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Monitoring dryland energy and water dynamics in India: an analysis of COSMOS-India and flux tower observations

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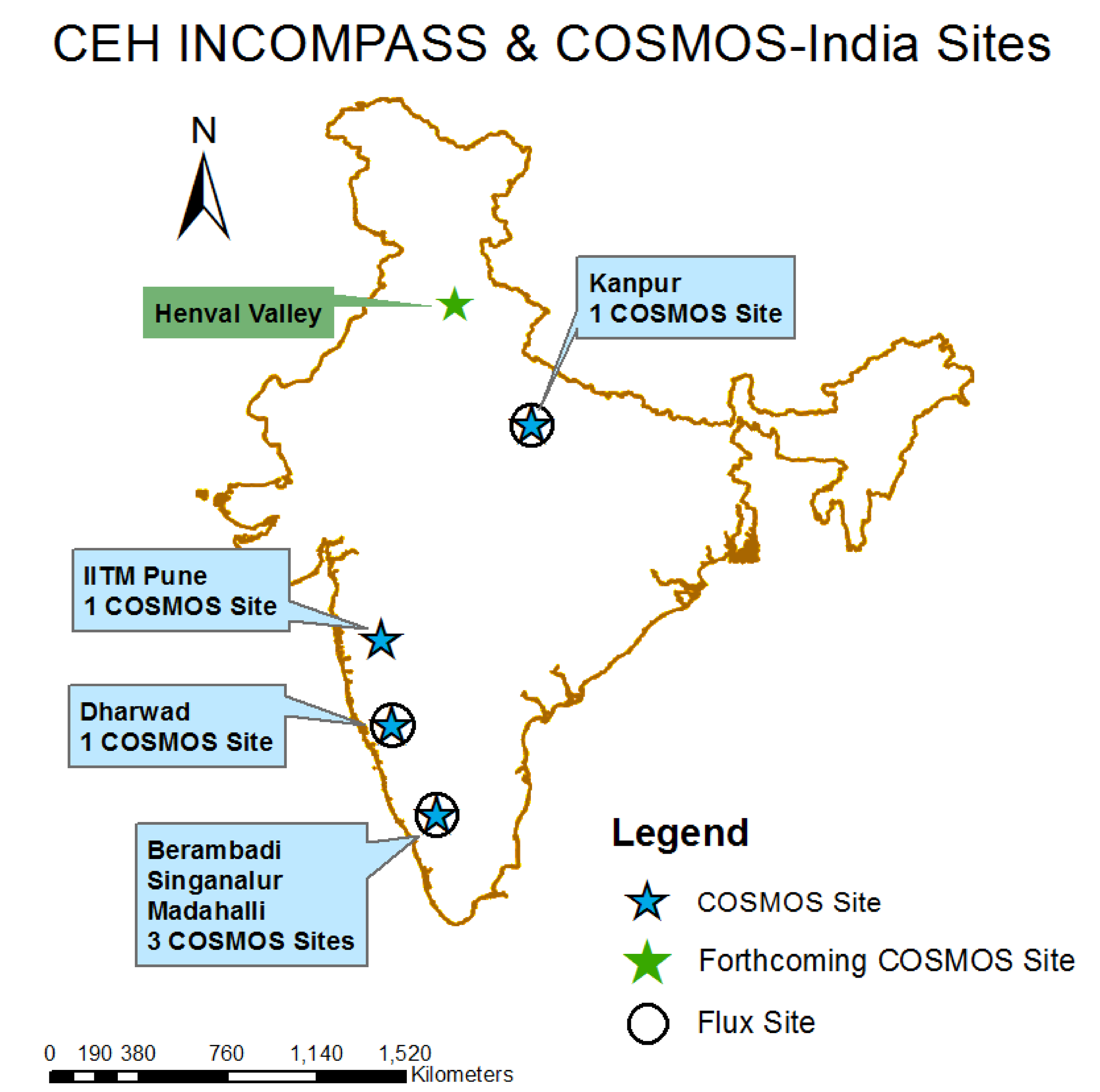
The INCOMPASS and COSMOS-India Networks

The “INteraction of Convective Organisation with Monsoon Precipitation, Atmosphere, Surface and Sea” (**INCOMPASS**) project consists of three eddy covariance flux towers located at IISc Bangalore, UAS Dharwad, and IIT Kanpur. Each station delivers sensible (H) and latent heat (LE) fluxes, micrometeorology, and soil physics; the network thereby provides crucial data for investigation into land surface and atmosphere interaction, and monsoon variability. These three stations also include Cosmic Ray Soil Moisture Sensors (CRS) as part of the “COsmic ray Soil Moisture Observing System” (**COSMOS-India**) network; this equipment measures near-surface soil water content at field scale, inferred by counting fast neutrons from cosmic-rays.

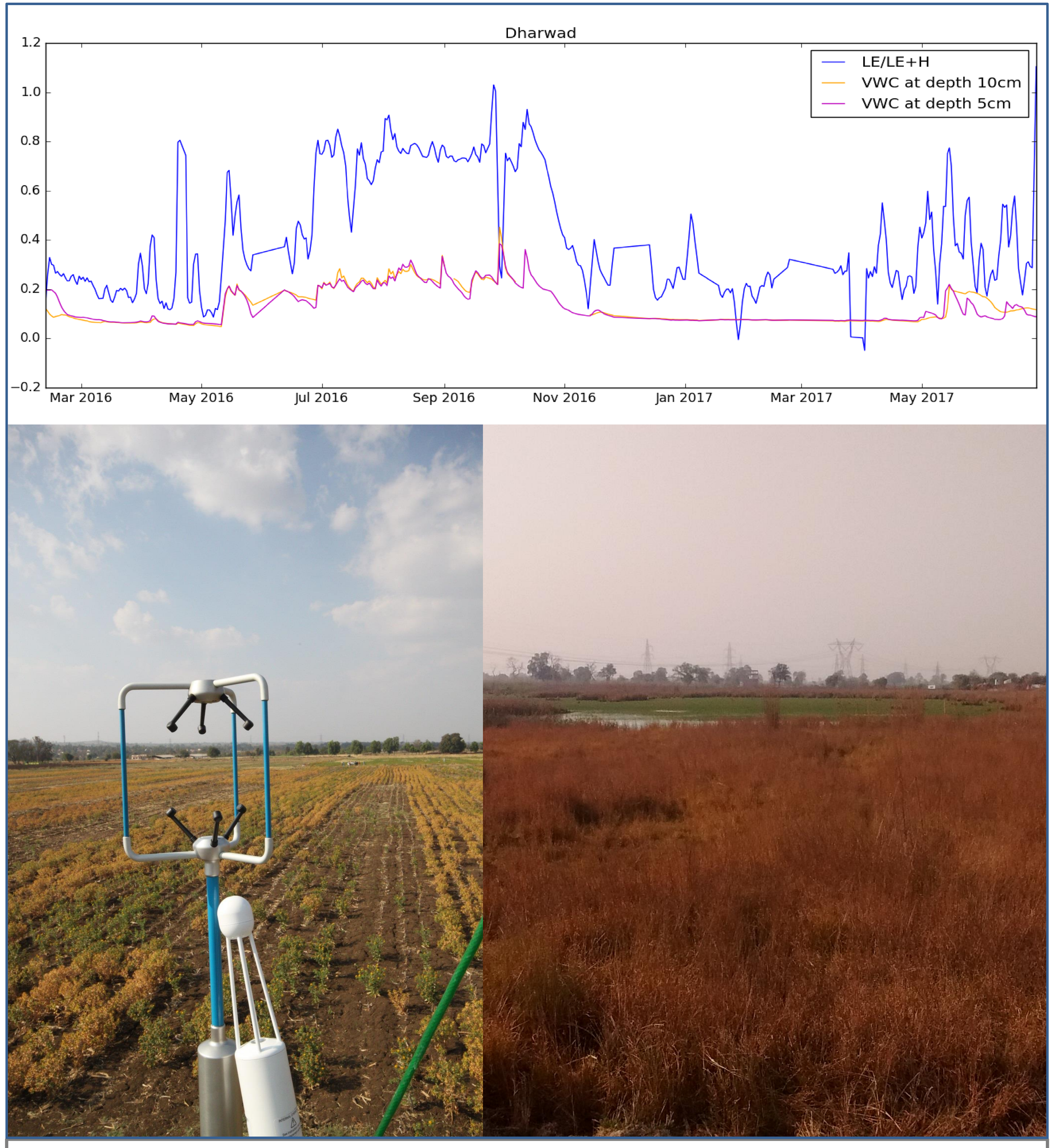


Map of current COSMOS-India sites, showing the three locations where an INCOMPASS Eddy Covariance Flux station is also installed.

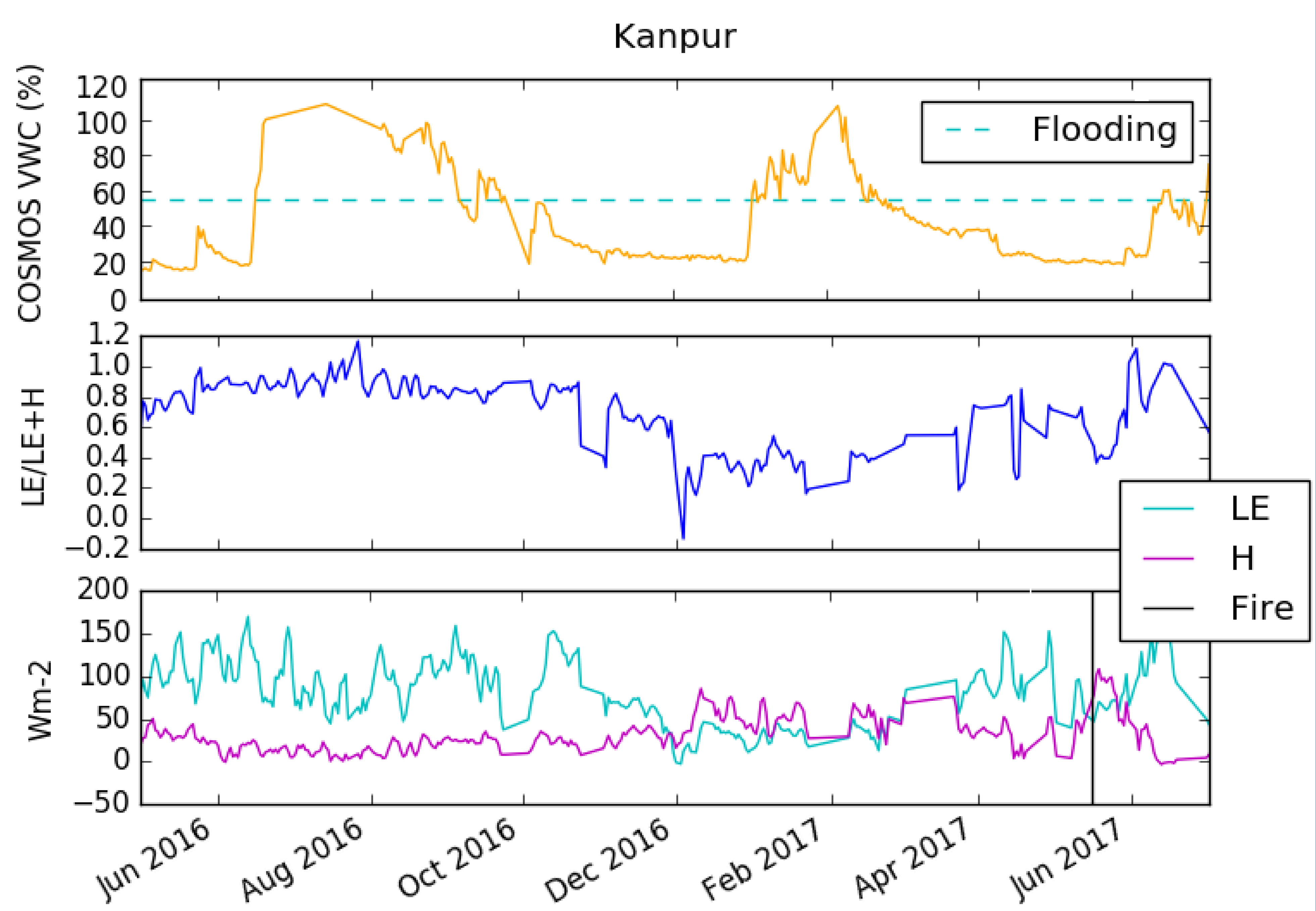
Dryland Fluxes

The combination of COSMOS-India and INCOMPASS networks allows for investigation into the dryland energy and water dynamics in India; we are therefore able to address the following points:

- The important role of **soil moisture** in the land-atmosphere fluxes in semi-arid areas.
- The relationship between **evapotranspiration** (ET) and soil moisture which, when limited, can lead to reduced **precipitation** due to lower atmospheric moisture (Taylor et al., 2012).
- Identification of the onset of the Indian monsoon, and the nature of the onset.
- The influence of the presence and type of crops on the **evaporative fraction**.
- The effect of the use and intensity of **irrigation** on evaporation, and the subsequent impact on **humidity** and **temperature** in the local area (Tsarouchi et al., 2014).
- Additionally, how irrigation during one season can affect the fluxes in the following season due to stored moisture in the soil (Douglas et al., 2006).



Top: *Evaporative fraction plotted with volumetric water content at two soil depths at Dharwad;* ***bottom left:*** *View from flux tower over Dharwad’s cropland; and* ***bottom right:*** *Partially flooded area of Kanpur’s natural grassland. Both photos captured in February 2016.*



Kanpur soil moisture from CRS (VWC), evaporative fraction (LE/(LE+H)), and latent and sensible heat (Wm^2). Blue dashed line indicates site flooding, and solid black line indicates a large site wildfire event.

- In India, **evaporation** is not energy-limited due to high surface and air temperatures; instead, evaporation is limited by moisture availability.
- Early monsoon rain and wetting of Indian soils leads to rapid **vegetation** growth; during this time we can therefore see an increase in latent heat flux (Parker et al., 2016).
- Different types of vegetation will determine different soil moisture conditions. The physiology and development of present vegetation must therefore be accurately captured for a full understanding of dryland fluxes.

Taylor, C. M., R. A. M. de Jeu, F. Guichard, P. P. Harris, and W. A. Dorigo (2012), Afternoon rain more likely over drier soils, *Nature*, *489*(7416), 423-426 (10.1038/nature11377)

Parker, D.J., Willetts, P., Birch, C., Turner, A.G., Marsham, J.H., Taylor, C.M., Kolusu, S. and Martin, G.M. (2016) The interaction of moist convection and mid-level dry air in the advance of the onset of the Indian monsoon, *Q. J. R. Meteorol. Soc.*, 142: 2256-2272 (10.1002/qj.2815)

Tsarouchi, G.M., Buytaert, W. and Mijic, A. (2014) Coupling a land-surface model with a crop growth model to improve ET flux estimations in the Upper Ganges basin, India, *Hydrol. Earth Syst. Sci.*, 18: 4223-4238 (10.5194/hess-18-4223-2014)

Douglas, E.M., Niyogi, D., Frolking, S., Yeluripati, J.B., Pielke Sr., R.A., Niyogi, N., Vörösmarty, C.J. and Mohanty, U.C. (2006) Changes in moisture and energy fluxes due to agricultural land use and irrigation in the Indian Monsoon Belt, *Geophysical Research Letters*, 33: L14403 (10.1029/2006GL026550)

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