ESRL Theme Presentation on the Weather-Climate Connection

Synoptic Impacts on Arctic Pack Ice Surface Energy Budgets
or
Linking Synoptic Events with Variability of Arctic Sea Ice Thickness

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"Our [satellite] data reveal a high-frequency interannual variability in mean Arctic ice thickness that is dominated by changes in the amount of summer melt, rather than by changes in circulation. Our results suggest that a continued increase in melt season length would lead to further thinning of Arctic sea ice." (Laxon et al 2003)

- what determines length of summer melt over Arctic sea ice?
- what causes the start and end of the summer melt?
- how much can the length of the melt season change?

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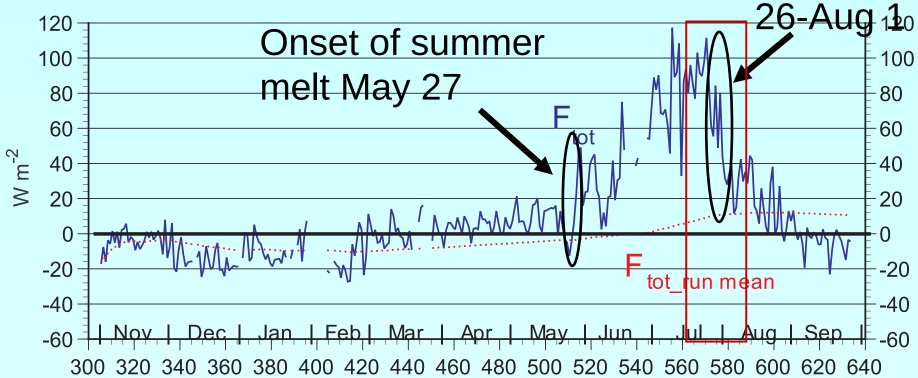
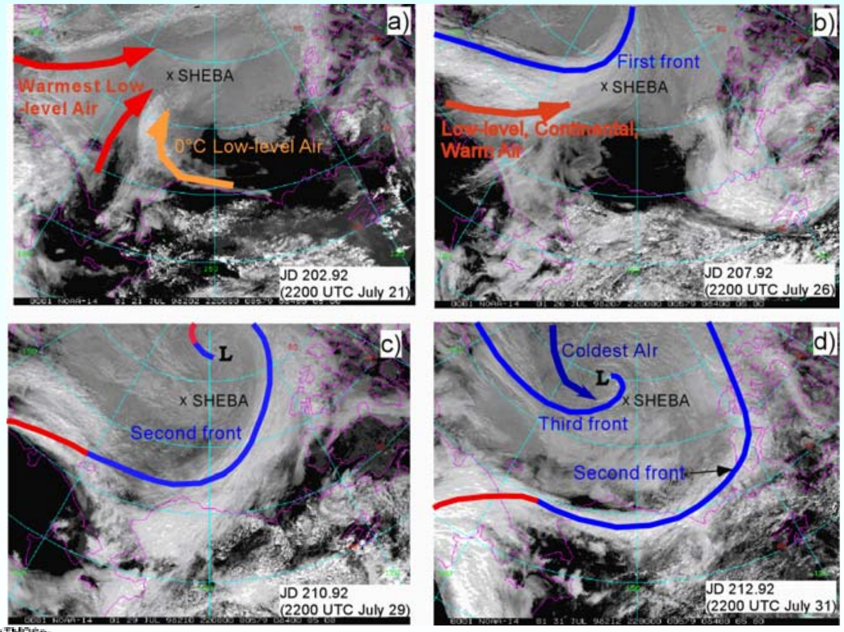
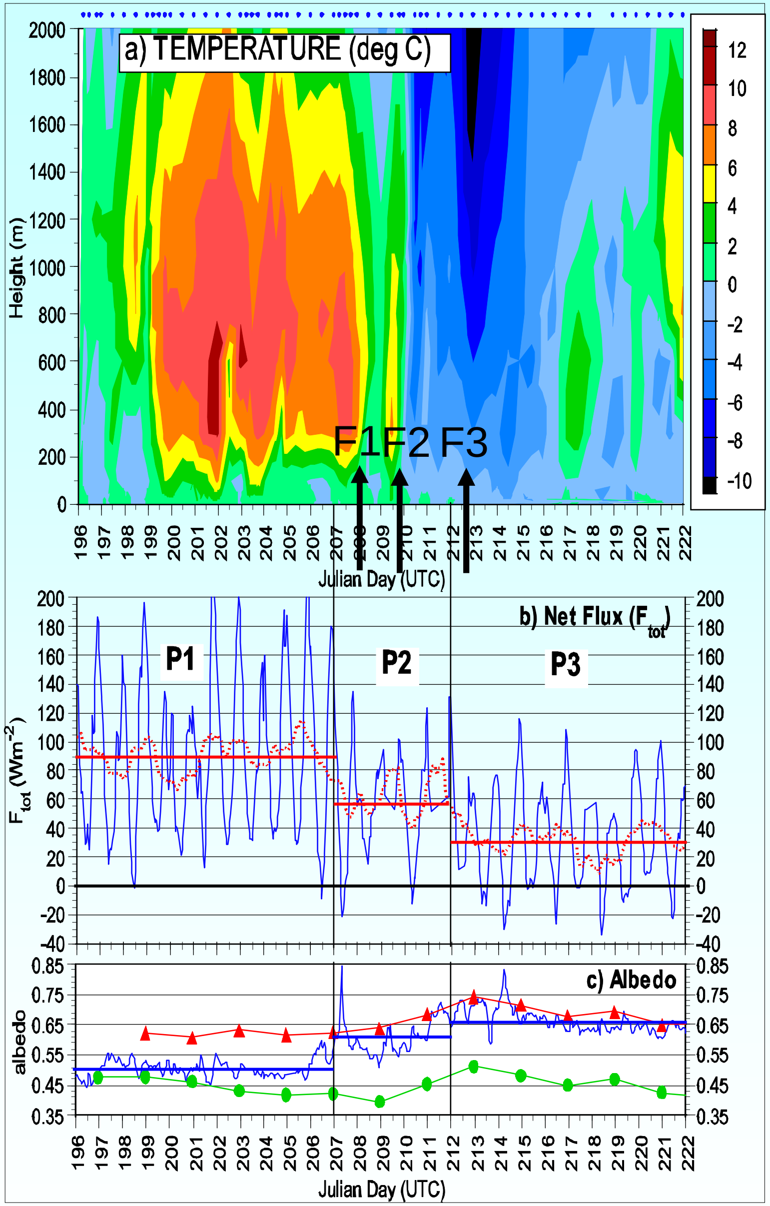
SHEBA Daily Net Surface Energy Flux

$$F_{tot} = Q_{si}(1-\alpha) + Q_{li} - Q_{lo} - H_s - H_l + C$$

Rapid decline in surface melt July 26-Aug 1



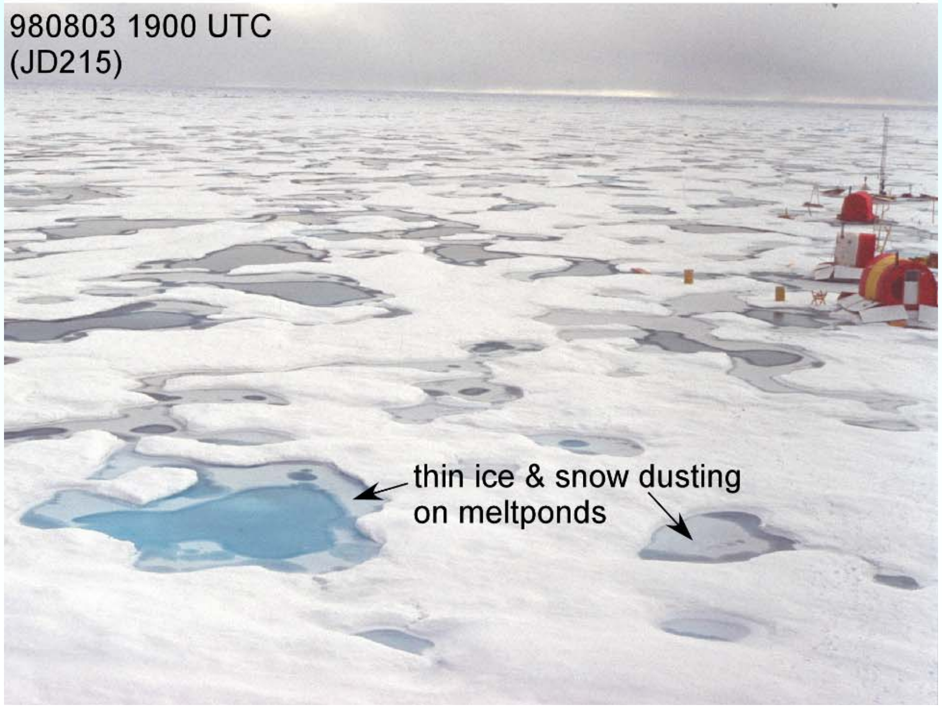




- All terms but C contributed 10% or more to the 58 W m^{-2} decrease in F_{tot}
- Over 70% of decrease due to processes related to synoptic disturbance, rather than seasonal cycle of Q_{si}.

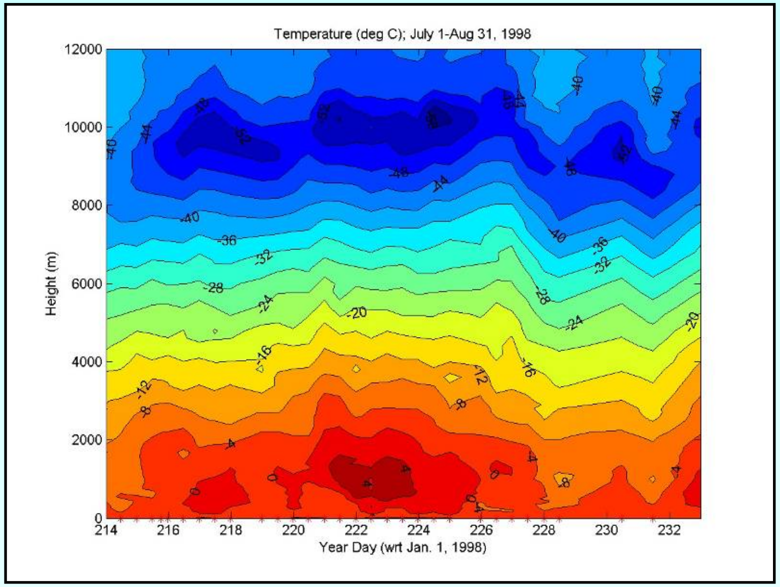
End

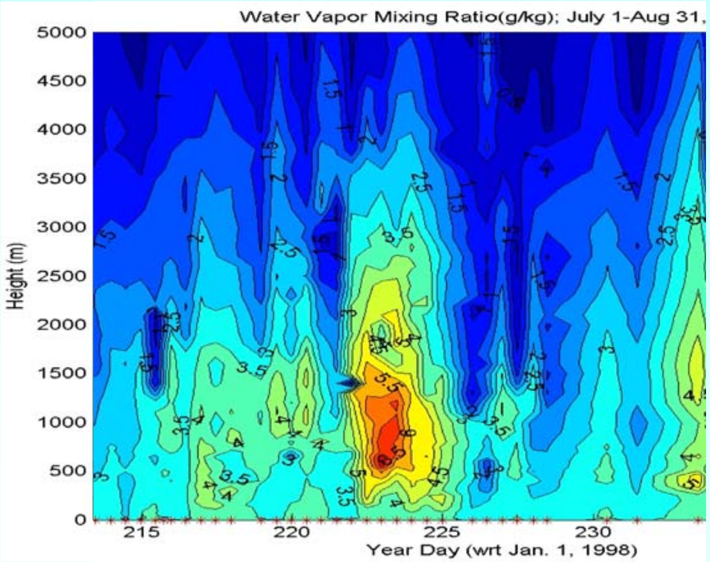

980726 0300 UTC
(JD207)


980803 1900 UTC
(JD215)
thin ice & snow dusting
on meltponds

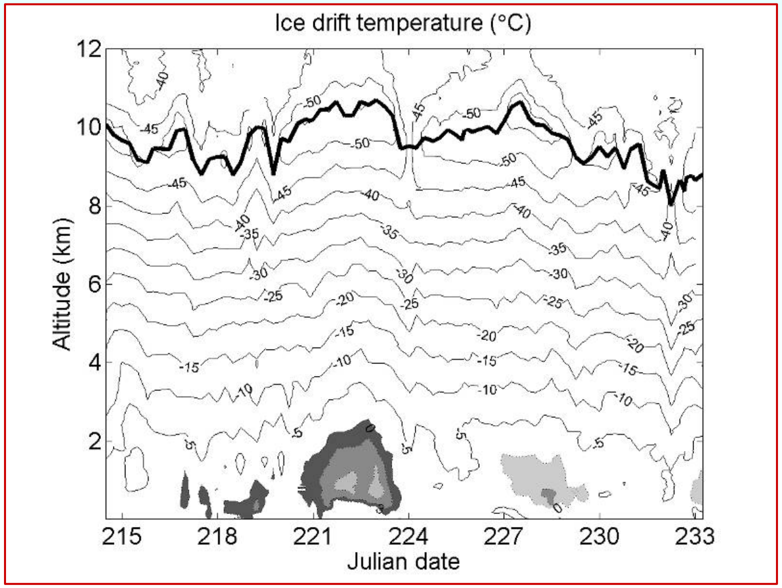
Comparison of SHEBA & AOE-2001 Aug 2-21 Soundings

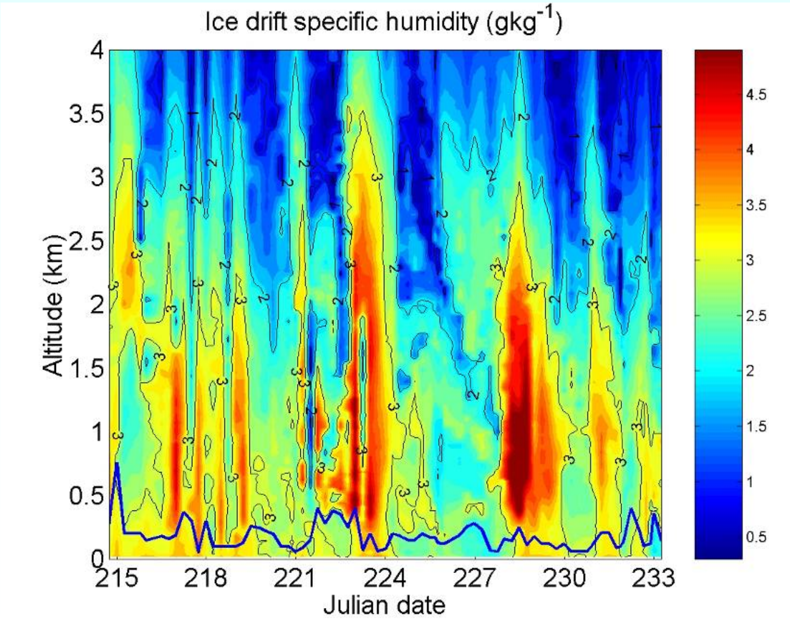
SHEBA





AOE-2001





SUMMARY SEB contributions to change in F_{tot}

$\Delta F_{tot} = F_{tot2} - F_{tot1}$

- **$= \Delta Q^* - \Delta H_s - \Delta H_l + \Delta C,$ (3.1)**

•where

$\Delta Q^* = \Delta Q_s + \Delta Q_l$ (3.2a)

- **$= \Delta Q_{si} - \Delta Q_{so} + \Delta Q_{li} + \Delta Q_{lo}$ (3.2b)**
- **$= (1-\alpha_1)\Delta Q_{si} + \Delta Q_{li} - \Delta Q_{lo} - Q_{si2}\Delta\alpha$ (3.2c)**

Decrease of 58 W m^{-2} in F_{tot} from period 1 to period 3 produced by:

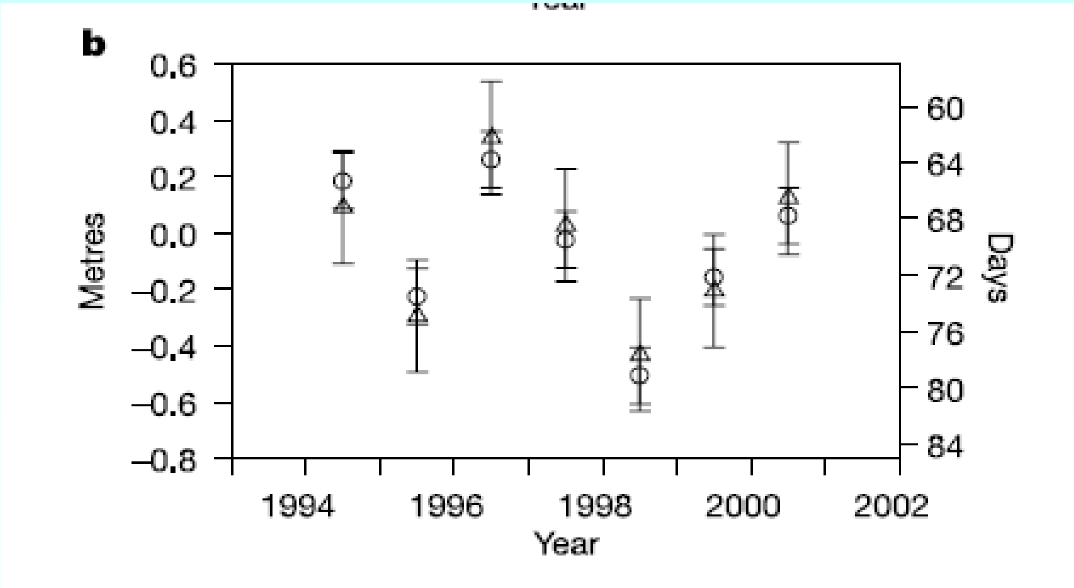
1) albedo effect (25.2 W m^{-2} or 43%),
2) change in Q_{si} (15.3 W m^{-2} or 26%; 14.8 Wm^{-2} due to seasonal change in Q_{si_clear}),
3) change in Q_{li} (9.6 W m^{-2} or 17%),
4) change in H_s+ H_l (6.1 W m^{-2} or 11%).

Surface temperature changed very little:

- minimized compensating effect of decreases in Q_{lo}.
- negligible changes in C

All terms but C contributed 10% or more to the decrease in F_{tot}

Over 70% of decrease due to processes related to synoptic disturbance



b, Changes in ice thickness between consecutive winters (circles) and melt season length (triangles) during the intervening summer period, derived from passive microwave observations. The correlation between ice thickness change and melt season length is $R^2 = 0.926$, showing that, during the period of our observations, the variability of mean Arctic sea ice thickness was controlled almost entirely by changes in thermodynamic forcing (Laxon et al 2003)

Operational NWP Perspective on W Coast Heavy Pcpn events

"Easy" Problem (relative to other pcpn fcst problems)

- Known "fixed" forcing
- Convection usually not of first-order importance

Biggest challenges

- Effective use of data over Pacific
- Risk of 6-10d period of heavy pcpn
- Snow-level evolution
- Response of individual river basins

NWP Perspective, continued

Responses needed

- Better assimilation procedures
- Capture of uncertainty (ensembles)
    * NCEP ensembles need more spread
    * Ensemble runs need sufficient resolution to capture strong oceanic baroclinic developments
- Downscaling for flood threat to particular river basins
    * High-resolution coupled (weather-hydro) models
    * Reforecasting

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Climate Variability and Air Quality

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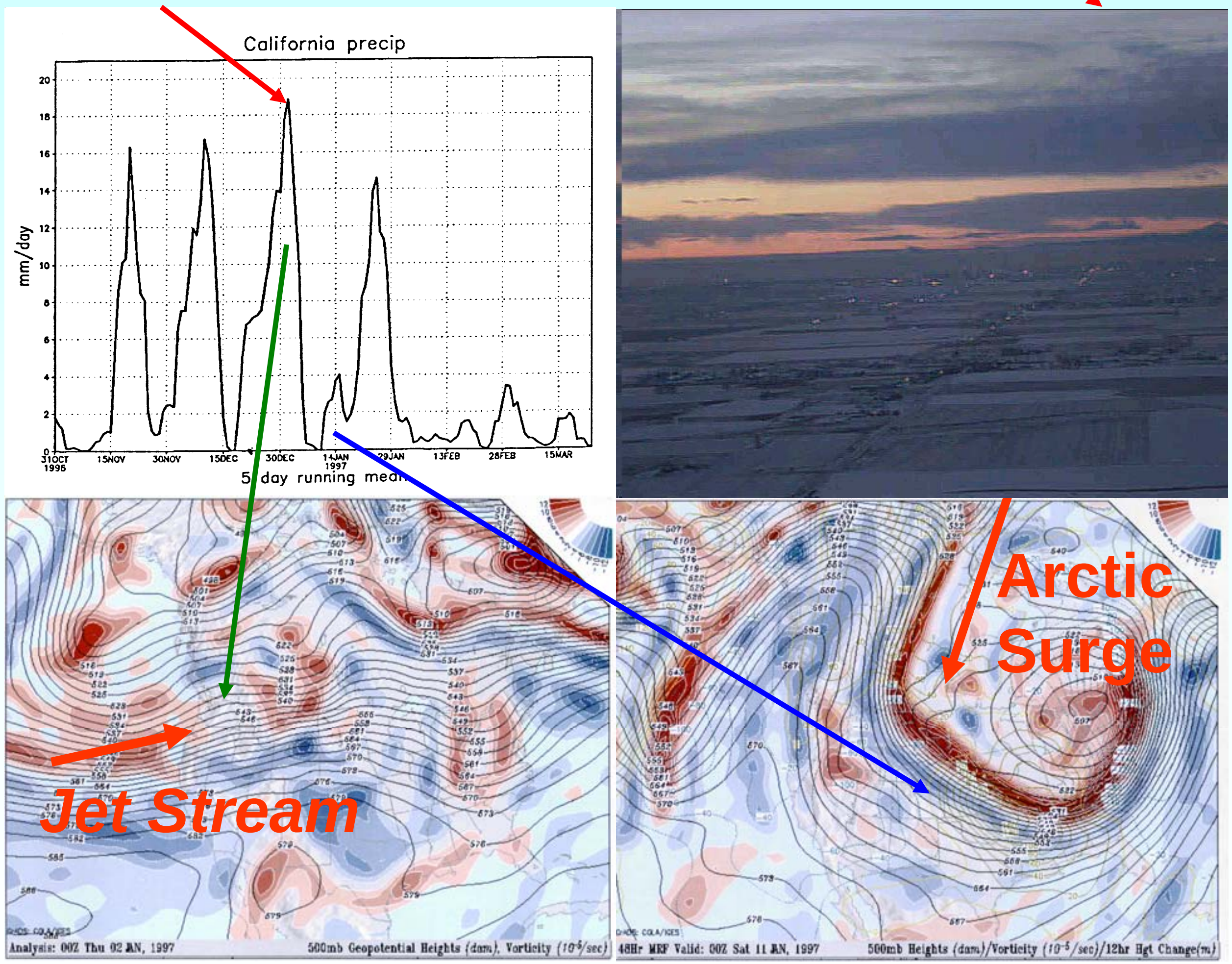
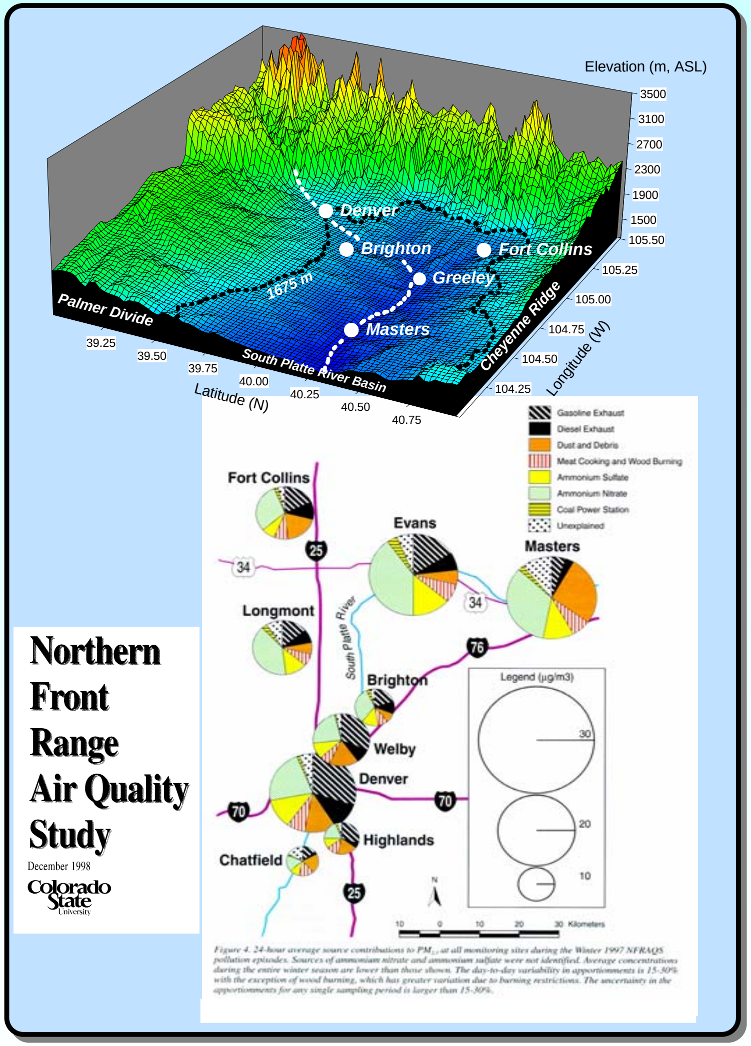
Sub-seasonal variability affects “traditional” weather phenomena as well as air quality:

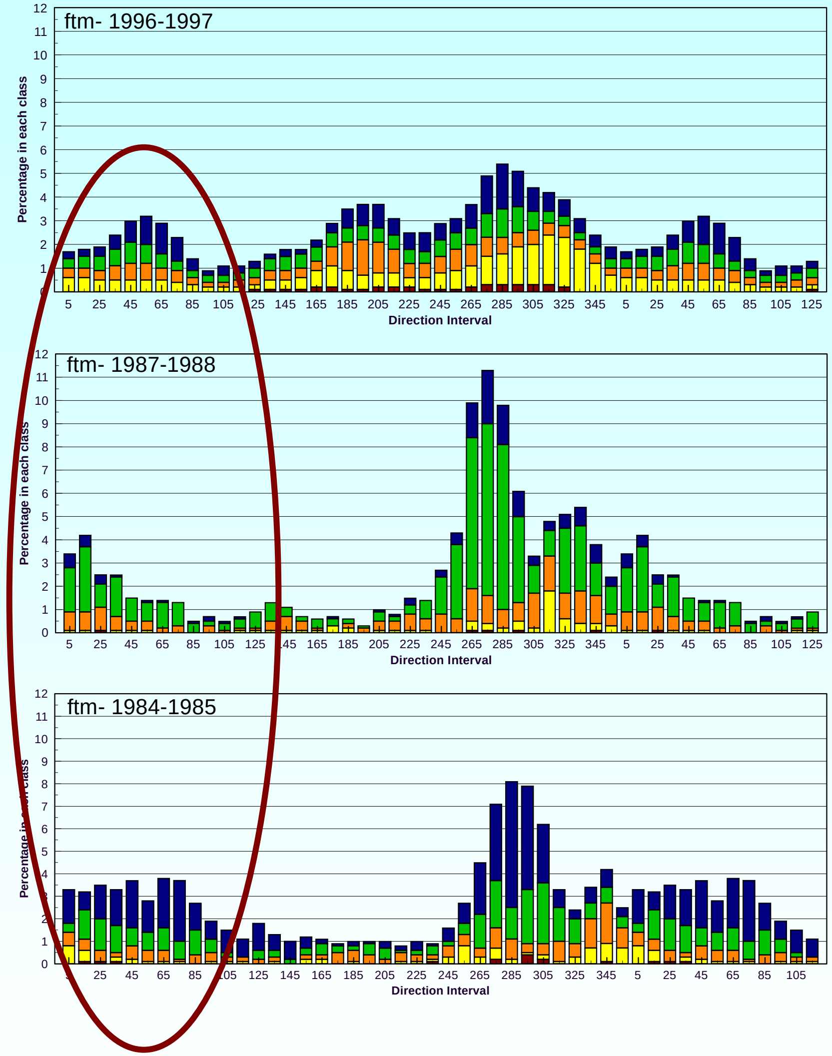
January 1, 1997 California Floods

Fine particle pollution in lee of the Rocky Mountains (mostly ammonium nitrate, ammonium sulfate and carbon)



00Z 2 January **00Z 11 January**



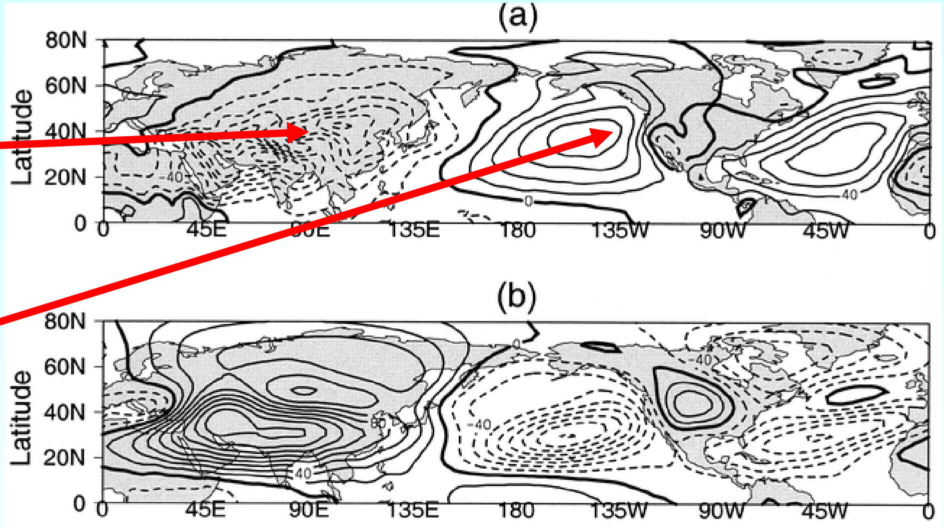


Year-to-year variability in upslope moisture events

Summer planetary wave structure presents a difficult prediction problem and may be forced by conditions far upstream

Thermal forcing over Asia creates downstream response with high pressure over the eastern Pacific: Slight shifts in this pattern affect where conditions for poor air quality occur.

In a climate change scenario, how will these patterns evolve?



July climatology (a:1000 hPa, b:150 hPa)

--Chen, Hoerling, & Dole, *JAS*, July 2001

Future challenges:

- Prediction of regional air quality changes under a climate change scenario will require an assessment of
  - Physical changes: SSTs, planetary waves, tropical forcing, ENSO to multi-decadal variability in the atmospheric circulation, extreme events (such as the enhanced Arctic Oscillation of this last winter), etc.
  - Chemical changes: changes in atmospheric composition and ancillary effects due to changing moisture and thermal regimes.
- There are challenges in our observational and modeling systems
- Predicting changes through changing seasonal cycles will present additional challenges.