



Forest and city fluxes and their effect on the boundary layers and clouds

Adriaan J. Teuling

Ruisdael Science Day, 19 June 2019, KNMI



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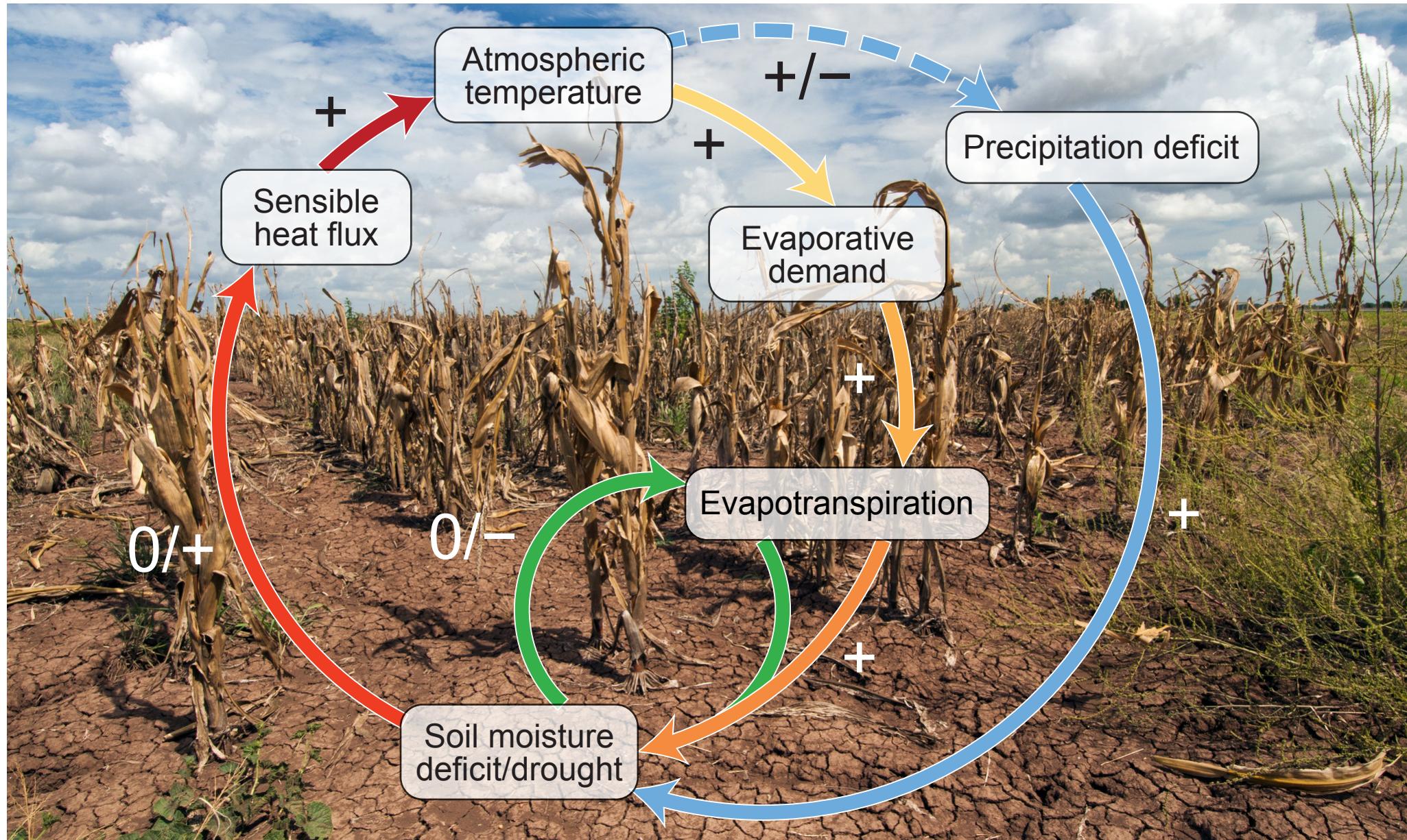
View towards NE



View towards W



Main pathways of the drought-heat link



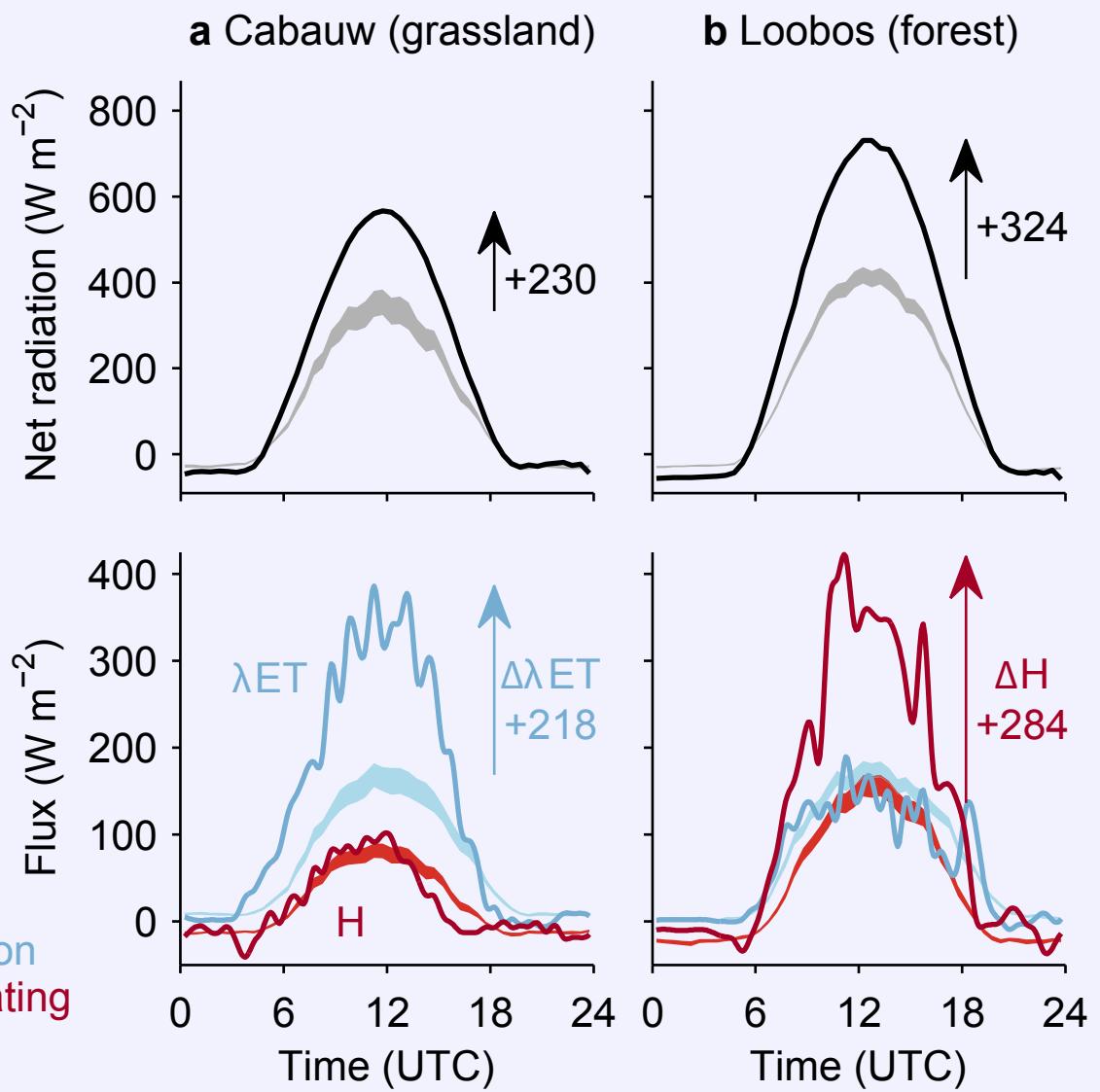
Teuling (2018), *Nature Climate Change* 8

Heating during the July 2006 heat wave

19 July 2006



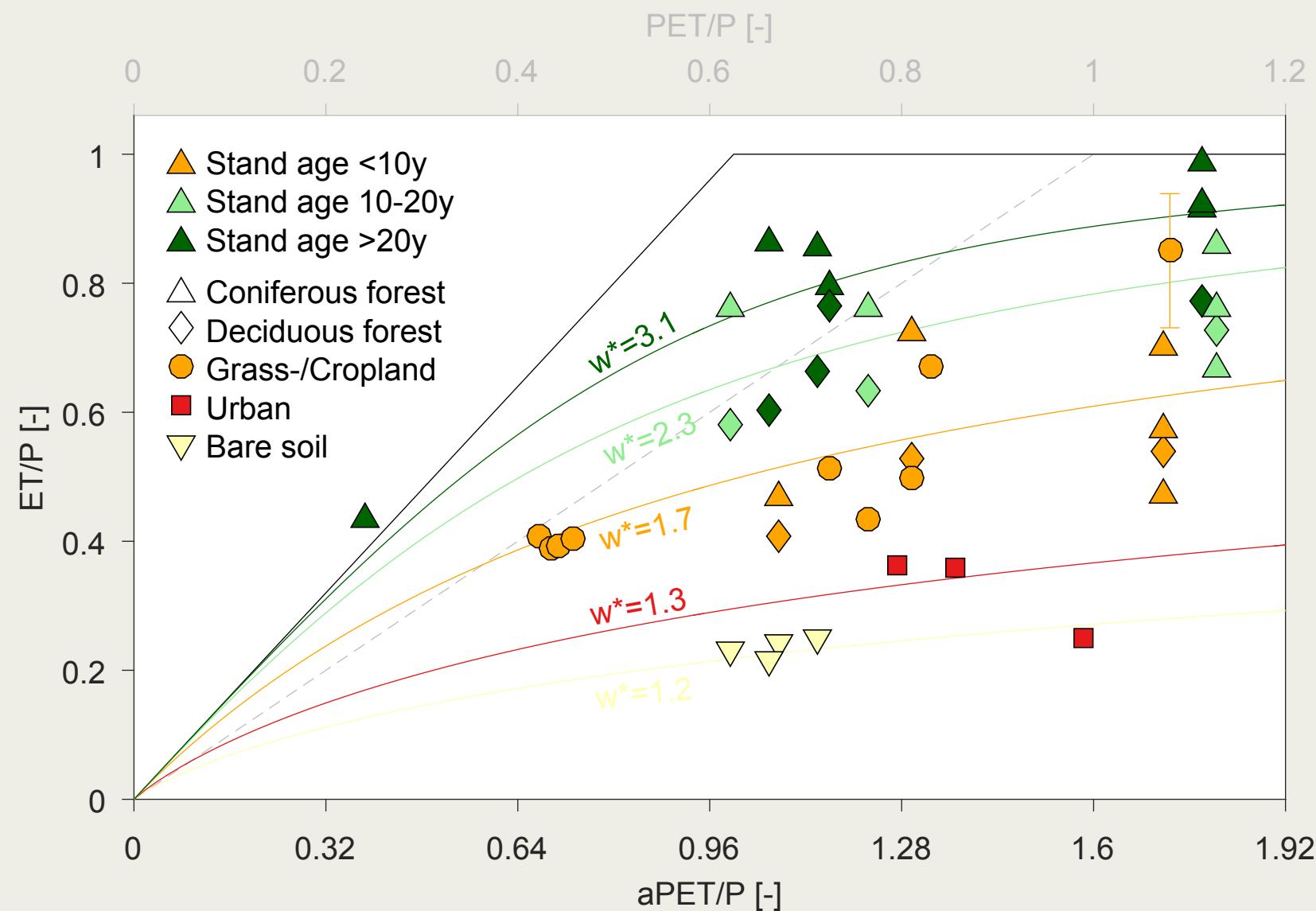
Evaporation
Direct heating



Teuling et al (2010), Contrasting response of European forest and grassland energy exchange to heatwaves. *Nature Geosci.* 3



Budyko parameters from lysimeter data



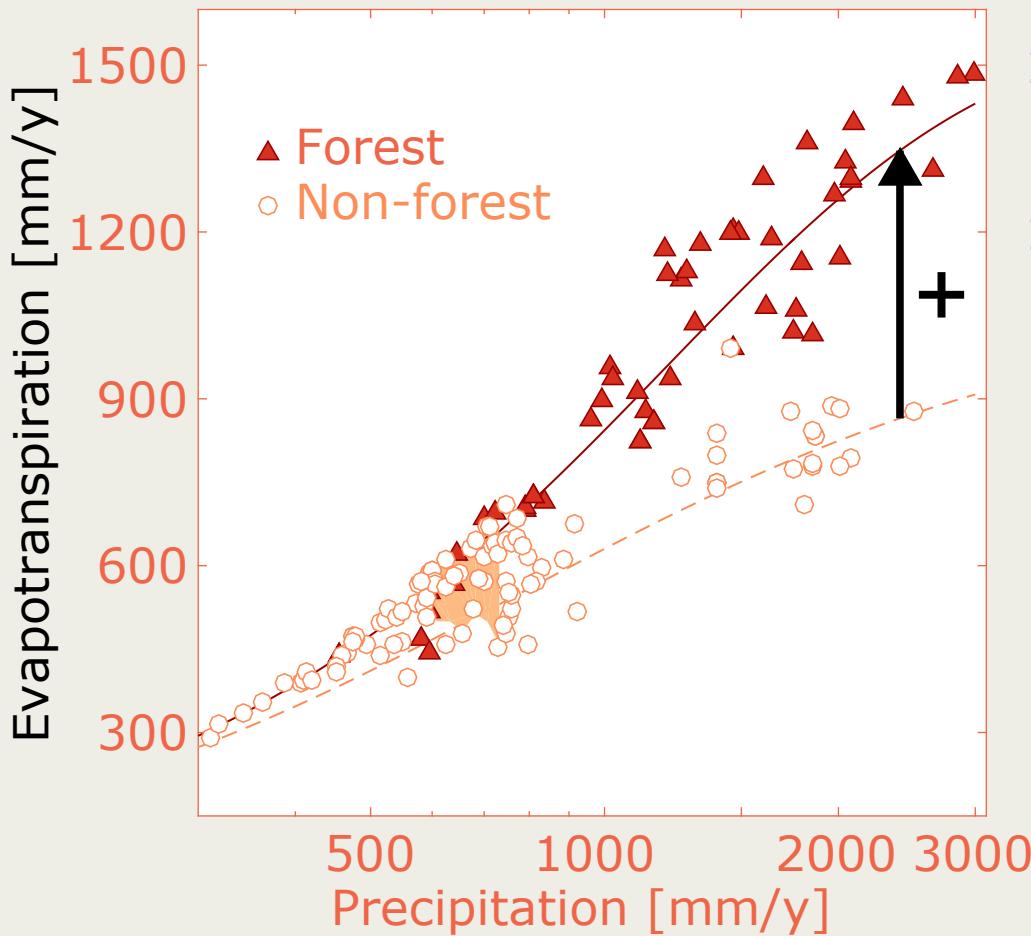
Calder (1976), *J. Hydrol.* **30**

Jacobs et al. (2015), *Build. Environm.* **83**

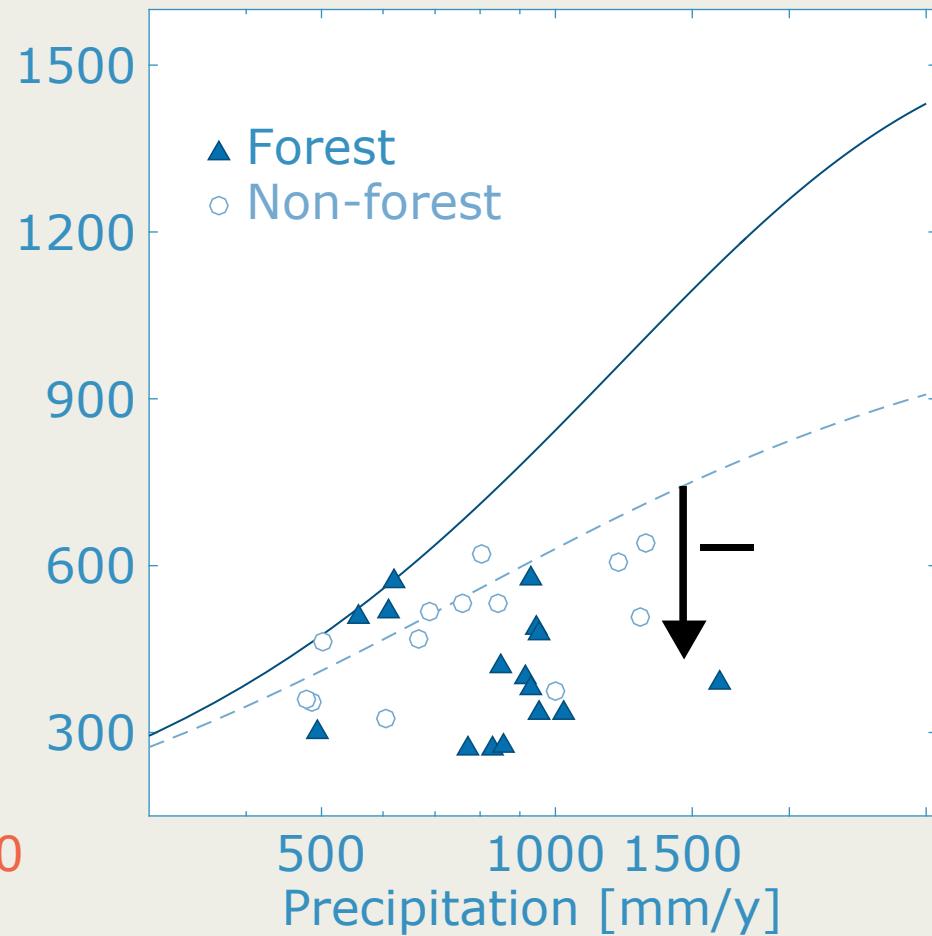
Teuling (2018), *Vadose Zone J.* **17**

A forest evapotranspiration paradox?

Catchment water balance



Surface energy balance



Paradox: Sign of ET difference depends on method!

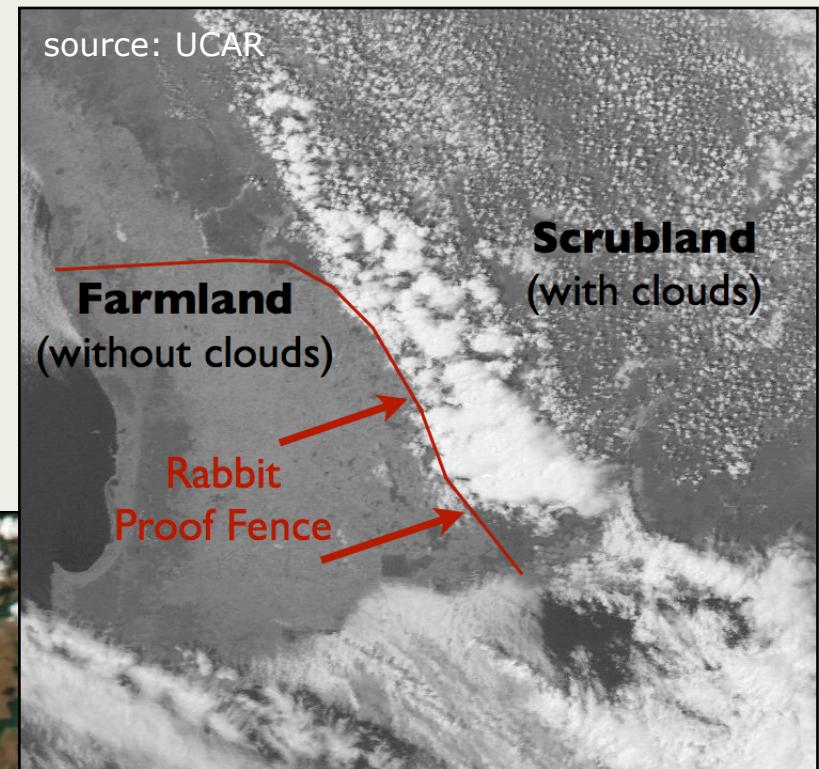
Zhang et al. (2001), *Water Resour. Res.* **37**

Williams et al. (2012), *Water Resour. Res.* **48**

Teuling (2018), *Vadose Zone J.* **17**

Previous studies on forests and clouds

In **Amazonia**, several studies have identified a local increase in cloud cover following deforestation. In contrast, more clouds were found over natural bushland along the rabbit fence in semi-arid south-western **Australia**.



Forest impacts on clouds are often obscured by correlation between forest cover and **topography**.

- Wang et al. (2009), *Proc. Natl. Acad. Sci. USA* **106**
Ray et al. (2003), *J. Geophys. Res.* **108**
Gentine et al. (2013), *J. Geophys. Res.* **118**
Sandel & Svenning (2013), *Nature Commun.* **4**

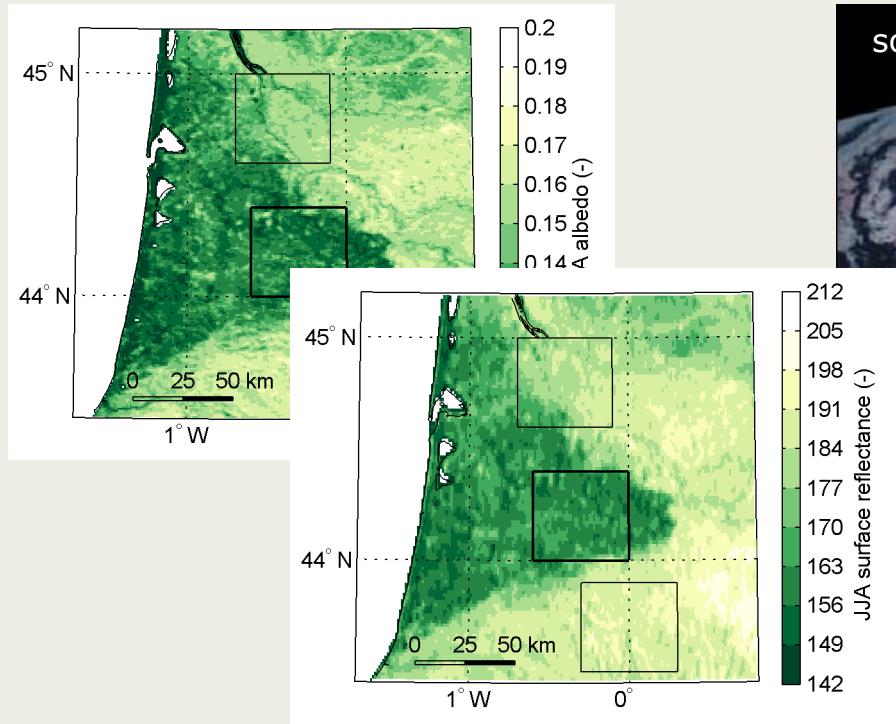


Data: MSG/SEVIRI cloud products

Geostationary operational weather satellite, **15 min** resolution for period **2004-2013**. Several VIS + IR channels and High Resolution Visible (HRV) channel for nowcasting (**1 km** resolution)

Two independent datasets were used in the study:

- Cloud Physical Properties MSG-CPP algorithm developed at KNMI
- Newly developed product based on ecdf of HRV reflectance



Roebeling et al. (2006), *J. Geophys. Res.* **111**

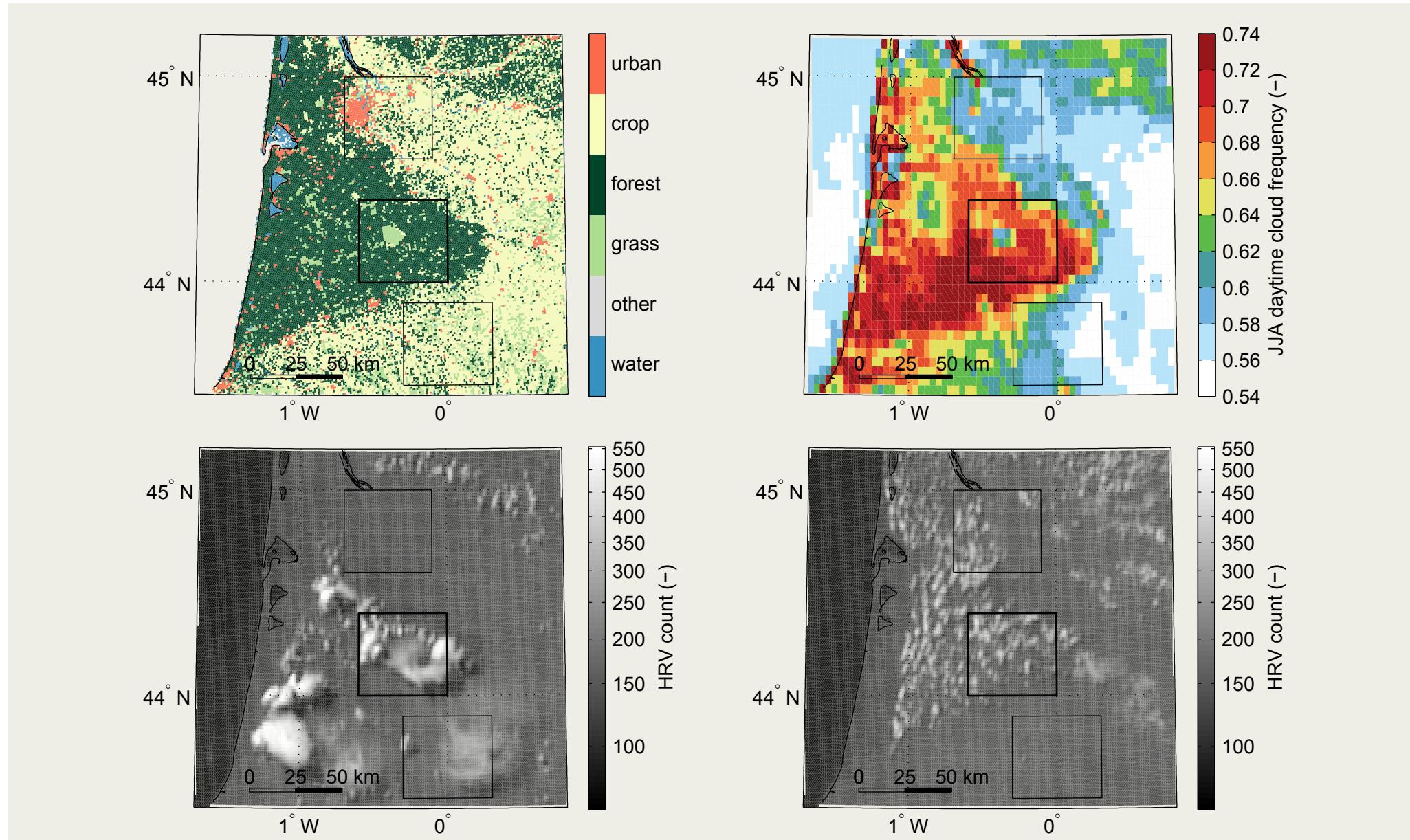
Roebeling et al. (2008), *J. Appl. Meteorol. Clim.* **47**

Meirink et al. (2013), *Atm. Meas. Tech.* **6**

Stengel et al. (2014), *Atm. Chem. Phys.* **14**



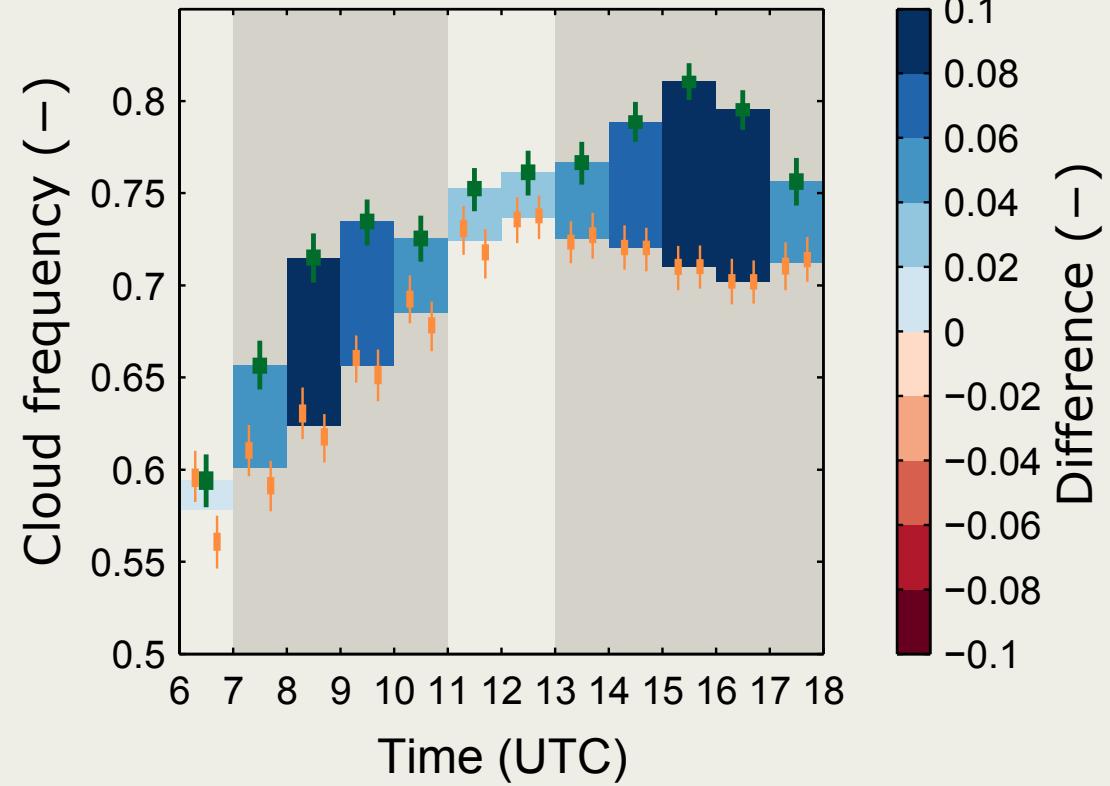
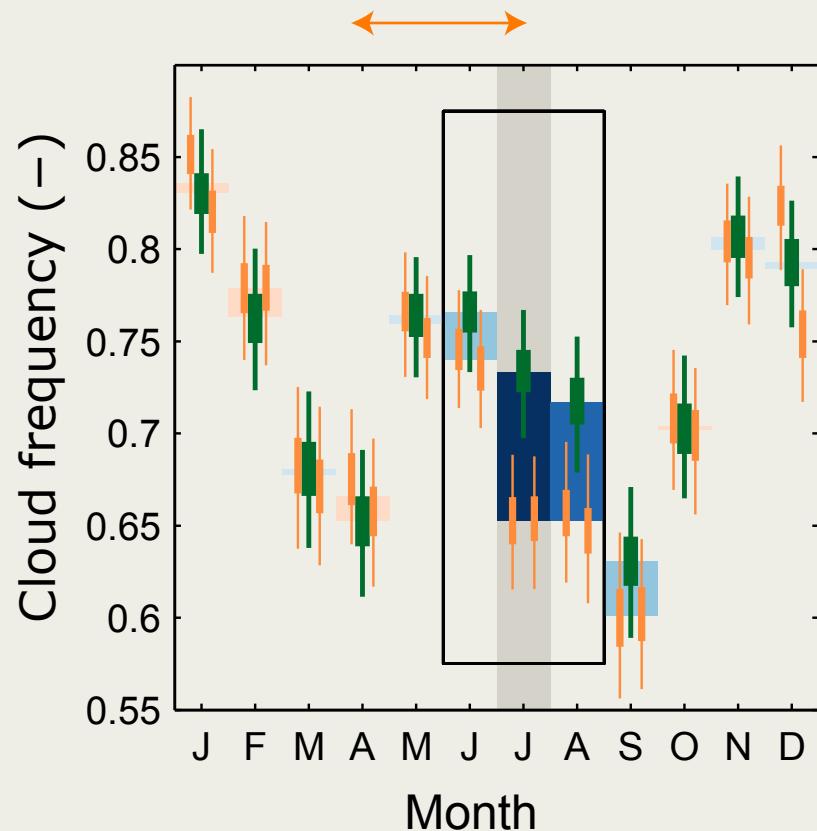
Cloud cover enhancement over forest



Teuling et al. (2017), *Nature Commun.* 8

Seasonal and diurnal variability

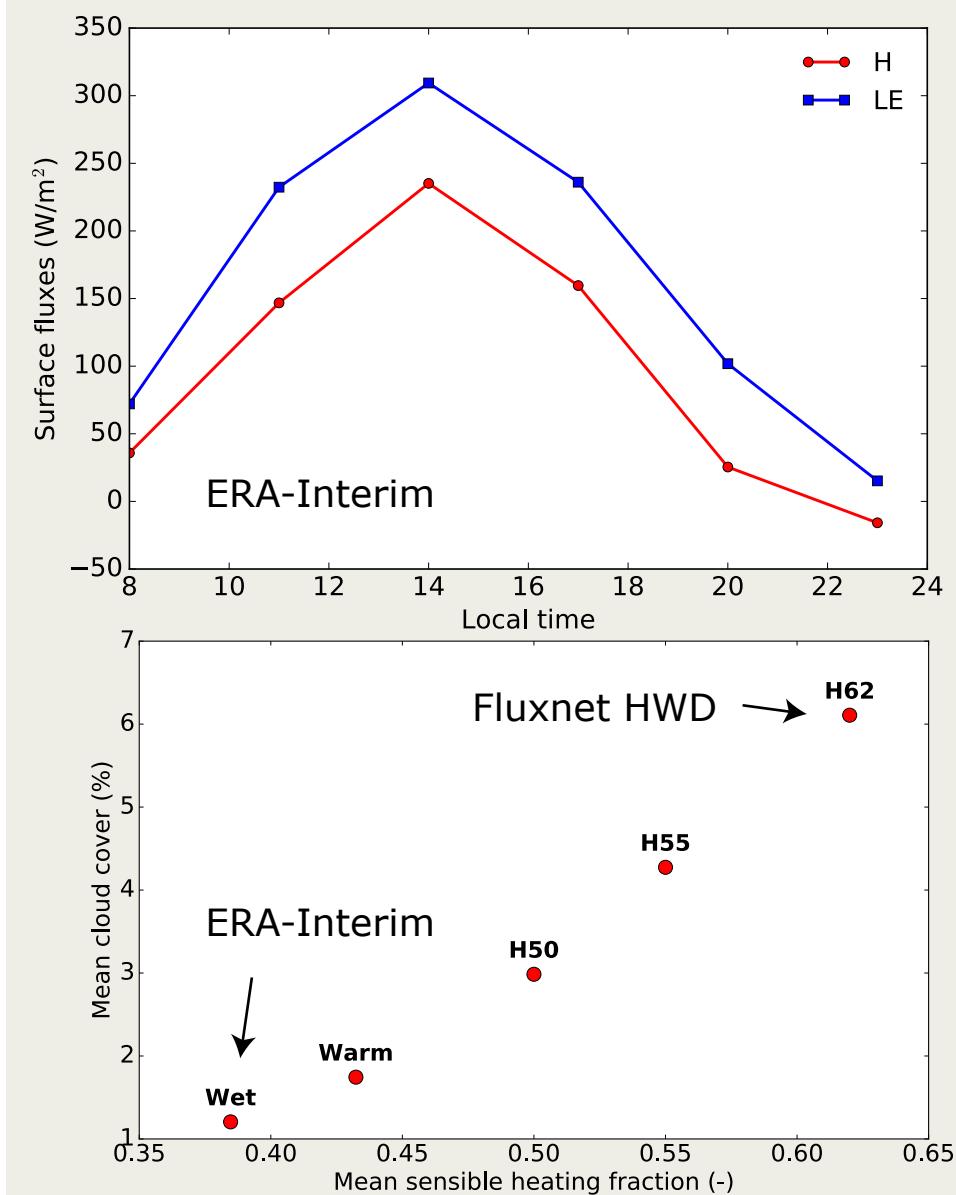
Sign reversal likely reflects changes
in land surface energy balance



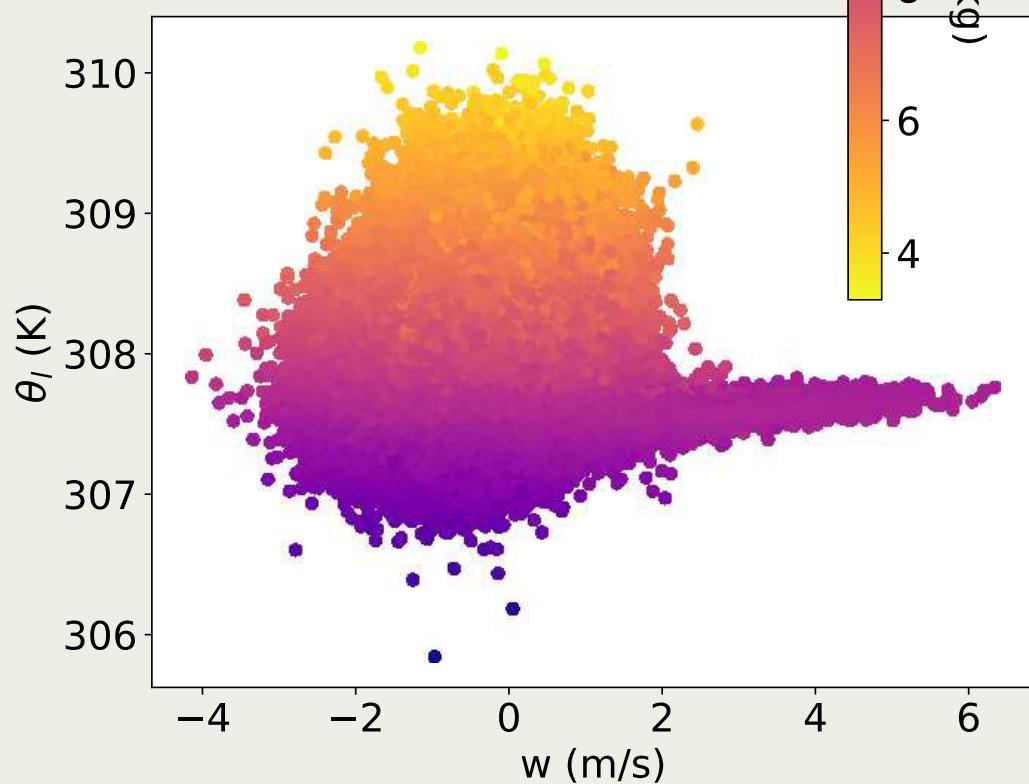
Strongest signal in morning and
early evening, not during midday



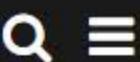
Cloud formation over Landes using LES



Bimodal distribution of air parcel properties at ABL top with most rapid and wettest parcels originating from land surface



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NICK SCOTT/ALAMY STOCK PHOTO

Large cities may create their own clouds

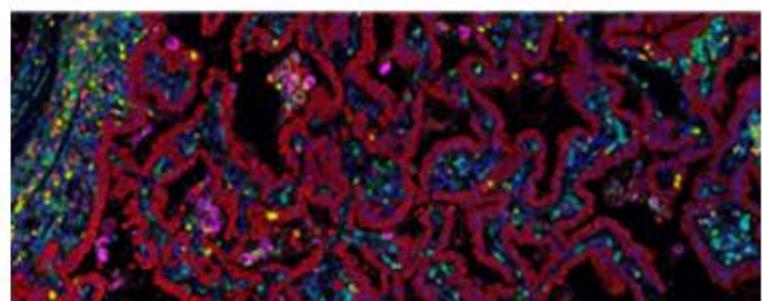
By Paul Voosen | May. 28, 2019, 4:00 PM

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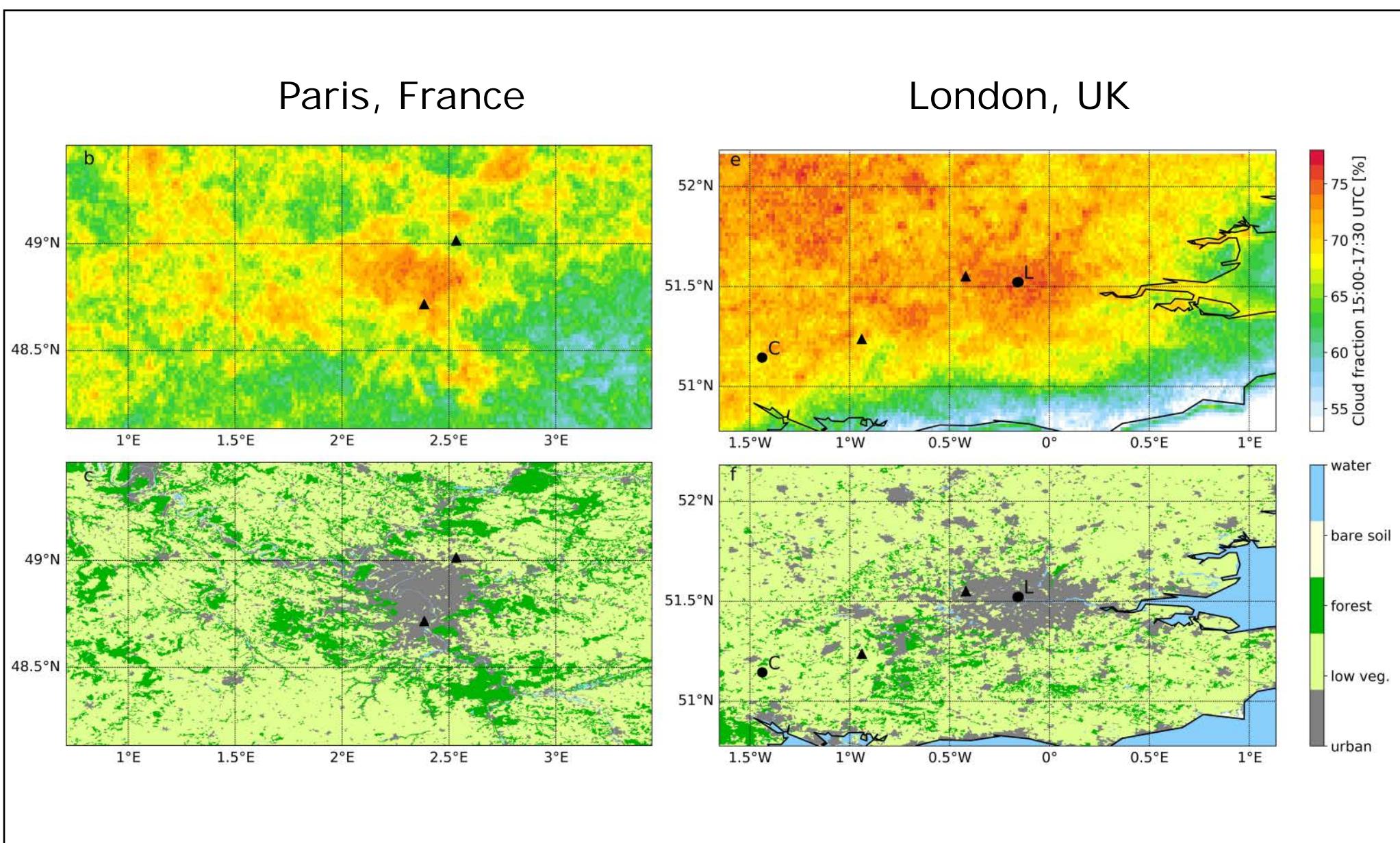
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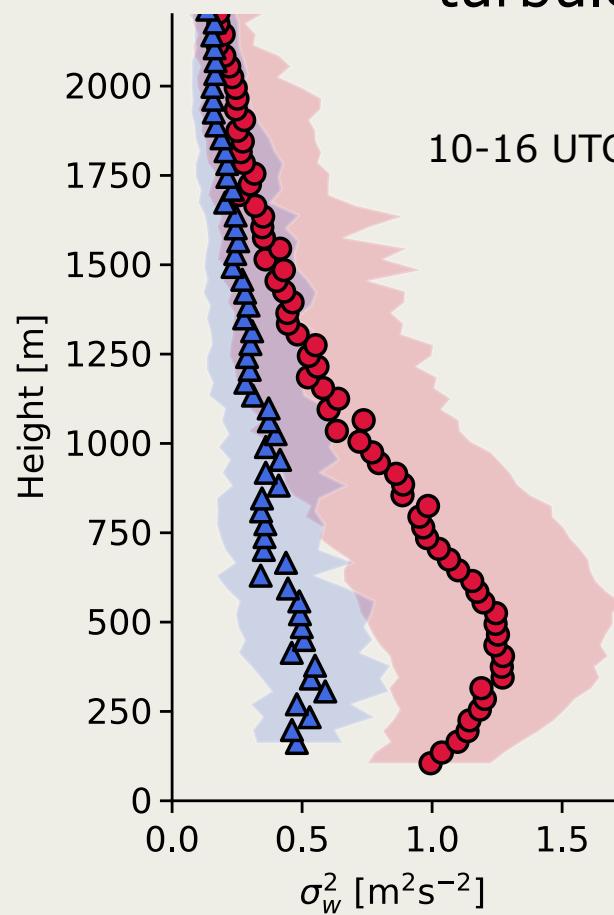
Persistent cloud cover over mega-cities



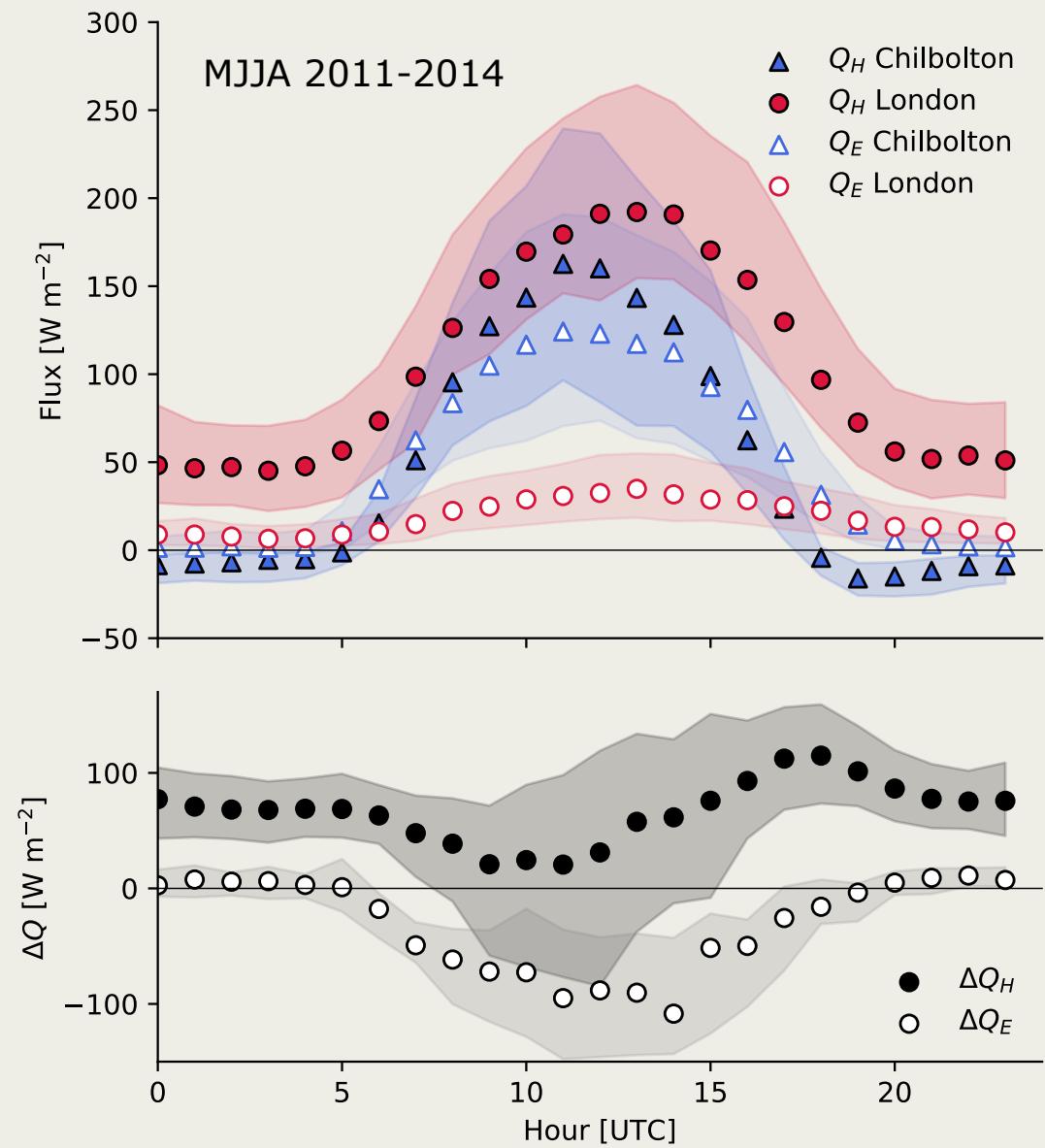
Theeuwes et al. (2019), *npj Clim. Atmos. Sci.*

Persistent cloud cover over mega-cities

More evening clouds linked
to lagged surface heat re-
lease and associated ABL
turbulence

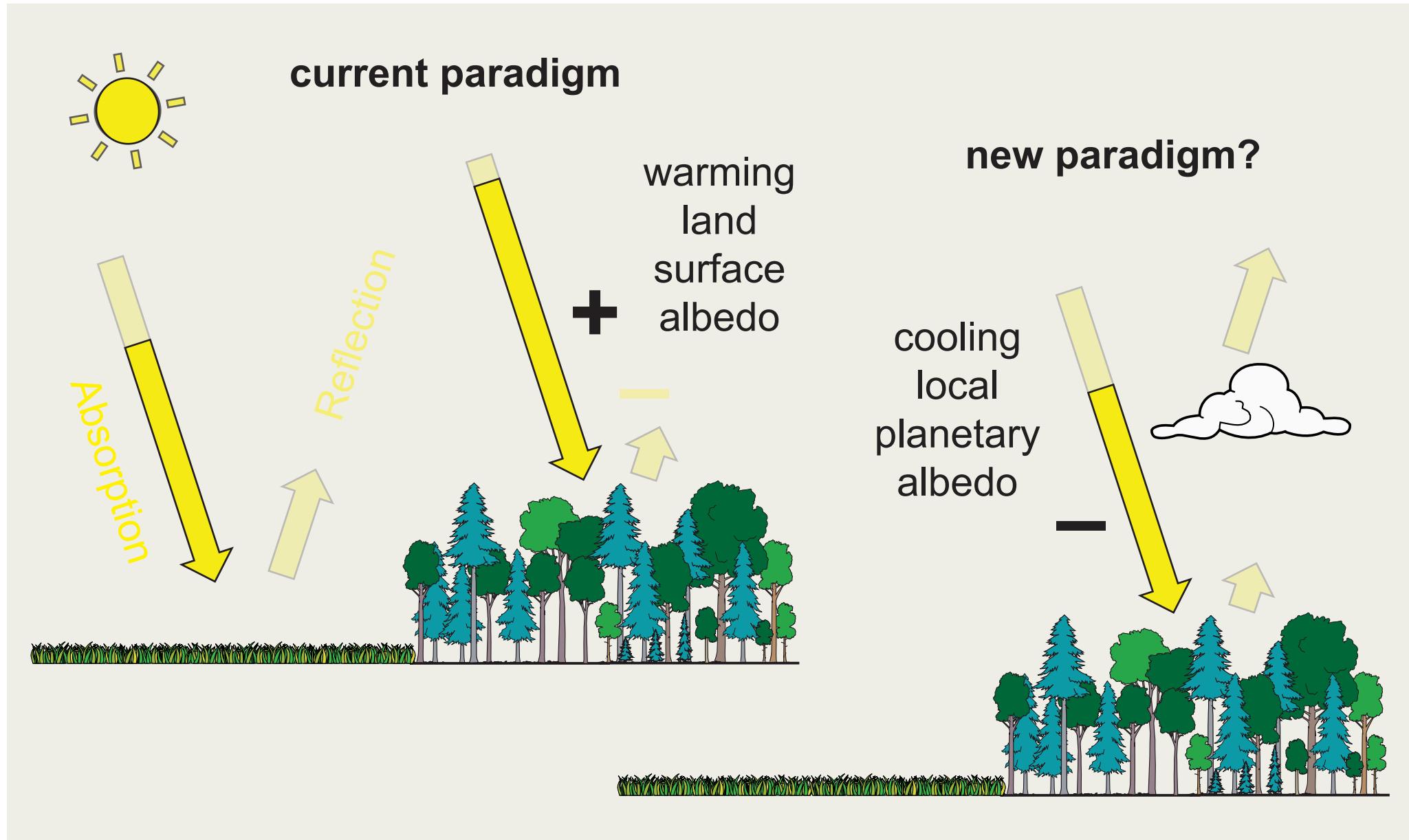


10-16 UTC



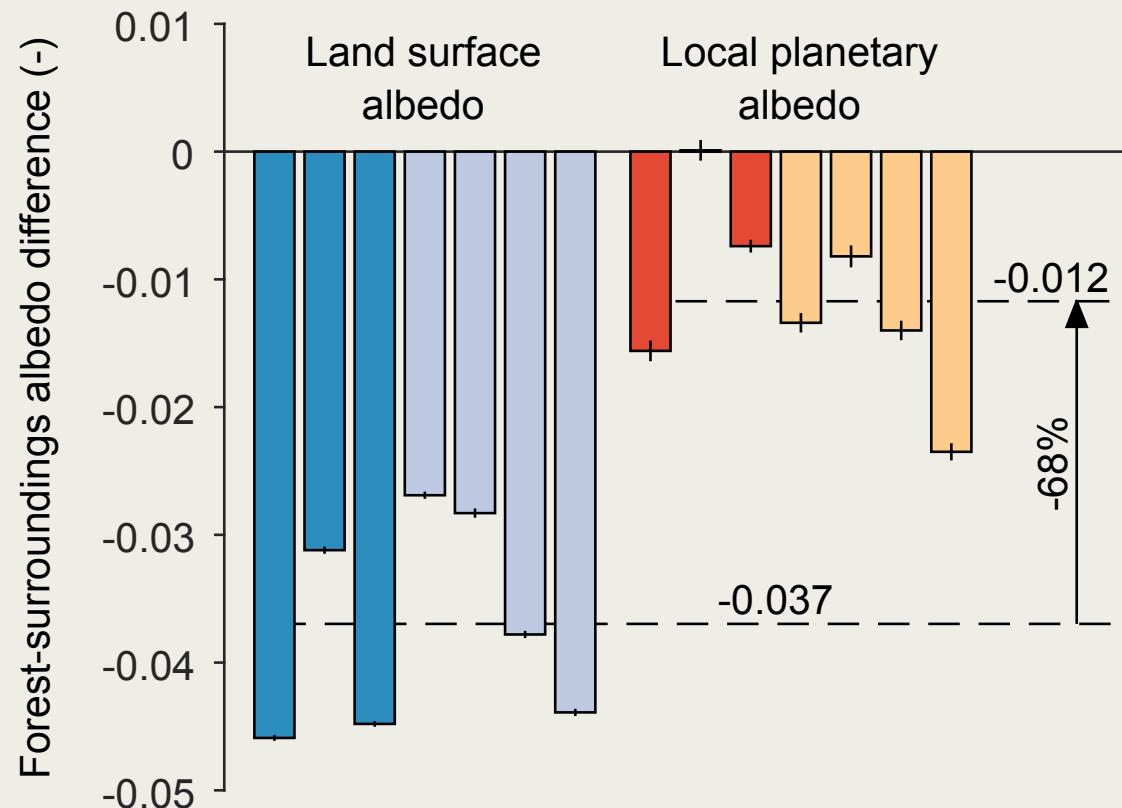
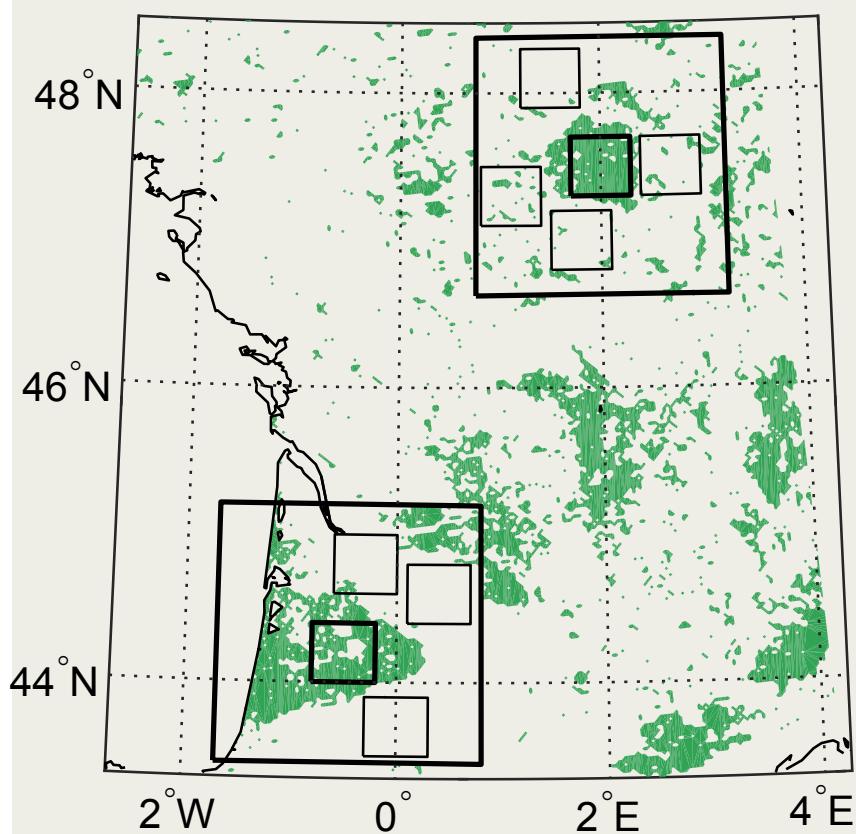
Theeuwes et al. (2019), *npj Clim. Atmos. Sci.*

Surface vs. local planetary albedo



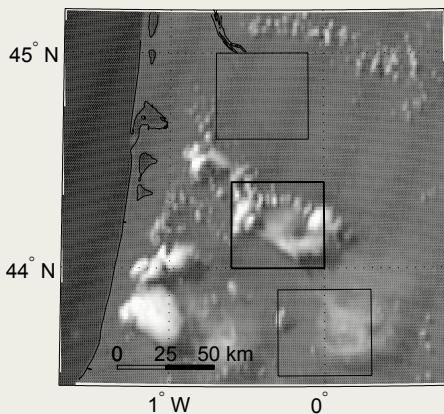
Teuling et al. (2019), *in preparation*

Land surface vs. local planetary albedo

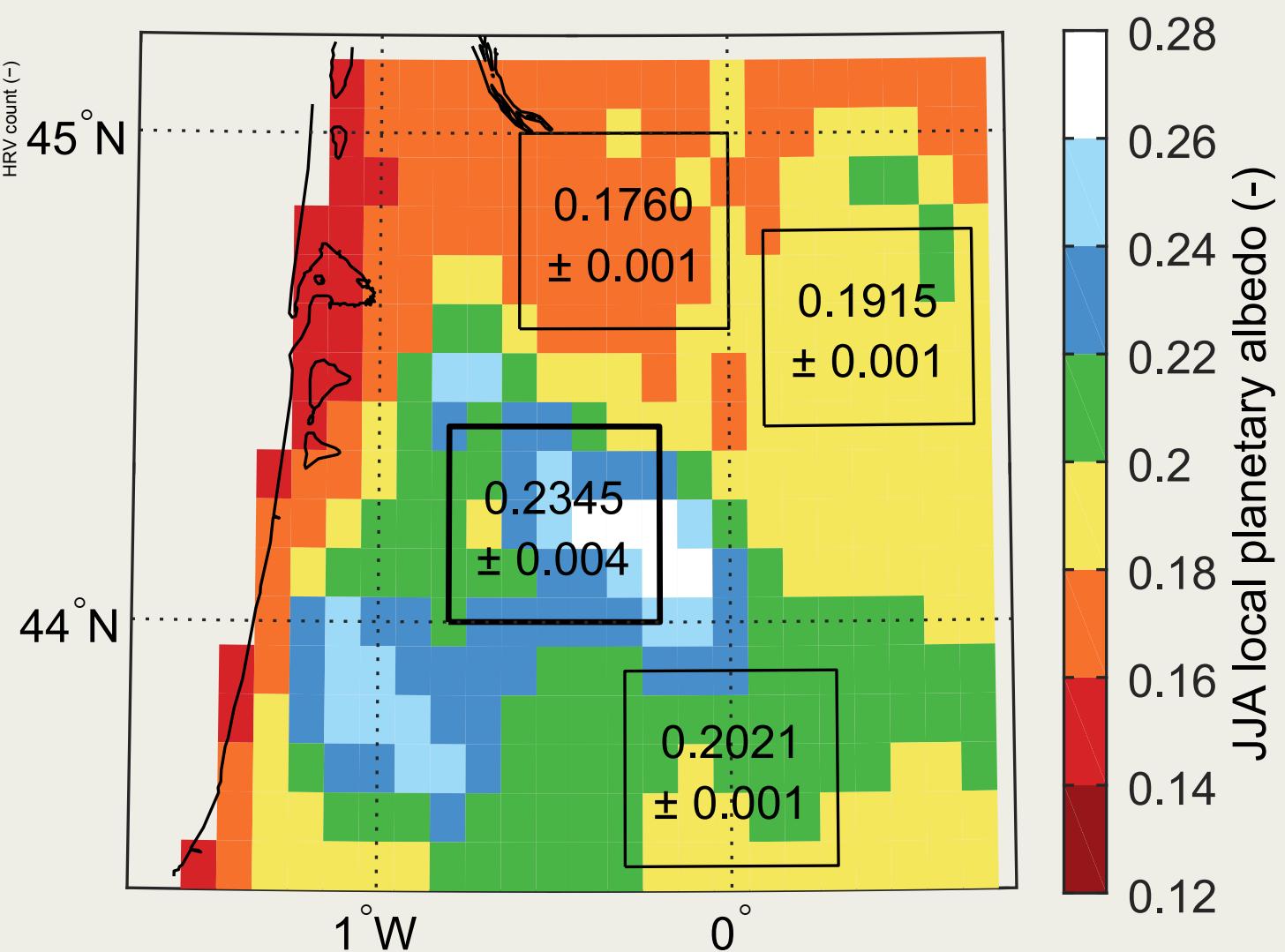


Considerable reduction in forest surface albedo effect at top of atmosphere due to enhanced cloud formation

Land surface vs. local planetary albedo



Enhanced cloud cover over forest can increase local surface albedo to over value of surrounding land (example 17 June 2006)



Take home messages

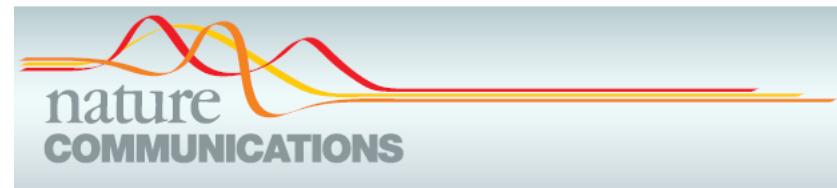
- Complex evaporation signal over forest
- More clouds over forests due to strong surface heating
- Similar signal found over large cities
- Clouds reduce forest impact on local planetary albedo

Sensible heating as a potential mechanism for enhanced cloud formation over temperate forest

Quarterly Journal of the Royal Meteorological Society



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ARTICLE

Received 15 Apr 2016 | Accepted 25 Nov 2016 | Published 11 Jan 2017

DOI: 10.1038/ncomms14065

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Observational evidence for cloud cover enhancement over western European forests

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& Jordi Vilà-Guerau de Arellano⁷

npj Climate and Atmospheric Science

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Persistent cloud cover over mega-cities linked to surface heat release

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