

Impact of agriculture, forest and cloud feedback on the surface energy balance in BOREAS

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Differences: boreal forest & agriculture

- Albedo: lower for forests
 - especially with snow
- Roughness: forests are rougher: impact?
- Growing season: conifers > deciduous > crops
- Rooting: trees > crops [moss layers]
- Stomatal resistance: crops < conifers -
increases evaporation; lowers cloud-base
- Increases cloud-cover; cloud albedo

Outline

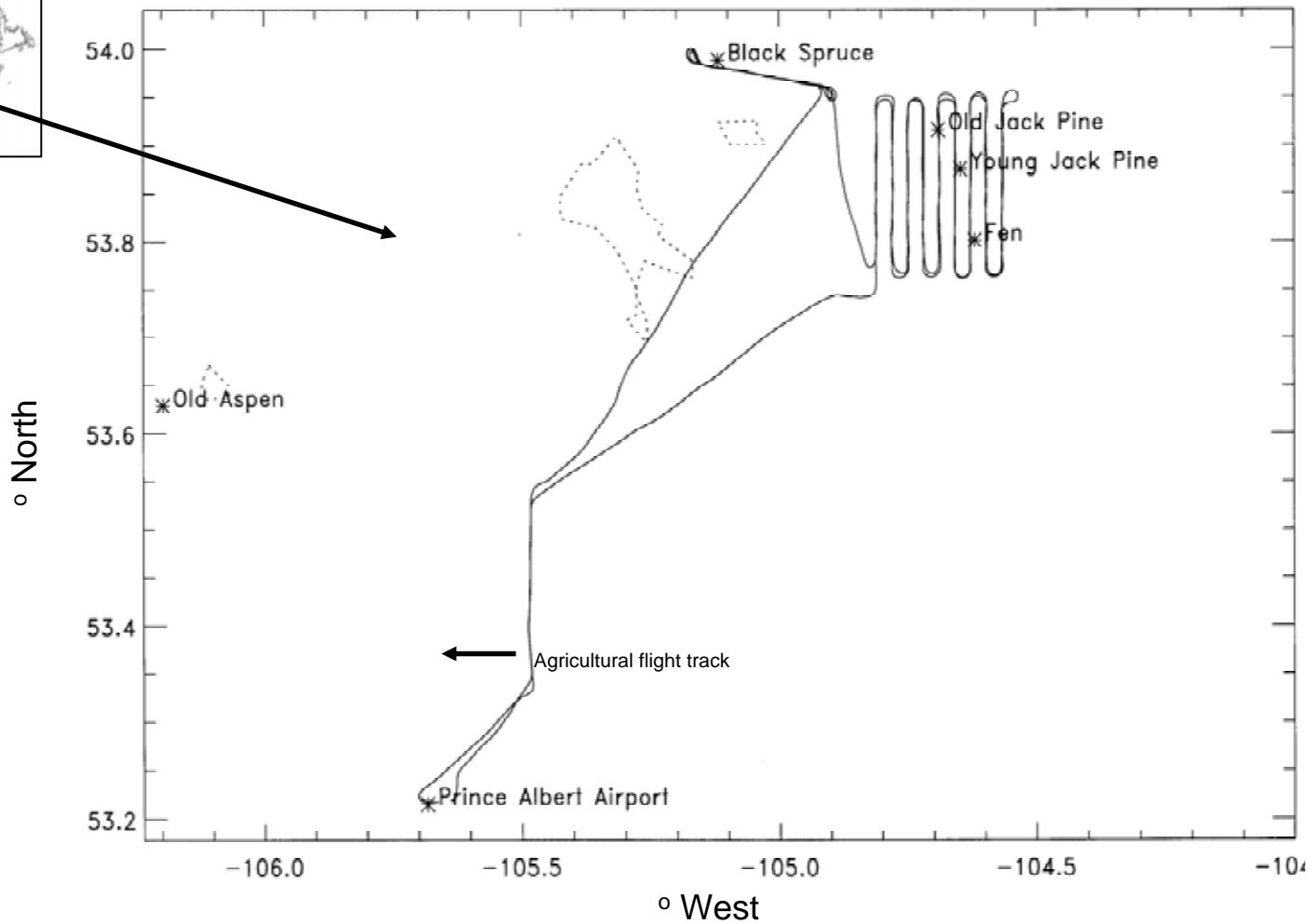
- Agriculture and forest: BOREAS TW aircraft
- Grass and forest radiative fluxes: Mesonet
- Surface-BL-cloud-radiation feedback: ERA40

BOREAS – BOReal Ecosystem Atmosphere Study



Study Sites for BOREAS

Flight Tracks in the SSA



BOREAS Flight Tracks



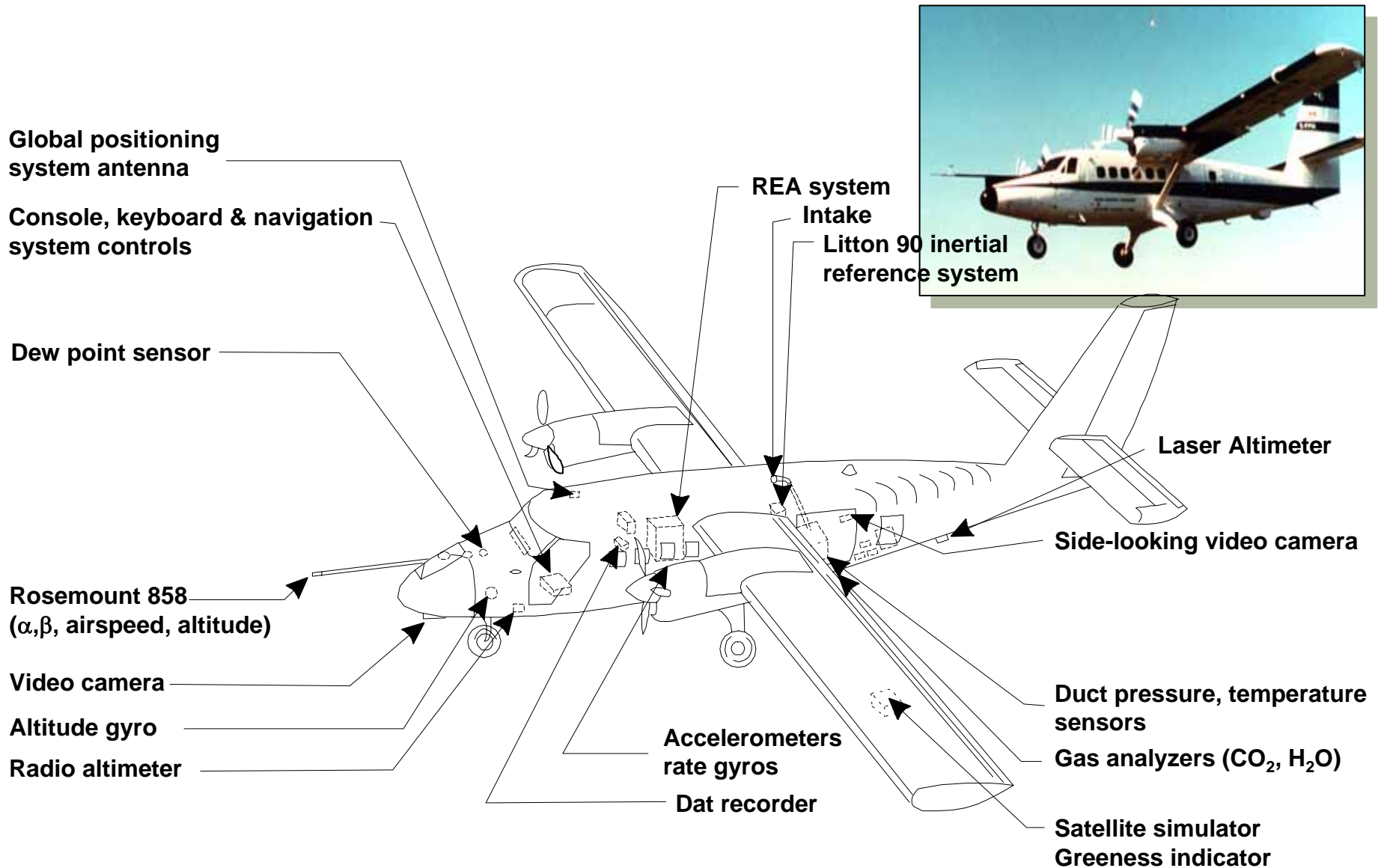
Agricultural



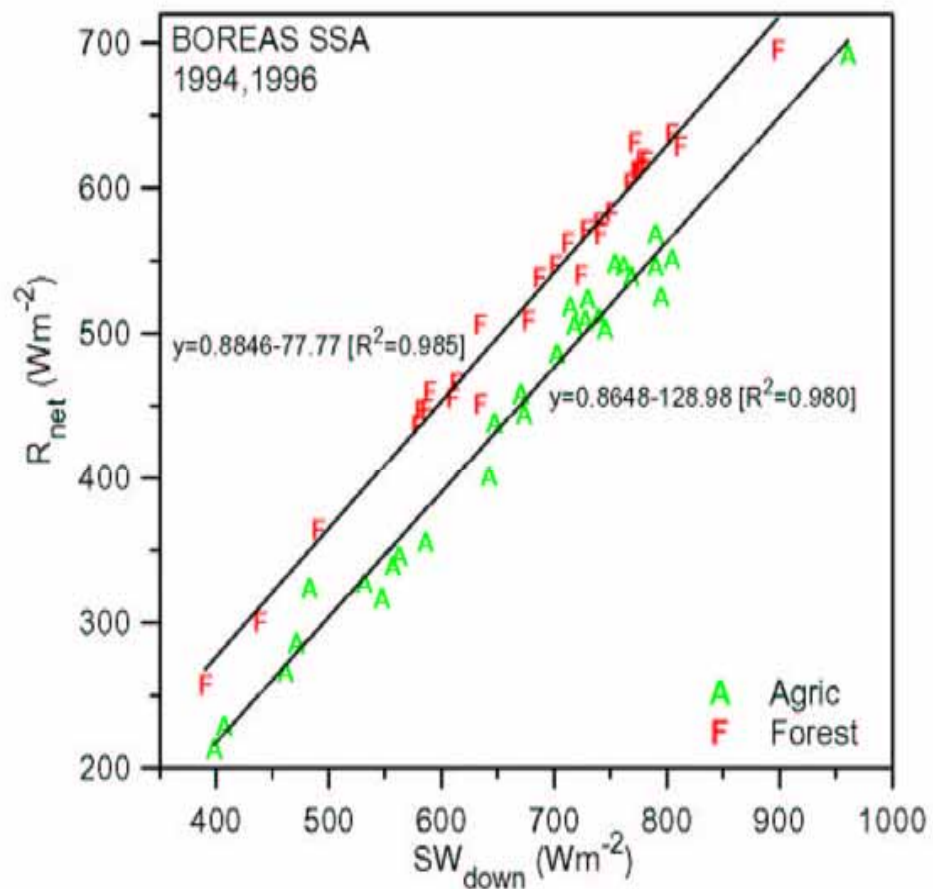
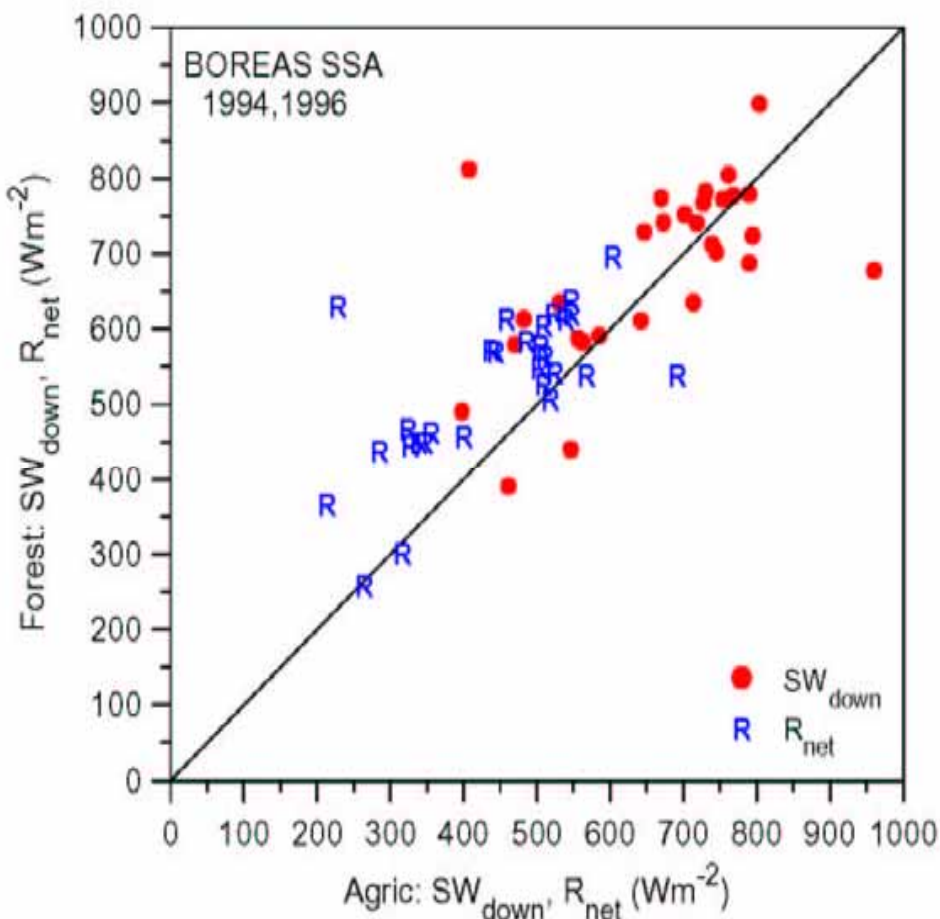
Forested/Old Black Spruce



Twin Otter Instrumentation

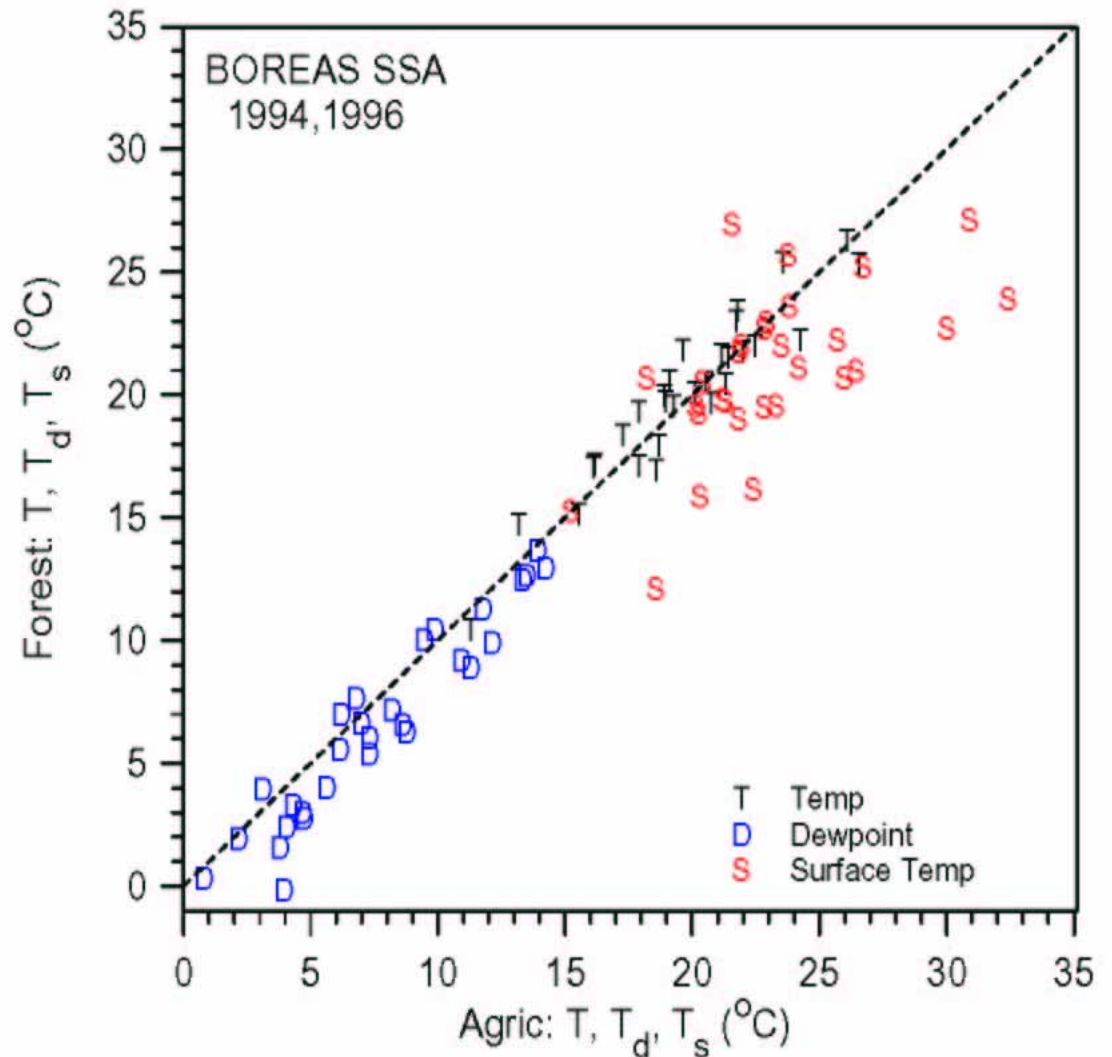


Radiative flux comparison: forest and agriculture

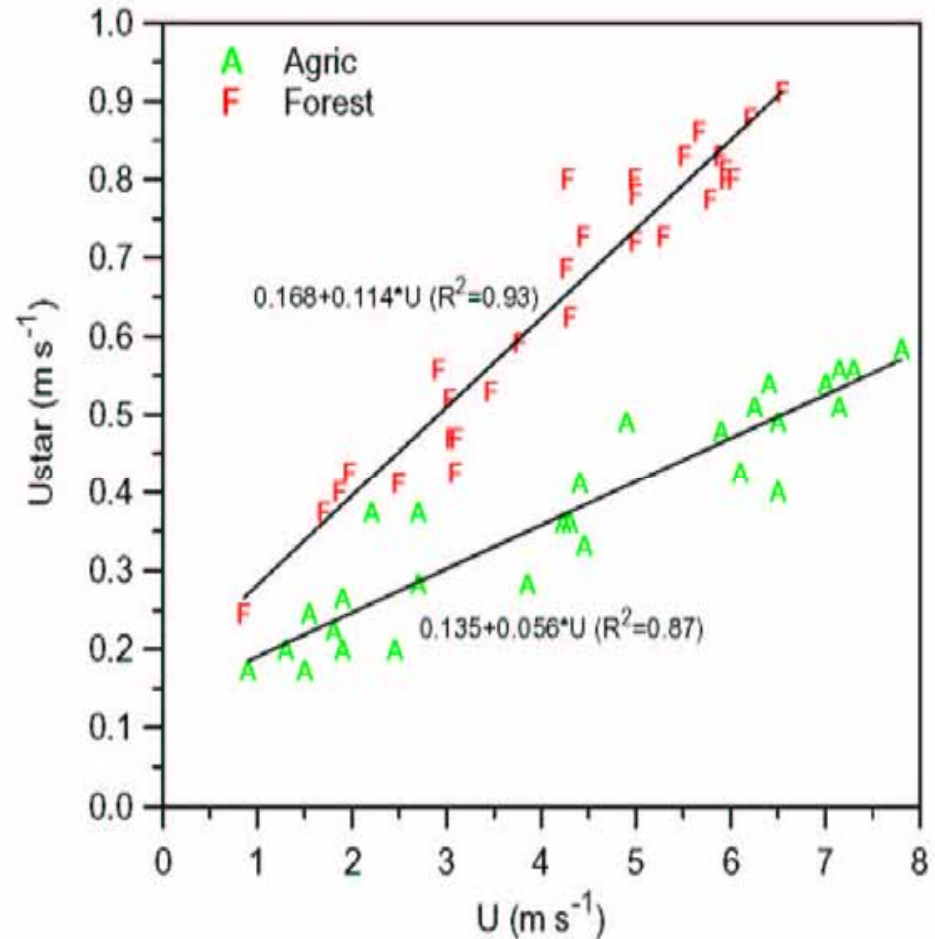
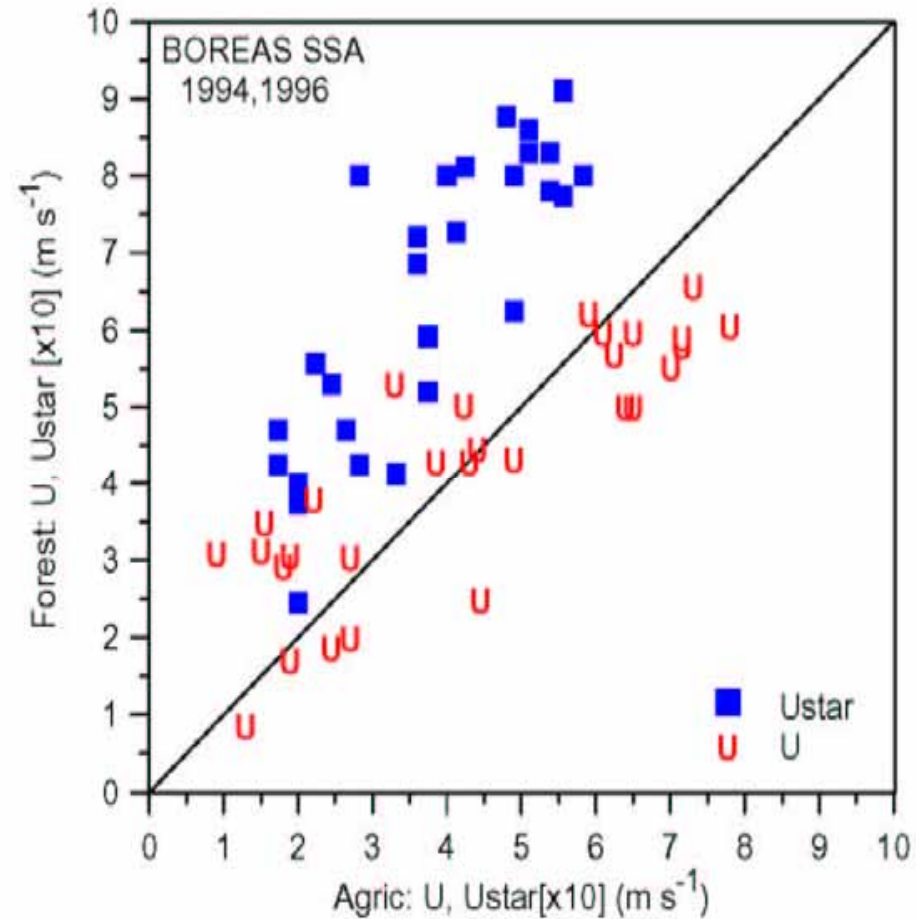


Temperature comparison

- Similar air T
- Larger T_d , T_s over agriculture

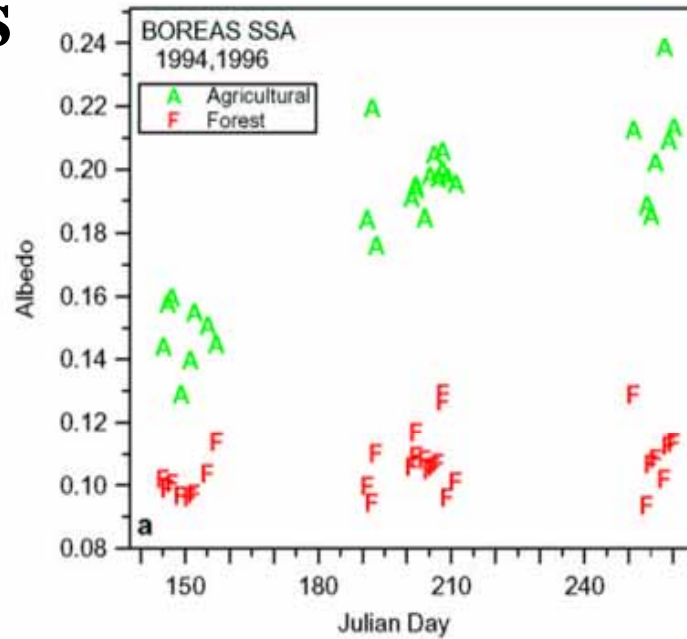


Wind and stress comparison

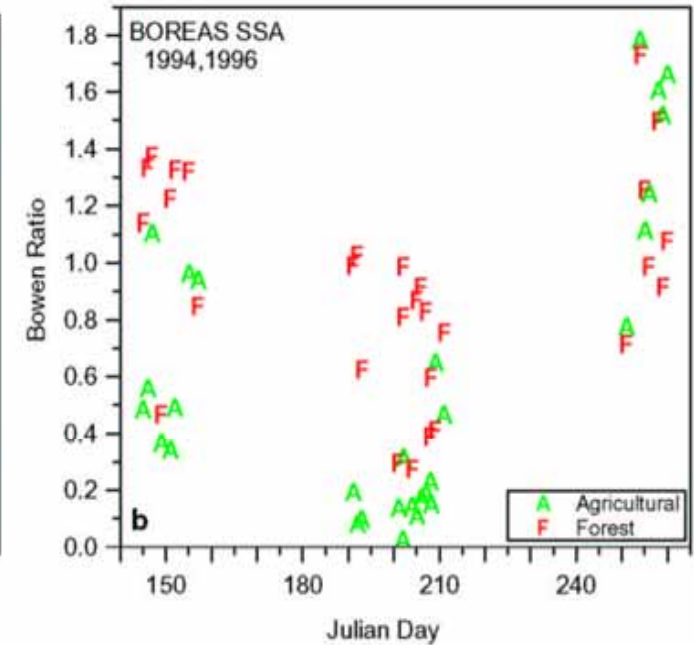


Daily means

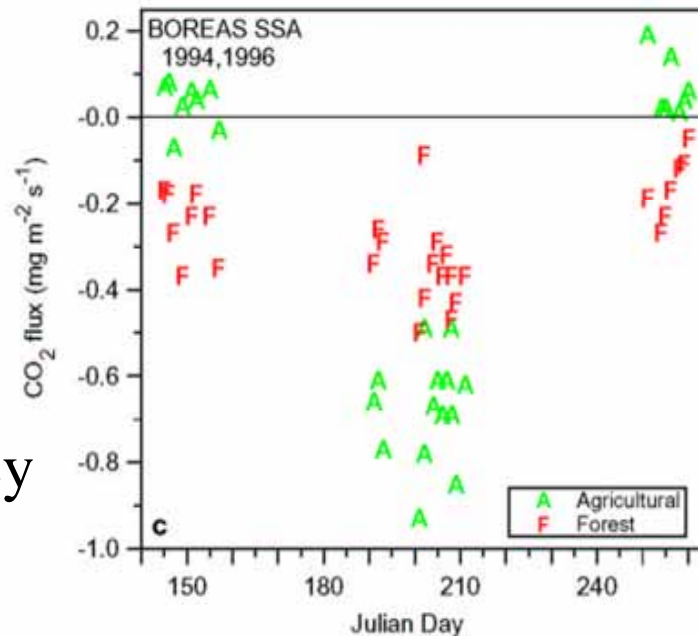
a) Albedo



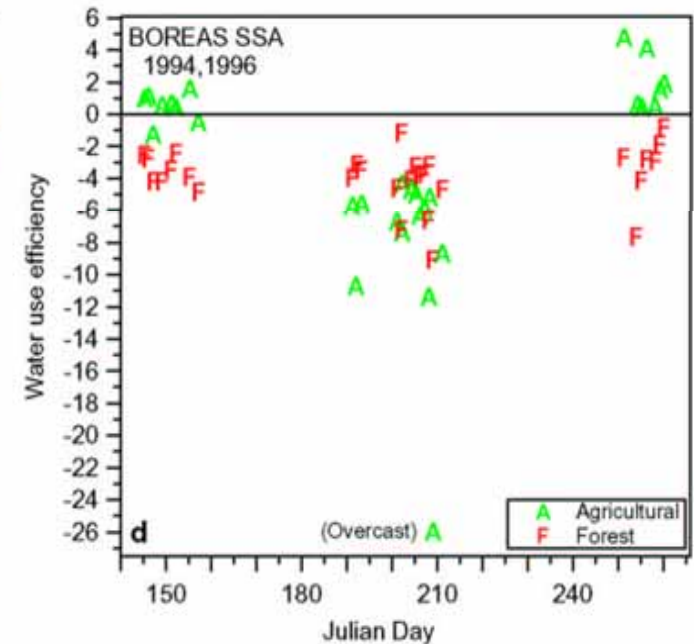
b) Bowen ratio



c) CO₂ flux

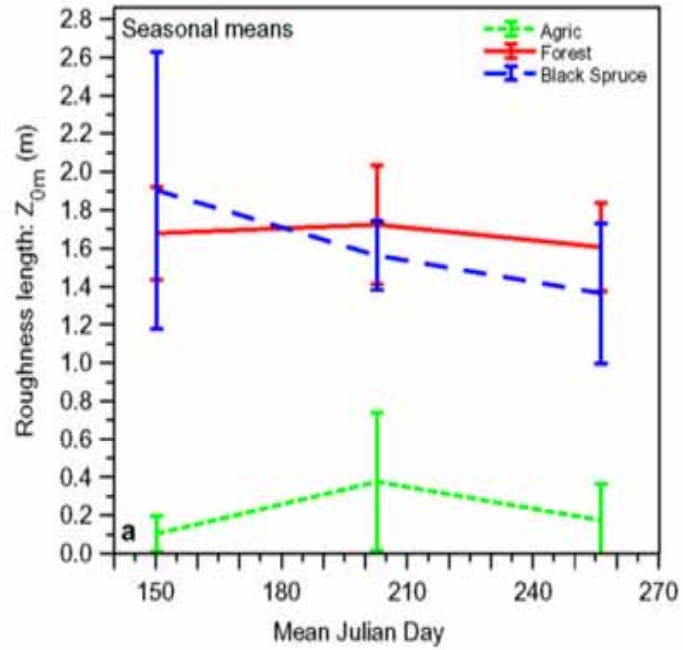


d) Water use efficiency

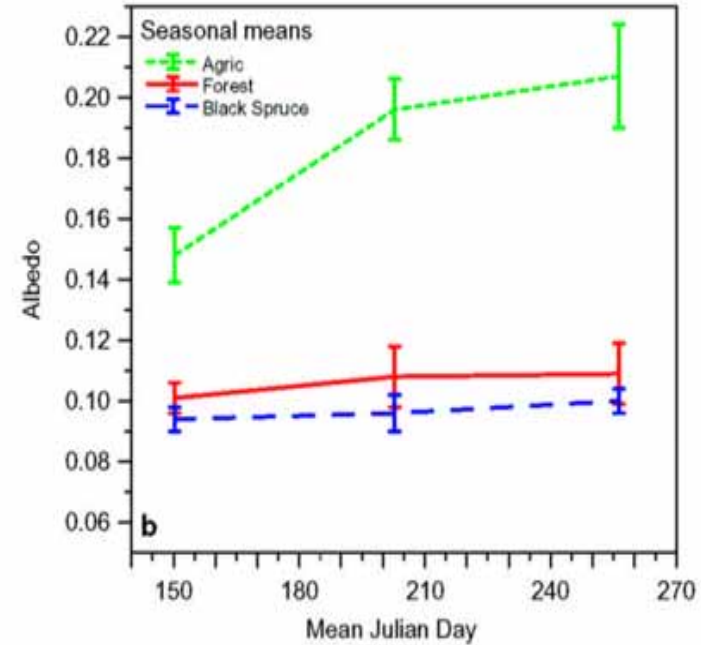


Seasonal means

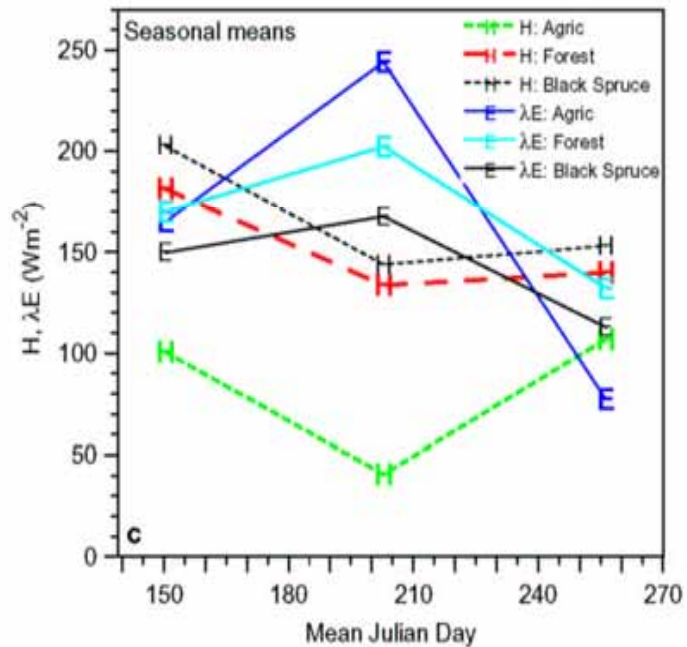
a) Roughness Z_0



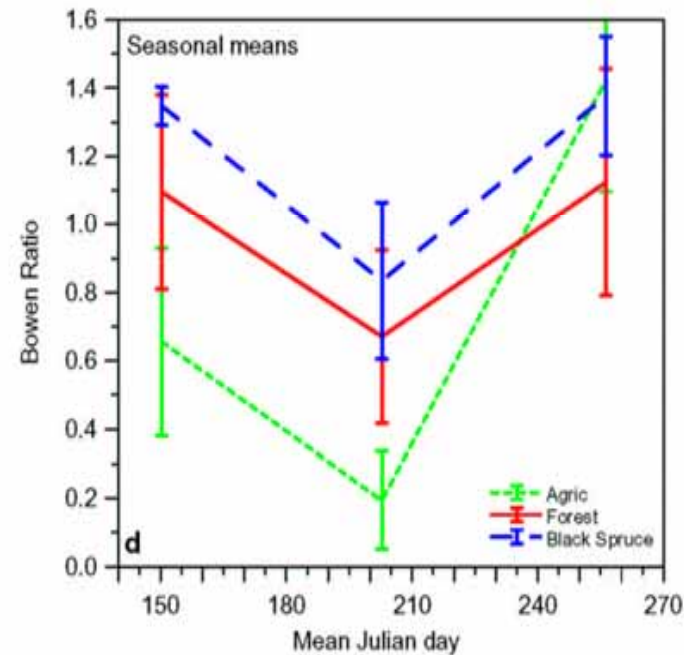
b) Albedo



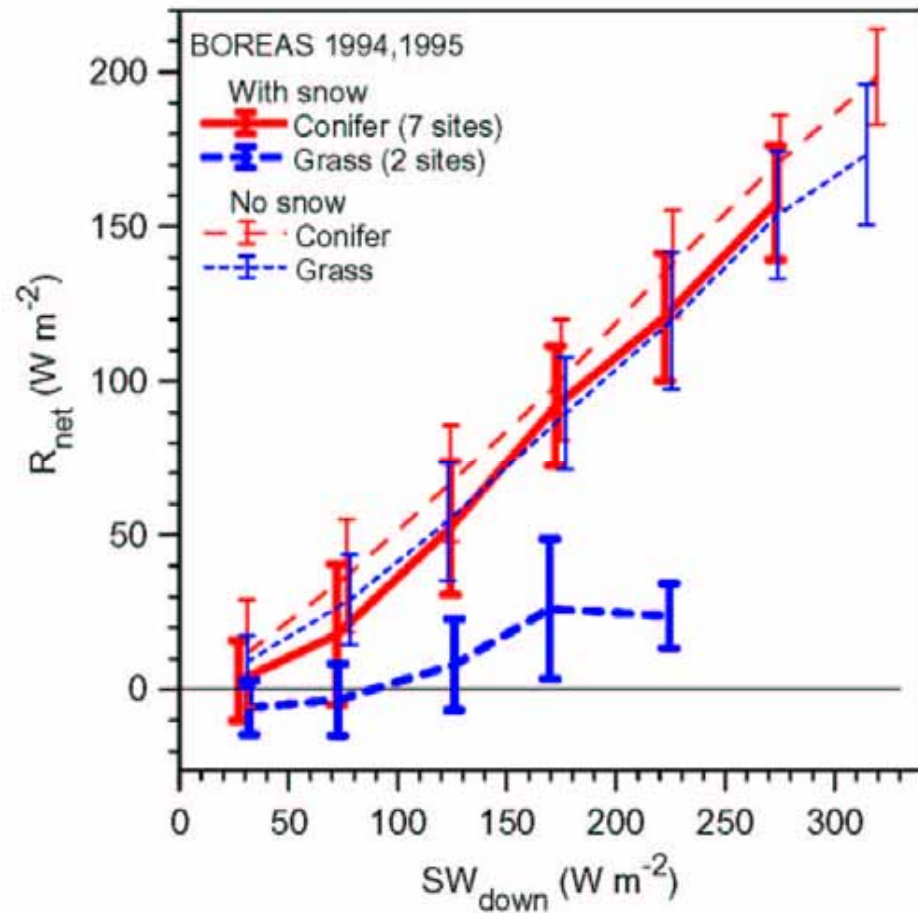
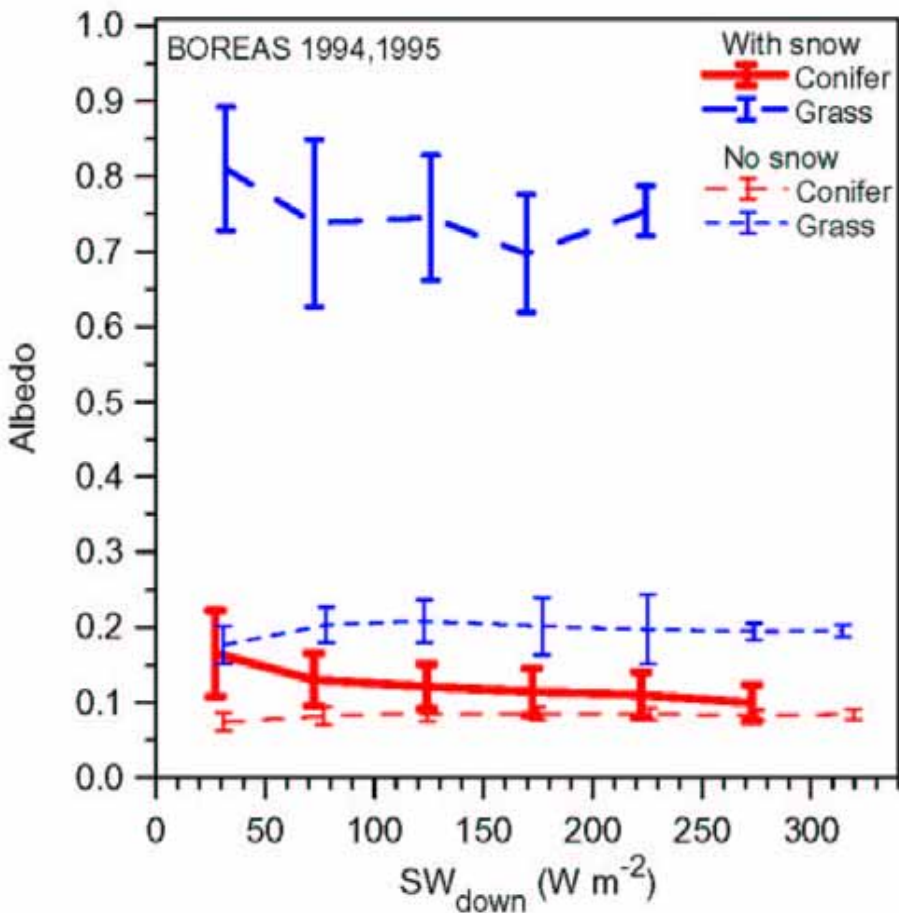
c) Sensible
& latent heat



d) Bowen ratio



Radiation balance with and without snow

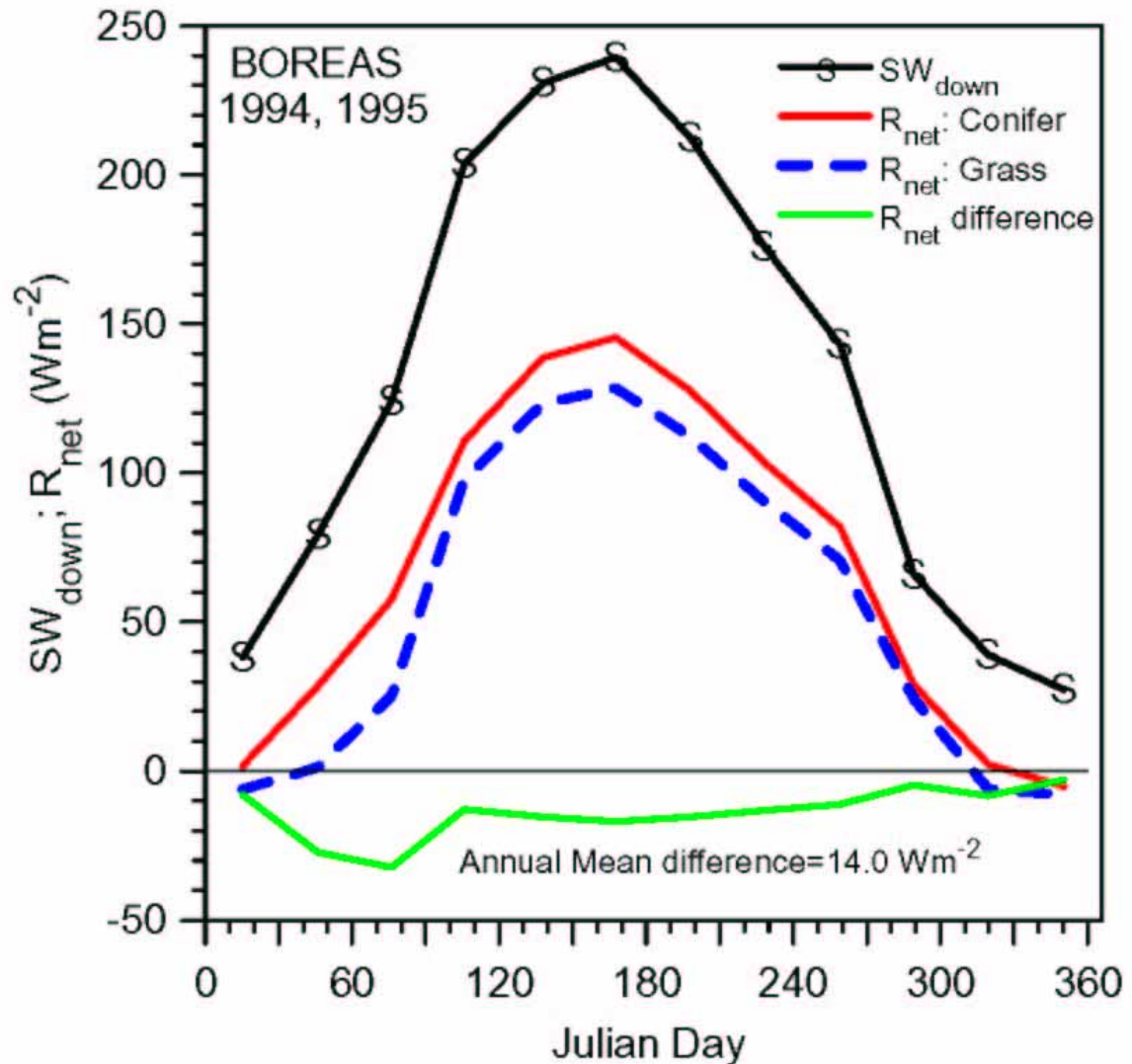


Seasonal radiation difference

Conifer – Grass: R_{net}

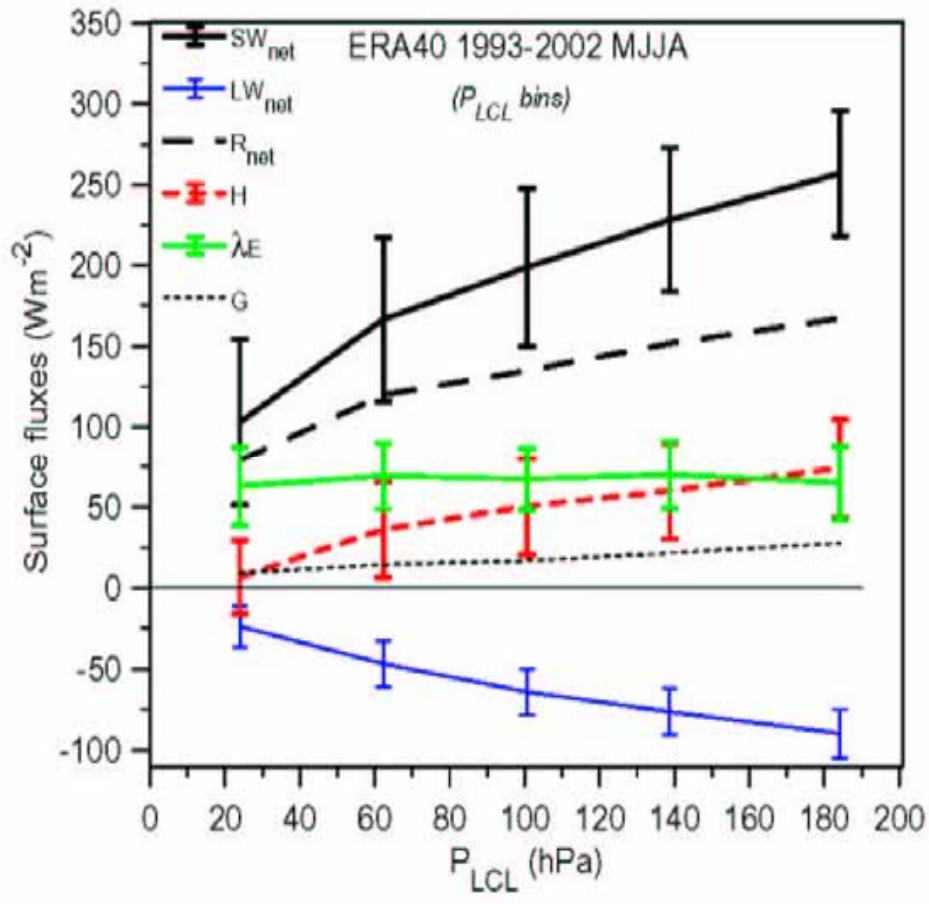
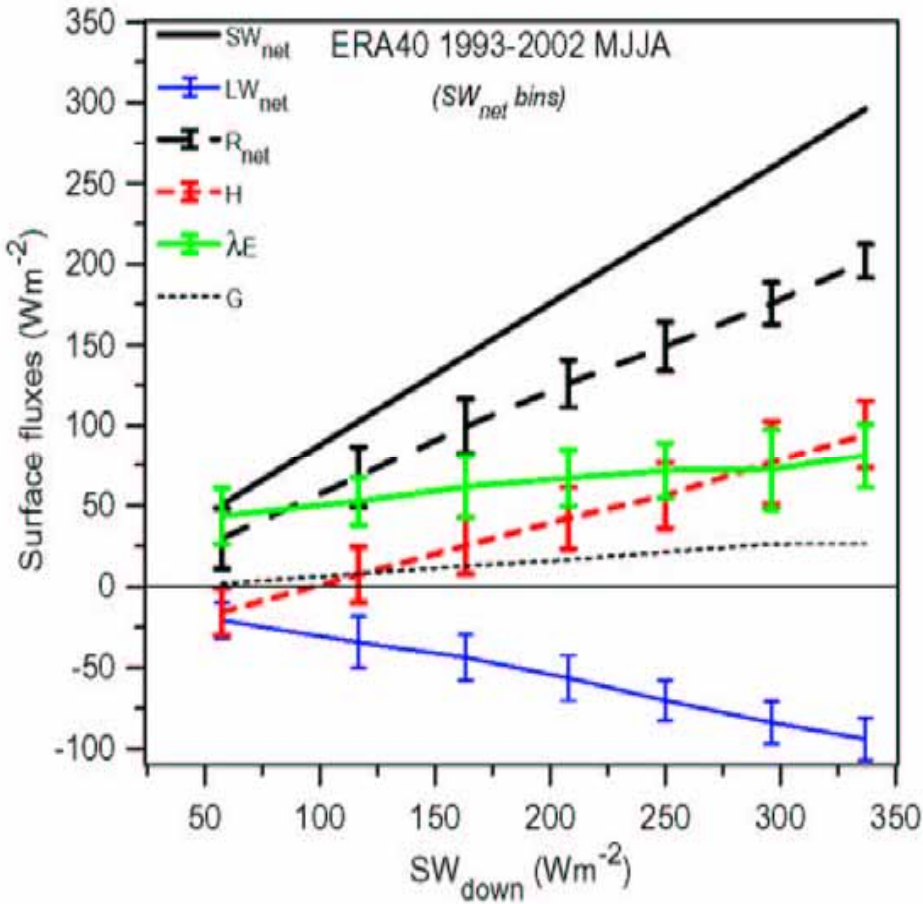
Mean annual difference
= 14 Wm^{-2}

Difference largest
in spring



Binned daily means from ERA40

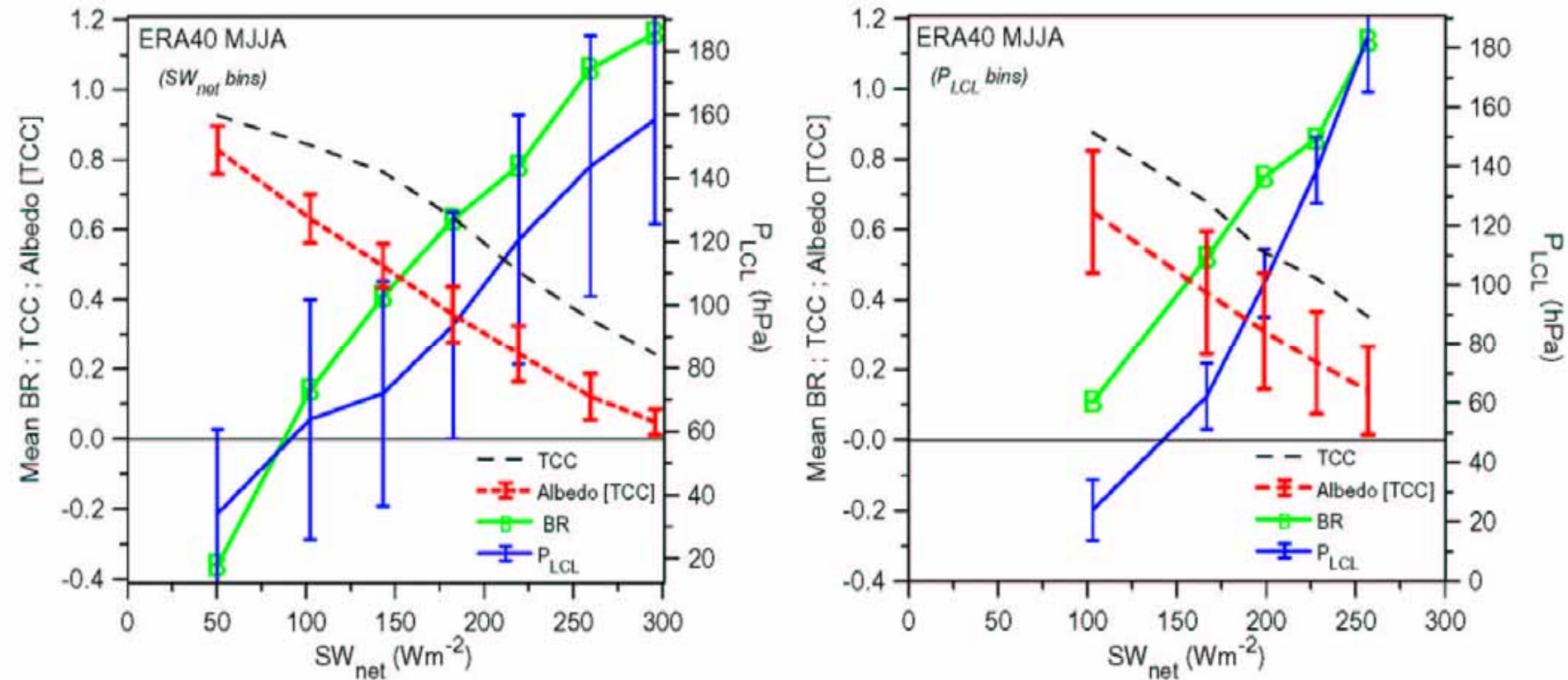
- coupling of surface and cloud fields



SW_{down} bins: linear fluxes

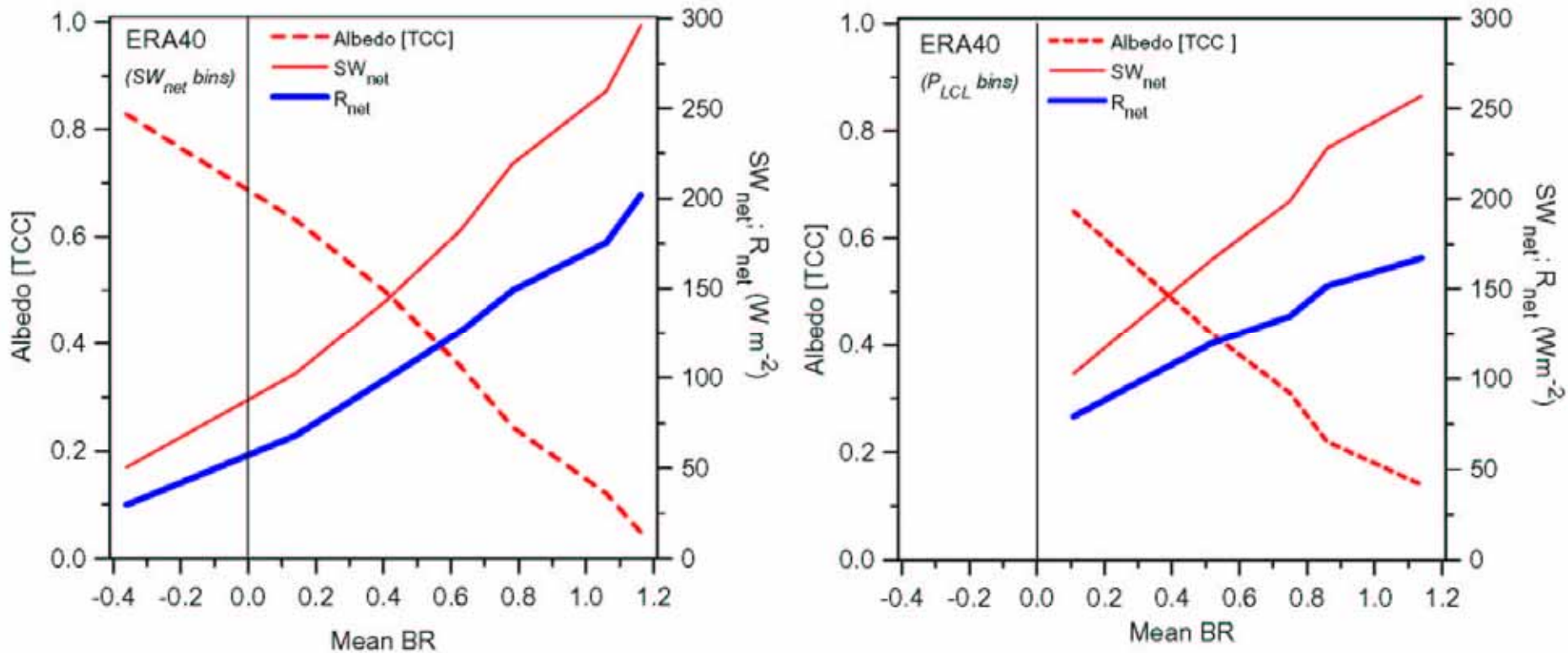
P_{LCL} bins: cloud dependence

Dependence of BR, cloud albedo, and cloud-base on SW_{net}



Less cloud, more SW_{net} , higher cloud-base, higher BR

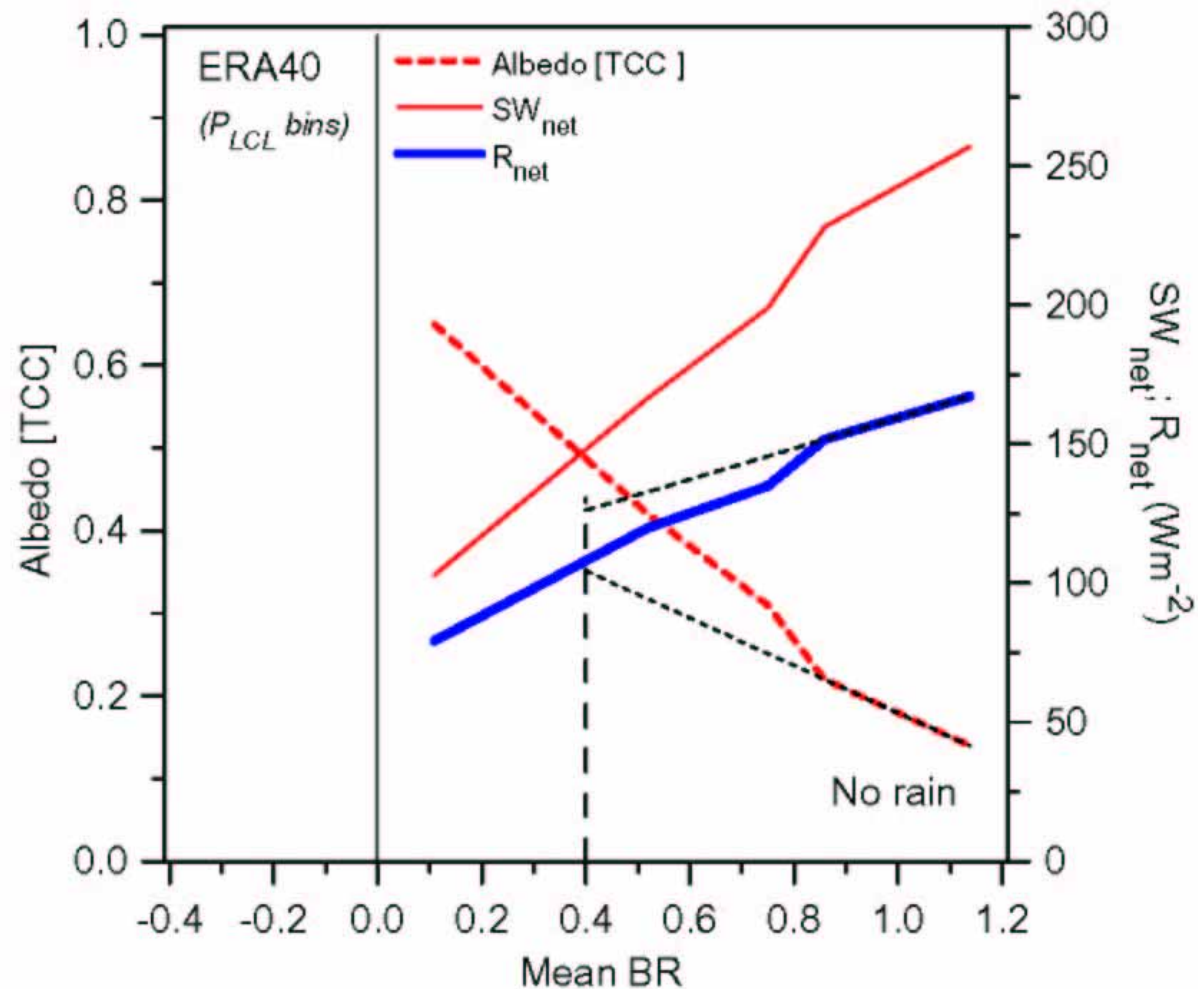
Dependence of cloud albedo, and radiation fluxes on Bowen Ratio



Lower BR, more cloud; reduced R_{net}

Extrapolate impact of BR on cloud albedo?

- BR: 0.85 to 0.4
- R_{net} : 152 to 126 Wm^{-2}
- Cloud albedo: 0.22 to 0.35



Conclusions

- Paired aircraft flux runs provide useful daytime comparison of agriculture and forest
- Forest has lower albedo: summer by 0.1
[With snow by 0.2-0.5]
- Forest has larger roughness
- Conifers have longer growing season
- Agricultural crops: shorter growing season but larger summer peak of λE and CO_2 uptake

Surface albedo difference

- Surface albedo difference gives forests larger R_{net} by 14Wm^{-2} [annual mean]
- Snow covered grass and agricultural land have very small R_{net} in winter and early spring because of large albedo

Coupling of BR, cloud-base, cloud fraction and radiative fluxes

- In fully coupled models, surface evaporation determines cloud-base, cloud fraction, cloud albedo and hence surface SW_{down}
- Boreal forest to agriculture lowers summer BR
- Rough estimate: BR change of 0.85 to 0.4 may increase cloud albedo by 0.13 and reduce R_{net} by 26 Wm^{-1}

Coupled feed-backs need careful analysis

- What are larger scale impacts of lower summer BR, and larger total albedo?
- In *ECMWF model*, increased summer evaporation gives increased precipitation
[Betts, 2004]