Land-atmosphere feedbacks associated with intraseasonal precipitation variability.

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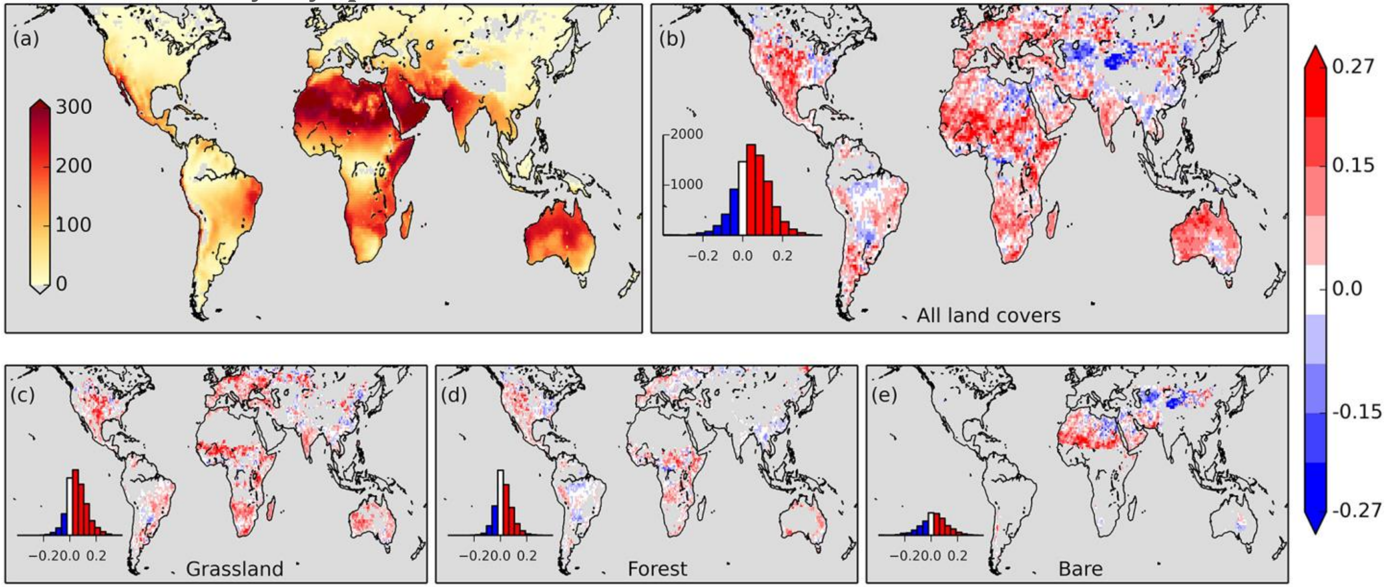
NCEO CEOI Conference
24th June 2020.
1115 – 1130 BST

UK Centre for Ecology & Hydrology

Land surface response to dry spells

- Satellite and reanalysis data highlights land surface temperatures (LSTs) increase more rapidly than near-surface air temperatures during dry spells.
- This indicates water-stressed conditions and increased surface sensible heat flux.

Number of 10-day dry spells.



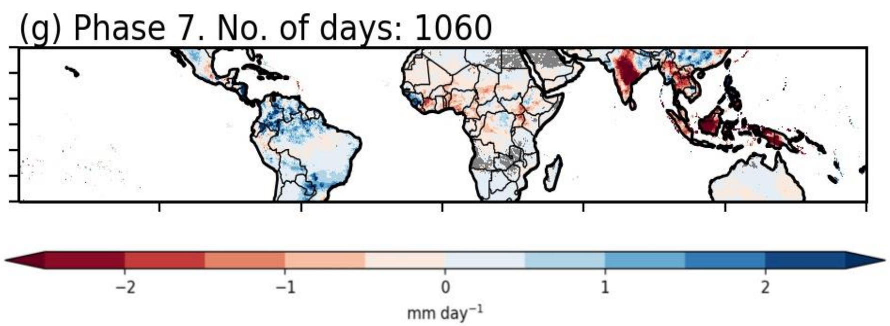
Relative warming rate metric - Measure of how rapidly LST warms relative to the near-surface atmosphere during dry spells.

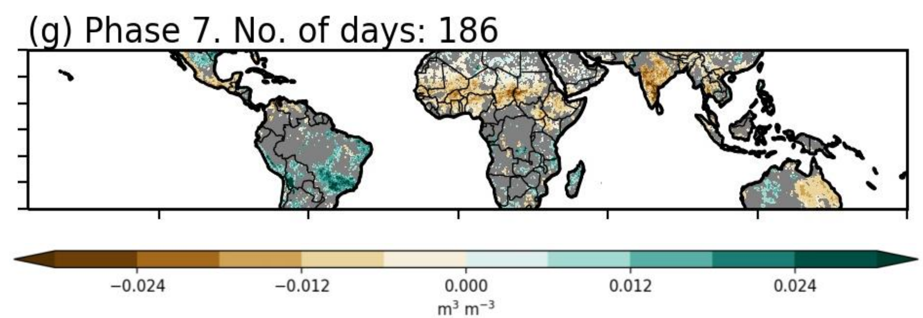
Gallego-Elvira et al., 2016 **Observed 2000-2014 mean (at a 1° resolution) (a) number of dry spell days per year; (b–e) rate of surface warming relative to overlying air during dry spells (RWR, K day^{-1})**

What atmospheric drivers cause these dry spells?

Intraseasonal modes of rainfall variability can lead to dry spells across tropical regions.

Modes of rainfall variability could include Madden Julian Oscillation (MJO), Boreal Summer Intraseasonal Oscillation (BSISO), Silk Road Pattern, Active and Break cycles of the South Asian Monsoon, Quasi-Biweekly zonal dipole, Sahel mode, ...





Intraseasonal rainfall variability → Land surface response → Feedback onto the atmosphere

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Regional example of intraseasonal land-atmosphere feedbacks

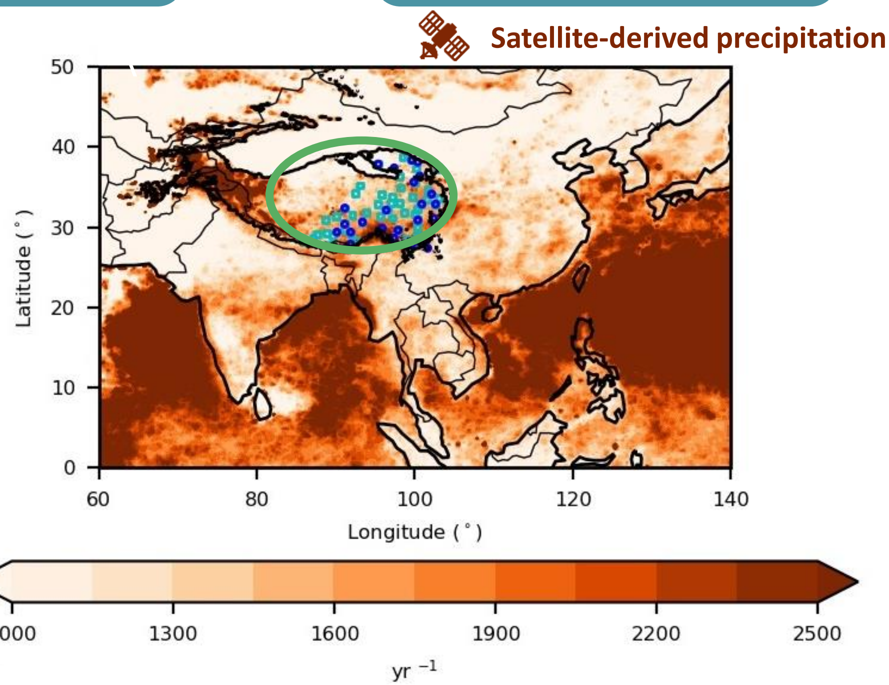
Intraseasonal rainfall variability → Land surface response → Feedback onto the atmosphere

Focus on intraseasonal land-atmosphere feedbacks on the Tibetan Plateau circulation

Dark orange shading highlights regions with high intraseasonal precipitation variability.

The TP is a land region that stands out!

Work submitted to the Journal of Climate, *Intraseasonal land-atmosphere feedbacks on the Tibetan Plateau circulation.*



Average power associated with 7 to 30 day variability of standardised JJA TRMM precipitation (filled, dimensionless) between 2000 and 2014.

Sensitivity of land surface temperatures to precipitation variability

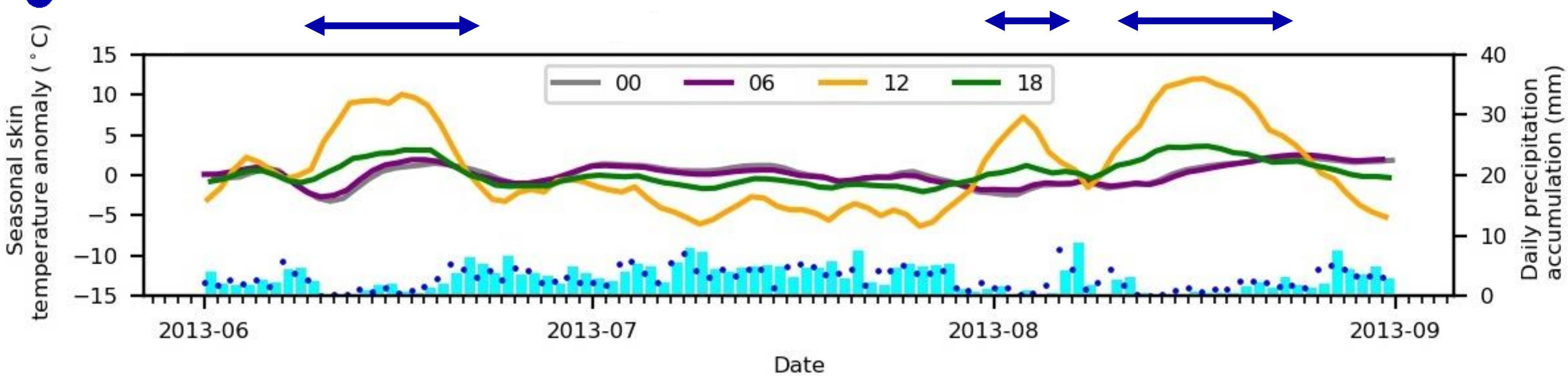
Weather station data highlights a sensitivity of LSTs to intraseasonal precipitation variability associated with surface drying.

Example of station-mean precipitation and LST during boreal summer 2013:

During periods of minimal rainfall, daytime (12 LST) anomalous surface temperatures increase to approximately 10°C.

Weather station data

Weather station data



5-day running-mean CMA station-mean surface temperature anomalies (°C) at 00 (grey), 06 (purple), 12 (orange), and 18 (green) LST during JJA 2013.

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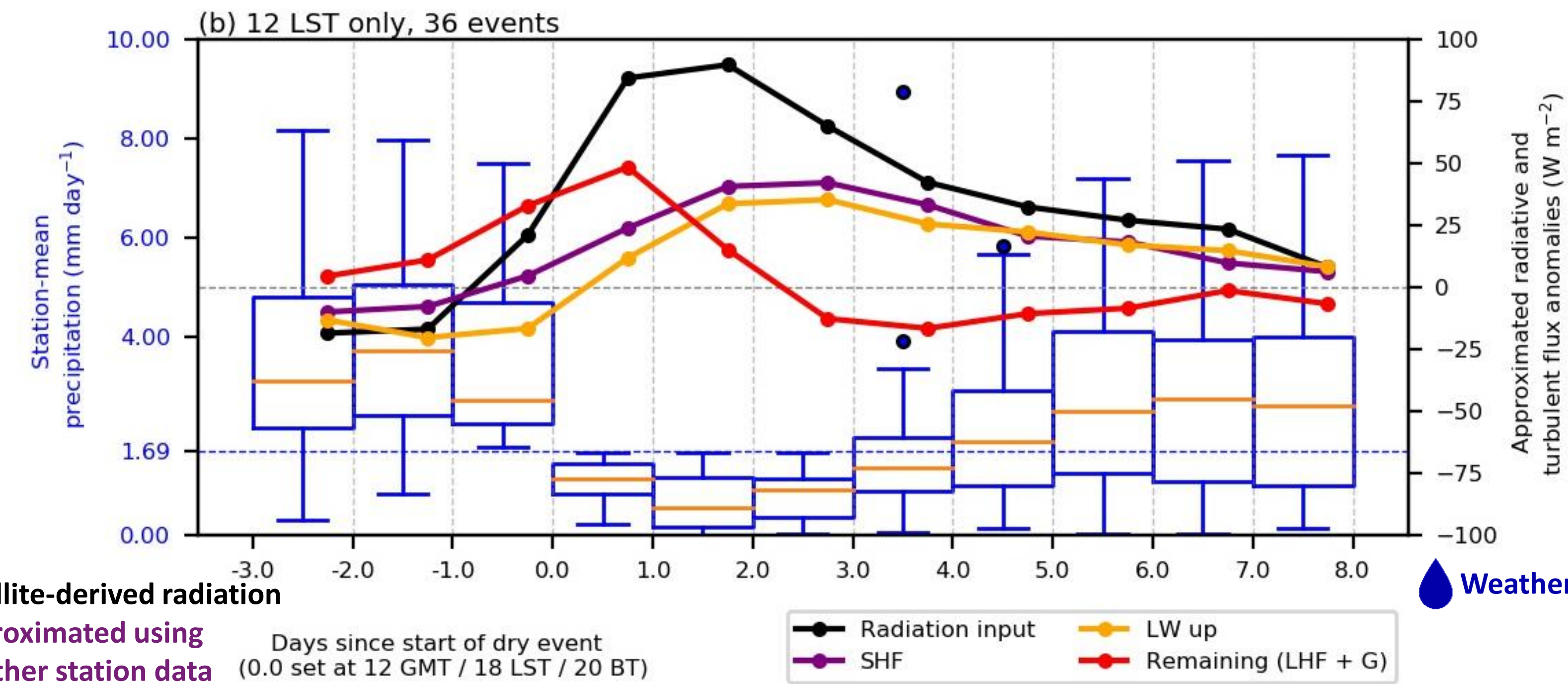
Sensitivity of surface fluxes to precipitation variability

"Regional dry event": Station-mean precipitation < twentieth percentile of daily station-mean precipitation for three days.

Regional dry events show a sensitivity of surface fluxes to periods of minimal rainfall.

During a regional dry event SHF increases by ≈ 40 W m^{-2} whilst LHF decreases by ≈ 50 W m^{-2} associated with decreased soil moisture.



Satellite-derived radiation

Approximated using weather station data

Weather station data

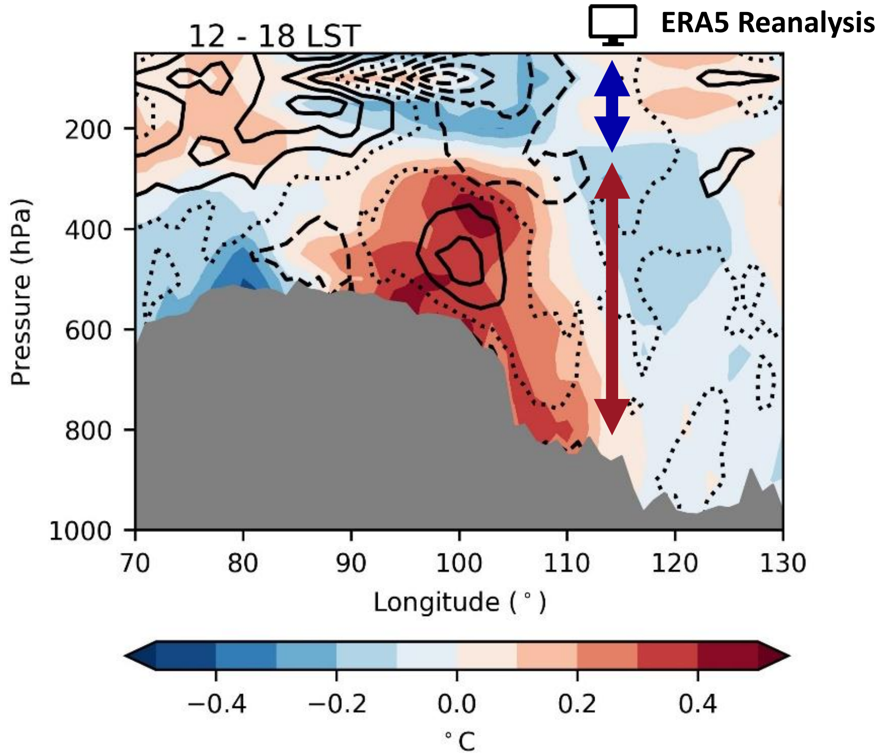
Anomalous station-mean surface upward longwave radiation (orange), approximated surface SHF (purple), CERES-derived sum of net-downward shortwave and longwave downward radiation (black), and LHF and G (red, W m^{-2}) during regional dry events.

Heat low development across the TP associated with surface drying

Minimal precipitation across the TP leads to surface drying and increased surface SHF.

Positive lower-level and negative upper-level temperature tendencies are observed during the daytime of regional dry spells.

Averaged over regional dry events extracted from APHRODITE precipitation.



Changes in composite-mean, daily-mean, meridional-mean (30 to 40° latitude) temperature (filled, °C) and zonal wind (lined, m s^{-1}) during 12 to 18 LST.

Heat low development across the TP associated with surface drying

Minimal precipitation across the TP leads to surface drying and increased surface SHF.

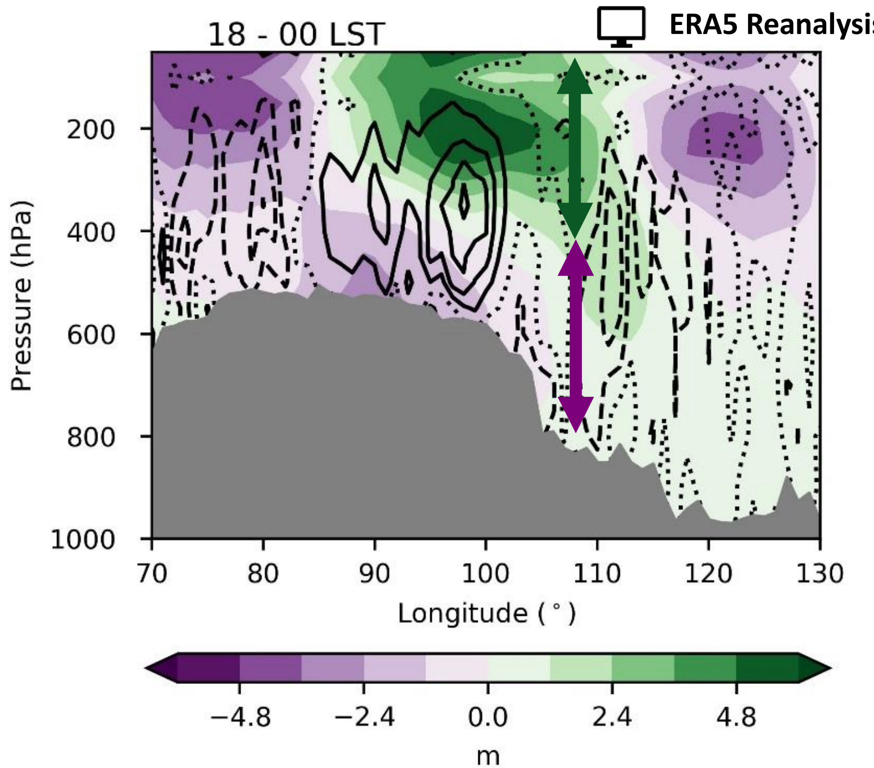
↓

Positive lower-level and negative upper-level temperature tendencies are observed during the daytime of regional dry spells.

↓

The change in temperature associated with surface drying influences winds and intensifies a heat low circulation across the Tibetan Plateau.

Averaged over regional dry events extracted from APHRODITE precipitation.



Changes in composite-mean, daily-mean, meridional-mean (30 to 40° latitude) geopotential (filled, m) and vertical wind (lined, hPa s^{-1}) during 18 to 00 LST.

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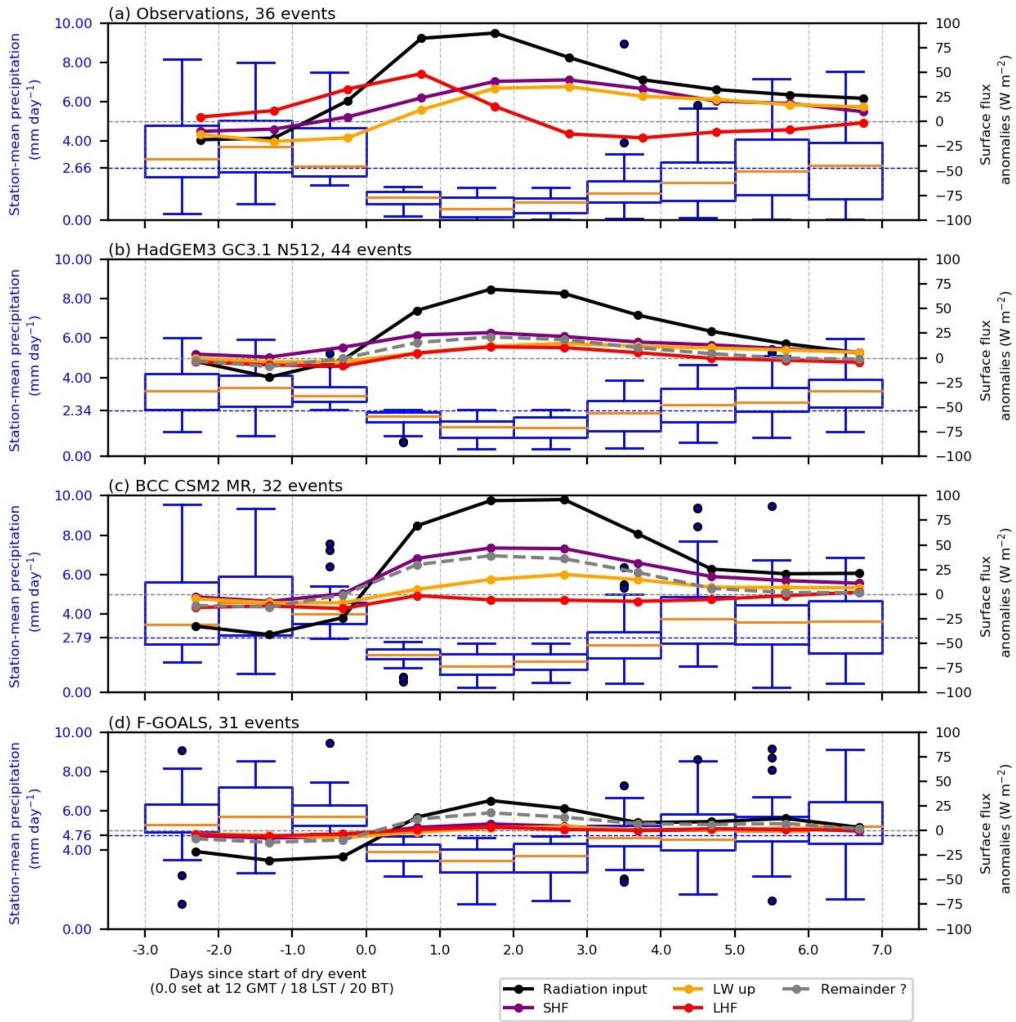
Model evaluation of land surface response across TP

Simulation of surface energy balance response to three-day dry spells across the TP in climate models is poor.

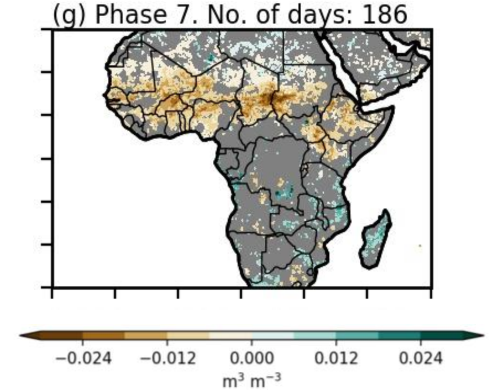
Reduction in evaporative fraction (LHF/[SHF+LHF]) is much greater in observations compared to models.



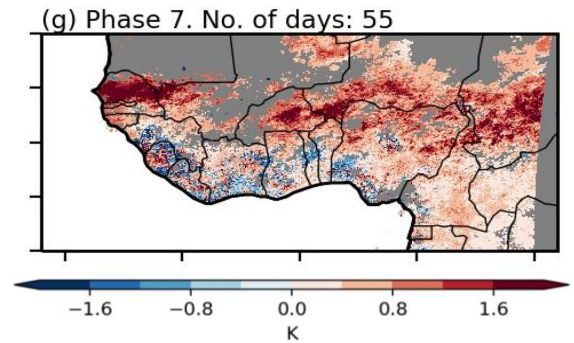
Future work

- In partnership with African-SWIFT investigate the influence of MJO-driven land-atmosphere feedbacks on the West African monsoon.
- Working alongside Bethan Harris (UKCEH), produce a global assessment of intraseasonal variability of land-atmosphere feedbacks.

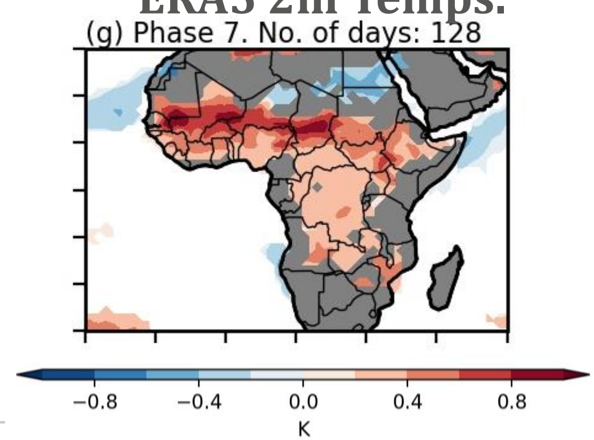
ESA CCI Soil Moisture



SEVIRI LST



ERA5 2m Temps.



Conclusions

- The land surface response to intraseasonal rainfall variability feedbacks onto the local atmosphere.
  - Across the Tibetan Plateau, surface drying promotes the development of a heat low circulation.
  - The surface energy balance response to minimal precipitation across the Tibetan Plateau is poorly represented in climate models.
- Future work - Investigate the influence of intraseasonal variability of land-atmosphere feedbacks across West Africa, and produce a global assessment of intraseasonal variability of land-atmosphere feedbacks.

Any questions:

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This work was supported by UK Research and Innovation as part of the Global Challenges Research Fund, African SWIFT programme, grant number NE/P021077/1, and UK-China Research & Innovation Partnership Fund through the Met Office Climate Science for Service Partnership (CSSP) China as part of the Newton Fund.