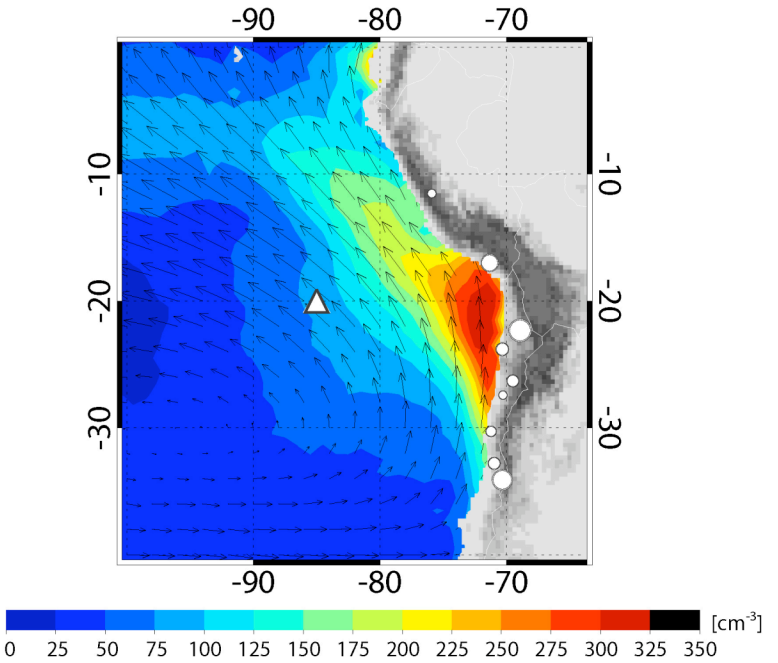
CIRPAS Twin Otter -- Scientific Objectives

- Aerosol-Cloud-Drizzle Interactions
  - Process Studies
  - Gradients in Clouds and Aerosols
- Coastal Processes
  - Diurnal Cycle
  - Stagnation Effects



VOCAL REx Hypotheses

- Hypothesis 1a: Variability in the physicochemical properties of aerosols has a measurable impact upon the formation of drizzle in stratocumulus clouds.

- Hypothesis 1b: Precipitation is a necessary condition for the formation of pockets of open cells (POCs) within stratocumulus clouds.

- Hypothesis 1 c: The small effective radii measured from space over the SEP are primarily controlled by anthropogenic, rather than natural aerosol production, and the entrainment of polluted air from the lower free troposphere is an important source of cloud condensation nuclei (CCN)

- Hypothesis 1d: Depletion of aerosols by coalescence scavenging is a major sink term for cloud condensation nuclei over the SEP.

Questions Addressing REx Hypotheses

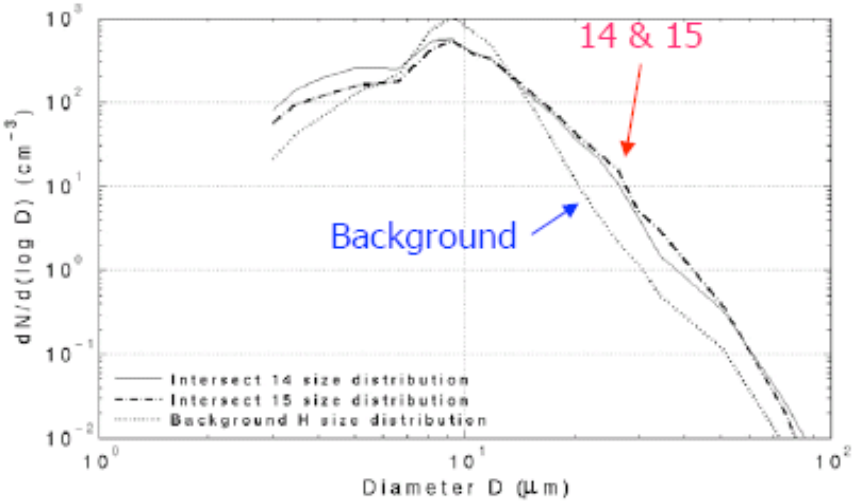
- *What is the variability of the turbulence structures in marine stratocumulus clouds and how does drizzle and decoupling affect these structures?*
- *How does cloud-drizzle processing and evaporation of drizzle below cloud base alter CCN concentrations in the subcloud layer?*
- *What effects do sub-cloud aerosols have on cloud and drizzle characteristics?*
- *How do surface processes affect boundary layer aerosols?*
- *What is the variability of updrafts near cloud base in marine stratocumulus and how can this variability affect the activation of subcloud layer aerosols?*

Proactive Sampling Strategies for Addressing VOCALS REx Hypotheses

- Cloud Seeding:
  - Under what conditions will the introduction of giant nuclei into non-precipitating stratocumulus clouds stimulate drizzle formation?
  - Can small areas of drizzle in a mostly non-drizzling cloud initiate larger-scale (mesoscale) cloud transitions?

Proactive Sampling Strategies for Addressing VOCALS REx Hypotheses

- Cloud Seeding: Past

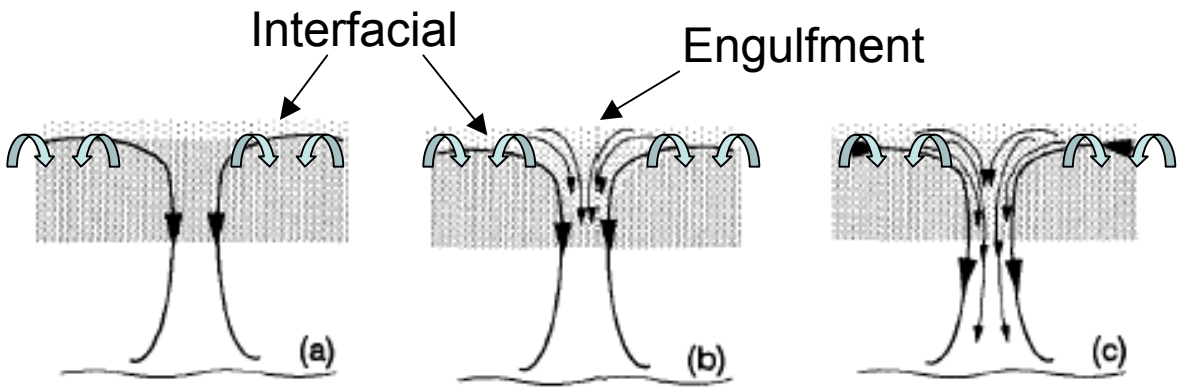


Ghate et al., 2007, GRL

- Cloud Seeding VOCALS
  - Seeding Material: Milled $CaCl_2$ 3-5 µm
  - Delivery: Controlled feed into fluidized bed and controlled flow out
  - Plume signatures and tracking:

Proactive Sampling Strategies for Addressing VOCALS REx Hypotheses

- Radar Chaff:
  - What are the mechanisms by which entrainment affects boundary layer aerosol properties?



Proactive Sampling Strategies for Addressing VOCALS Rex Hypotheses

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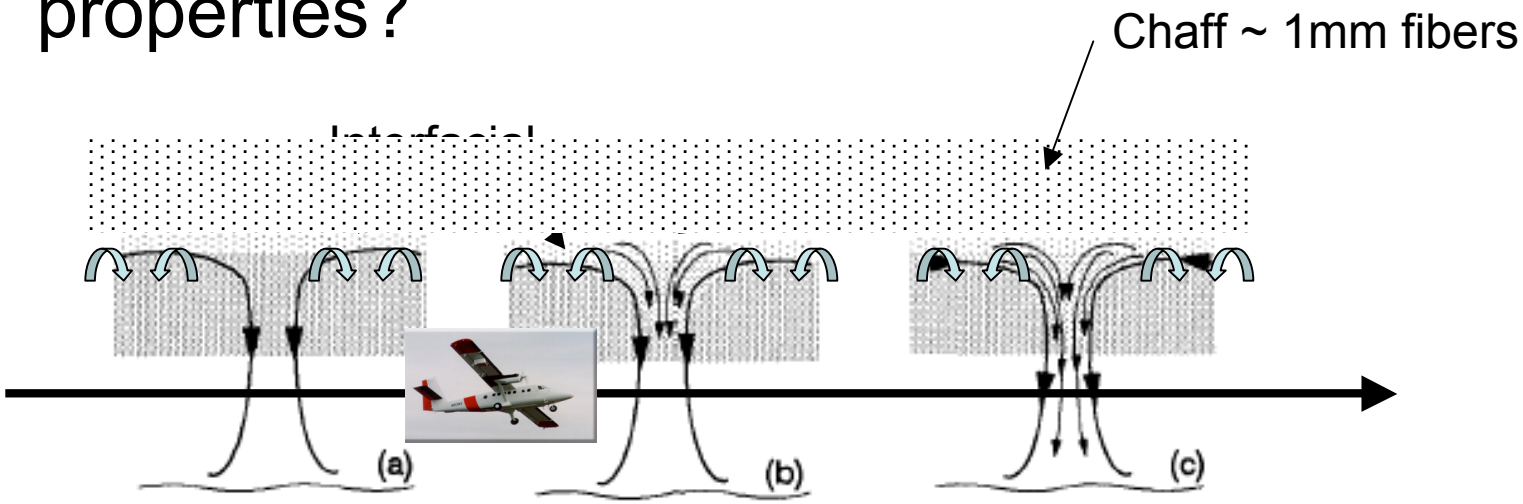
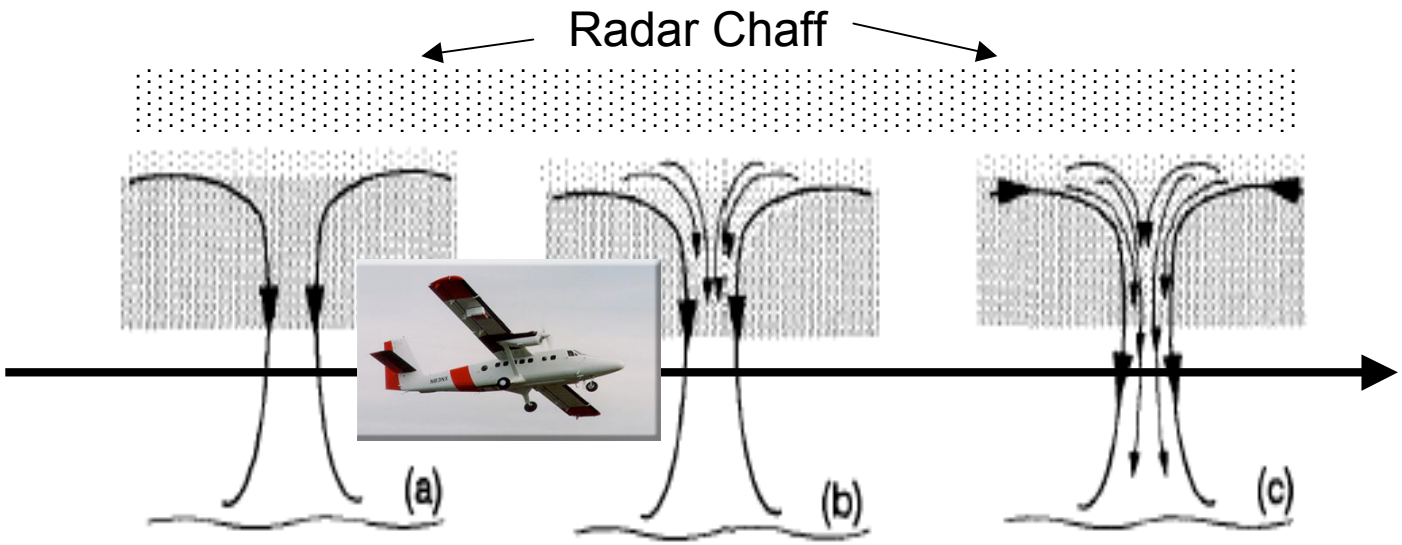


Entrainment Processes—Effects of lower-tropospheric aerosols



Coastal Hypotheses

Hypothesis A1: The near-stagnation area around 18ºS is produced by the mechanical blocking of the southerly wind by part of the coastal mountains of southern Perú.

Hypothesis A2: The low wind speeds in this area are conducive for a build-up of pollutants, some of which may act as CCN leading to significant high cloud droplet concentration.

Hypothesis B: Increased afternoon subsidence in the coastal area at levels 500-4000 masl is forced by a mechanical/heating effect of the Andes mountains to the east and controls the diurnal cycle of the MABL at the coast.

Hypothesis C: The marked diurnal cycle of cloudiness and temperature off the coast of northern Chile and Southern Perú is largely caused by a gravity wave generated along the coast that acts on a very stratified troposphere.

Hypothesis D1. In connection with easterly wind events associated with coastal lows, anthropogenic sulfate reaches the stratus deck altering its optical properties.
Hypothesis D2. The composition and size distribution of activated aerosols acting as cloud condencation nuclei (CCN) changes in connection with easterly wind events, showing a distinct signal of anthropogenic sulfate, particularly in nearshore stratus.

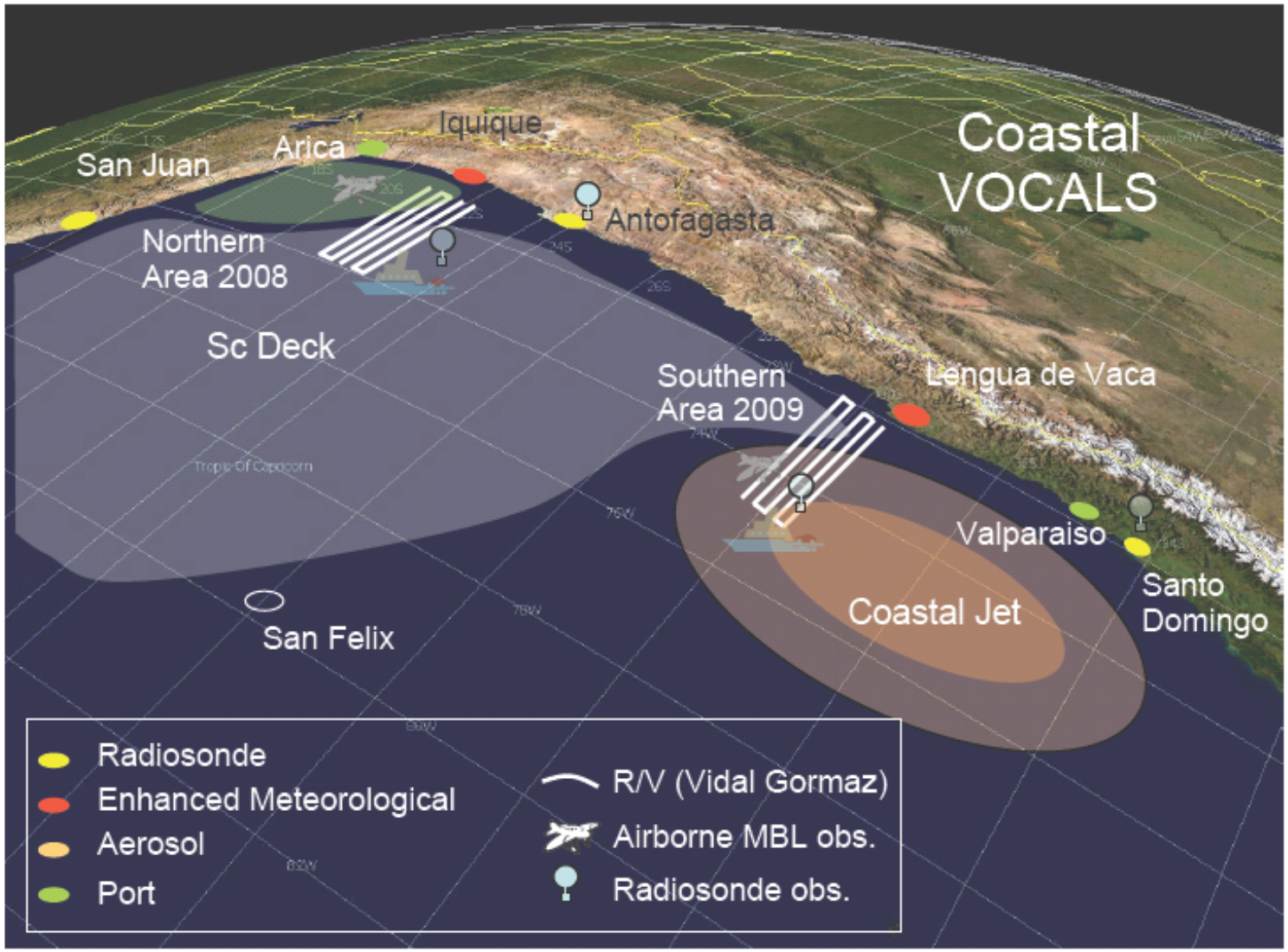
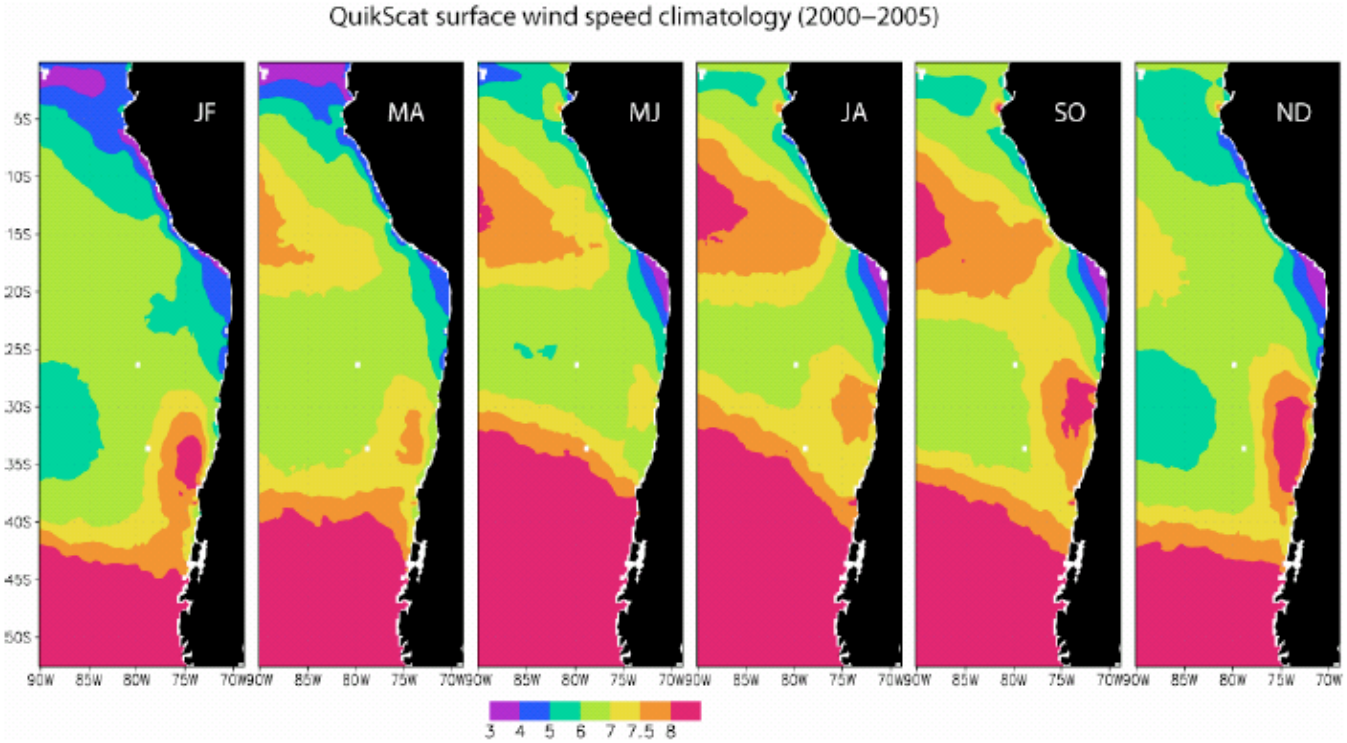
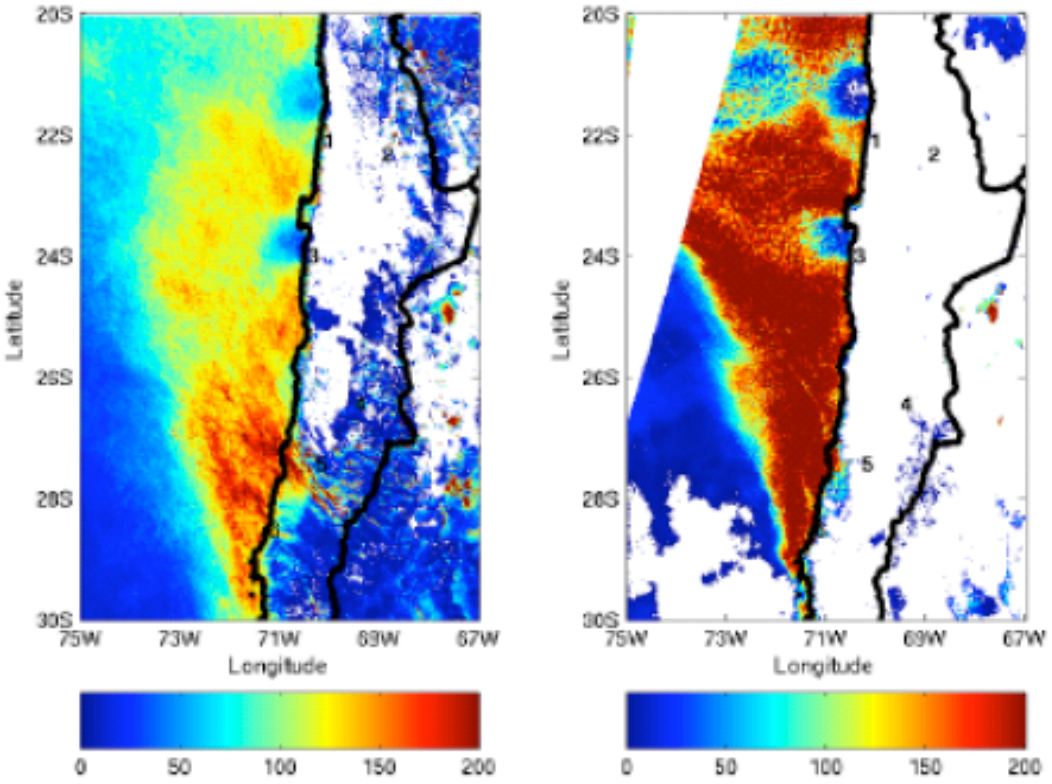


Figure 1. General Overview of platforms and atmospheric phenomena

TO Operations Center -- Iquique

Stagnation Zone




20S
22S
24S
26S
28S
30S
Latitude
75W
73W
71W
69W
67W
Longitude
1
2
3
4
5
0
50
100
150
200

VOCALS
CIRPAS Twin Otter

Aircraft Specs:

- Airspeed: ~ 100 knots
- Duration: 4-5 hours
- Range: 200-400 km

VOCALS Deployment:

80-100 hours: 20-25 hours/week

Twin Otter Instrumentation

Instrument	Observations/Purpose
Standard met	Winds, temp, dewpoint, cloud liquid water, sfc temp
Turbulence Probes	High speed wind, t emp, and moisture (Carl Friehe)
94 GHz Doppler FMCW radar	Cloud properties; in -cloud turbulence
Chaff (Dropsonde) Dispenser (with radar)	Track air movements — entrainment, sub -cloud cloud layer coupling, large eddies
CPCs	Ultrafine aerosols
PCASP	Aerosols 0.1 -3 _m
FSSP	Clouds 2 -40 _m
CIP	Drizzle 25 -1500 _m
N-Mass	5 channel CN, fast response
CCN-200	CCN (fast -2-point; slow -6 points)
Phased Doppler Interferometer (Patrick Chuang)	Cloud -drizzle 2 -600 _m
SP2-Black Carbon	BC mass and ratio to total particles

UC Santa Cruz @ VOCALS

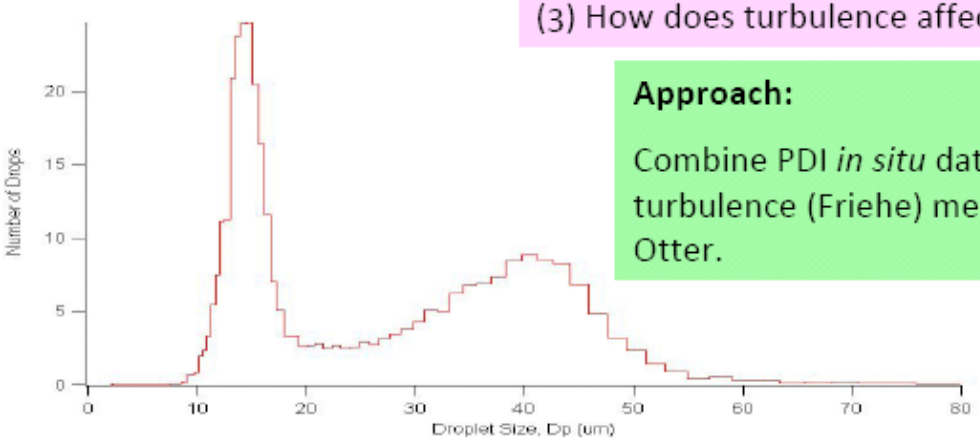
- **Phase-Doppler Interferometer (PDI)** has been developed for airborne measurements (*photo left*).
- Measures cloud drop:
  - ***size distribution***
  - ***velocity distribution***
  - ***inter-drop spacing***
- Size range: 3 to 150 µm

Objectives:

(1) What is the observed nature of drizzle in the VOCALS region?

(2) What processes control these observed drizzle properties?

(3) How does turbulence affect cloud microphysical properties?



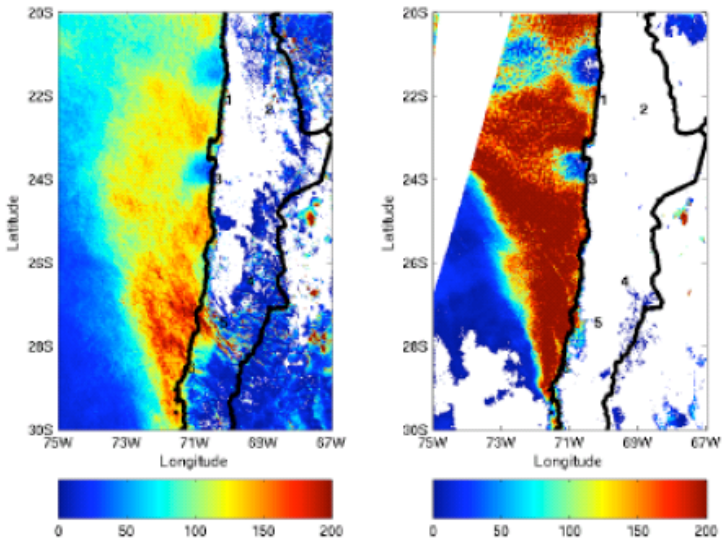
Approach:

Combine PDI *in situ* data with airborne radar (Albrecht) and turbulence (Friehe) measurements, all on the CIRPAS Twin Otter.

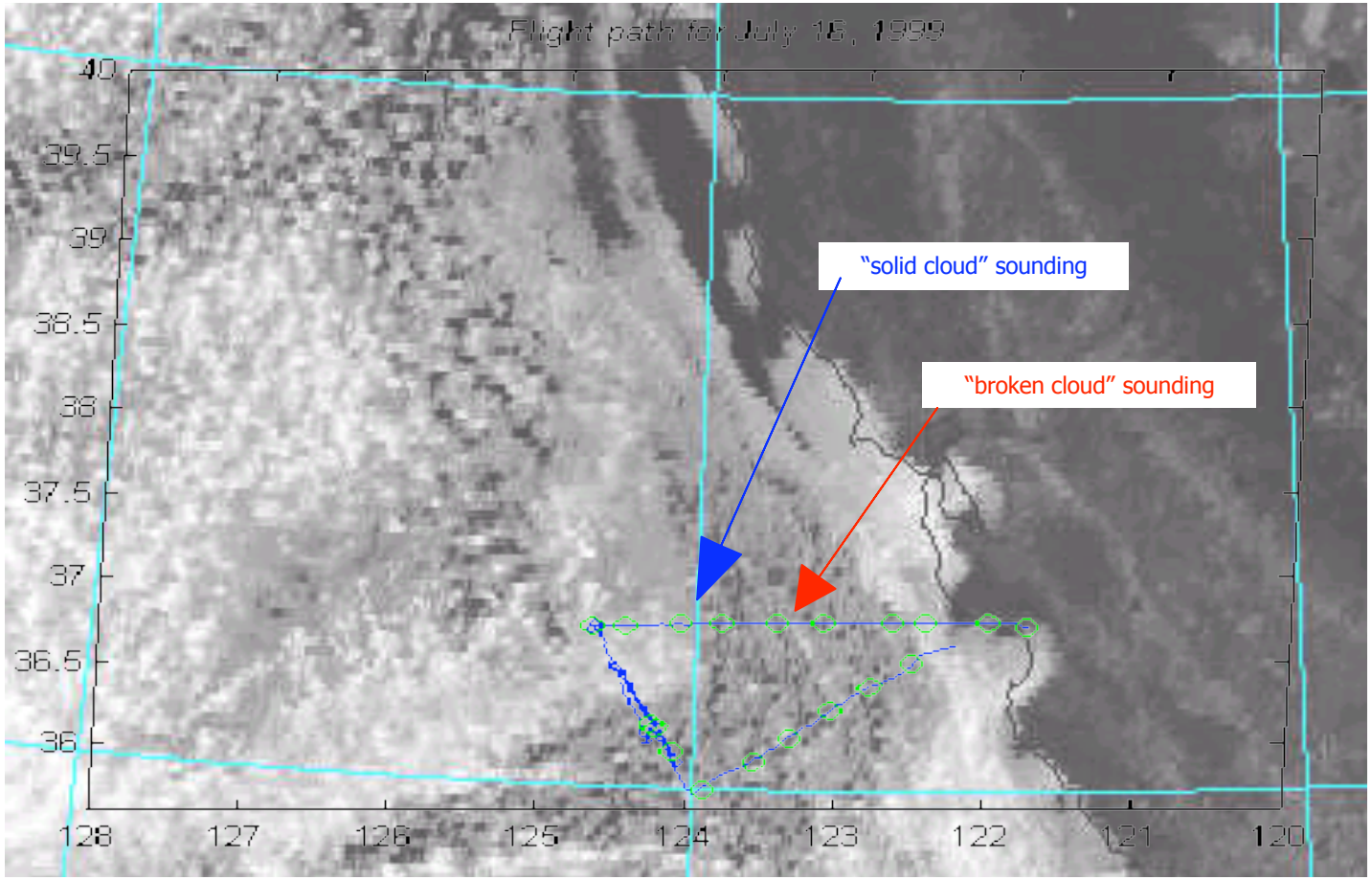
Left: PDI measurements in stratocumulus near Santa Cruz, CA showing two drop modes.

Flight Plans for VOCALS

- Feature/Process Sampling
- Diurnal Cycle
- Coastal Gradient Mapping

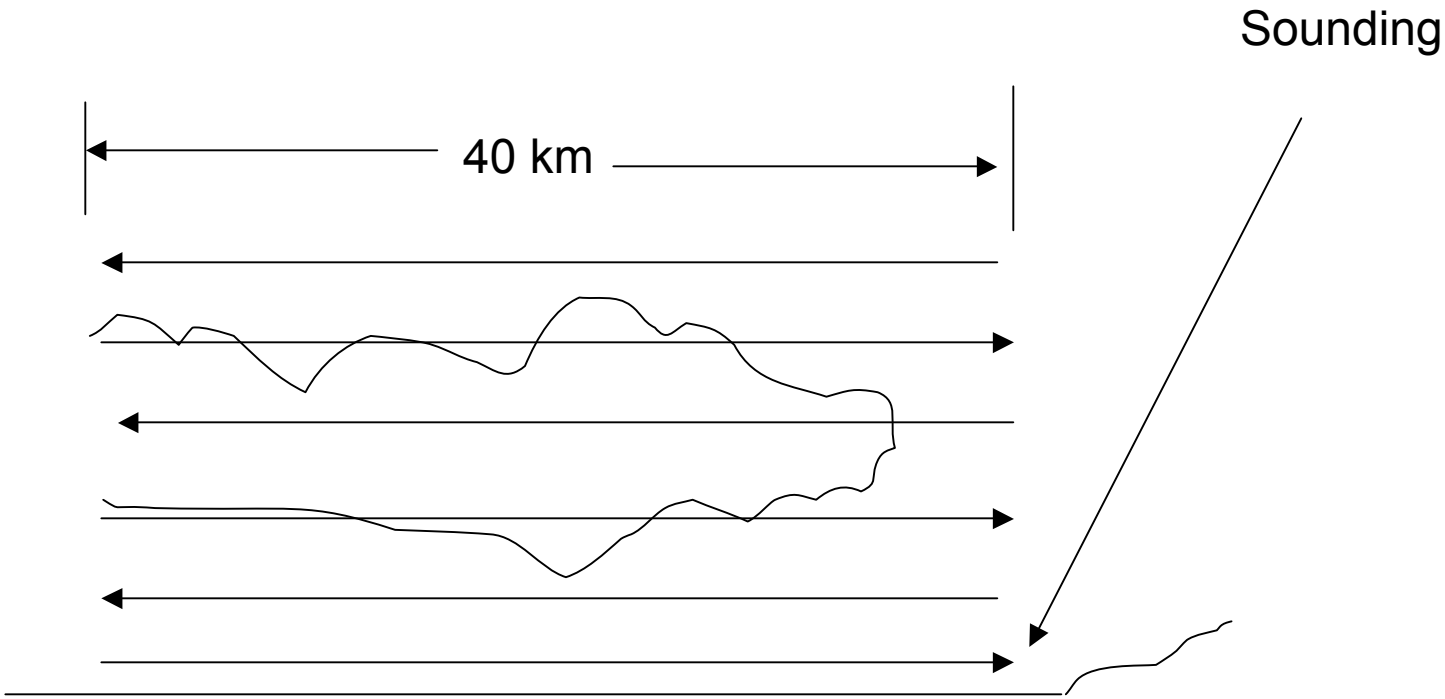


Feature Sampling –Soundings and Horizontal Legs at Different Levels



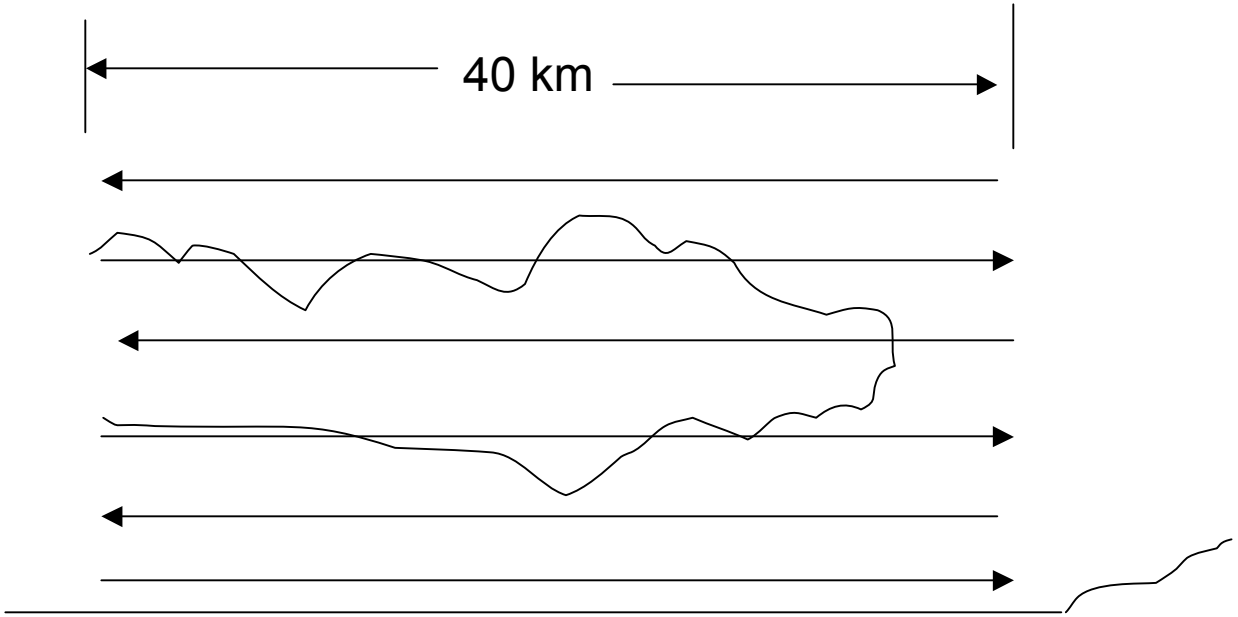
Basic Flight Patterns

- Soundings at beginning and end
- Gradient mapping—fewer longer legs



Basic Flight Patterns

- Levels at 30 m, 500,1000,1500m; soundings at beginning and end of legs
- 05-06 AM and 04-05 PM



Missions (~20 total)

- Features and Process Studies
- Diurnal (05-06 AM and 04-05 PM)
- Coastal Mapping
- Coordination with other aircraft
  - Remote sensing
  - Lagrangian missions

Mission Planning and Operations

- Coordination with VOCALS Operations Center Activities
- Local Planning and Operations
  - Daily afternoon briefings
    - Review current cloud and weather conditions and instrument status
    - Decide on go or no-go for next day
    - Select tentative missions
    - Develop flight plans for missions planned
    - Coordinate with other VOCALS operations
  - Final go/no-go decision 3 hours before flight
  - Pilot briefings before mission
  - Pilot and airborne scientist debriefs following mission