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Climate change observed by decades of meteorological satellites

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Future Space, 16-17 Sept 2024

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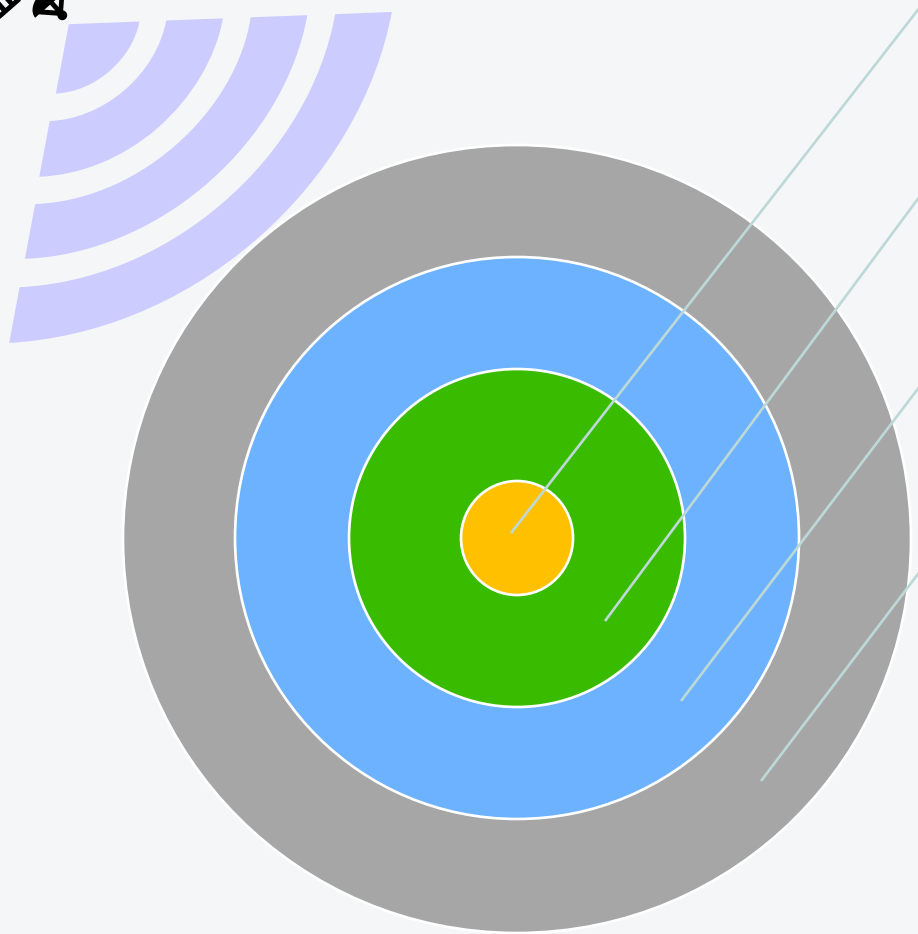
Satellites



Society

Biosphere

Hydrosphere

Atmosphere

A holistic view of Earth observations

The weather satellites have been flying since the last 40+ years

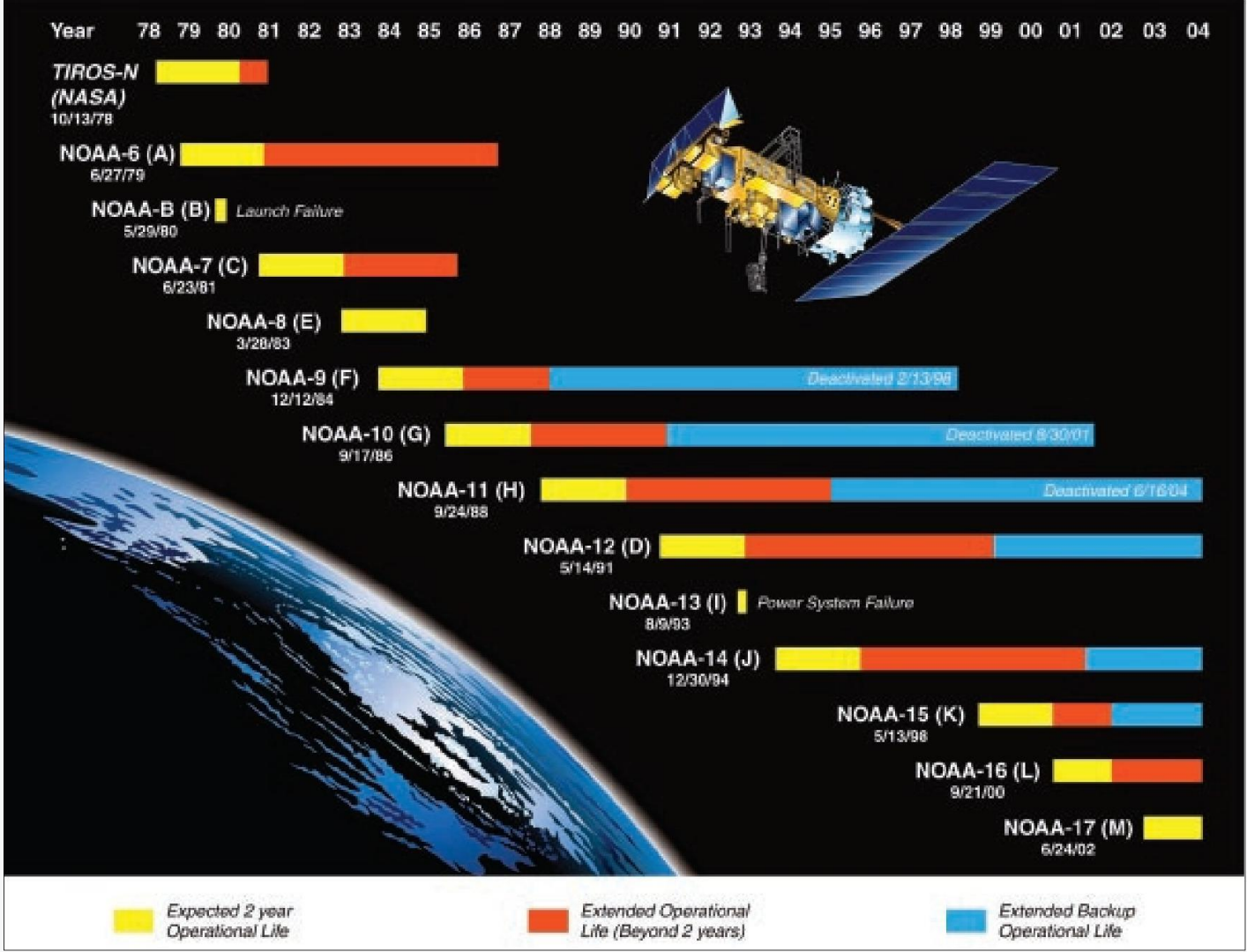


Image courtesy: NOAA

Overarching goals of our research at SMHI:

- Monitoring and understanding recent trends in essential climate variables (ECVs) using satellite based observations

- Connecting climate monitoring to emerging societal needs and climate adaptation

The concept of sector-relevant climate regimes based on ECVs

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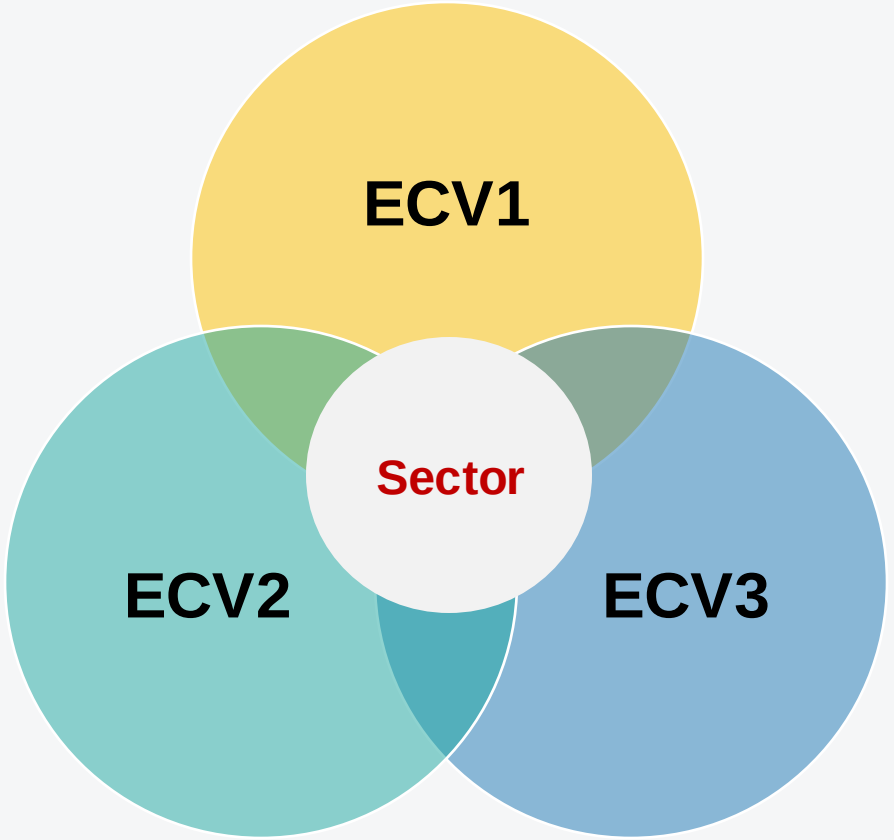
1. Identify ECVs relevant for a sector in question
2. Compute trends and statistical significance
3. Group their trends based on the outcomes (increasing or decreasing?)



- These climate regimes are a good predictor of near-future changes
- An user-oriented way of evaluating climate models

Focus on the solar energy sector

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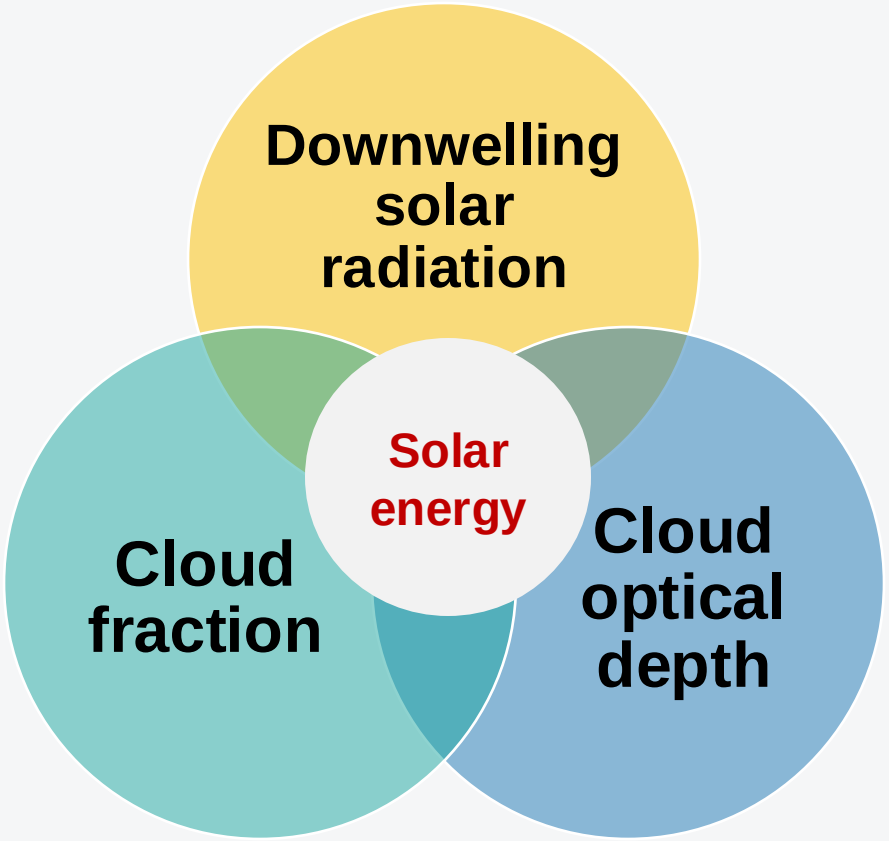
All these ECVs are obtained from satellites



Trends in ECVs and climate regimes relevant for the solar energy sector

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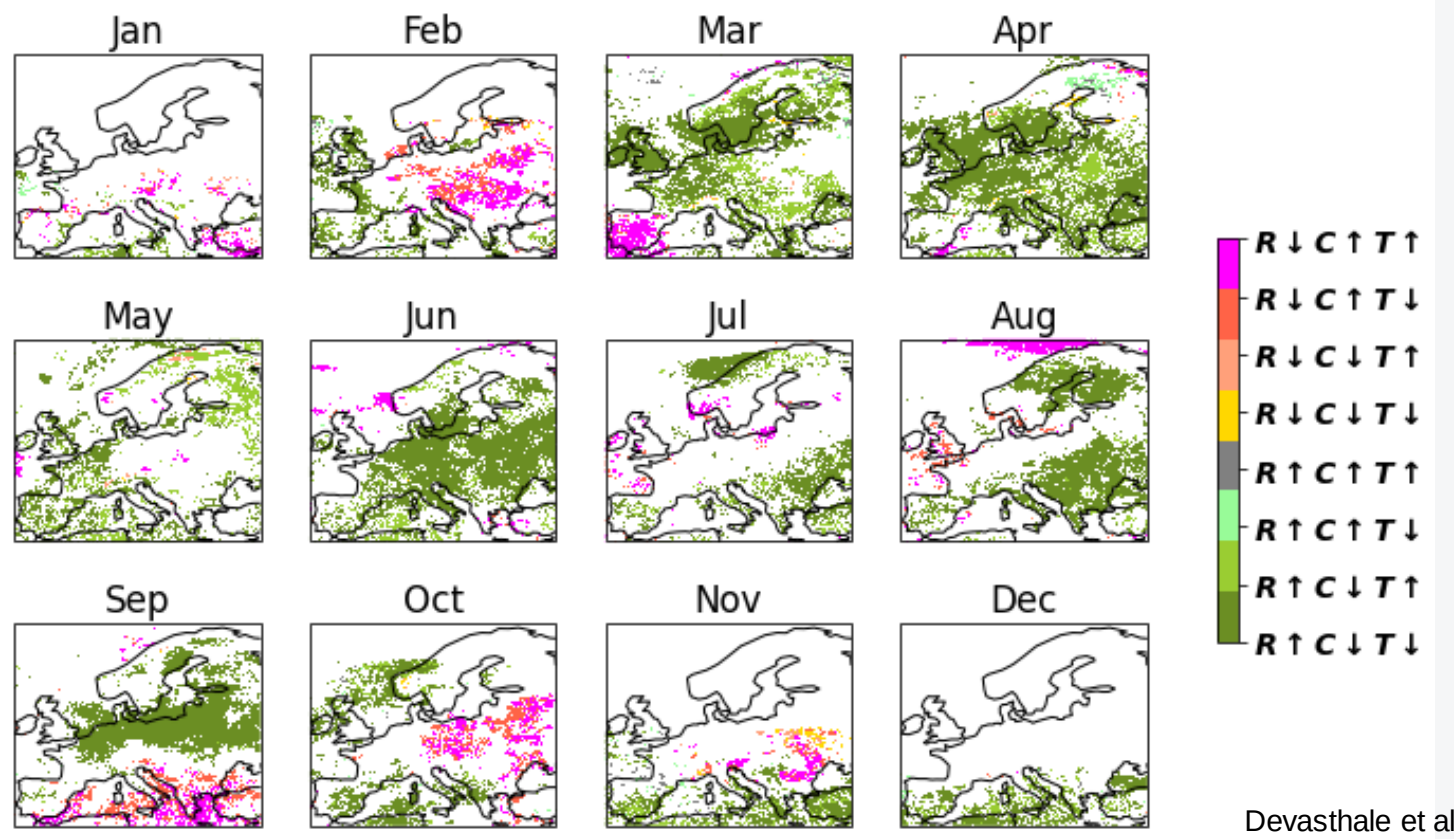


R: Surface downwelling SW radiation

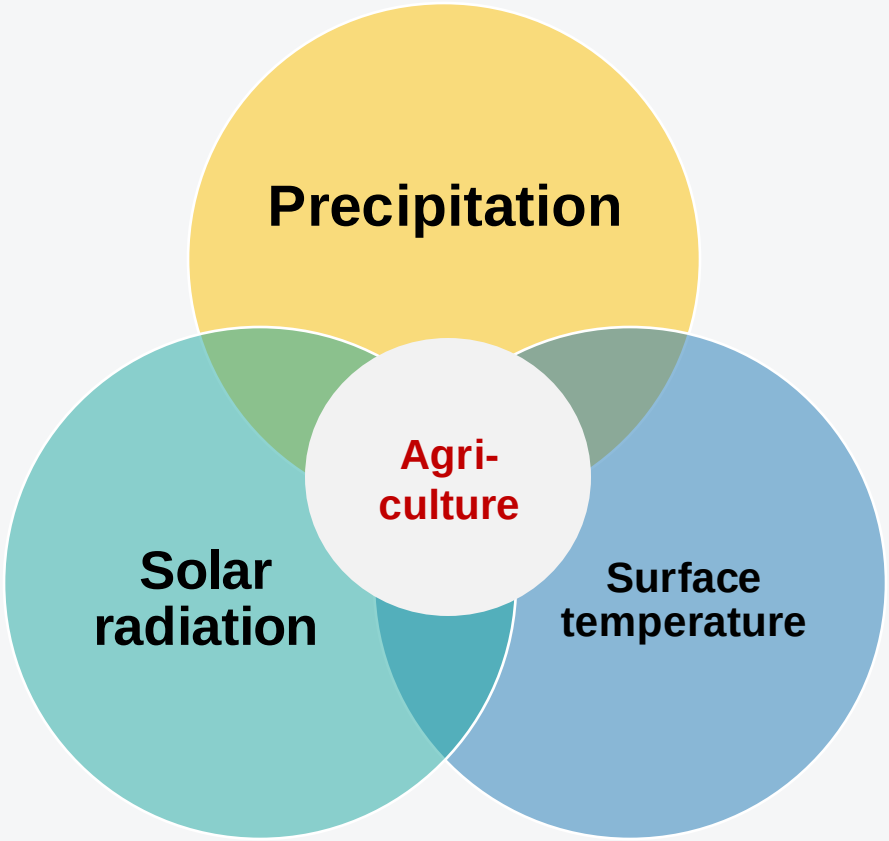
C: Cloud fraction

T: Optical thickness

Devasthale et al., submitted, 2024

Focus on the agriculture sector

A combination of ECVs from satellites, in-situ measurements and reanalysis



Trends in ECVs and climate regimes relevant for the agriculture sector

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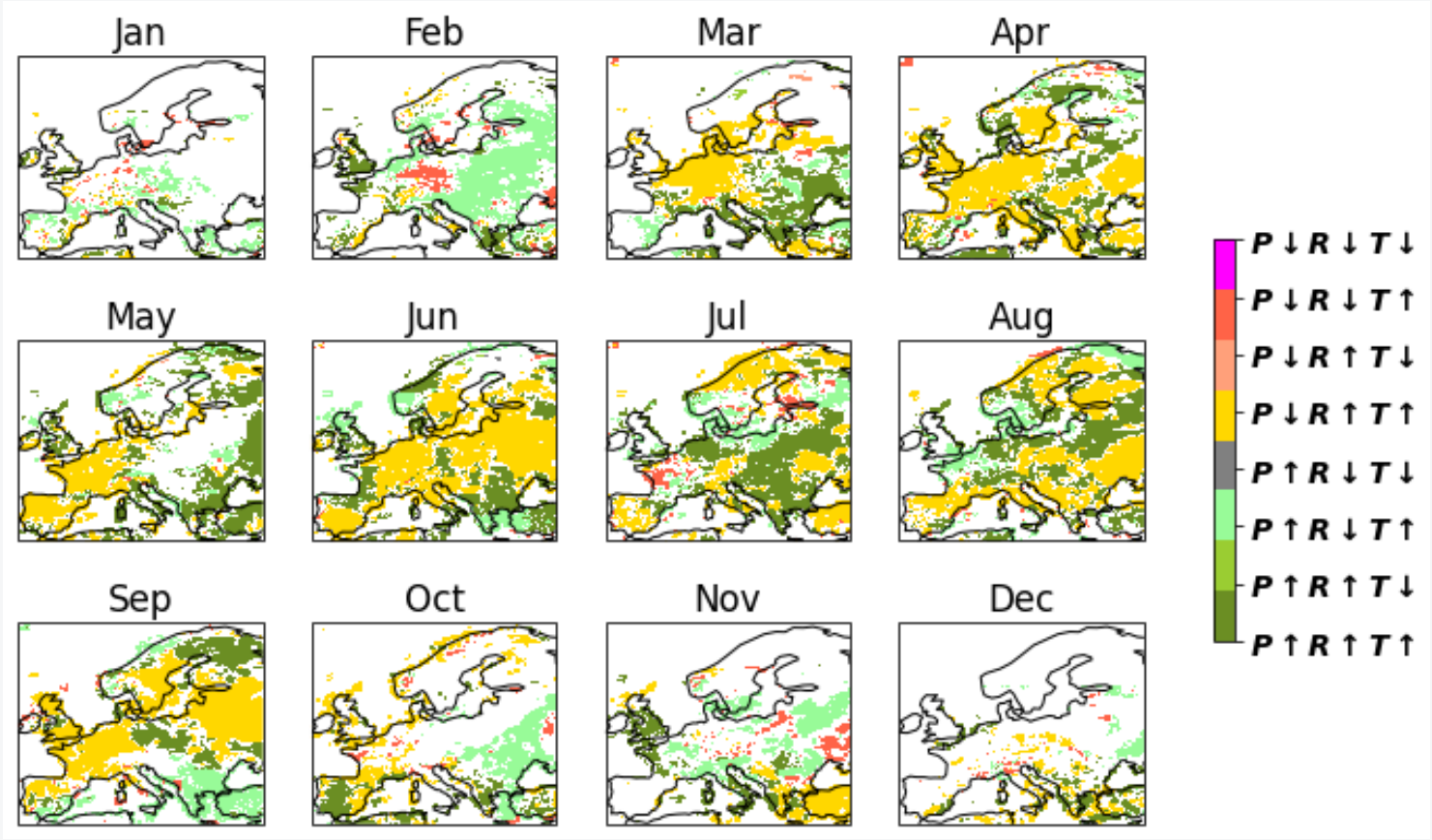

P: Precipitation

R: Surface downwelling SW radiation

T: Surface temperature

Understanding cloud-radiation-circulation coupling is key!

- Almost all sector-revelant ECVs are directly or indirectly influenced by changes in clouds

- Cloud processes still impose one of the largest uncertainties in future climate projections

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The sea surface temperatures are changing.

What would cloud response and feedbacks be in future?

Change in low cloud fraction per degree change in SST

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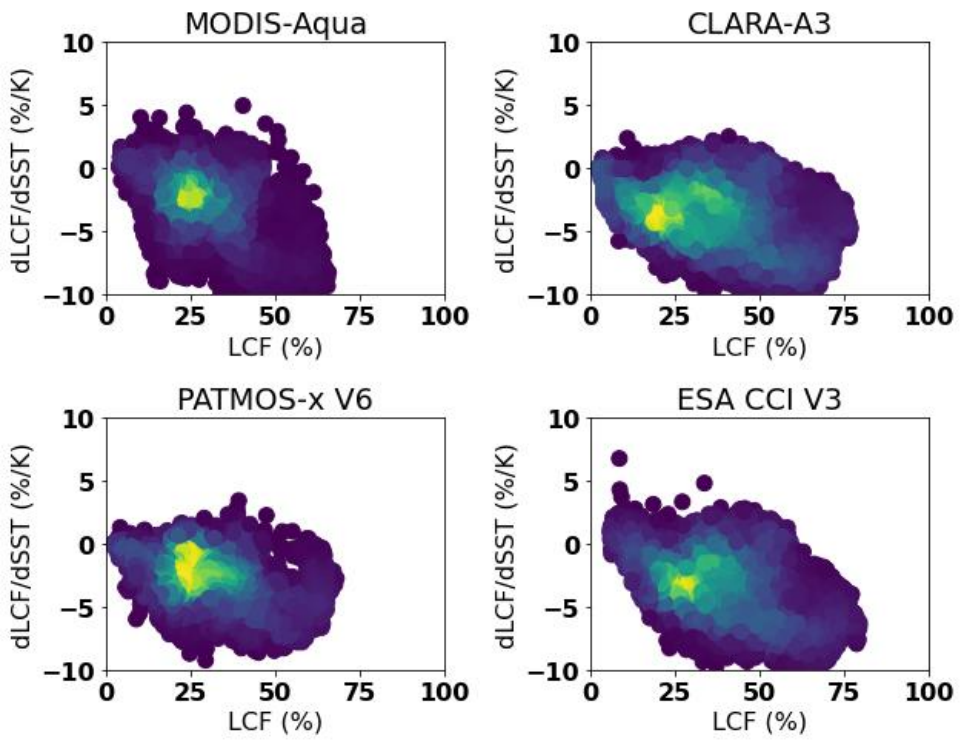
-2.56%/K



-3.67%/K

-2.63%/K

-3.62%/K

Devasthale et al., in prep, 2024

An estimated low level cloud feedback is +2.35 W/m2/K

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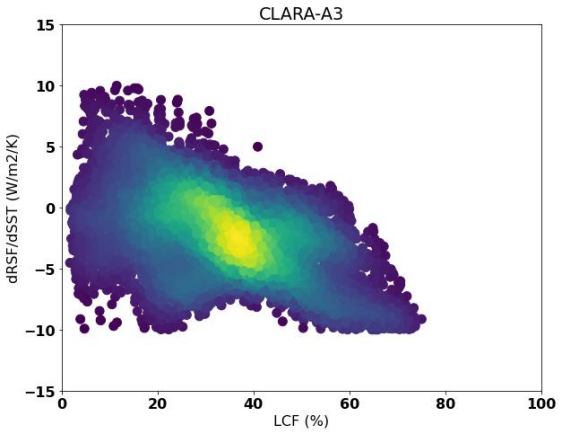
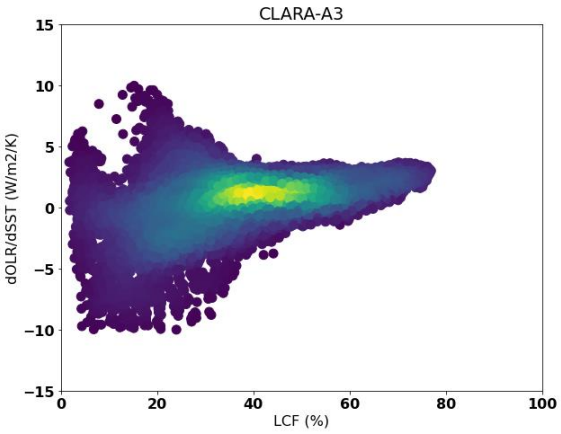
SW



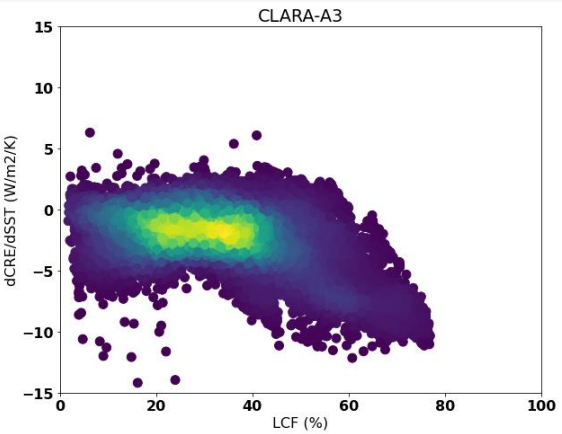
Mean = +2.9 W/m2/K

LW



Mean = -0.55 W/m2/K

Total



Mean = +2.35 W/m2/K

Dramatic climate change is happening in the Arctic

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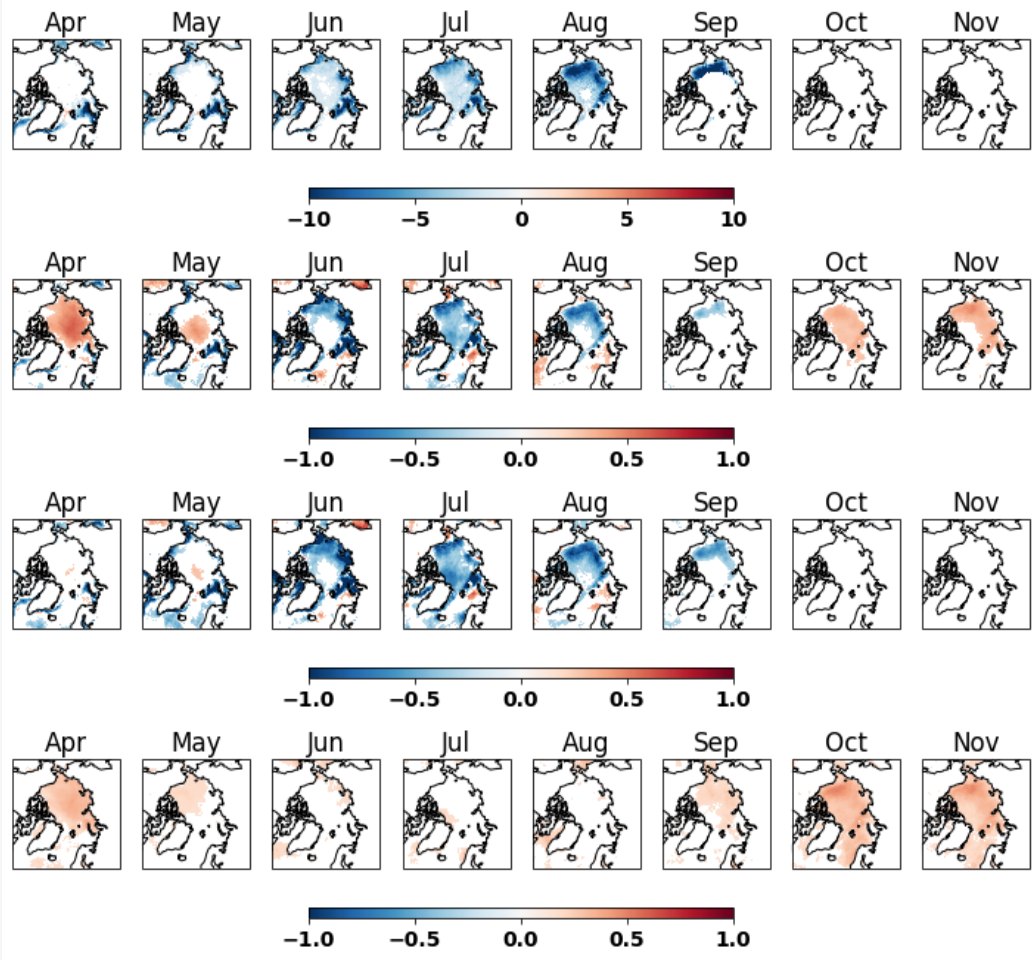

Trends in surface albedo (%/decade)

Trends in total TOA flux (W/m2/decade)

Trends in Reflected SW flux (W/m2/decade)

Trends in Outgoing LW radiation (W/m2/decade)

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Take-home messages

- Recent changes in the relevant ECVs indicate favourable conditions emerging for harnessing solar energy in spring and early summer over much of Europe.

- A mixed-bag for the agriculture sector. The changes in the relevant ECVs seem favourable, but their net effect is heavily preconditioned on precipitation patterns.

- The satellite-based datasets suggest that low-clouds over the oceans decrease by 2.5% to 3.5% per Kelvin increase in SSTs. An estimated total (SW+LW) low-level cloud feedback is +2.35 W/m2/K.

- The surface albedo in the Arctic is decreasing strongly in response to decreasing sea-ice. The reflected TOA SW flux is decreasing in summer and the OLR is increasing in spring and autumn, indicating positive feedback. These changes have far reaching implications.