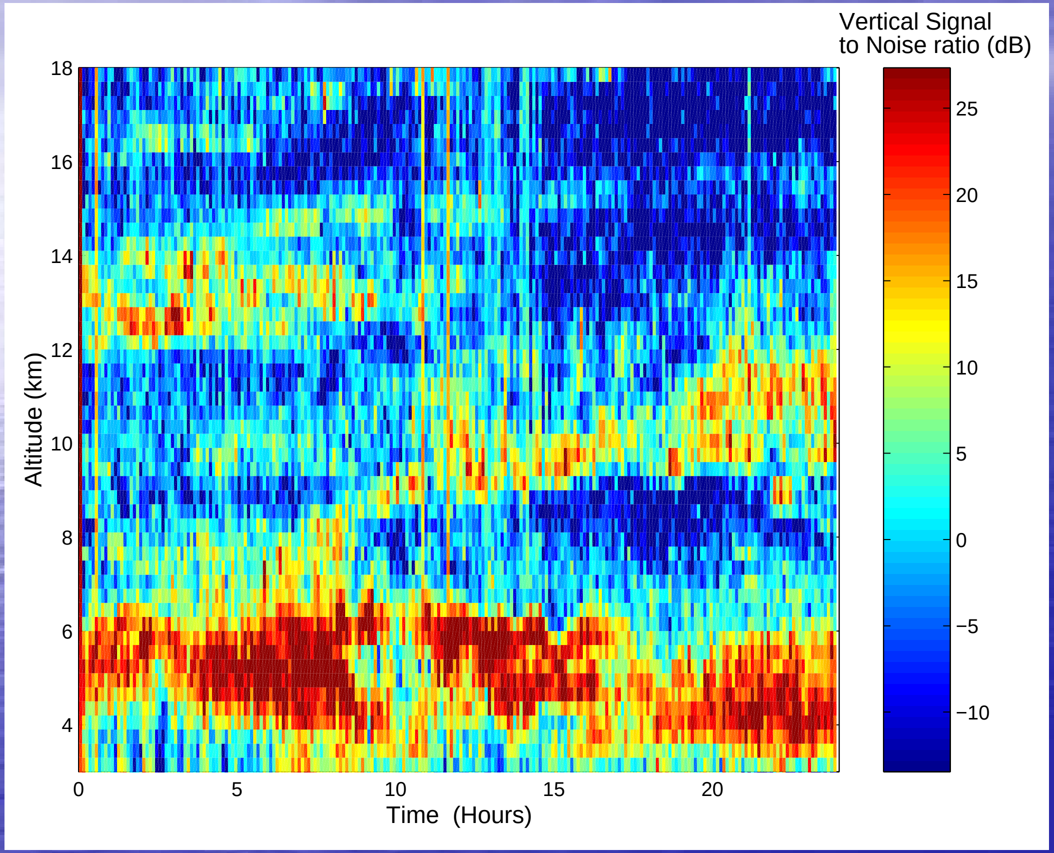
Low-level atmospheric measurements using an automated powered-glider and other developments at Canterbury University

Adrian McDonald, Geoff Graham, Ross Ritchie, Andreas Baumgärtner and others

Overview

- What's happening at University of Canterbury?
- The STAG Design
- Sea breeze studies using combined ground-based and STAG measurements
- Conclusions and further work

CUSTAR

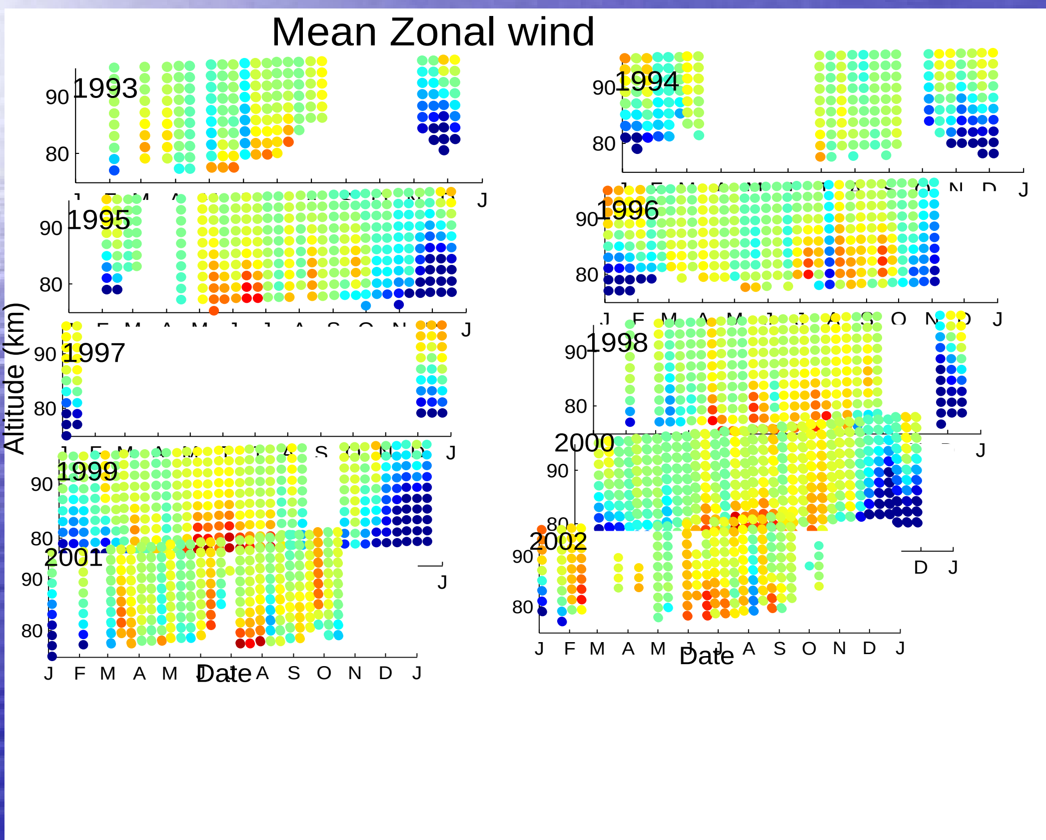


The first vertically pointed antenna beam for the VHF wind-profiler has been complete for nearly 1 year. The initial phase of building three additional receiving spaced antennas, which will allow horizontal velocity measurements between 3 and 14km to be made, is complete and work on a new receiver design and the final portion of the antenna build will be completed in mid-2004.

MF radar work at Canterbury

Scale

-20ms^{-1} Westward | 0ms^{-1} | 20ms^{-1} Eastward



Study of the seasonal and intra-seasonal behaviour of the wave-driven circulation in the middle atmosphere is ongoing Examination of the significance of trends in the 18-year span of Scott Base observations and the 30-year span of data from Birdlings Flat (the longest data record of this type in the world) of the mesospheric wind is in progress.

Collaboration with Prof. Bob Vincent at University of Adelaide, and Martin Jarvis at the British Antarctic Survey is ongoing.

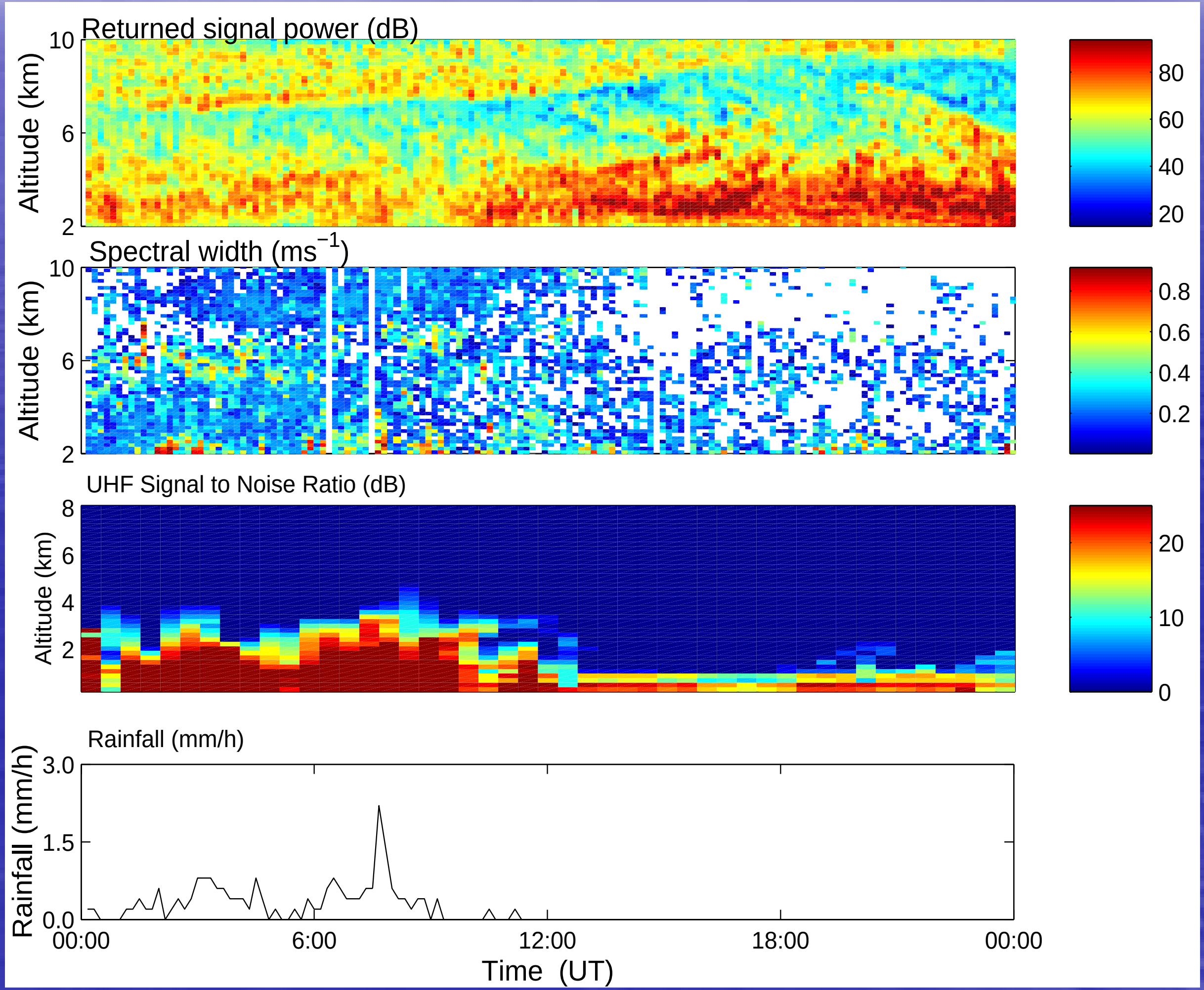
Precipitation Signatures in VHF wind profiler data

Reductions in the signal strength of clear air returns observed by VHF wind-profilers have been observed in regions of precipitation.

Data from the MST radar facility in Aberystwyth, Wales, and co-located tipping bucket rain gauge data show these variations are statistically significant.

Enhancements in UHF radar returns (i.e. precipitation) and reduced VHF returns are also observed.

Collaboration with Dr. David Hooper at RAL. Submitted to Annales Geophysicae.



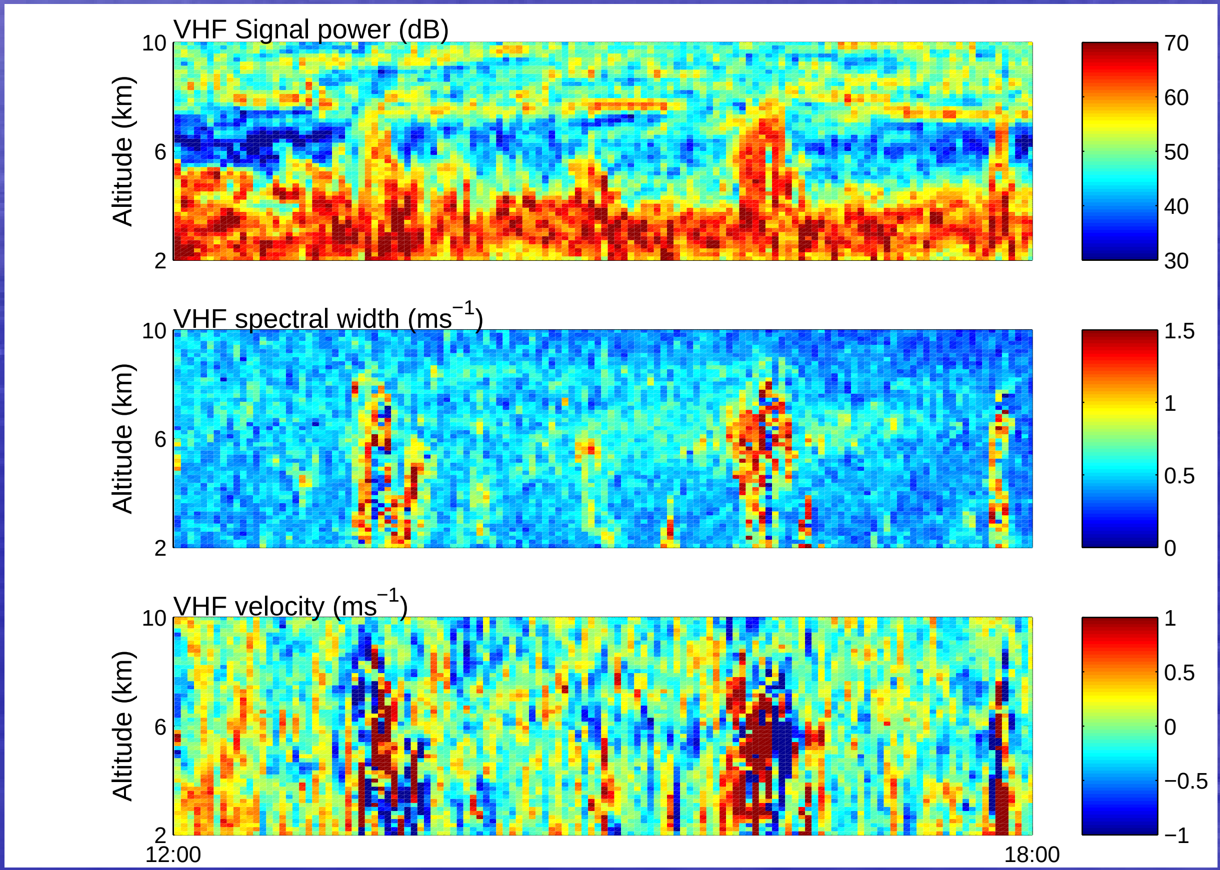
Studies of Convection using VHF radar

The previous study seemed to suggest that convective and stratiform precipitating clouds caused very difference responses in the signal power

This associated with large vertical velocity means that we can identify convective regions for analysis.

We are now ready to make the same measurements with the CUSTAR system.

Colaboration with Dr. David Hooper at RAL.



What is STAG?

- STAG is a small glider (≈2.0m wingspan) equipped with a set of meteorological measurement sensors which may be useful for low–level atmospheric studies.
- So far, STAG has made measurements of
  - Temperature
  - Humidity
  - Pressure
  - Air speed (poorly due to an error-prone digital compass which has now been replaced)
  - Ground speed

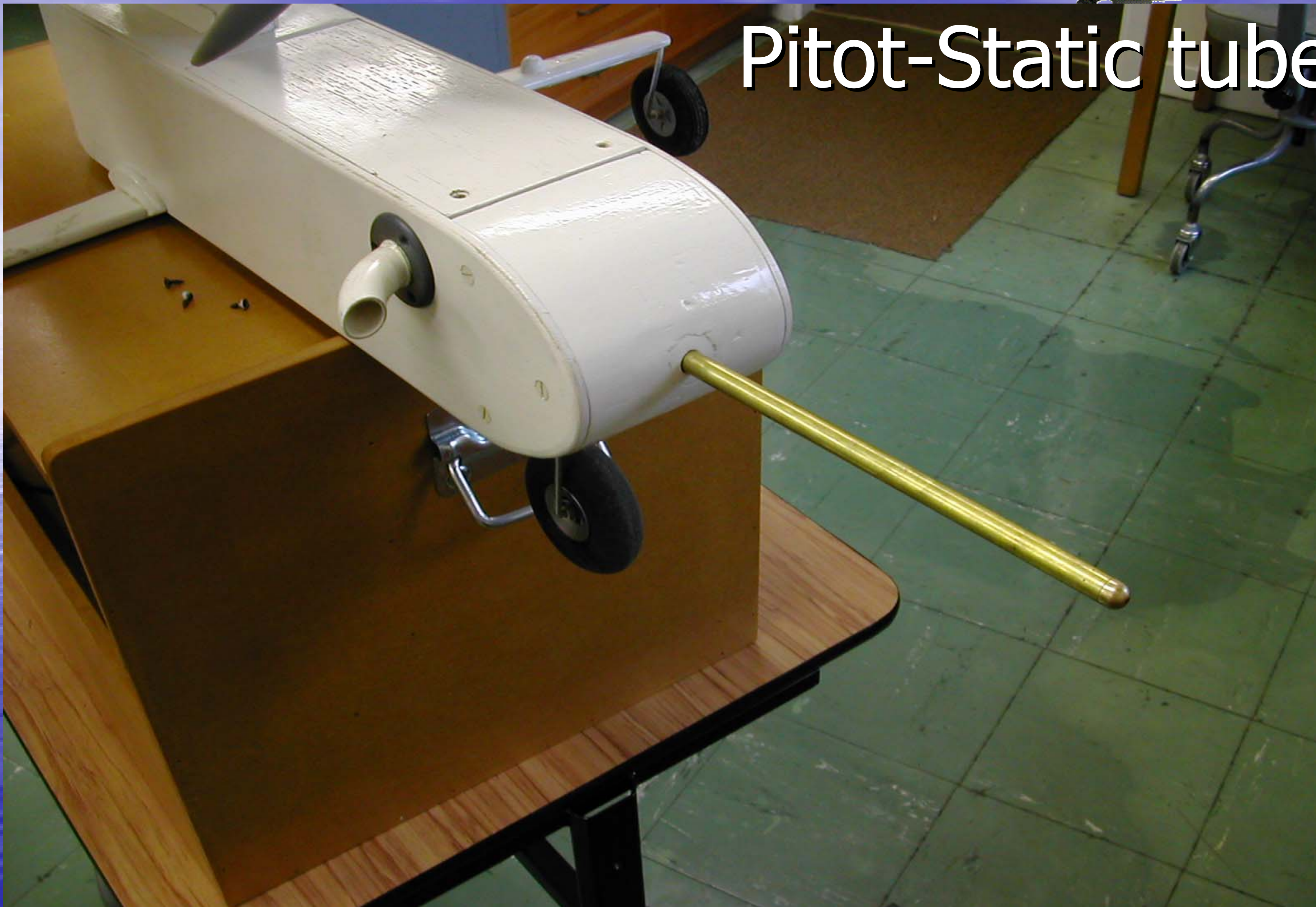
Typical Mission

The powered version of the STAG system can be used for low-level atmospheric monitoring. A possible mission would be:

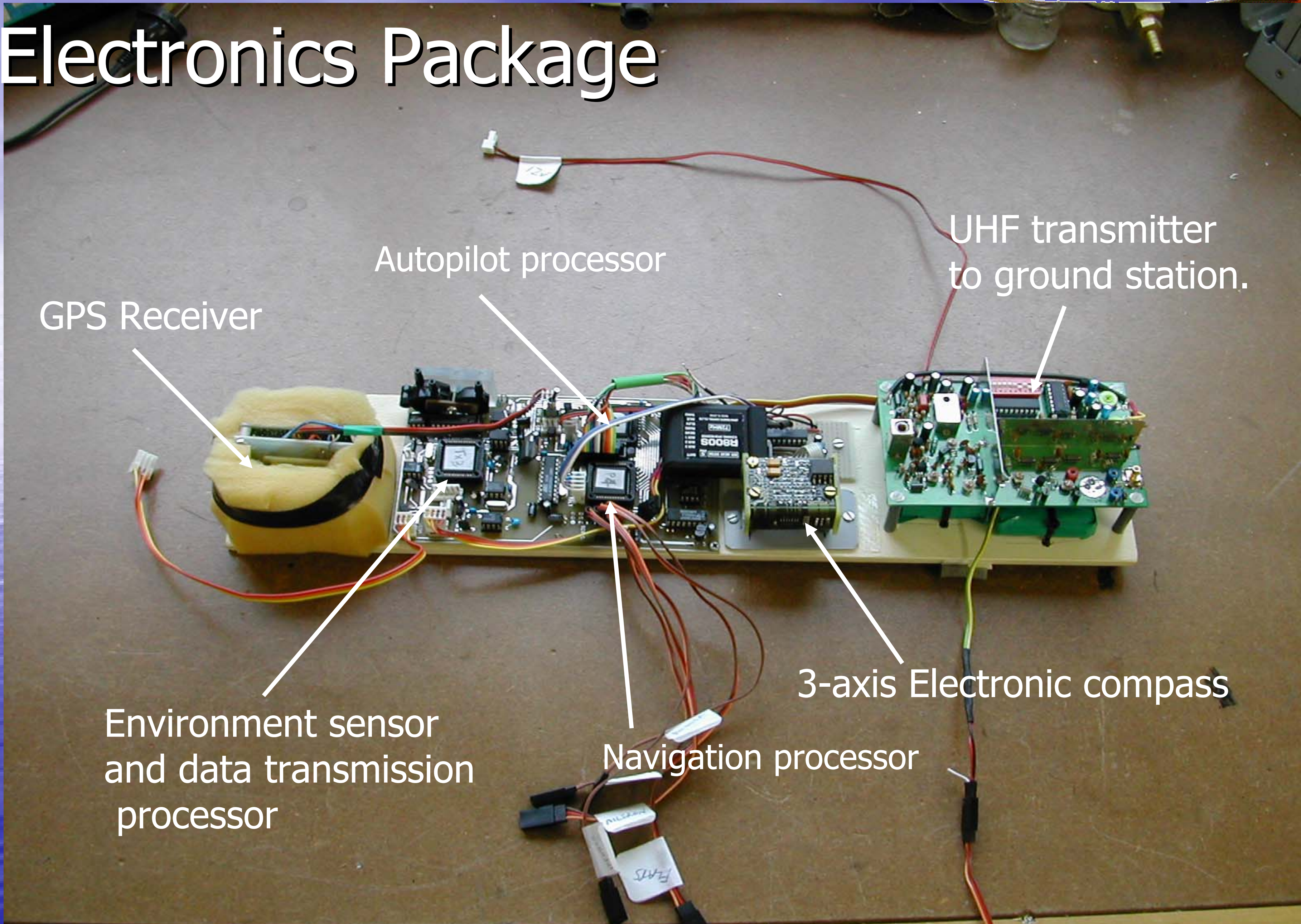
- Record pre-launch information, which includes pressure, temperature, relative humidity, and a launch position based upon GPS data.
- Launch under manual control via VHF link.
- Travel under autonomous control (not quite achieved but getting close) between a set of pre-defined waypoints.
- Land under manual control via VHF link.

Aircraft Design

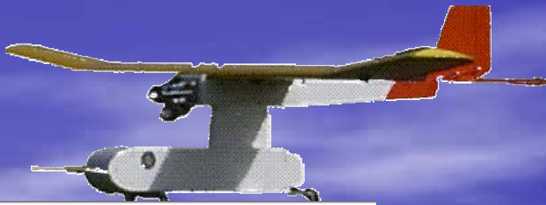
Pitot-Static tube

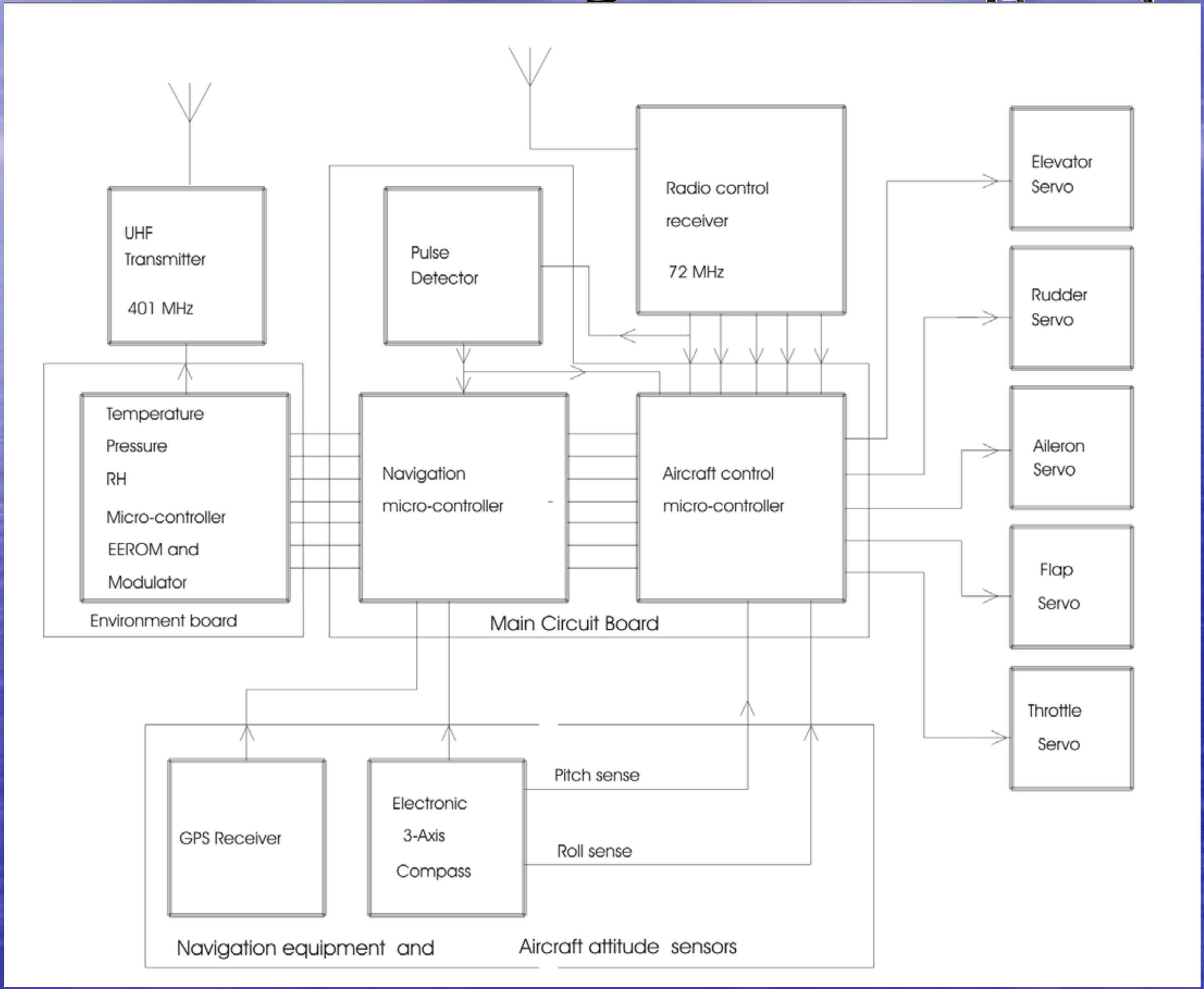


Electronics Package

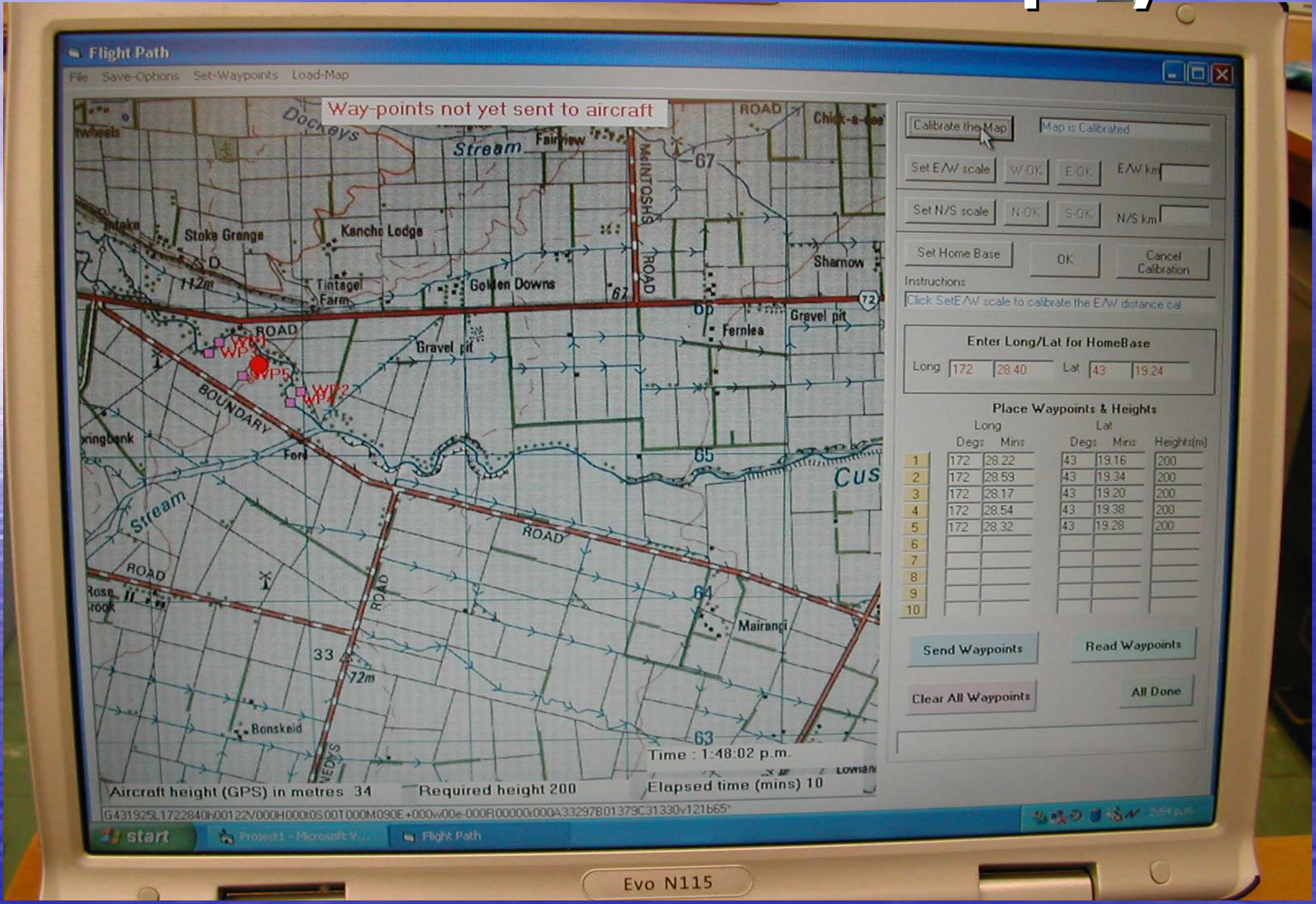


Electronics Block diagram





Ground station real-time display



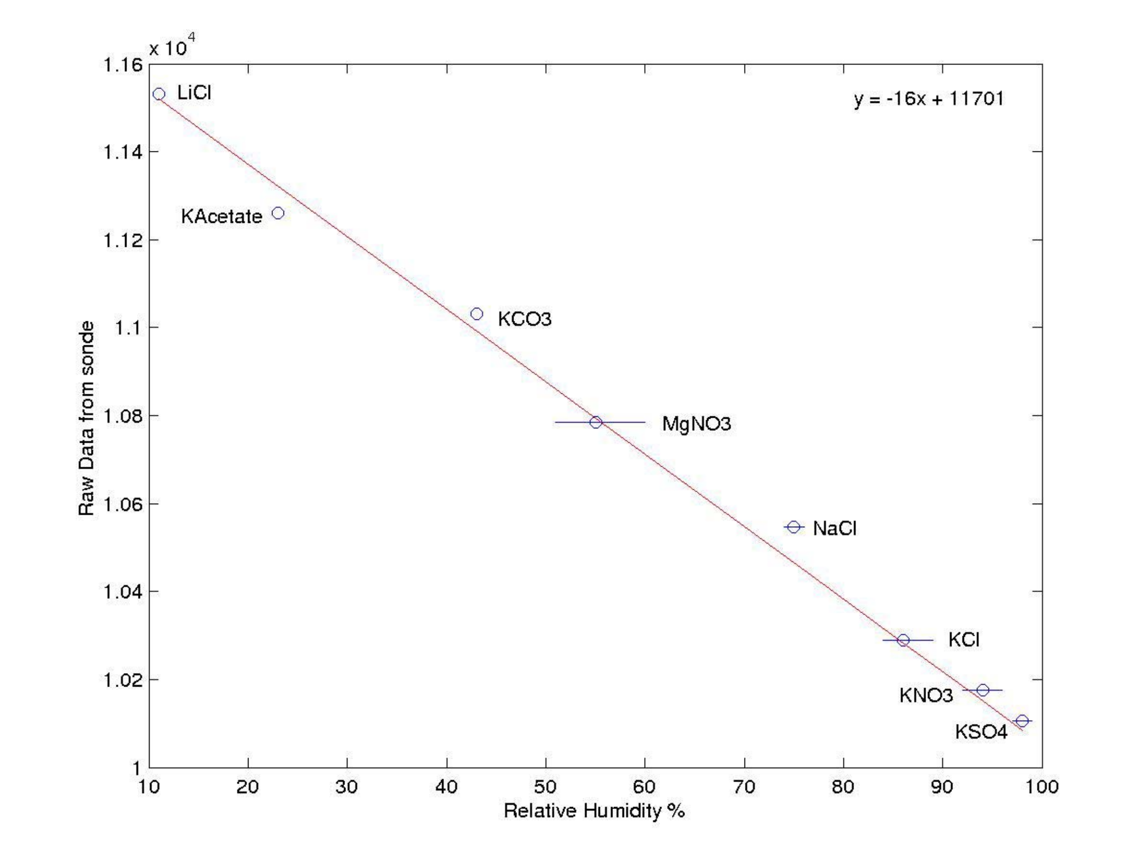
Pressure and temperature calibration

An environmental chamber which has been designed to simulate the conditions in the troposhere and lower stratosphere is being used to calibrate the pressure and temperature sensors used onboard STAG.

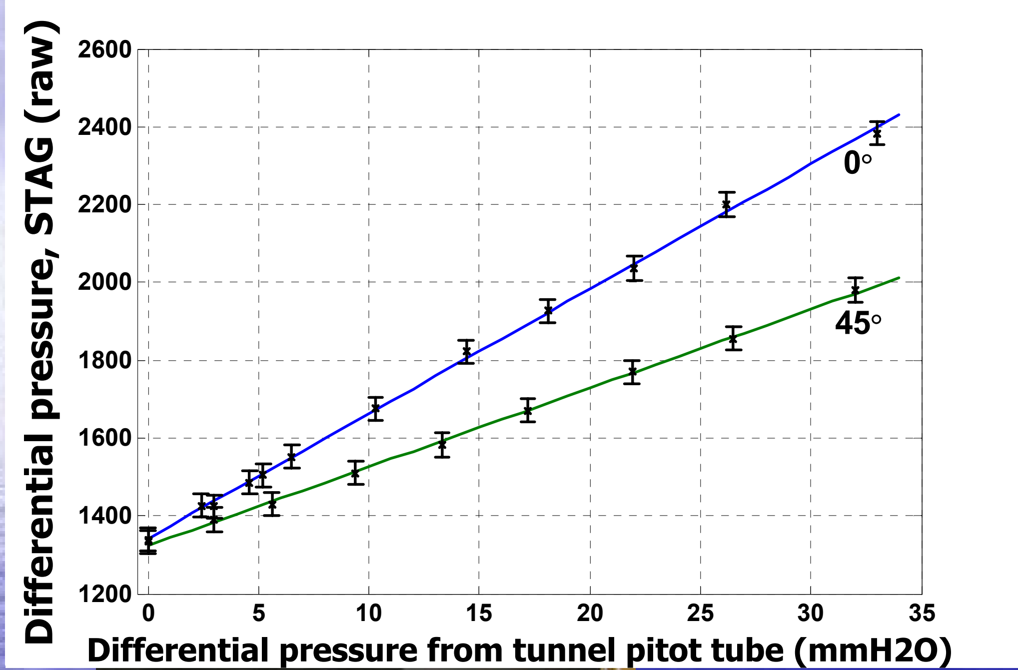
Relative humidity calibration

The instrument used to measure relative humidity onboard the glider is a Vaisala HumiCap (bought from NIWA).

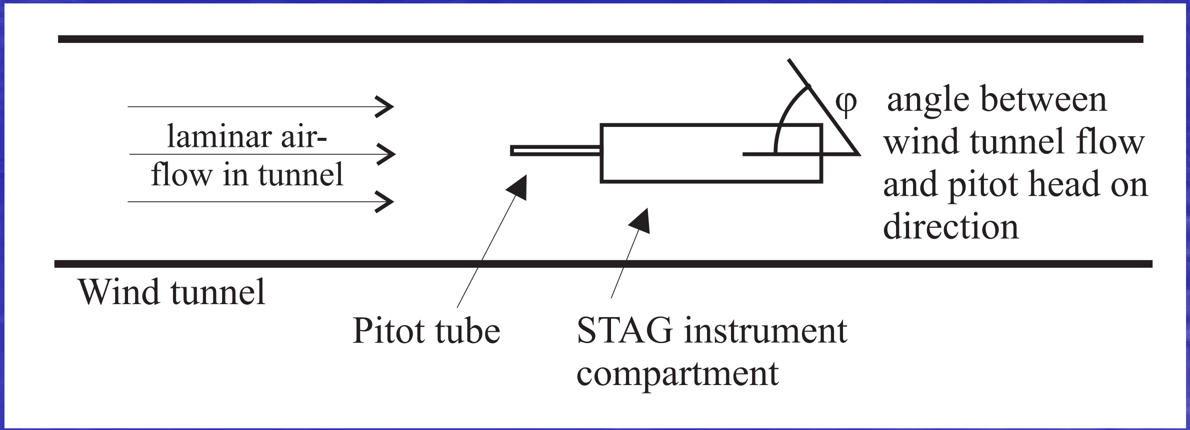
Calibrating the individual sensor involves creating a saturated salt solution, which when inside a sealed environment produces air with a well-defined theoretical relative humidity.



Air speed measurement



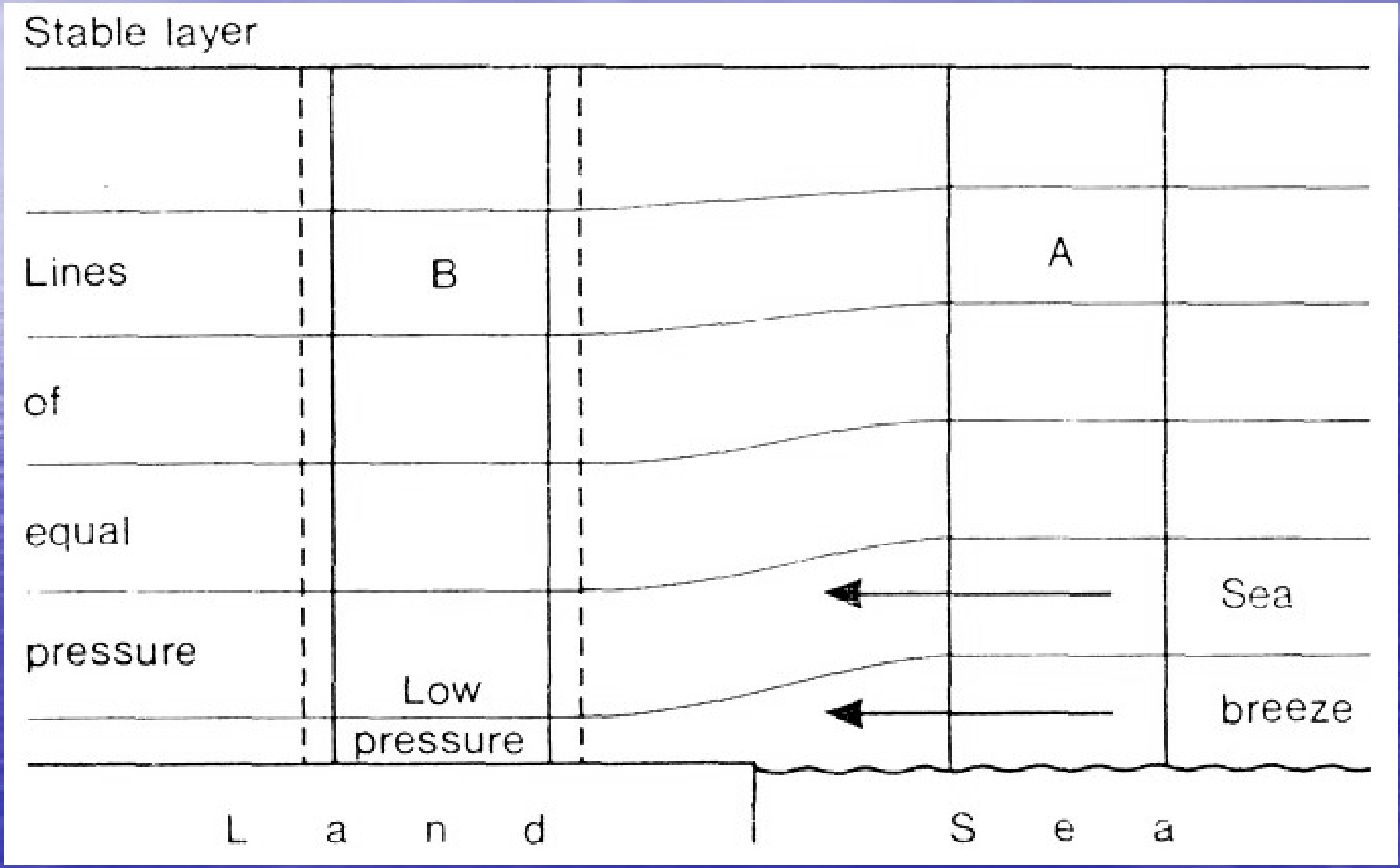
Calibration of the pitot-static tube differential pressure sensor was perfomed in a Wind-tunnel in the Department of Mechanical Engineering.



Sea breezes

- Important phenomenon in Canterbury (pollution)
- Strengths of up to 7 m/s
- At least 1 K temperature difference between land and sea air needed
- Associated with higher humidity and lower temperatures
- Very sensitive to opposing winds
- At Boundary air rises and forms cumulus clouds

Sea breezes



Stable layer
Lines
of
equal
pressure
B
Low
pressure
A
Sea
breeze
L a n d
S e a

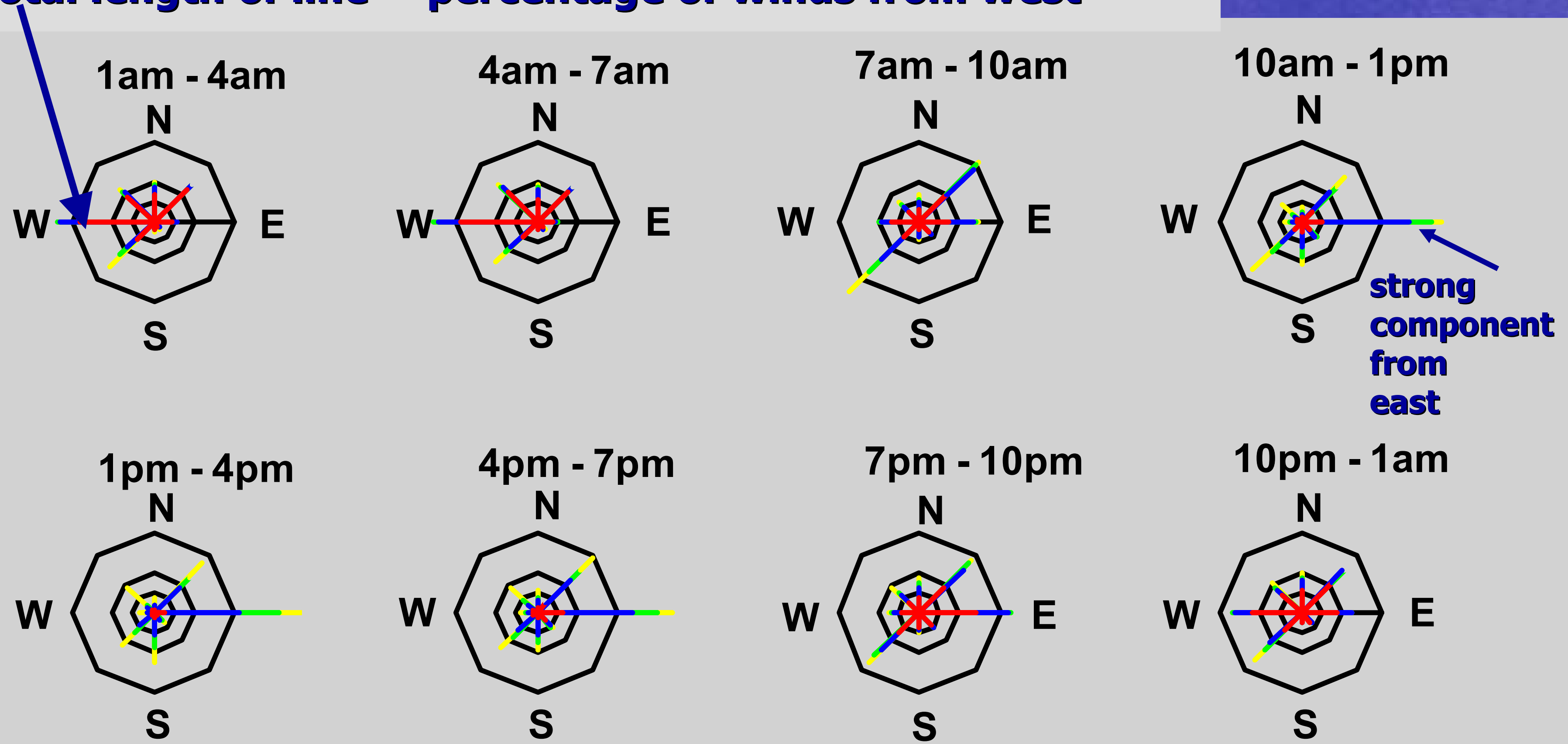
Statistical sea breeze analysis

Summers 2000-2003, Rangiora weather station (data from NIWA Climate database).

Colors indicate strength:

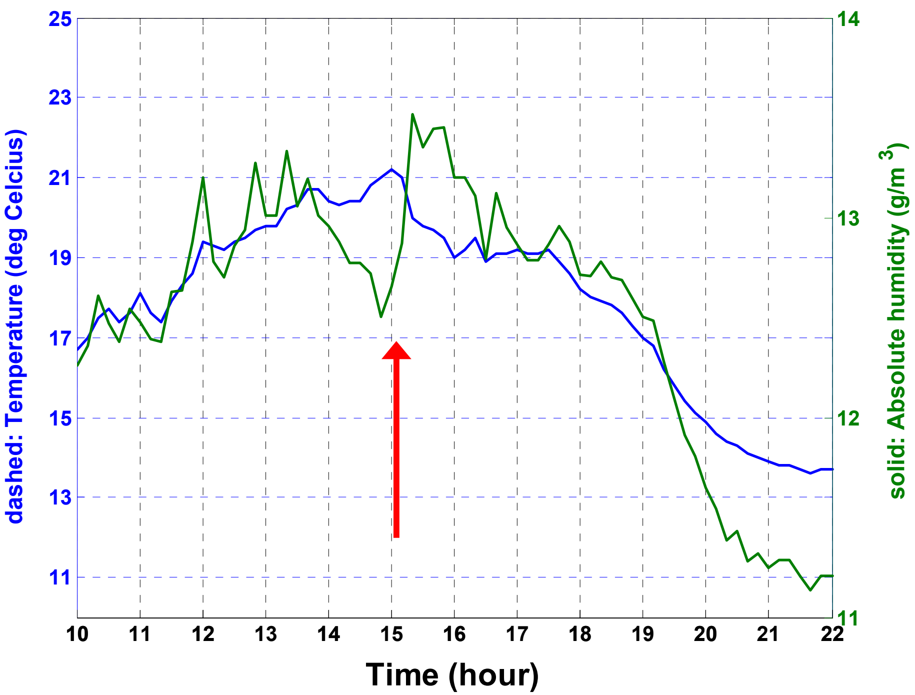
red: 1-3m/s blue: 3-5m/s green: 5-6m/s **yellow: >6m/s**

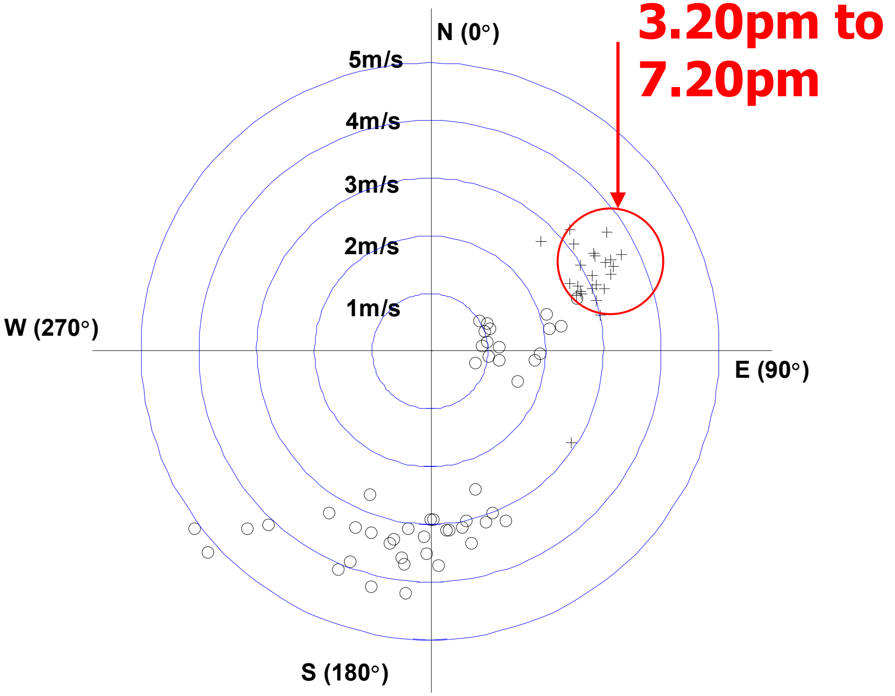
Total length of line = percentage of winds from west



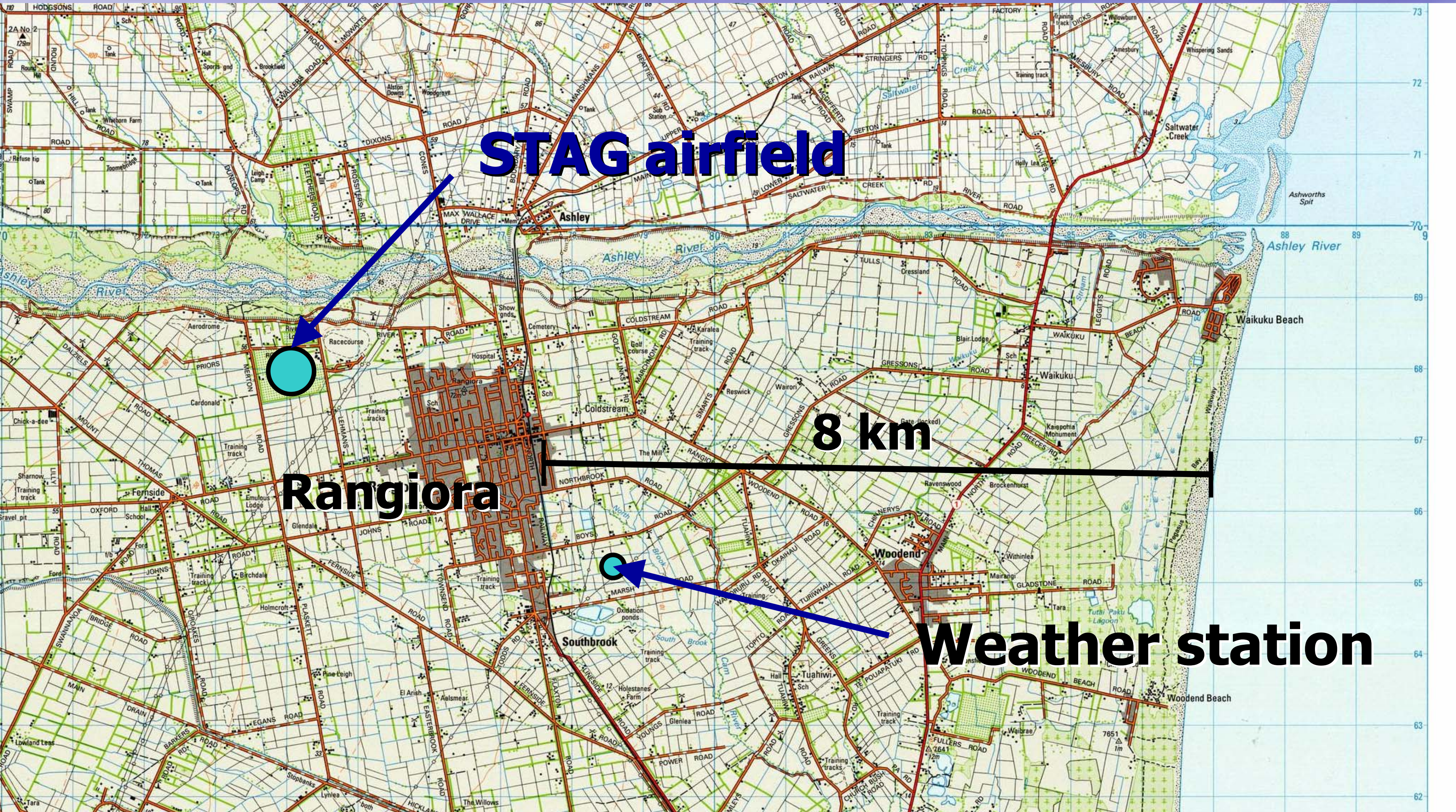
Typical sea breeze day

January 15, 2002 (summer), weatherstation data



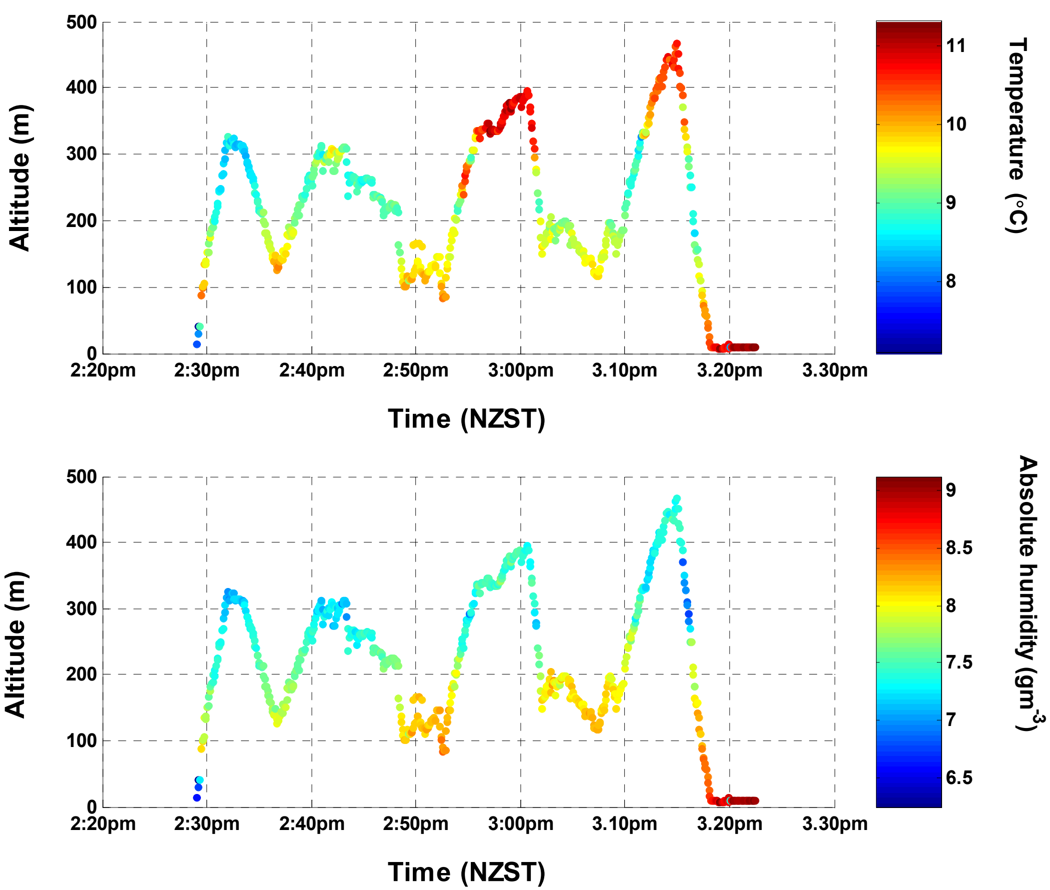


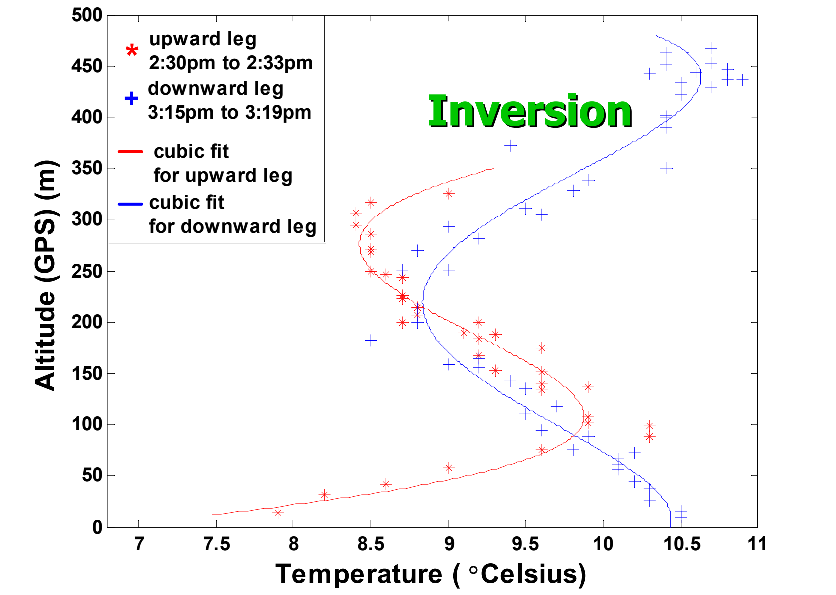
Location of STAG flight and weatherstation

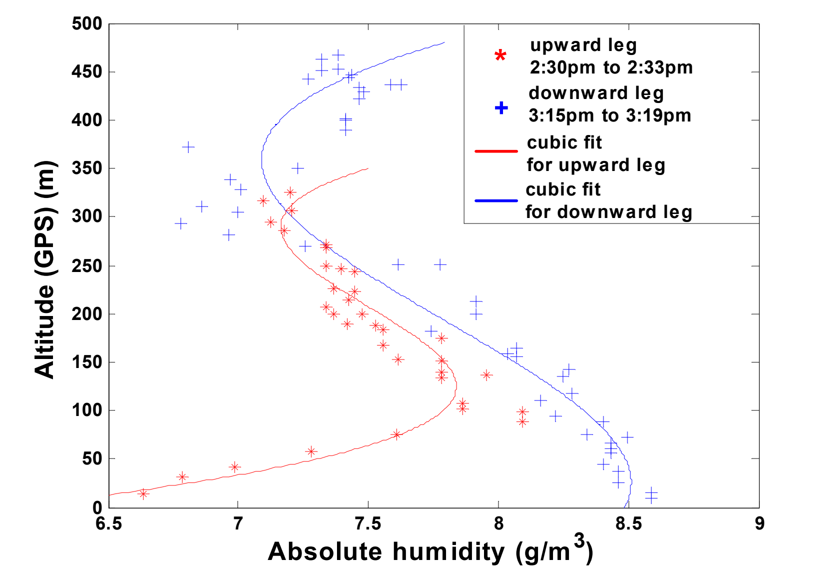


STAG sea breeze observation

August 6, 2003



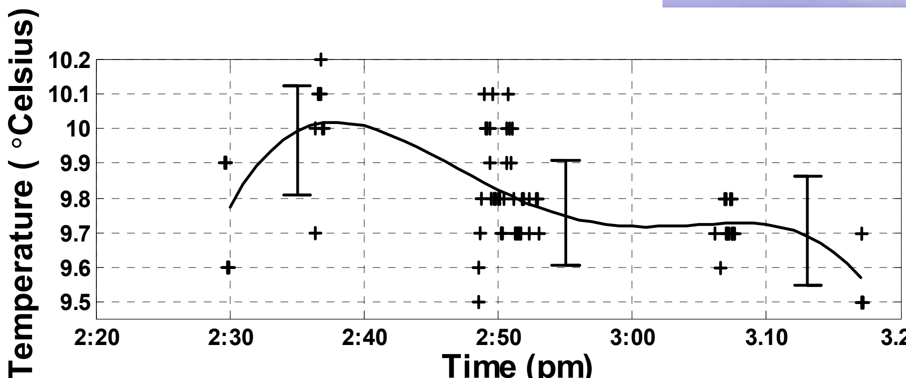


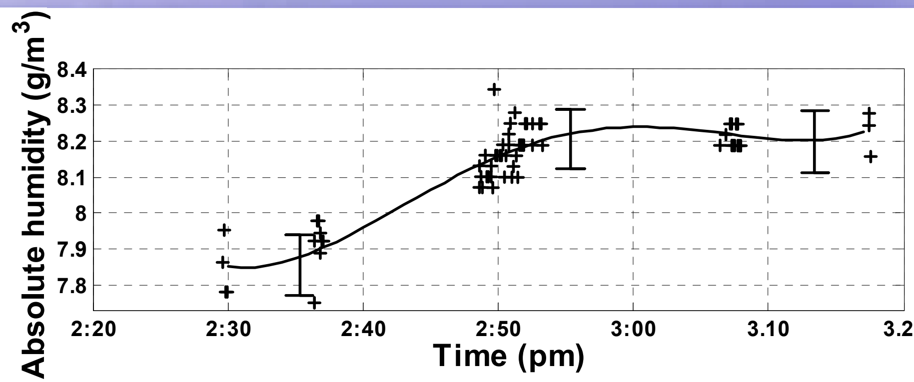


STAG sea breeze observation

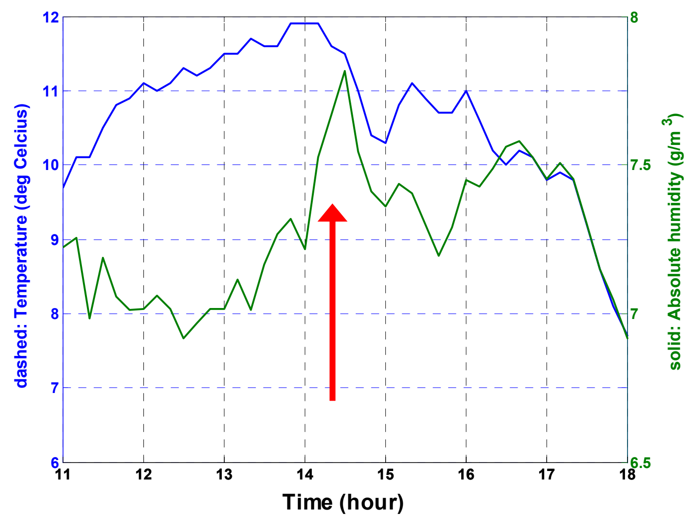
August 6, 2003

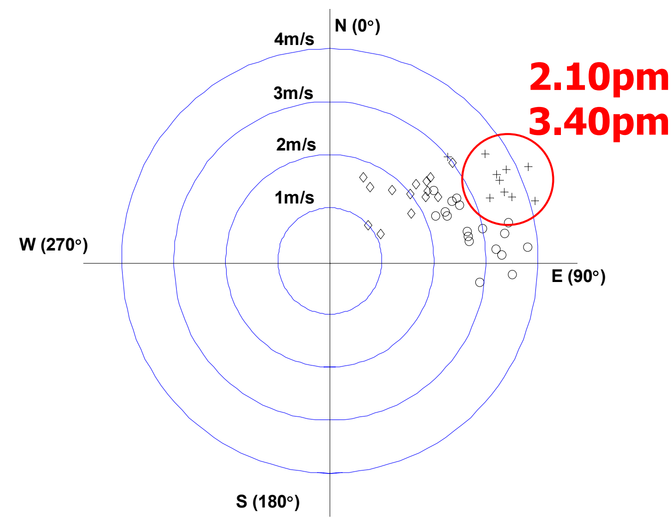
STAG data at 120m ±20m





Weatherstation





Time difference of the onset of the sea breeze and distance → frontal velocity 1 m/s

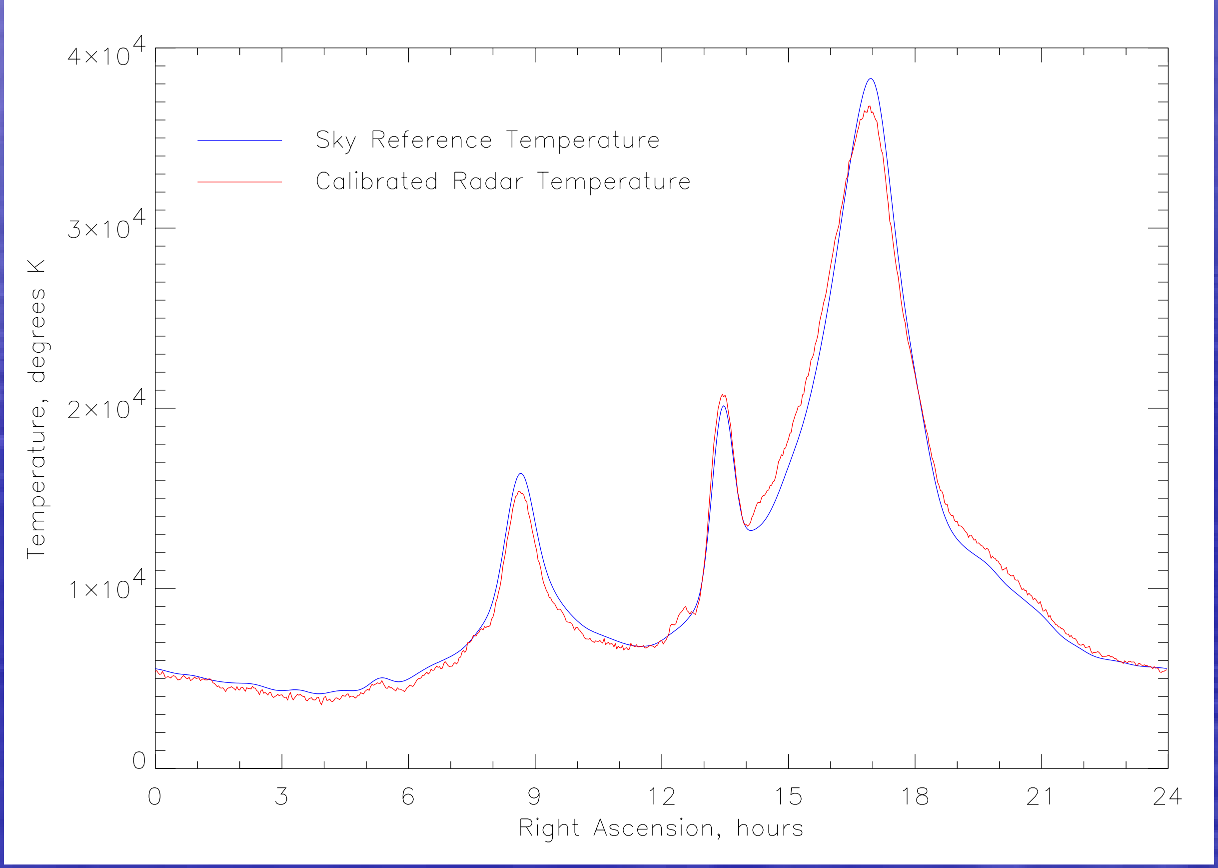
Conclusions

- System operational, apart from wind measurement system and self guidance. Hopefully, the new expensive 3-axis digital compass will solve these problems.
- Sea breeze above Rangiora was observed with aircraft; thickness: 250 m, frontal velocity: 1 m/s
- With GPS guidance and wind measurement: more detailled observation of low-altitude phenomena, such as the return current.

Further work

- Using reverse radio astronomy we have been able to determine the beam direction of the CUSTAR antenna by comparing the time of transit of specific astronomical radio sources with theoretical values.

- Using an omni-directional transmitter onboard STAG we hope to map our antenna pattern precisely and compare the results.



Further work

- We are likely to place sensors, based on the electronics developed for the STAG system, on the PERLAN glider when it returns next year.
- Ideally we'll build a generic independent sensor pod which can fit to any glider as we'd like to examine the horizontal and vertical structure of Lee waves using combined in-situ and CUSTAR data.